Workshop on Ambient Intelligence for Telemedicine and Automotive

Natividad Martínez, Ralf Seepold and

Juan Antonio Ortega (Editors)

Sevilla, Spain 29 – 30 November 2013

UNIVERSIDAD DE SEVILLA

HOCHSCHULE KONSTANZ
UNIVERSITY OF
APPLIED SCIENCES

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DAAD Deutscher Akademischer Austausch Dienst
German Academic Exchange Service

AITA 2013, Workshop on Ambient Intelligence for Telemedicine and Automotive / Natividad Martínez, Ralf Seepold and Juan Antonio Ortega, Editors.

ISBN: 978-84-697-0147-8

Editor:

Papers: Corresponding authors.
Figures and multimedia: Corresponding authors.
Edition: Natividad Martínez, Ralf Seepold y Juan A. Ortega

2013, November

ISBN: 978-84-697-0147-8
Legal Deposit: SE 894-2014

AITA 2013

Workshop on Ambient Intelligence for Telemedicine and Automotive

Seville, Spain
29-30 November de 2013

The workshop aims to discuss leading edge contributions to the interdisciplinary research area of ambient intelligence (AmI) applied to the domains of telemedicine and driving assistance. AmI refers to human centered environments attributed with sensors. The development of AmI in the two application domains of the workshop shares several commonalities: the extensive usage of networked devices and sensors, the design of artificial intelligence algorithms for diagnosis, including recommendation systems and qualitative reasoning or the application of mobile and wireless communication to their distributed systems. Together with the presentation of common aspects of Ambient Intelligence, a further goal of the workshop is to stimulate synergies among both application domains and present examples. The telemedicine domain can benefit from methodologies in designing complex devices, real-time conform system design, audiovisual or computer vision system design used in automotive driving assistance. Furthermore, the automotive domain can benefit from the user-centric view, biometric sensor data design, multi-user data bases for aggregation and diagnosis using big data like used in telemedicine.

The German Government supports these research lines in its Hightec-Strategie under the domains “Health and Nutrition” and “Climate and Energy”. In Spain the term “Spanish Program for R&D Challenged Oriented Society – Challenge in energy safe, efficient and clean & Challenge in sustainable transport, smart and integrated” is used.

Scientific contributions to the event are peer-reviewed by a suited program committee having members from Germany and Spain. The same committee is serving the JARCA workshop (Jornadas sobre Sistemas cualitativos y sus Aplicaciones en Diagnosis, Robótica e Inteligencia Ambiental - Conference on Qualitative Systems and their Applications in Diagnoses, Robotics and Ambient Intelligence) since 15 years.

This workshop is sponsored by the German Academic Exchange Service (DAAD) under contract number 57070010.

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AITA 2013 Program

29th November (Higher Technical School of Computer Engineering):

- Session 1 (Telemedicine. Session chair: Natividad Martínez).

  - ***Virtual Patient*** **..**
    Paula Delgado López
  - ***Experiences in Ambient Assistance Living competitions*** **...................................**
    Juan Antonio Álvarez García
  - ***Hi-Res activity recognition system based on EEG and WoT*** **..............................**
    Luis Miguel Soria, Miguel Ángel Álvarez, Juan Antonio Ortega and Rafael Vergara.
  - ***Military Telemedicine in Spain*** **..**
    Vicente Velamazán.
  - ***Aggregating individual stress-levels for dynamic clusters*** **................................**
    Patrick Datko, Javier Martinez and Ralf Seepold
  - ***Public Resource usage in Health Systems: A Data Envelopment Analysis of the Efficiency of Regional Health Systems in Spain*** **..**
    Mari Sol Campos Lucena, Francisco Velasco Morente, J. M. Gavilán and Alejandro Fernández-Montes

- Session 2 (Automotive. Session chair: Cecilio Angulo).

  - ***An adaptive driving system regarding energy-efficiency and safety*** **.................**
    Emre Yay and Natividad Martínez Madrid
  - ***Using qualitative methods in order to recognize traffic signs*** **..........................**
    Lledo Museros, Zoe Falomir, Ismael Sanz and Luis González Abril
  - ***Monitoring driving behaviour and biometric data to detect stress patterns*** **............**
    Wilhelm Daniel Scherz, Javier Martínez and Ralf Seepold
  - ***Comparing Energy Efficiency of drivers and vehicles using Data Envelopment Analysis*** **..**
    Alejandro Fernández-Montes, Juan Antonio Álvarez, Damián Fernández-Cerero, Victor Corcoba, Mario Muñoz and Juan Antonio Ortega
  - ***An approach to a reference model for perception in a sentient smart city*** **.........**
    José Ignacio Sánchez
  - ***Stress map development reducing routing risks*** **...**
    Thomas Wegmann, Javier Martinez and Ralf Seepold

- Session 3 (Disertations. Session chair: Ralf Seepold).
  - ***MapReduce and Applications* ....**
    Jesús Antonio Sánchez Méndez and Juan Antonio Alvarez-García
  - ***A collaborative standard-based mobile telemonitoring platform* ....**
    Maksim Kolesnik and Natividad Martínez Madrid
  - ***Helping sales managers to understand their business environment* ....**
    Germán Sánchez-Hernández, Núria Agell, Juan Carlos Aguado and Mònica Casabayó
  - ***Designing a qualitative human-machine interaction framework based on the cloud for robot learning about the environment*...**
    Lledó Museros, Ismael Sanz, Zoe Falomir and Luis Gonzalez-Abril
  - ***Social Skills Training with Robots for Children's Education*...............................**
  - *Cecilio Angulo, Marta Díaz, Cristóbal Raya, Jordi Albo-Canals, Alex Barco, Carles Garriga, Jaume Campistol and Vanesa Padillo*
  - ***Beyond the artificial pancreas. Ambient Intelligence and diabetes self-management* ....**
    Josep Vehí
  - ***A Holistic Approach to the Sustainable Empowerment of the Ageing Society* ...**
    Natividad Martinez Madrid and Ralf Seepold

30th November (Scientific Computing Center of Andalusia):

- Guest Session. Sensors and Robots in Ambient Intelligence for Telemedicine and Education. Cecilio Angulo Bahón

Guest session

Sensors and Robots in Ambient Intelligence for Telemedicine and Education

Linked to the AITA workshop (Ambient Intelligence for Telemedicine and Automotive domains) we will discuss leading edge contributions from our research group to the interdisciplinary research area of ambient intelligence (AmI) applied to the domains of telemedicine and education. AmI refers to human centered environments attributed with sensors (and robots, it should be said). The development of AmI in the two application domains shares several commonalities: the extensive usage of networked devices, sensors, and robots, the design of artificial intelligence algorithms for diagnosis, including recommendation systems and qualitative reasoning or the application of mobile and wireless communication to their distributed systems.

Cecilio Angulo Bahón

Cecilio Angulo holds a BSc/MSc in Mathematics from the University of Barcelona (UB) and a PhD in Sciences from the Department of Automatic Control of the Technical University of Catalonia (UPC). He has been a visiting professor at LP2A – Univ. de Perpignan, Universidad de Sevilla (2003), IIIA – CSIC (2004), and DIBE Univeristà degli Studi di Genova (2006). He obtained an I3 Programme's research grant (Sep 2008 – Sep 2011) on Social Robotics. He has been leading research in five coordinated research projects from 2006 (ADA, SOFIA, ACROSS, ROSA, PATRICIA). He's currently the Coordinator of the Official master's degree in Automatic Control and Robotics (UPC). His research is mainly focused on ambient intelligence systems based on inertial sensors and robotics platforms.

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VIRTUAL PATIENT

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Abstract

The virtual patient is a tool for improving the current clinical system. Its main use is in the assistance provided to facilitate at students study of health environment in order to avoid risks and emergency situations due to lack of inexperience of those students.

1 Introduction

The study was based on the choice of different articles, which will be explained below each. The thematic of this studio is the virtual patient, where the articles explain the cause of their use and the need, how the interface of the virtual patient simulator is implemented and areas where it has more utility this learning method.

2 Why?

"Virtual patient simulators: 8 reasons to incorporate VPS into healthcare training"

Keywords: costs, consistency, available, realism.

When you want to optimize economic resources and security of a medical training system, one aspect to consider is the inclusion of a virtual patient simulator.

This likely helps to improve patient safety and quality of care but is certainly not maximizing the training budget.

✓ *Lower initial investment and operating costs.*
High-fidelity simulated patient hardware requires a large initial investment, whether it involves adding a simulated patient manikin or a complete medical simulation environment.

✓ *Simulation metrics mean measurable outcomes.*
It presents a patient, an environment, and a scenario, with which the learner must interact. Actual parameters for the interface so that the software represents reality through certain configurable parameters depending upon specialty treated are used.

✓ *Virtual scenario versatility, realism and experimental learning.*
In VPS scenarios, human actors portray patients with a variety of diseases and therapeutic conditions. Learners interact with the patient simulation similar to how they would conduct a real medical visit. They reviewing vitals and medical history and they have the compendium of diagnosis and treatments accessible at the click of a button.

Figure 1: Screenshot of the user interface

✓ *Replication and consistency.*
In practice, very few clinical situations are the same for everyone, and there is not just one correct response. Virtual patient simulation training provides consistent feedback with feedback that easily absorbed by learners.

✓ *Always available.*
The application is available 24 hours a day to be an online application, and cuts that can occur due to errors or updates are minimal.

✓ *Beyond psychomotor simulation.*
High fidelity manikins provide risk-free simulation for the critical psychomotor skills such as intubation, sutures, or injections.

✓ *Constantly integrate new medical knowledge.*
It is a challenge for health care training institutions to keep up with the ever growing and changing compilation of medical knowledge, and it is nearly impossible to quickly integrate changes into standard simulation platforms.

Figure 2: standard high-fidelity mannequin.

✓ *Ease of use – for instructors and learners.*
Virtual patient simulators are easy to use and there are tutorials to explain in a detailed way.

To improve patient safety, a good option is to include a virtual patient in a healthcare organization's training system.

3 How?

"***Virtual Patient Simulator for Distributed Collaborative Medical Education***"

<u>Keywords</u>: virtual patient, artificial intelligence, medical education, patient simulation, problem-based learning, TOUCH (Telehealth Outreach for Unified Community Health).

The main objective of the TOUCH project is to develop a computing environment computer that it is facilitate students to perform health studies through the telemedicine determining whether an integrated, collaborative and immersive virtual environment can be developed to facilitate enhanced human comprehension.

In the first stage a scan has been performed and has involved initial development of advanced computing tools by using virtual reality and a newly developed virtual patient simulator making use of a novel virtual environment development tool called Flatland distributed to distant learning sites.

The students interact with the virtual patient through the virtual reality (VR). The TOUCH demonstration case is composed of three Flatland application modules:

- ✓ The Virtual Patient Environment
- ✓ The Artificial Intelligence simulator
- ✓ The Spycam

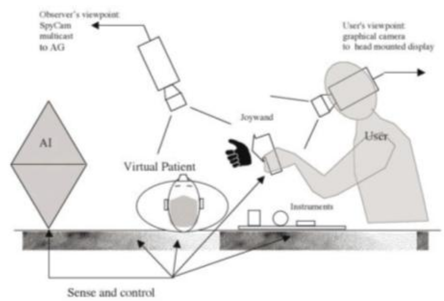

Figure 3: Diagram showing the relationships between the components of the TOUCH System. The user interacts with the scene through hand-held joywands represented was a floating hand with the corresponding orientation.

A typical Access Grid (AG) studio consists of a meeting room with a multi-projector wall screen, multiview cameras, microphones and speakers. On the screen are live images of remote collaborators, a Spycam view into Flatland.

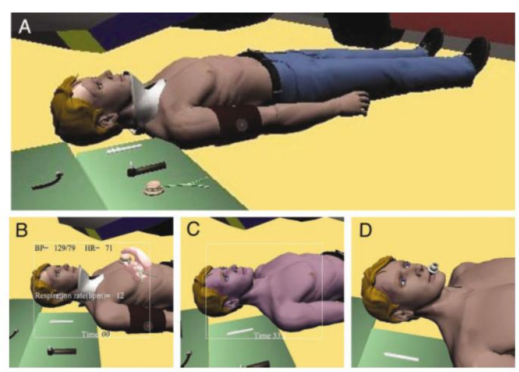

Figure 6:
A. A view of the TOUCH system in a standard Flatland environment, showing the virtual patient with a set of the medical devices.
B. Vital signs and data are presented to the immersed user upon their "head up" display.
C. The artificial intelligence timeline in the virtual reality patient becoming cyanotic at which point an airway must be inserted or death ensues.
D. After the airway is inserted, the patient regains hue.

Figure 5: A view of the Access Grid studio during one of the experimental sessions.

The TOUCH project is determining the feasibility of using emerging technologies to overcome geographic barriers to delivery of medical education and to enhance the learning process with immersive virtual reality.

The participants were divided into two groups, each of them received knowledge about one of the two vignettes developed.

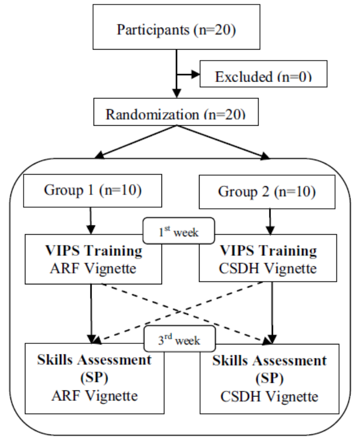

Figure 7: Study Design

4 Where?

"Developing Clinical Skills Using a Virtual Patient Simulator in a Resource-Limited Setting"

Keywords: virtual patient, telemedicine, virtual patient simulator.

The concept of virtual patient simulator is to perform a simulation of a medical practice, focuses on gathering critical information for diagnosis and appropriateness of medical decisions.

The main objective is to measure the effect of training with a patient simulator system virtual clinical skills of health professionals in Africa, because this continent is a resource-constrained environment and the role of telemedicine is one of the major medical challenges. This article performed to find the various advantages and disadvantages of the use of this interface. It uses an objective, structured clinical examination (OSCE = Objective Structured Clinical Examination).

One the other hand, the intervention consisted of two groups training on one of the two clinical vignettes implemented in the VP simulator. The performance score of participants were assessed on both clinical vignettes.

Advantages

❖ **Validity**. The virtual patients are carefully informed to simulate real patients with specific medical conditions.

❖ **Availability**. The VP is available at any time.

❖ **Security (Precision).** The roles of VP are standardized and repeatable.

❖ **Is enforceable**. The situation, the stage and level of difficulty are flexible and controllable.

❖ **Adaptability**. There are no time constraints, scenarios can be modified as needed.

❖ **No risk. N**o causes discomfort or inconvenience as is the case with the real patient.

❖ **Feedback**. Immediate and constructive, participants benefit listening to the perspectives of patients.

Moreover, the difference in overall score was observed between participants who received training from the virtual patient system and those who did not receive the training.

	Vignette $_{ARF}$	Vignette $_{CSDH}$
Topic	Acute Renal Failure (ARF)	Chronic Subdural Hematoma (CSDH)
Background	35% of ARF cases in Africa are due to drug intoxication with traditional herbal medication	Underdiagnosed pathology, especially in the absence of medical imaging (CT scan)
Learning Objectives	Sensitize health care professionals to diagnose ARF due to intoxication with traditional herbal medication	Improve the CSDH diagnostic to improve prognosis

Table 1: Summary of clinical vignettes implemented in the virtual patient system (VIPS)

The task was to make a medical consultation, after which they must identify the problem by asking questions, and then take appropriate decisions for the proper management of the case. Data were analyzed with statistical program SPSS 17.0.

	VIPS	**Control**	***P****
Vignette $_{ARF}$ (%)			
Mean (SD)	73.9 (4.4)	63.8 (11.7)	
CI 95%	71.3 – 76.5	56.6 – 71.1	*0,019*
Median	74.4	59.9	
Min-Max	65.0 - 80.0	50.0 - 80.0	
Vignette $_{CSDH}$ (%)			
Mean (SD)	66.1 (6.2)	60.2 (7.9)	
CI 95%	62.6 – 70.0	55.5 – 64.3	*0,077*
Median	65.7	62.1	

Table 2: Overall group scores for each vignette and their comparison.

Scores

- ✓ 0: if the item was ignored by the participant.
- ✓ 1: It was assigned if the participant considered the issue, but not optimally.
- ✓ 2: It was assigned if it was included in the medical consultation.

Limitations

Difficulty in recruiting participants, so that the validity of the results and the inability to make a generalization is reduced.

Furthermore, has not been investigated monitoring the progress of a group, before and after using VIPS, to assess the impact of training.

Conclusions

To conclude, this study suggests that the training with a medical consultation VP simulator can develop the operational clinical skills of the user.

❖ Mean performance scores obtained by participants who had been trained with VIPS were higher than those obtained by the participants belonging to the control group (who had not received such training).

❖ Therefore, the results suggest that people who were trained by a virtual patient whose educational activity is based on the medical consultation tends to significantly improve their clinical skills, compared with those who received no such training.

❖ This study demonstrates the relevance and feasibility of this type of continuing medical education for education in the African context, offering new opportunities for medical education in countries with limited resources. Using a patient simulator provides an opportunity to supplement or offset the lack of teachers required for the supervision of students during medical training, and the lack of hospital infrastructure as seen in most African countries.

❖ It was demonstrated the evaluation the feasibility of clinical skills with standardized patients.

This study suggests that the training with a medical consultation VP simulator can develop the operational clinical skills of the user.

Example

It can find different online virtual patient simulators with which it can observe the operation of the study. One advantage of this particular example it is available in several (INMEDEA Simulator).

Definition

✓ The users browse the interactive virtual patients in a clinic. In a playful way improve their basic medical knowledge and learn to make clinical decisions.

✓ It has examples of real cases enriched with multimedia content.
✓ Based on playful learning to transfer the theoretical medical knowledge.

✓ Learning-centered skills and competencies related to dealing with patients.

✓ Users should make independent decisions after evaluating the case and are then evaluated.

✓ It is possible to have contents as the center.

Figure 8: The reception of the simulator virtual patient.

Content
✓ Disease patterns are represented by cases of actual patients.

✓ The multimedia library includes documents enlargement as scripts, reference books, medical journals or videos.

✓ Each teacher has their own virtual clinic.

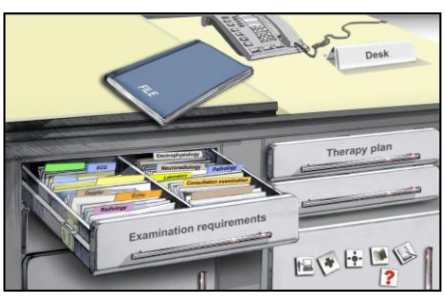

Figure 9: Screenshot of the examination requirements where it can find many exams and tests to patients. Depending on the clinical specialty where it is, these tests can vary.

✓ In the area of Internet Café users can directly contact with tutors and other users through the chat boards and virtual ads.

✓ Administration online. Includes various editing tools.

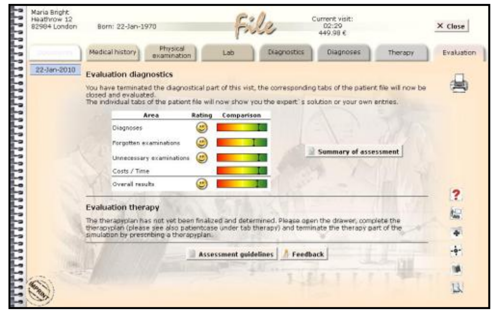

Figure 10: Screenshot of the performance and evaluation of the patients. These data can be compared with the ideal values to address the case properly.

This simulator can ask the relevant questions in the medical record or communicate directly with the patient. You can also examine the patient in the recognition room with the tools available and to request laboratory tests or it can refer the patient for further testing with the requirements of review.

Diagnoses, tests or patient records are stored in a knowledge base.

When you have already made the diagnosis, it has to assign a given therapy to the patient. For this, it set a plan of treatment for the diagnosed disease states. Then, it select from the following options: prescription drugs, surgery, non-drug treatments or referral to a specialist.

Improve patient safety by incorporating a virtual patient simulator into your health care organization's training system.

Conclusions

The studies show multiple advantages of using a virtual patient in the health sector and how it can be a useful tool in such an environment.

One of the main advantages is the possibility of that interface with practices, avoiding potential risks with real cases due to the inexperience of the students.

However, it is shown that by using this interface the student training is not complete and it could produce misdealing with real patients.

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Hi-Res activity recognition system based on EEG and WoT

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Abstract

Nowadays, the recognition of physical activity (PA) is a well-known problem with many solutions. Several kind of algorithms, using MEMS sensors, allow determine the most likely activity. Indeed, these applications work well when physical activity is performed for long periods of time and steadily. However, indoors, these systems are not entirely suitable and have several problems. In this paper, thanks to the introduction of new context information, such as EEG, and through communication between WoT based elements interface at home, it would be possible to perform a more accurate and low-level recognition. By using uPnP protocol and additional services, information from other smart housing elements with user device itself can be shared, enriching traditional systems based on ac-celerometry.

1 Introduction

Just 30 minutes of moderate activity five days a week, can improve your health according to the Centers for Disease Control and Prevention. By enabling activity monitoring on an individual scale, over an extended period of time in a ubiquitous way, physical and psychological health and fitness can be improved. Studies performed by certain health institutes initiative [Manson *et al.*, 2002, Ellekjaer *et al.*, 2000, Sattelmair *et al.*, 2010, Lee, 2001] have shown significant associations between physical activity and reduced risk of incident coronary heart disease and coronary events. Their results can be seen in Figure 1, where the inverse correlation between the risk of cardiovascular incidents and physical activity level is shown through the comparison of four separate studies.

In recent years, thanks largely to the increased interest in monitoring certain sectors of the population such those of as elderly people with dementia and of people in rehabilitation, activity recognition systems have increased in both number and quality. Furthermore, communication between relatives, friends and professionals can be improved by means of graphs of weekly activity (high relevant for sportsmen and for the relatives of elderly people) whereby the doctor can be automatically alerted if any strange activity is detected. By using data acquired from accelerometer, *NFC*, or even microphone sensors and applying some classification algorithm, it is possible to recognize human activities. Artificial neural networks (*ANN*) method will be analyzed and compared with our work. Results show the main differences between different studies, and certain drawbacks are determined which rules them out for development on users' smartphones To reduce the cost related to process accelerometer signals, this paper opts for an innovative technique, through which the work is performed in the field of discrete variables. Thanks to a discretization process, the classification cost is much lower than that obtained when working with continuous variables. Any dependence between variables during the recognition process is therefore eliminated and, on the other hand, energy consumption from the process itself is minimized.

Activity recognition

1.1 Data Collection

Certain related studies attain results on activity recognition off-line. A comprehensive training set from the accelerometer output is first needed before data can be classified into any of the recognized activities. However, this paper has sought to minimize the waiting time for recognition, thereby providing valid information of the activity very frequently. To this end, both training and recognition sets are obtained using time windows of fixed duration. After having conducted a performance and system accuracy analysis, it is determined that the optimum length for these windows is 5 seconds. Five seconds windows was chosen due to for our system it's extremely important to ensure that in each time window there is, at least, one activity cycle. Where activity cycle is define as an complete execution of some activity pattern. For instance, two steps are an activity cycle for walking and one pedal stroke is the activity cycle for cycling. If at least one activity cycle can not be ensure in each time window, it's not possible to determine, basing on accelerometer patterns, the activity performed. This statement could be seen in the next example. Suppose a two second cycle is having and the actor is jumping continuously, that is, we have a cadence of one jump for each two seconds. The system is configured with one second time window and thus, for each activity cycle will have two windows. In the first one, while the user is rising, vertical acceleration is negative. In the other one, because the

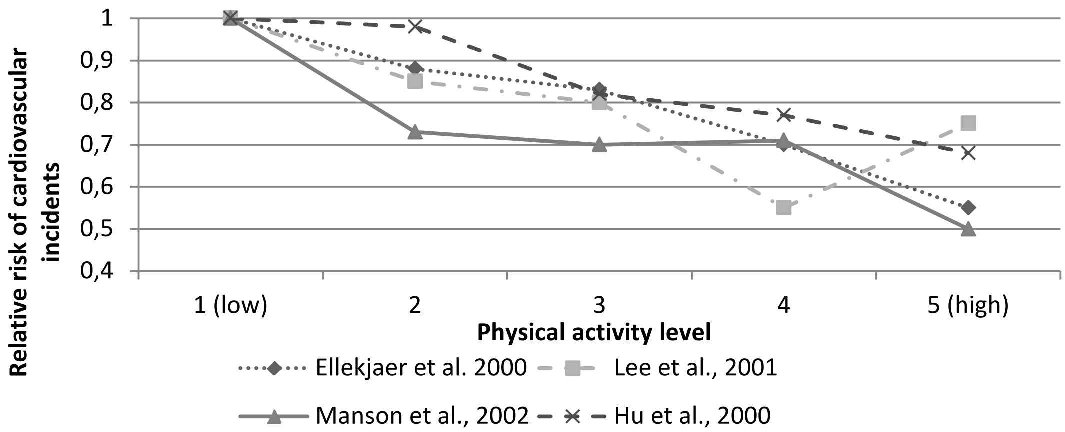

Figure 1: Associations between physical activity and reduced risk of incident coronary heart disease and coronary events

user is falling, vertical acceleration will positive. If user increase the cadence by two, mean between acceleration set is close to , due to vertical positive and negative accelerations will be counteracted. For this reason, it's very important to ensure that one cycle of all activities, regardless of the speed performed, is contained in a time window. Segmentation process and activity cycle is shown in Figure 2.

Based on these time windows, which contain data for each accelerometer axis, the signal module has been chosen in order to reduce the computational cost of the new solution. In addition to rendering the system more efficient, this choice of module eliminates the problem caused by device rotation [He and Jin, 2009]. Furthermore, user comfort with the system is decreased by removing the restriction that forces its orientation to be maintained during the process of learning and recognition. Using the accelerometer module, a data from each of the different readings taken within a time window $a_i = (a_{x,i}, a_{y,i}, a_{z,i})$ for the x, y, and z axes is defined as follows

$$|a_i| = \sqrt{(a_{x,i})^2, (a_{y,i})^2, (a_{z,i})^2} \tag{1}$$

For each temporal window is obtained Arithmetic Mean, Minimum, Maximum, Median, Std deviation, Geometric mean and other measures. In addition to the above variables, hereafter called temporal variables, a new set of statistics from the frequency domain of the problem is generated. This second set of variables will be called frecuencial variables. In order to obtain the frequency characteristics, the Fast Fourier Transform (*FFT*) for each time window is applied. In this way, and based on the frequency components obtained.

2 Qualitative method

2.1 Ameva Algorithm

Let $X = \{x_1, x_2, \ldots, x_N\}$ be a data set of a continuous attribute $\mathcal{X}$ of mixed-mode data such that each example x_i belongs to only one of ℓ classes of the variable denoted by

$$\mathcal{C} = \{C_1, C_2, \ldots, C_\ell\}, \quad \ell \geq 2$$

A continuous attribute discretization is a function $\mathcal{D} : \mathcal{X} \to \mathcal{C}$ which assigns a class $C_i \in \mathcal{C}$ to each value $x \in \mathcal{X}$ in the domain of the property that is being discretized.

Let us consider a discretization $\mathcal{D}$ which discretizes the continuous domain of $\mathcal{X}$ into k discrete intervals:

$$\mathcal{L}(k; \mathcal{X}; \mathcal{C}) = \{[d_0, d_1], (d_1, d_2], \cdots, (d_{k-1}, d_k]\}$$

In this discretization, d_0 is the minimum value and d_k is the maximum value of the attribute $\mathcal{X}$, and the d_i values are in ascendent order.

If L_1 is the interval $[d_0, d_1]$ and L_j is the interval $(d_{j-1}, d_j]$, $j = 2, 3, \ldots, k$, then

$$\mathcal{L}(k; \mathcal{X}; \mathcal{C}) = \{L_1, L_2, \cdots, L_k\}$$

Therefore, the aim of the Ameva method [Abril *et al.*, 2009] is to maximize the dependency relationship between the class labels $\mathcal{C}$ and the continuous-values attribute $\mathcal{L}(k)$, and at the same time to minimize the number of discrete intervals k.

As a result from applying the above algorithm to each statistical value of the system, a series of intervals associated with a particular $\mathcal{C}$ tag is obtained. Thus, after processing all system statistics, a three-dimensional matrix is obtained. In the first two dimensions, the label of the activity $\mathcal{C}$ associated with the interval $L_i = (L_i^l, L_i^s]$, as well as with the lower limit L_i^l and the upper limit L_i^s of that range is stored. In a third dimension, the matrix contains the above data for each statistic $\mathcal{S} = \{S_1, S_2, ..., S_{\mathbb{S}}\}, \mathbb{S} \geq 2$. This three-dimensional matrix containing the set of interval limits for each statistic is called the *Discretization Matrix* and is denoted by $Dm\{\mathcal{C}, L^{l,s}, \mathcal{S}\}$. The *Discretization Matrix* therefore determines the interval to which each item of data belongs with respect to each statistical value, by means of carrying out a simple and fast discretization process.

Class Integration

The next step of the algorithm determines the probability associated with the statistical data for each of the activities based on previously generated intervals. To this end, each element of the training set $x = \{\mathcal{X}; \mathcal{C}\}$ is processed, to which,

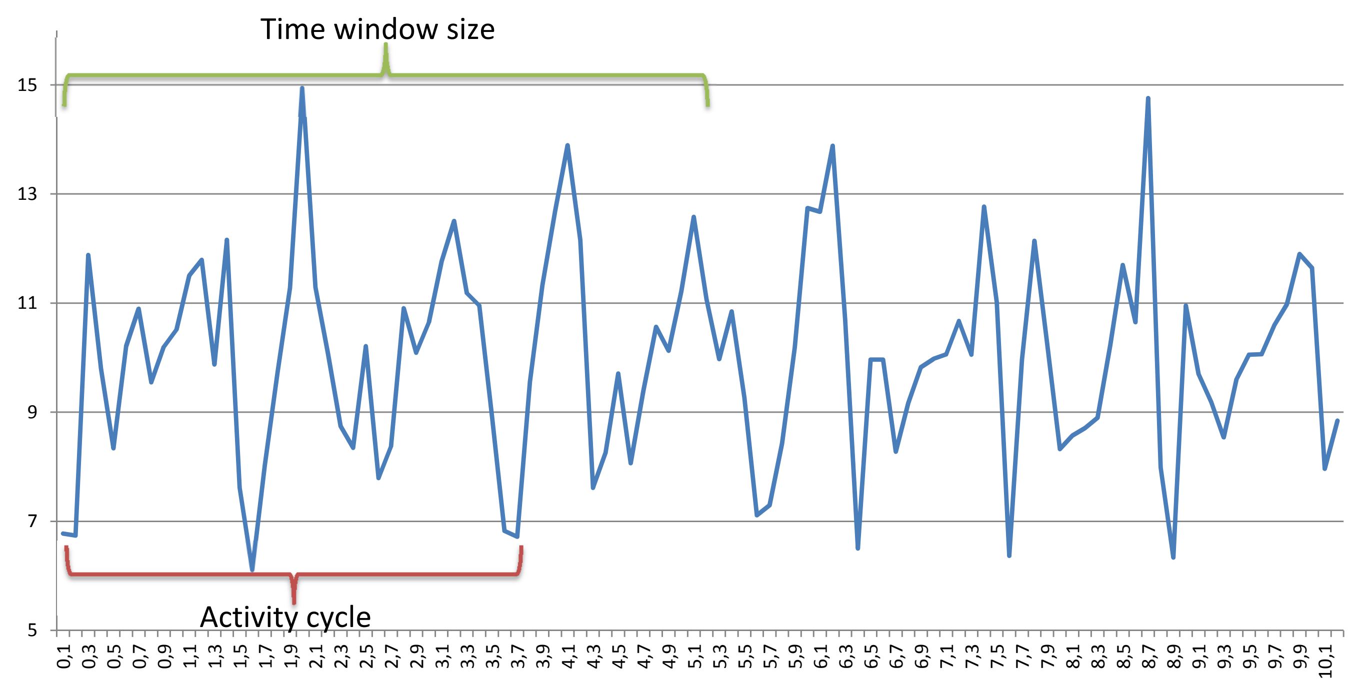

Figure 2: Time windows split method over accelerometer signal

in addition to the value of each statistic whose calculation is based on the time window, is also associated the label of the specific activity in the training set. In order to carry out this process, *Class-Matrix* is denoted by $Cm\{x, L_i, \mathcal{S}\}$ and is defined as a three-dimensional matrix that contains the number of data x from the training set associated with each L_i interval for each statistical $\mathcal{S}$ of the system. This matrix is defined as follows,

$$Cm_{x,i,s} = |x \in \mathcal{X}|x \geq L_i^l \wedge x < L_i^s \wedge x\{\mathcal{C}\} = C_s \quad (2)$$

Therefore, by this definition, each position in the *Class-Matrix* is uniquely associated with a position in the *Discretization-Matrix*, as determined by its range.

At this point not only is it possible to determine the discretization interval likelihood, but the *Class-Matrix* also helps to obtain the probability associated with the discretization process performed with the *Ameva* algorithm.

Activity-Interval Matrix

The next step in the learning process is to obtain the matrix of relative probabilities. This three-dimensional matrix, called the *Activity-Interval Matrix* and denoted by $AIm\{x, L_i, \mathcal{S}\}$, determines the likelihood that a given value x associated to an $\mathcal{S}$ statistic corresponds to a specific C_i activity. This ratio is based on the quality of the discretization performed by *Ameva*, and in order to determine the most probable activity from the generated data and the intervals of the training set. First the contents of the array *AIm* is defined as follows,

$$AIm_{c,i,s} = \frac{Cm_{c,i,s}}{total_{c,s}} \cdot \frac{1}{\ell - 1} \sum_{j=1, j\neq c}^{\ell} (1 - \frac{Cm_{j,i,s}}{total_{j,s}}) \quad (3)$$

where $total_{c,s}$ is the total number of time windows of the training process labeled with the c activity for the $\int$ statistic.

Figure 3 shows the overall process described on this section for carry on data analysis and interval determination.

2.2 Classification Process

Having obtained the discretization intervals and the probabilities of belonging to each interval, the process by which the classification is performed can be described. This classification is based on data from the analysis of time windows. The process is divided into two main steps: the way in which to perform the recognition of physical activity is first described; and the process to determine the frequency at which some particular activity is then presented.

Classifying Data

For the classification process, the most probable activity is decided by a majority voting system. This process starts from the *Activity-Interval Matrix* and uses a set of data $x \in \mathcal{X}$ for each of the statistics belonging to the $\mathcal{S}$ set. The process consists of finding an activity $mpa \in \mathcal{C}$ such that the likelihood is maximized. The above criterion is included in the following expression,

$$mpa(\mathcal{X}) = \max \sum_{s=1}^{s} AIm_{c,i,s} | x_s \in (L_i^l, L_i^s] \quad (4)$$

Figure 4 shows the overall process described on this section for recognition process from Activity-Interval Matrix calculated in the previous stage.

The expression shows that the weight contributed by each statistic to the calculation of the probability is identical. This

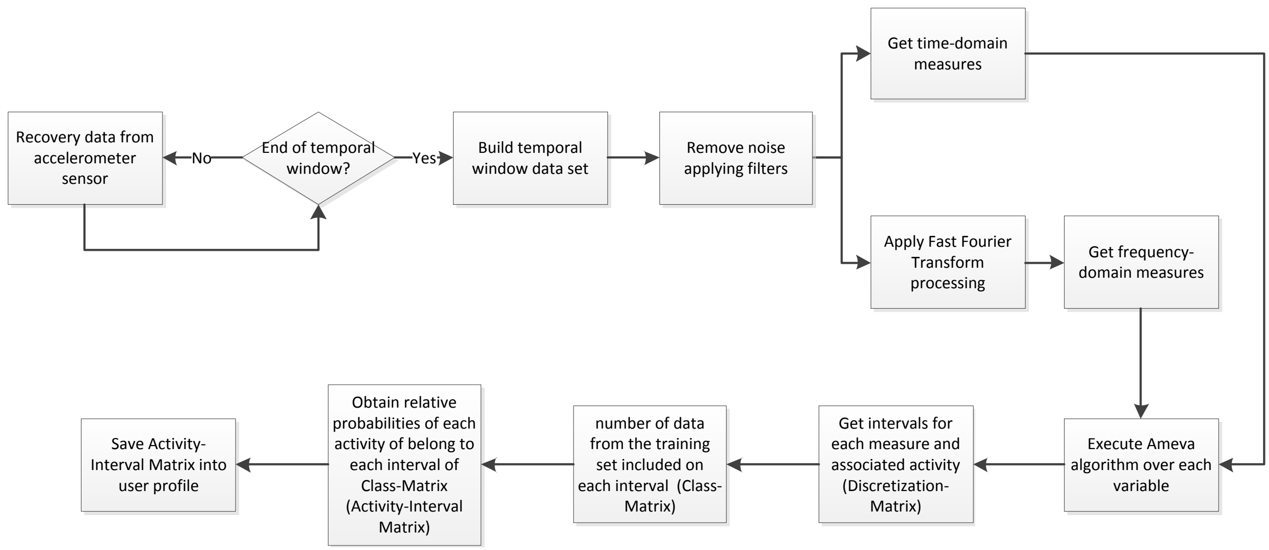

Figure 3: Overall process of data analysis and interval determination

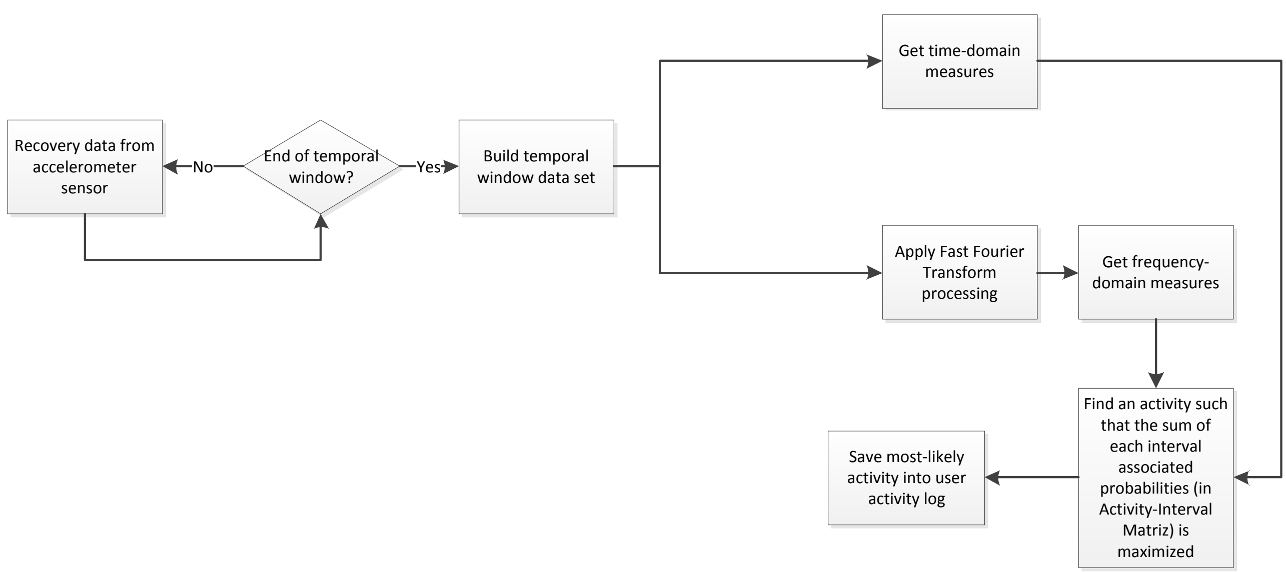

Figure 4: Overall recognition process from data sensors

can be carried out under the assumption that all statistics provide the same information to the system, and that there is no correlation between them. Thus, the most probable activity, or mpa, represents those activities whose data, obtained through the processing time window, is more suited to the AIm set values. In this way, the proposed algorithm not only determine the mpa, but also its associated probability. From this likelihood, certain activities that do not adapt well to sets of generic classification can be identified. This could be an indication that the user is carrying out new activities for which the system has not been previously trained.

3 Conclusions and future work

In this work, a highly successful recognition system based on discrete variables is presented, which uses the *Ameva* discretization algorithm and a new *Ameva*-based classification system. It has therefore been possible to achieve an average accuracy of 98% for the recognition of 8 types of activities. Furthermore, working with discrete variables has significantly reduced the computational cost associated to data processing during the recognition process. By using this process to increase recognition frequency, it has been possible to obtain a physical activity reading every 5 seconds and to enter these readings into the user activity log. However, the main problem of this system based on statistical learning is the limit to the number of activities that can be recognized. Working only with accelerometer sensors implies a limit to the number of system variables and therefore may lead to a strong correlation between these variables.

Acknowledgments

This research is partially supported by the projects of the Spanish Ministry of Economy and Competitiveness ARTEMISA (TIN2009-14378-C02-01) and Simon (TIC-8052) of the Andalusian Regional Ministry of Economy.

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Aggregating individual stress-levels for dynamic clusters

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Abstract

The impact of stress of every human being has become a serious problem. The result is a higher rate of health disorders like heart disorders, obesity, asthma, diabetes, depressions and many others. An individual in a stressful situation has to deal with altered cognition as well as an affected decision making skill and problem solving. This could lead to a higher risk in dynamic environments like in automotive. Different papers faced the estimation as well as prediction of drivers' stress level during driving. Another important question is not only the stress level of the driver himself, but also the influence on and of a group of other drivers in the near area. This paper proposes a system, which determines a group of drivers in a near area as clusters and it derives or computes the individual stress level. This information will be analyzed to detect anomalies in groups' stress level and when indicated notify the considered persons. As well as the corresponding group as a warning and therefore increase the potential risk of accidents.

1 Introduction

Stress has become a great problem in daily life of every human being. A long-term influence of stress could lead to health disorders like heart diseases, obesity, diabetes, depressions, burn-out and many others. Another aspect is the short-term influence of stress. Persons in a stressed state not only have an altered cognition, but they are affected in decision making and problem solving [Lisetti and Nasoz, 2004; Fernandez *et al.*, 2009]. These impacts can result in misbehavior in unpredictable environments as for example driving and therefore is one of the most important causes for car accidents [R.G. *et al.*, 2005].

The stress level of drivers can be based on different factors external and internal. External factors are considered as not driving-dependend in fact they might occur before starting to drive. Some of these sources are based on financial, economical, political or social aspects like unemployment, financial issues and others. Based on this, internal stress factors can increase the basic stress level of the driver during a trip as for example time pressure, information overload (e.g. observing navigation system, check traffic notifications, usage of smartphone) or the behaviour of other drivers on the street.

Thinking not only about an individual driver but a group of drivers on the road with the same stress level respectively monotonic stress level can significant increase the common risk of car accidents. Because of the external influence of members of a near area group on an individual. It would be interesting to estimate the influence of individuals on a group and vice-versa. Estimate the influence among each other and compare the individuals with the whole group. This paper proposes a system that supports automatic clustering of neighbourhood drivers into a driver's group, monitoring and analyzing an individual stress level and disseminate relevant information to the group in order to improve driving security.

In the following section, different projects and approaches supporting a driver's stress level determination are shown. In section 3 a basic model for clustering groups of people is described. Dynamic changes based on mobility and the corresponding information exchange are taken into account for all members of a group. Likewise a concrete model for the automotive domain will be presented. A short conclusion with an outlook on the future work will conclude the paper.

2 State of the Art

Researches as well as industry are very interested in the area of stress measurement and detection. Many papers were published addressing this area. In [Yamakoshi *et al.*, 2008] a method was introduced to estimate drivers' stress level based on differential skin temperature measurement. Another approach was described in [Choi and Gutierrez-Osuna, 2009], using unobtrusive wearable sensors to detect mental stress. The authors used accessed information to estimate the state of the the autonomic nervous system adapted from analysis of heart rate variability (HRV). Likewise [Salahuddin *et al.*, 2007] extend the basic idea of mental stress detection based on HRV, they tried to relate given stress factors and the age of the person to find a corresponding influence on the status of the mental stress level. A potentially raising of drivers' stress level is motivated in information overload like road signs and traffic lights [Nakamura *et al.*, 2013].

But not only a high stress level is a risk for a driver, another important aspects are the drowsiness of a driver [Vicente *et al.*, 2011] and a monotonous driving-behaviour. A lot of drivers are daily faced with monotonous situations, without the need for long-term driving-tasks. For example routes which are well known for the driver like the workplace or home. The result of this is an increasing monotonic stress level [Yamakoshi *et al.*, 2006]. For improving driving security, drivers' stress level have to be on a moderate level to afford a higher performance [Yerkes and Dodson, 1908], which has influence on its attention during driving.

Numerous scientific papers attempt to combine stress detection or the prediction of drivers' stress level as a base for intelligent car assistance systems (ICAS). An analysis of HRV parameters aiming to detect the most promising HRV parameters for workload measurement during real world driving, was published in [Eilebrecht *et al.*, 2012]. In [Rigas *et al.*, 2008] a reasoning-based framework was introduced to predict stress level of drivers due specific driving events. Based on salivary amylase as biomarkers the authors in [Yamaguchi *et al.*, 2006] evaluated drivers' stress potential using a driving simulator. All described references used only an individual driver and an individual driver's stress level for stress detection or prediction. The influence of other drivers' stress level or the monitoring of a group of drivers was not considered.

For interchanging information between cars in close areas vehicular communication systems (VCS) were introduced as a base for intelligent transport systems (ITS) targeted the increase of road safety, as proposed in [802.11p, 2010; Lee *et al.*, 2011]. Information exchange among each car, called Vehicle-to-Vehicle (V2V) or with a given infrastrucure (V2I) are provided by Vehicular AdHoc NETworks (VANETs). This solution becomes less effective when the group of vehicles, which build a network is sparse so the number of network nodes are low. A proposal to close this gap is given in [Kloiber *et al.*, 2012]. The authors used a VANET as one cluster respectively as a group of vehicles, to interchange information with another cluster not near, e.g. a reason like low density of equipped vehicles, a satellite system is used as a notification dispatcher. With this approach different clusters (of grouped vehicles) can share information among each other. But distributed information examine only the cluster in its entirety but not the individuals in a group as against the common group.

In the following section a basic architecture will be proposed for clustering a group of vehicles, analyze additional information given by the vehicle itself and/or the driver, compare it with the own cluster and distribute notifications within and among clusters.

3 Architecture Model

The system is based on a client-server architecture. Basic information interchange is demonstrated in Figure 1. The server is represented by a backbone connected to the Internet. The client is gathering location based and external sensor data (e.g. heart rate, stress level) data and forward all collected information either via Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS) or Long Term Evolution (LTE) periodically to the server.

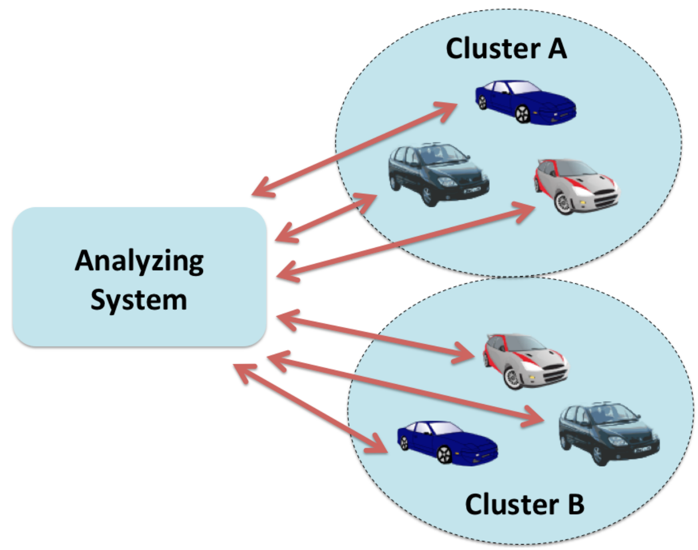

Figure 1: Basic information exchange between clients (vehicle) and server

The components are described in detail as follows:

1. **Communication interface**
The communication interface is the connection part between client (e.g. vehicle), the logical service components (software parts) and therefore the communication access point. It works as information dispatcher, which has to assimilate all communication between client and server. So the communication interface use basic techniques such as sockets to comply the given requirements.

2. **Clustering service**
The clustering service uses received location-based information for clustering individual clients into concrete groups. For the estimation of clusters, known algorithms of the area of data mining or image processing can be used like k-Means[1] or Spectral Clustering[2]. The calculated clusters will be forwarded with all gathered individual's information to the analyzing and processing component.

3. **Data analyzing and processing**
The main component of the system is the data analyzing and processing component. This component uses accessible information of the group to compare one group

[1] http://en.wikipedia.org/wiki/K-means_clustering

[2] http://en.wikipedia.org/wiki/Spectral_clustering

with another and monitor individuals against the group. Previous recorded data of all clients will be used as a reference to detect anomaly in the dynamic behaviour in groups. For example one client has completely different information sent as the other in the group, and to predict possible influence and behaviour for each group and/or among different groups recorded data is necessary. Detected exceptions will lead to notifications, to inform affected clients (groups) or external observers like traffic supervisors or intelligent driving assistance systems.

4. **Notification service**
   As well as the analyzing of data the requisite notification of clients is required. Based on the calculated results of the data analyzing and processing component, the notification service is adopting this task and assigns important information, like an increasing stress level of surrounding drivers, to the corresponding receivers, like in this case groups, individuals or external observers. The notification will broadcasted via the communication interface directly to the clients.

5. **Database**
   Long-term observations raw and/or analyzed data should be saved in a persistence environment with ordinary methods of searching and combining like in databases. Because of a high amount of received data, special types of databases should be used to handle an easy and fast access. This information source could be interesting on the one hand for external persons like traffic supervisors to analyze anomalies in a given area and on the other hand as base for further calculation resulting in predictions of the data analyzing and processing component.

The architecture of the server software is shown in Figure 2. The software architecture is layered-based with different service components aggregating and interchanging information among each other.

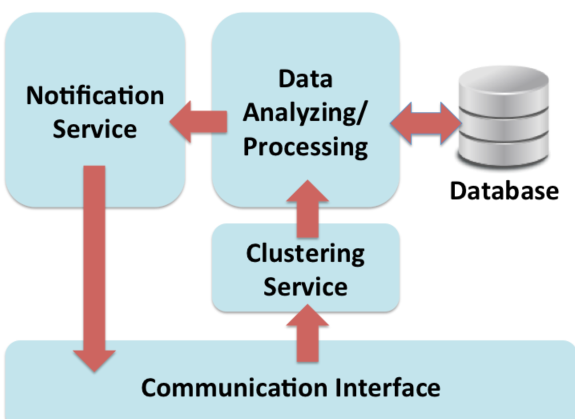

Figure 2: Layered architecture of server system

We designed this abstract model to facilitate the usage of it in different kind of fields or domains like for example crowd clustering in events. In the following subsection, this model will be used to apply as an use case to the area of automotive.

3.1 Use case

A suitable scenario is shown in Figure 3 where one vehicle (V1) is driving on a long-way route (e.g. highway), it is on a constant level of speed as well as its driver being on a constant level of stress. For a long distance, the vehicle is part of a group (Cluster B) with the same conditions. After a few minutes a vehicle (V2) is entering the group with a much higher speed and a driver's stress level higher than the current group. The basic question is, what influence has the new vehicle on the group.

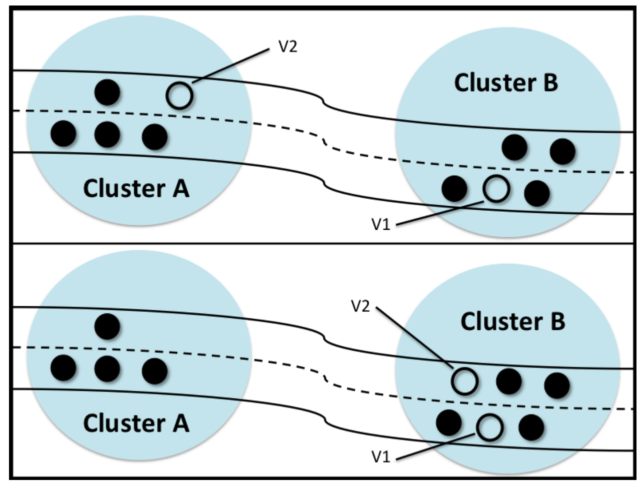

Figure 3: Scenario of a dynamic cluster change of one vehicle

In this scenario the system works as follows:

1. The estimation of the stress level will be done with an external sensor and transmitted to the smartphone or navigation system with the ability to use external sensors. Each individual vehicle sends its own GPS position combined with the gathered information to the server, via internet.
2. On the server side, the received location data of every client will be used to determine the clusters of vehicles on the road. After that the remaining information about the stress level of each driver will be analyzed and compared with the group. If there are no anomalies detected, no notification will be broadcasted out.
3. As described in the scenario, a new vehicle is entering the area of an existing cluster. Its driver's stress level is significant different to the average of the group and consequently higher then most of each individual of the current cluster. The position update and the stress measurement of each vehicle and its driver will be done periodically and send to the server.
4. The same procedure like in step two will be executed on the server. The server detects a new member in the area of cluster B and appends it to the corresponding cluster. The analyses of the gathered stress level of all clients of cluster B shows a rising of their individual stress level since the entering of the new member (V2) to the cluster. Even the increasing of one individual's stress level (e.g.

the vehicle directly in front of V2) will be detected because it is higher than the average of the cluster. The increased stress level of the cluster represents a higher accident potential to the whole group. As a consequence, the notification service will be instructed to notify all individuals of cluster B about the potential risk as well as clusters near the affected group (e.g. cluster A) to rise drivers' attention level. Also possible traffic supervisors or intelligent traffic systems can be informed about this situation.

5. All individuals which are concerned about the potential risk, will receive a notification with the current situation of their environment. Furthermore can contain advices to improve the safety for example original members of cluster B will be delegated how each vehicle has to be ordered so V2 has the possibility to leave the cluster as fast as it can.

Due to the fact that this is a concrete scenario, we should bear in mind that the possibilities of two or more vehicles are able to leave/enter a cluster simultaneous. Another aspect could be to inform clusters which have a higher distance but depending on their speed level could be potentially affected by an accident of a measured group and other aspects. We deal with these factors after a first prototype.

4 Conclusion and Future work

Stress has a big influence on individuals behaviour like attention level or decision making. In a dynamic environment like in automotive, is may result a higher risk for accidents. To decrease the hazard, this approach proposes to relate individual stress levels to clustered dynamic groups of nearby, creating a group dependent stress level. This concept has not been tackled by other studies. Automatic detection of stress influences or a common stress raising will be used for notifications to the affected drivers/groups to improve driving safety with current technologies. The next step will be the implementation of model as a prototype, to deal with the factors described, and to extend the model/prototype to handle several vehicles entering a cluster. Finally it has to be evaluated how intelligent traffic control system can be incorporated.

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Public Resource usage in Health Systems: A Data Envelopment Analysis of the Efficiency of Regional Health Systems in Spain.

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Abstract

The efficiency in the management of public resources is on of the main pillars of the welfare state. The objective of this work is to analyze the efficiency of the public resources that regional governments invest in health systems. To this end, Data Envelopment Analysis (DEA) is applied which enable researchers and managers to obtain measurements of efficiency of the analyzed regions, and proposing corrective steps to achieve efficiency for non-efficient regions.
Results show that not every health systems present technical efficiency, nor scale efficiency.

Keywords: efficiency, public health, regional public health, DEA, public resources.

1 Introduction

In the last decades the Spanish public health system has been radically transformed. The universality, equity and solidarity are the basic pillars of the current health system due to "*individuals' health and the quality of health systems are essential signs* of the level of welfare and social protection of the society" (CES 2010). Decentralization of the health system and giving the governance to the regions increased region development itself by managing health services in a better manner for each region, taking always into account the solidarity between each region of the nation.
This decentralization motivated the creation of a public health service in each region. The efficiency of these services is nowadays under study, proposing private management of services as an alternative to better management. This is the main reason for analyzing the efficiency of public resources in general and health services particularly, even more in this current economic situation.
The objective of this work is to study the efficiency of public regional health systems through the management of the resources invested in them and how much of these resources are invested in employing and by studying the frequency of admissions in hospitals, specialists or primary attention, nursing etc. that citizens receive. The fact of analyzing investments in employees is motivated by: the weight of the costs in employees comparing to the total cost of health systems (from 30% to 50% of costs) and motivated by the effects of investments in employing over the welfare status, even more with a rate of unemployment of 26%.
The analysis of the efficiency can be performed from two perspectives [Gonzalez, 2010] a) using managements indicators based on the analysis of ratios, which could return conflicting results depending on the indicators used [Smith, 2003], and b) using global indicators of efficiency that measure distances between the analyzed units (DMUs) and the production frontier which is established by the efficient units depending on the resources and obtained results.
DEA is a method of analysis of the second (b) perspective, considered as a very accepted system of measurement of efficiency of the public sector [Lowell, 2003]. DEA has the benefit of being able of including several variables as inputs and several variables as outputs. This system began as an extension of the work from Farrel in 1957, where it is shown a satisfactory measurement of the productive efficiency and how it can be computed [Coelli, 1996], [Coll, 2006], [Cooper, 2007]-
Performing DEA provide the distances between non-efficient units and the frontier established by the production functions of efficient units, when production factors operate in variable scale or constant scale, that means when the peculiarities of each measurement units (each health system) are taken into account or when the global efficiency is the main objective and not taking into account these peculiarities.
DEA analysis technique requires an input or output orientation. Researches has to choose between one or another depending on which variables are susceptible to be changed or not. The input-orientated model should be chosen when inputs variables are adaptable, while output-oriented model should be chosen when output variables are adaptable [Ramanathan, 2003].
In this work the model input-oriented is going to be chosen due to inputs variables include: expenses per individual, percentage of expenses to cover employing costs. Regional governments control both variables. Outputs variables are the number of health visits for 1000 inhabitants and the number of primary and nursing attention for 1000 inhabitants. These variables depend on factors that are not controlled by regions like times individuals ask for attention or the type of attention required. However, in this second case

variables could be controlled applying management systems based on objectives or incentives.

Acknowledgments

This research is partially supported by the projects of the Spanish Ministry of Economy and Competitiveness ARTEMISA (TIN2009-14378-C02-01) and Simon (TIC-8052) of the Andalusian Regional Ministry of Economy, Innovation and Science.

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A new back-propagation algorithm with momentum coefficient for medical datasets

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Abstract

The standard backward propagation of errors algorithm (abbreviated as back-propagation algorithm) is commonly used for decision making in medicine. Using the back-propagation algorithm in medical diagnosis is desirable since it avoids human subjectivity and applies a large knowledge base, which makes this algorithm very reliable. However, it is generally believed that it is very slow if it does converge, especially if the network size is not of sufficient size compared to the problem at hand. A drawback of the back-propagation algorithm is that it has a constant learning rate coefficient, while different regions of the error surface may have different characteristic gradients. Variation in the nature of the surface may require a dynamic change of learning rate coefficient. A new back-propagation algorithm with momentum has been developed in order to be used to speed up the learning process, which accelerates the convergence of back-propagation algorithm.

1 Introduction

In many real-world situations, we are faced with incomplete information or noisy. It is also important to be able to make reasonable predictions on new cases of information available and a backpropagation network adapts its weights to acquire learning from a training set.

Back propagation is to propagate error backwards, ie, from the output layer to the input layer, through intermediate hidden layers and adjusting the weights of the connections in order to reduce the error. There are various versions of the backpropagation algorithm rules and connectionist different architectures to which they can be applied.

Examples of possible applications are the diagnosis of cardiac abnormalities, prescription diets or the diagnosis of abnormalities in electrocardiograms.

The backpropagation network is based on the generalization of the delta rule. Like the perceptron, Adaline and Madaline[Widrow and Lehr, 1990], backpropagation network is characterized by a layered architecture and strictly forward connections between neurons. Use supervised gradient-based network error with respect to weights learning neural networks.

The advantages and the disavantages of the artificial neural networks are described below[Tu, 1996].

1.1 Advantages of ANNs

- Are not linear distributed systems: a neuron it is a nonlinear element so that interconnect them (neural network) will also be a nonlinear device. This property allows the simulation of nonlinear and chaotic systems, simulation with the linear classical systems, can not be performed.
- Are fault tolerant systems: a neural network, as a distributed system, allows the fault of some individual elements (neurons) without significantly altering the total system response. This makes them particularly attractive compared to existing computers, typically such systems are sequential so that a failure in one of its components implies that the whole system does not work.
- Adaptability: a neural network has the ability to modify the parameters which influence its operation according to the changes that occur in their work environment (changes in the inputs, the presence of noise, etc..). Regarding adaptability to be taken into account that it can not be excessively large since it would lead to an unstable system have to respond to small disturbances.
- Establish nonlinear relationships between data: neural networks are able to relate two sets of data by complex relationships.
- Possibility of VLSI implementation: this capability allows these systems to be applied in real-time systems, simulating biological systems using silicon elements.
- Learning capability (automatic): neural models eliminate the need for adaptation of expert systems. The data inputs are fed directly to the prediction software, without interpretation or modification (not previously involved an expert who takes a mental model).

1.2 Disadvantages of ANNs

- It is necessary to know well the problem to be modeled.
- The black box effect: the data enters into the black box and the predictions are obtained, but are not usually re-

veals the nature of the relationships between the independent and dependent variables. In some cases, the neural networks do not explain, as with other traditional approaches.

- Lengthy processes.
- Require the definition of many parameters before applying the methodology.

2 PROBEN1

The PROBEN1 benchmark[Prechelt and others, 1994] is a collection of problems prepared for learning ANNs in order to test different algorithms and get a direct comparison of results. PROBEN1 contains 15 problems divided into 12 different areas, and also provides a set of rules and conventions advised regarding documentation of the results. The problems cover arguments in classification problems and functional interpolation. In our case it is used to test the operation of the developed system.

2.1 Backpropagation algorithm

The training of the neural network using the multi-propagation algorithm or propagation or back-propagation of errors consists of the following steps:

1. The structure of the network (number of layers and of neurons in each layer) is decided: L layers, n neurons in the input layer (layer 1), m in the output (layer L).
2. An activation function of neurons differentiable is chosen. Usually sigmoidal type[Harrington, 1993] (ie S-shaped), ie the logistic function $g(x) = \frac{1}{1+e^{-x}}$.
3. The w_{ij} weights and the polarizations are randomly initialized and with small values $(-0.5, 0.5)$.
4. The training data is generated: set of tuples inputs - desired outputs, ie, if there are 2 inputs, 2 outputs and M training tuples are necessary:
$$\{(x_{11}, x_{12}), (y_{d11}, y_{d12})\}, \{(x_{21}, x_{22}), (y_{d21}, y_{d22})\}, \\ \ldots, \{(x_{M1}, x_{M2}), (y_{dM1}, y_{dM2})\}$$
5. A training data is chosen, ie r: $\{(x_{r1}, x_{r2}), (y_{dr1}, y_{dr2})\}$.
6. The outputs of the network (x_{r1}, x_{r2}) with available weights propagating the values from the input neurons to forward are calculated, ie from $l = 1$ to L:
   - $in_i =$ input receiving a i unit.
   - $a_i =$ output of the i unit.
   - If i is an input neuron $(l = 1) \rightarrow a_i = x_{ri}$.
   - In a i neuron of layer l (with $l \neq 1$):
   $$in_i = \sum_j w_{ij} a_j, a_i = g(in_i)$$
7. The difference between the outputs of the network for x_r data (i outputs of neurons output layer) obtained with current weights (a_i) and desired outputs (y_{dri}), so we get the error vector with the error of each output neuron for that data is calculated.
8. The weights of the network so that the error is minimized are adjusted. In the output layer:
$$w_{ji}(t+1) = w_{ji}(t) + \eta a_j \Delta_i, \Delta_i = g'(in_i)(y_{dri} - a_i)$$
But if the neuron does not belong to the output layer do not know what is the expected value of output: the same formula can not be used. How to update the connection weights of the hidden layers? Come back Δ_j calculating the error of each unit of the hidden layer $l-1$ from error units layer l with which they are connected j.
$$w_{kj}(t+1) = w_{kj}(t) + \eta a_k \Delta_j, \Delta_j = g'(in_j) \sum_i w_{ji} \Delta_i$$
Ie, each unit j is "responsible" for the error that each of the units to which sends its output, contributing in proportion to their weight. To calculate the modification of the weights, the error is calculated in the output stage and the change propagates backward: backpropagation.
9. The above steps for each pair of training (time) are repeated and iterated until the error for all training sets is acceptable.

3 Momentum

The system is an improved version of backpropagation, which uses a term called Momentum[Phansalkar and Sastry, 1994] for the elimination of local minimum.

The term Momentum introduces error of the previous weight as a parameter for the computation of the new change. This avoids the problems common swing with backpropagation algorithm when the error surface has a minimum very narrow area. Calculating weights corresponding to:

$$\delta_j = \begin{cases} (f'_j(net_j) + c)(t_j - o_j), & \text{if } j \text{ neuron is output} \\ (f'_j(net_j) + c) \sum_k \delta_k w_{jk}, & \text{if } j \text{ neuron is hidden} \end{cases}$$

The effect of these improvements is that the flat spots on the error surface are traversed relatively quickly with some big steps while the step size is decreased when the surface is irregular. This adaptation of the step size increases learning speed significantly.

Keep in mind that the above change in weight is lost every time the parameters are changed, new patterns are loaded, or network changes.

Momentum is a heuristic optimization technique while other techniques of numerical optimization. Examples of other optimizations backpropagation algorithm are:

- The QuickProp algorithm that significantly speeds up the gradient descent backpropagation algorithm.
- The LMBP is the fastest algorithm that has been proven to train multilayer neural networks of moderate size. Its main drawback is the memory requirements, if the network has more than a few hundred parameters the algorithm becomes impractical.

- The cascade-correlation algorithm has the particularity of hidden neurons use to minimize the residual error that is output to an input pattern, in addition to grow to reach their optimum size.

4 Experimentation

In our algorithm we used basic data types such as arrays, for example, to optimize the execution time, code is more complex to use these data types as it does not give us the ease of implementation that would give us other non-core types like lists but has advantages in runtime.

For each experiment we tested our algorithm with various inputs of hidden (hidden layer), string length n (learning factor). Mostly what we can change is the learning factor to bring us closer to the results obtained in the benchmark. For each example we calculate the mean square error, standard deviation and by the time it stops.

Problem	Training Set		Validation Set		Test Set		Test Set Classifications		Overfit		Total Epochs		Revelant epochs		n
	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	---
Cander1	3.168	2.4E-4	1.886	7.1E-4	1.167	0.001	1.72	0.0	5.044	0.0253	132.4	0.699	47.4	0.516	0.5
Cander2	2.178	0.002	1.743	0.0041	3.218	0.0032	4.569	0.091	5.033	0.0195	87.2	1.229	28.6	0.516	0.14
Cander3	1.785	0.0021	2.925	0.003	2.803	7.5E-4	4.598	9E-16	5.027	0.019	115.7	1.059	37.2	0.422	0.122
Card1	8.998	0.012	7.654	0.009	10.687	0.017	15.698	0.0	5.039	0.02	62.2	1.229	11.1	0.316	0.068
Card2	7.494	0.017	10.03	0.025	13.76	0.039	18.60	0.0	5.063	0.031	63.6	1.578	19.8	0.422	0.015
Card3	8.675	0.006	7.248	0.014	13.419	0.024	18.60	0.0	5.039	0.019	101.6	1.174	29.6	0.516	0.029
Heart1	10.69	0.01	13.37	0.031	14.83	0.002	19.56	0.0	5.00	0.004	133.3	17.16	1.4	0.516	0.101
Heart2	11.06	6.927	11.91	0.005	14.50	0.004	17.39	3.74	5.023	0.008	182.9	0.99	36.2	0.42	0.095
Heart3	10.31	0.001	10.32	0.008	16.89	0.004	24.78	3E-15	5.019	0.013	147.3	1.15	36.2	0.42	0.065
Heartc1	10.09	0.286	7.72	0.13	15.75	0.77	18.79	0.42	5.15	0.19	139.1	44.27	85.1	10.78	0.345
Heartc2	9.67	0.01	19.7	0.02	6.00	0.02	8.0	0.0	5.00	0.003	134.1	13.14	9.2	0.42	0.185
Heartc3	10.12	0.03	12.80	0.04	11.44	0.01	13.93	0.37	5.13	0.06	24.5	0.85	5.7	0,48	0.035
Horse1	10.003	0.059	14.542	0.068	13.179	0.048	18.462	0.429	5.212	0.095	28.1	0.994	7.2	0.788	0.06
Horse2	6.434	0.231	15.314	0.072	18.70	0.036	25.01	0.247	5.06	0.038	44.1	4.86	3.9	0.567	0.075
Horse3	9.464	0.143	15.130	0.090	15.239	0.087	21.94	0.320	5.101	0.044	26.3	2.162	4.1	0.316	0.036

Figure 1: Table of results

Some conclusions we can take from the tests performed. First the mean of the times out relevant PROBEN1 documentation different from this may be because the algorithm implemented for this work that is more effective. But the results in the stdev column of Total Epochs and Revelants Epochs, are too low compared with respect to the document because each RUN out these results are very similar. Finally, the column Overfit values goes too high, this may be shaped by the algorithm is implemented.

Meanwhile, here in this document have not included all the examples to classify the test set. This is because the examples are not included in this table because their values did not correspond to the table and also proben learning factors were difficult to predict its range. This may be due to several reasons, one of them that this work has not been taken into account that the inputs or outputs can be negative as well as having problems in finding their learning facto. The foregoing on negative values, could be a point when an improved algorithm in the future.

This table contained a number of problems, all problems table PROBEN1 not be classified by the algorithm implemented in this work because when you find a learning factor that approximates the results to the table PROBEN1, if we make several executions , we do very different values at

Problem	Training Set		Validation Set		Test Set		Overfit		Total Epochs		Revelant epochs		n
	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	Mean	Stdev	
Building1	0.28	0.0	1.32	0.002	1.15	0.40	5.07	0.11	308.6	945.6	3.0.	0.0	3.77
Buildin2	1.48	0.009	1.31	0.145	1.43	0.521	19.43	18.53	303.1	947.5	214.9	675.35	3.21
Flare1	0.341	0.00	0.33	0.00	0.60	0.00	5.03	0.01	44.3	5.96	3.9	0.31	1
Flare2	0.43	0.00	0.42	0.00	0.32	0.00	5.20	0.11	37.2	1.31	17.9	1.19	0.08
Flare3	0.41	0.00	0.48	0.00	0.36	0.00	5.03	0.02	37.5	3.1	2.0	0.0	0.44

Figure 2: Problems that has no a classification in the test set

relevant times and total times, for example in learning building3.dt with factor 3.18, at different values minds if we complete several RUN.

5 Conclusions

The conclusions of this work can make training an artificial neural network, is that for almost all problems proben the target will reach. For other deployment for various reasons, has not been po-dido achieve the overall objective of the work.

As future work and extension could be discover-fix two problems in the previous sections, trying to give the reason why no data required is the PROBEN1. The algorithm is also able to expand not only have the input layer and out-put but it includes a hidden or intermediate layer endow a more general approach to ANN work.

Acknowledgments

This research is partially supported by the projects of the Spanish Ministry of Economy and Competitiveness ARTEMISA (TIN2009-14378-C02-01) and Simon (TIC-8052) of the Andalusian Regional Ministry of Economy.

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An adaptive driving system regarding energy-efficiency and safety

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Abstract

Energy-efficiency and safety became an important factor for car manufacturers. Thus, the cars have been optimised regarding the energy consumption and safety by optimising for example the power train or the engine. Besides the optimisation of the car itself, energy-efficiency and safety can also be increased by adapting the individual driving behaviour to the current driving situation. This paper introduces a driving system, which is in development. Its goal is to optimise the driving behaviour in terms of energy-efficiency and safety by giving recommendations to the driver. For the creation of a recommendation the driving system monitors the driver and the current driving situation as well as the car using in-vehicle sensors and serial-bus systems. On the basis of the acquired data, the driving system will give individual energy-efficiency and safety recommendations in real-time. This will allow eliminating bad driving habits, while considering the driver needs.

1 Introduction

As the result of the climate change and society's awareness of the finiteness of oil, which increased due to several oil crises in the past, saving energy and protecting the environment became fundamental for politics and society [Yay, 2010]. Additionally, statistics showed that the increasing number of cars and drivers increased the accidents and fatalities on the road [Statistical Office, 2011]. Fan et al. [Fan et al., 2011] revealed that driving behaviour has a great factor to safety. Furthermore, an adaptation of the driving behaviour can save energy up to 30% [Haworth and Symmons, 2001; Helms et al., 2010; Van Mierlo et al., 2004].

On the basis of the above facts a driving system is presented in this paper, which has the goal to optimise the driving behaviour with respect to safety and energy-efficiency by giving adequate driving recommendation for the current driving situation. The recommendations will depend on the chosen are of improvement like safety and/or energy-efficiency. It is possible to fulfil energy-efficiency and safety potential, if the driver follows the given recommendations.

There are already several driving systems with the goal to optimise the driving behaviour by giving energy-efficiency or safety relevant hints [Fiat, 2013, Kia 2013; Lotan and Toledo, 2006]. These driving systems, however, cover either the area of energy-efficiency or safety. In contrast, our driving system will try to improve both areas. By using a driving profile, which represents the typical driving behaviour, our driving system will adapt itself to the individual driving behaviour. This will allow creating a warning based on any negative change of the driving behaviour or the driver condition. Furthermore, the acceptance of the driving system will be increased as it generates only useful recommendations. These recommendations will be given on time, as the driving system predicts the car state. Thus, the reaction of the driver to a dangerous driving situation will be appropriate. The first prototype of the driving system will be developed on the basis of a driving simulator. The second prototype will be connected to a real car, to test the driving system in a real environment.

2 Related Work

The goal of energy-efficient and safe driving is to change the driving habits of the driver to reduce the energy demand of the car and to increase the road safety. Energy-efficient and safe driving are described by a set of rules, why the cooperation for the driver is needed to achieve the goal of the reduced energy consumption and increased road safety.

In [Van Mierlo et al., 2004] driving rules for energy-efficient driving are evaluated. The results showed that the correct interpretation of the driving rules decreases the energy consumption and vehicle emissions. The drivers decreased the driving speed during the practice of the driving rules as well. As revealed in [Haworth and Symmons, 2001], the reduced driving speed leads to an increase of the road safety.

Beside the driving systems in the research area, there are also driving systems with the focus on energy-efficiency or ecological driving developed by the car manufacturers Kia and Fiat. The driving system of the manufacturer Kia [Kia 2013] gives feedback to the driver by activating different coloured lamps, which stand for energy-efficient driving, stand-by of the driving system or normal fuel consumption of the car. However, this driving system shows neither the

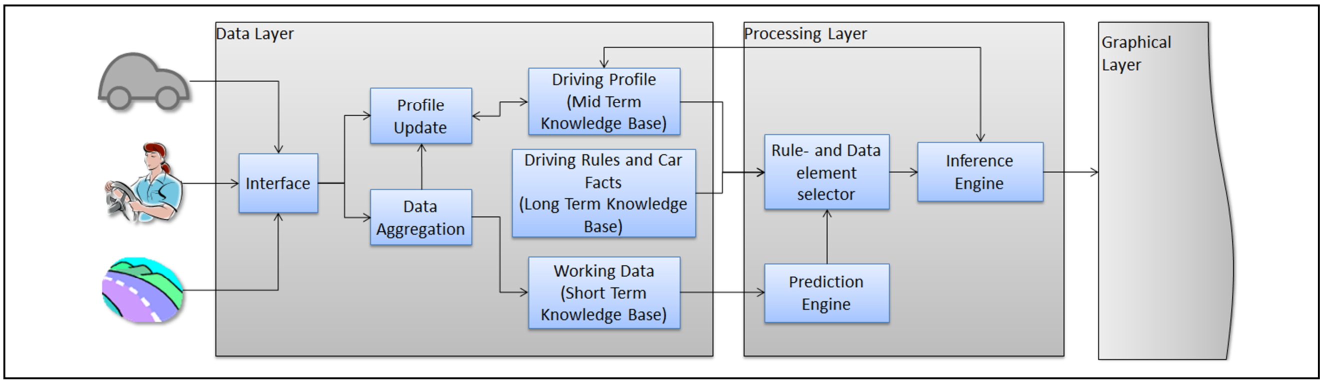

Figure 1: Architecture of our driving system

wrongdoings of the driver nor generates recommendations to eliminate the bad driving habits, which are the causes of the inefficient driving behaviour.

In contrast to the Kia's driving system, Fiat [Fiat, 2013] tries to improve the energy-efficient driving by analysing and rating the recorded driving behaviour on the Fiat website. Therefore, the driving system of Fiat first collects information about the driving behaviour, which the driver has then to upload the collected data on the Fiat website. However, this approach does not include a real-time feedback, which would allow an improvement of the driving behaviour by alerting human errors in terms of energy-efficiency.

Another eco-driving system is introduced in [Magana and Munoz Organero, 2011], which is based on the interaction between a car and a mobile device. The focus of this driving system is to educate the driver in eco-driving by giving hints to eliminate the bad driving habits. The driving system runs on a mobile device, why the needed information is gathered through the diagnostic port of the car and the internet connection of the mobile device. However, the driving system relies on an internet connection, why it is not guaranteed that it is able to obtain all needed data during the journey, as the internet connection may not be available during the whole journey. Furthermore, the driving system does not consider the individual driving behaviour, which can be used for the generation of individual driving hints.

Beside these driving systems with the focus on energy-efficiency, there are also driving systems with the goal to increase the road safety. However, an energy-efficient driving behaviour has also a positive effect on road safety, as it prevents an aggressive driving behaviour, which is the main cause of accidents [Haworth and Symmons, 2001].

Several safety relevant driving systems are trying to increase the road safety by warning the driver on recognition of a dangerous driving situation, like the driving system DAISY [Onken, 1994]. It monitors therefore the current driving situation and the driver condition. On the basis of the gathered information it recognises and warns the driver in dangerous situations, especially in situations, which are susceptible for distractions. However, DAISY does not try to improve the driving behaviour although the bad driving habits of the driver might have caused the dangerous situation.

Another driving system with the focus on safety is DriveDiagnostics [Lotan and Toleda, 2006]. In contrast to DAISY, it has the goal to educate the driver in safe driving. Therefore, it indicates the trip safety by monitoring and analysing the car movement. The real-time feedback warns the driver when his current driving behaviour does not match his typical driving behaviour or when the driver drives aggressively. In addition, DriveDiagnostics provides also an offline feedback by recording the trip and showing the average trip safety to the driver afterwards. However, the road safety could be increased more by observing the driver condition. This would allow recognising an untypical driver conditions like fatigue using tracking systems [Singh et al., 2010] and drowsiness using vital sensors [Sahayadhas et al., 2012]. Thus, dangerous driving situations could be detected also on the basis of the driver condition.

The driving systems presented in this chapter cover either the area of energy-efficiency or safety. Furthermore, they do not consider the individual driving behaviour or the driver condition, which are important factors in energy-efficiency and safety as well. In contrast to the presented driving systems, our driving system adapts itself to the individual driving behaviour as well as considers the driver condition. Furthermore, our driving system covers both areas: energy-efficiency and safety. This allows the generation of individual energy-efficiency and safety relevant recommendations in real-time, while considering the driver needs.

3 Architecture

Our driving system is based on the multi-tier architecture. Figure 1 shows the three main components of our driving system, which will be described in the following:

- **Data Layer**: It gathers all necessary data from the car, the driver and the environment. It is connected to the in-car serial-bus systems to gather data from the car, to vital sensors for monitoring the driver condition and to other sensors, which are relevant for acquiring information about the environment, like the current weather condition. The collected data is then fuzzified using fuzzy logic, as some data has more value when they are fuzzified. On the basis of the incoming data, the

Raw Data	Fuzzy set	Fuzzy rule
Engine speed	Very low - … - very high	-
Manner of driving	-	IF Engine speed low THEN driving style low speed; …
Acceleration	High negative - … - high positive	-
Weather condition	-	IF temperature at freeze point OR temperature less then freeze point AND is raining THEN danger is high; …
Rain	No rain - less - … - heavy rain	-
Temperature	Less than freeze point - at freeze point - higher than freeze point	-

Table 1: Excerpt of the fuzzy sets and rules

data layer creates a driving profile, which describes the typical driving behaviour of the driver. Beside the described tasks, the data layer administrates all relevant information, which is needed for further processing, as well.

- **Processing Layer**: The collected information and driver profile are used to analyse the driving behaviour in the Processing Layer. Additionally, it predicts the state of the car using the collected information stored in the Data Layer. Based on the prediction and the analysis of the driving behaviour, recommendations are generated, which guide the driver to drive energy-efficient or safe.
- **Graphical Layer**: Its main purpose is the rendering of the graphical user interface on the in-vehicle display unit. Furthermore, it shows the generated recommendations to the driver for example using the graphical user interface or an acoustic signal. The Graphical Layer provides also the opportunity to configure the driving profile by choosing an area of improvement: energy-efficiency, safety or both.

3.1 Data Layer

The Data Layer acquires all necessary data from the sensors and the in-car serial-bus system. Based on the gathered information it generates a driving profile, which represents the typical driving behaviour of the driver, and aggregates the incoming data using fuzzy logic. All necessary information for further processing such as the driving rules, the car facts, the collected and aggregated information are stored in the Data Layer. Figure 1 shows the different modules of the Data Layer, which will be described in the following.

Interface Module

The Interface Module is responsible for the communication with the in-car serial-bus systems and with the connected sensors. For the communication with the serial-bus systems it passes the message identifier of the desired information to the serial-bus system interface, which forwards then the corresponding data to the Interface Module. In contrast, the connected sensors send their data to the Interface Module without registering any identifier. After the collection of the data, it will be passed to the Data Aggregation and Profile Update Module for further processing.

Data Aggregation Module

The incoming data is prepared in the Data Aggregation Module using fuzzy logic, as some information has more value when it is fuzzy, for example it is clearer to define the manner of driving as high instead of using the crisp value1 of the engine speed to describe the manner of driving.

For the preparation of the incoming data the Data Aggregation Module uses Fuzzy logic. Its main purpose is to interpret fuzzy information with the help of fuzzy sets and fuzzy rules. Fuzzy sets are described by sets of elements, which have a degree of membership. Fuzzy rules are conditional statements, which are often used for control purposes. Table 1 shows an excerpt of fuzzy sets and rules used in the Data Aggregation Module to prepare the incoming data.

The first step of the Data Aggregation Module is the transformation of the incoming crisp data into grades of memberships of linguistic terms with the help of the defined fuzzy sets. This process is called the fuzzification. For example, the engine speed value 2000 rpm is transformed into the degree of membership of two linguistic terms: 80% low and 20% very low. The next step applies the defined fuzzy rules on the fuzzy values. The fuzzy rules allow the aggregation of different fuzzy values to get more information out of the existing data. For instance a dangerous driving weather condition is the result of heavy rain and temperature below freeze point.

Finally, the Data Aggregation Module transforms the linguistic terms, including the results of the fuzzy rules, into crisp values. This process is called defuzzification. There are different methods to transform the linguistic terms into crisp values. The simplest method is to choose the set with the highest degree of membership and ignore the other sets. Thus, in our example with the engine speed the defuzzification process would transform the 80% low into a crisp value, which represents a low engine speed.

The result of the defizzification process is then passed to the Profile Update Module. Simultaneously, the aggregated data

[1] A crisp value is an exact value like a real number. It is the opposite of a fuzzy value.

is stored along with the incoming data, which were not relevant to the fuzzification process, in the working memory.

Profile Update Module

The Profile Update Module is responsible for creating and updating the driving profile, which is used to describe the typical driving behaviour of the driver. The basis for the driving profile is the incoming data from the Interface- and the Data Aggregation Module. First, the Profile Update Module checks if a driving profile is available for the driver and creates a driving profile if it is not available. Every entry in the driving profile is described by the name of the value, the value itself, which represents the average value of that entry, and the update count of that value. For example the driving profile stores the driving behaviour, while a certain speed limit:

- Name of the value: Average speed at speed limit of 70 km/h
- Value:72 km/h
- Update count: 2000

In our example the value represents the average driving speed of the car during the speed limit of 70 km/h. The update process calculates the average the mean of the value by using the update count, the value itself and the incoming value. The update count is increased by one on every update of the value. The following formula shows the calculation of the average value:

$$\mathrm{newValue} = \frac{(\mathrm{count} \times \mathrm{profileValue}) + \mathrm{incomingValue}}{\mathrm{count} + 1}$$

Based on the calculation done by the Profile Update Module the driving profile represents the average or typical driving behaviour of the driver. The calculation is done and stored for every journey separately. This allows the driving system to analyse the driving behaviour over time to find positive or negative changes in the driving behaviour. However, when the Profile Update Module creates the driving profile, it has to be updated a couple times until the driving profile is able to represent the typical driving behaviour.

Short Term Knowledge Base

The prepared data from the Data Aggregation Module as well as the incoming data form the Interface Module are stored in the working memory, which is placed in the Short Term Knowledge Base. The stored information is used in the Processing Layer for further processing. The following list shows an excerpt of the stored values.

- speed
- speed limit
- distance to preceding car
- current gear
- acceleration force

Mid Term Knowledge Base

The driving profile, which is created and updated by the Profile Update Module, is stored in the Mid Term Knowledge Base. It contains information about the driving behaviour, the already given recommendations and the area of improvement that the driver has chosen. The stored information is used for the analysis of the driving behaviour and the generation of recommendations. The following list shows an excerpt of the stored values in the Mid Term Knowledge Base.

- Average Manner of driving
- Average Driving Speed
- Average Distance to preceding car
- Area of improvement
- History of given recommendations
- Adherence to the recommendations

Long Term Knowledge Base

The Long Term Knowledge Base is separated in two parts. One store the driving rules for energy-efficient and safe driving and the other part describes the facts about the car like the mileage, maximum speed or rpm. Both parts are the basis for the generation of the recommendations and will be described in the following:

Safety relevant driving rules

- Keep enough distance to preceding car
- Look ahead and anticipate to surrounding traffic
- Adapt your speed to the given situation
- Don't exceed the speed limit
- Avoid any distractions, for example don't use the mobile phone during the journey

Energy-efficient driving rules

- Shift the gear as soon as possible
- Drive at steady speed using the highest gear
- Skip gears when it is appropriate
- Decelerate smoothly by releasing the accelerator on time, while the car is in gear

3.2 Processing Layer

The Processing Layer is responsible for the analysis of the driving behaviour regarding the aspects of energy-efficiency and safety and for the generation of the recommendations, based on the individual driving behaviour. For these procedures an expert system is used, which is separated in two modules: the Rule- and Data Element Selector and Inference Engine. Furthermore, as our driving system tries to prevent bad driving habits, the Prediction Engine predicts the state of the car. This allows the expert system to generate a recommendation before a braking of a driving rule occurs. The data used in the expert system is gathered from the Long-, Mid- and Short Term Knowledge Base, which are placed in the Data Layer. The correlation between the different modules is illustrated in Figure 1. In the following chapters the modules of the Processing Layer will be described in detail.

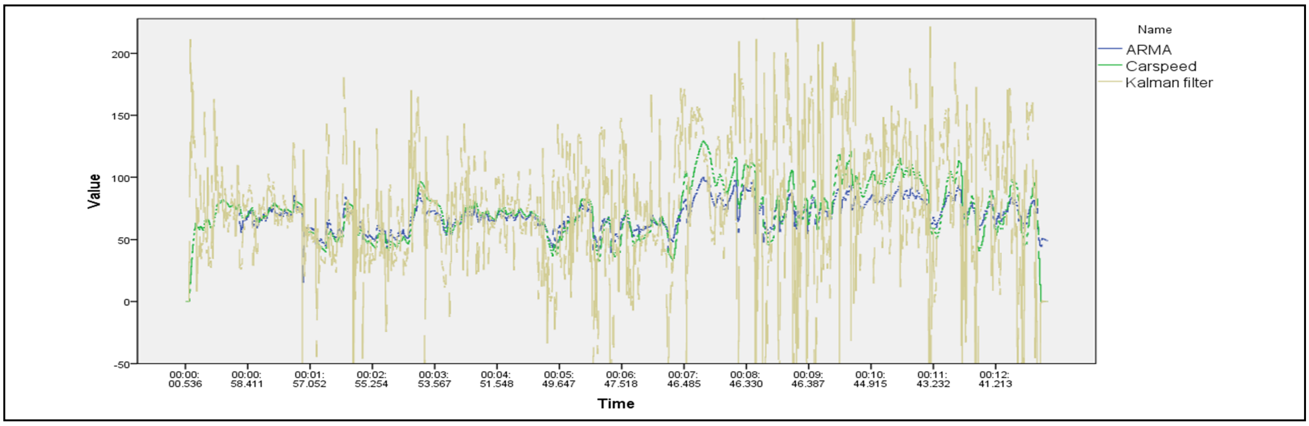

Figure 2: Result of 100 seconds prediction ahead using ARMA and Kalman filter

Prediction Engine Module

Our driving system has the goal to show energy-efficient and safe driving recommendations to the driver before a breaking of a driving rule occurs. Therefore, it is necessary to know the future state of the car. The Prediction Engine Module tries to predict the state of the car for the next cycles. A cycle is defined by passing the Processing Layer once from the Prediction Engine Module to the Inference Engine Module. It has to be figured out how many cycles are appropriate for the prediction. As the prediction is done in real-time and the performance is an important point, the Prediction Engine Module predicts only the values speed, distance to the preceding car and the engine speed. So, these values represent the state of the car in the Prediction Engine Module, as these values are the core values for the detection of the breakings of the rules. The prediction allows the expert system an early recognition of any breakings of the driving rules. Thus, the expert system can prevent the breaking of the driving rules by giving driving recommendations to the driver before the driver does a driving mistake.

There are prediction algorithms, which allow the prediction of the car state like the Kalman filter [Welch and Bishop, 2006] or the Auto-Regressive Moving-Average (ARMA) [Brockwell and Davis, 2002]. The car state in our case is represented by the values car speed, engine speed ant the distance to the preceding car.

The modelling and recognition of simulated driving behaviour is presented in [Pentland and Liu, 1999] using a Markov chain2 with sequenced Kalman filters. According to Pentland and Liu the Kalman filter is only useful in short time prediction, for instance for the prediction of a quick hand motion. Thus, Pentland and Liu use the Kalman filter for a small-scale structure of the driving behaviour and coupled these together with a Markov chain, which represented the large-scale structure. The evaluation of this approach showed a prediction accuracy of 95% can be achieved. In contrast to the statement of Pentland and Liu, Bossanyi used the Kalman filter for the prediction of the short-term wind speed, where the Kalman filter predicted well for time periods below 10 minutes [Bossanyi, 1985].

The ARMA is another statistical prediction algorithm, which combines the autoregressive and the moving-average model. The output of the autoregressive model depends linearly on the previous output values. In contrast, the moving-average model is used to describe the mean of the time series data. The ARMA prediction is used for example in the area of econometrics, statistics or for wind speed prediction. In [Lujano-Rojas et al., 2011] an approach is presented for the hourly prediction of the average wind speed. The evaluation showed that the prediction accuracy for the time between one and then hours ahead can be improved about 17% using the presented approach.

The presented prediction algorithms have different approaches for the prediction of the values. Thus, we evaluated of the prediction algorithms using the data from the driving simulator. We collected the driving speed information of about 15 minutes of a journey. The result of the evaluation (see Figure 2) showed a more accuracy using the ARMA, as it considers the history of the values.

Rule and Data Element Selector Module

The Rule- and Data Element Selector Module is responsible for detecting any braking of a driving rule, deviation from the typical driving behaviour and any condition of the driver, which can be prejudicial for the driving task like anger, fatigue and so on. Thus, it compares the data from the working memory against the driving rules and car facts, which are stored in the Long Term Knowledge Base in the Data Layer. The data from the working memory is compared against the driving profile as well. The content of the working memory is not passed directly to the Rule and Data Element Selector Module. It is first passed to the Prediction Engine, which adds the predicted data to the data set of the working memory, and passes then the whole information to the Rule and Data Element Selector Module. On Recognition of a breaking of a driving rule, any deviation from the typical driving behaviour or an uncommon driver condition the associated data including the predicted data and the recognised abnormality is passed to the Inference Engine Module for further processing.

[2] A Markov chain describes the transition probability from one state to another state. Thus, it consists of states and transitions. The Markov chain is often used to model real world processes statistically.

The recognition of an abnormality in the driving behaviour is done by comparing each driving rule against the incoming data using fuzzy and crisp logic. Furthermore, the incoming data is also compared against the driving profile to detect any untypical driving behaviour or an uncommon driver condition. As there are only few driving rules for energy-efficient and safe driving and energy-efficient driving has a positive effect on safety, the module has not to deal with performance and contradictory driving rules. Hence, the Rule and Data Element Selector Module checks every single driving rule or value stored in the driving profile against the incoming data. However, if more driving rules or values to the driving profile are added, a solution to increase the performance and to solve driving rule conflicts has to be considered. A solution could be to weight manually the driving rules and values stored in the driving profile in relation to their importance to safety or energy-efficiency and to order them according to their relations to each other.

Inference Engine Module

The Inference Engine Module decides whether to generate and show a recommendation to the driver or not. Therefore, it checks the driver profile, especially the already given recommendations and the past reactions to them, if it is necessary to show the recommendation to the driver in order not to bother him. The reactions to the given recommendations will be analysed by checking the changes of the values during the next cycles, which are important for a specific recommendation. As there are delays until the driver is able to notice and to react to the given recommendation, the Inference Engine Module will wait a certain time until it starts the analysis of the driver reaction to the given recommendation. For example, after showing the recommendation “increase the distance to the preceding car” to the driver, the Inference Engine waits until it starts to measure the reaction. During the next cycles the distance to the preceding car will be analysed and checked if the distance is increased. On recognition of an increase the Inference Engine Module will assume that the given recommendation has been adhered. If an increase of the distance cannot be noticed, the Inference Engine Module will wait a certain time until a recommendation is given again, as it does not want to bother the driver by giving the same recommendation. In case of repeated ignorance of that recommendation, the Inference Engine will decrease the generation frequency of that ignored recommendation. This allows the driving system to consider the driver needs by adapting itself to the individual reaction to a given recommendation. Thus, the acceptance of the driving system can be increased as it avoids recommendations, which are unimportant in the sense of the driver.

Conclusion & Further Work

We presented in this paper an adaptive driving system, which is in development. The focus of the driving system is the analysis of the driving behaviour and the generation of adequate recommendations to improve the driving behaviour in terms of energy-efficiency and safety. In contrast to other existing driving systems the presented driving system considers energy-efficiency and safety as well as the individual driving behaviour and the driver condition while generation a recommendation. Furthermore, the driving system allows creating recommendations before the driver breaks a driving rule by predicting the car state.

As the driving system is under development, it has to be figured out, which algorithm fits the needs of the Inference Engine Module and the Rule- and Data Element Selector. Furthermore, a user friendly concept for the graphical user interface has to be worked out according to the usability guidelines for human-machine interfaces for in-vehicle systems [EU HMI, 1998]. Finally, the generated recommendations have to be displayed in a noticeable way without distracting the driver during the journey.

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Using qualitative methods for describing and recognizing traffic signs

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Abstract

A novel approach for traffic sign representation and classification is presented in this paper. Its main aim is to show that qualitative descriptions of shape, color and orientation combined with similarity methods can be useful for traffic sign recognition. An experiment is carried out using real color sign images and the results obtained are very promising.

1 Introduction

For car drivers, correctly identifying traffic signs at the right time and place plays a crucial role in ensuring their and their passengers' safety. Due to changing weather conditions or viewing angles, traffic signs are sometimes not easily seen until it is too late. Therefore the development of automatic systems for recognition of traffic signs is an important approach to improve driving safety [Handman et al. 2000; Hsien 2003; Liu et al. 2002; Yen et al. 2004].

In traffic sign recognition, feature representations should be robust and invariant to possible transformations of shapes and changing illumination conditions of colors, as it happens real in driving situations (i.e. foggy weather). Qualitative descriptions can deal with this kind of uncertainty, then they are expected to be useful for this task, and this paper is intended to demonstrate this statement.

In the process of recognizing traffic signs, first a method to detect the sign within an image is needed, and then the sign description and classification is done.

A method for sign description and classification is presented in this paper. With respect to the sign detection inside a real image, any method previously developed in other approaches [Hibi 1996; Miura et al. 2000; Fang 2003; Viola 2004; Barnes et al. 2004; Loy and Barnes 2004; Perez and Javidi 2002] can be used. Hence, the proposed approach is applied once the sign has been extracted from the real image.

For the recognition of traffic signs, other approaches in the literature have applied neural networks [Escalera et al. 2003; Kanda et al. 2000; Hsu and Huang 2001] or support vector machines (SVM) [Gil-Jiménez et al. 2007]. However, the proposed approach does not develop a neural network or a SVM, instead, traffic signs are classified only using a similarity measure between the qualitative description of the sign to classify and a set which contains all the possible signs defined and described offline, prior to the beginning of the experiment.

It is worth noting that qualitative models for shape description and approximate matching have been successful applied in object similarity calculus [Falomir et al. 2013a] and also in mosaic assembling combined with qualitative models for color description [Falomir et al. 2013b]. Here these approaches are extended to consider the inner figures of the objects and their orientation.

The proposed system, given a digital image with a single traffic sign, first applies an image segmentation method as explained by Falomir et al. [2012], and then the next information is automatically extracted: the shape and color of the exterior border of the sign, its interior color, and the shape and color of each object inside the sign. Using this information, each sign can be described and then classified. Each sign is described using a Qualitative Shape Description theory, which is presented in Section 2. The colors in each sign are also described qualitatively using a Qualitative Color Description theory presented in Section 3. Section 4 describes qualitatively how inner objects are located inside a sign. Section 5 describes how the similarity of each feature is calculated. The experimentation carried out and the results obtained are discussed in Section 6 and Section 7, respectively. Finally, some conclusions and ideas for future work are given in Section 8.

2 Qualitative Shape Description (QSD)

The QSD is based on segmenting an image and automatically extracting the boundary of any object contained within it. Then, the relevant points that characterize the shape of the object (mainly vertices and points of curvature) are obtained by analyzing the slope, defined by groups of points contained in the boundary. Finally, each relevant point (P) is described by a set of features, $<EC_p, A_p$ or $TC_p, L_p, C_p>$, defined as follows:

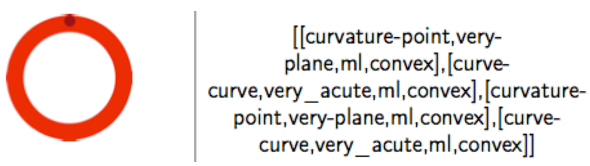
- Edges Connection (EC) by the relevant point *P*, described as {*line_line, line_curve, curve_line, curve_curve, curvature_point*};

- Angle (A) at the relevant point *P*, described as {*very_acute, acute, right, obtuse, very_obtuse*};
- Type of Curvature (TC) at the relevant point *P*, described as {*very_acute, acute, semicircular, plane, very_plane*};
- Compared Length (L) of the two edges connected by *P*, described as {*much_shorter (msh), half-length (hl), a_bit_shorter (absh), similar_length (sl), a_bit_longer (abl), double_length (dl), much_longer (ml)*};
- Convexity (C) at the relevant point *P*, described as {*convex, concave*}.

Let us indicate that the vertices are arranged and the first vertex is always that located at the upper-left part in the image..

An example of a qualitative shape description of a traffic sign is shown in Fig. 1, where there are four relevant points which have the same representation.

Fig. 1. QSD of a traffic sign.



3 Qualitative Color Description (QCD)

This approach is based on the standard Red, Green and Blue color channels (sRGB) of the predominant color of the object (the mean of the sRGB color channels of all the pixels of the image), which are translated into coordinates of Hue, Saturation and Lightness (HSL) color space in order to give a name to the color of the objects.

From the HSL color coordinates obtained, a reference system for qualitative color naming is defined as $QCRS = \{UH, US, UL, QC_{LAB1..5}, QC_{INT1..5}\}$ where *UH* is the Unit of Hue; *US* is the Unit of Saturation; *UL* is the Unit of Lightness; $QC_{LAB1..5}$ refers to the color names; and $QC_{INT1..5}$ refers to the intervals of HSL color coordinates associated with each color name. In the application considered in this paper, the QC_{LAB} and QC_{INT} are follows:

QC_{LAB1} = {*black (bk), dark_ grey (dg), grey (g), light_grey (lg), white (w)*}
QC_{LAB2} = {*red (r), orange (o), yellow (y), green (gn), turquoise (t), blue (b), purple (pu), pink (pk)*}
QC_{LAB3} = {*pale_* + QC_{LAB2}}
QC_{LAB4} = {*light_* + QC_{LAB2}}
QC_{LAB5} = {*dark_* + QC_{LAB2}}

The *US* coordinate of the HSL color space determines if the color corresponds to the grey scale or to the rainbow scale: QC_{LAB1} and QC_{LAB2}, respectively. This coordinate also determines the intensity of the color (pale or strong). The colors in the rainbow scale are considered as the strong ones, while the pale colors are given an explicit name in QC_{LAB3}. The *UH* coordinate determines the division into color names inside each scale. This value is circular, for example, both *0 uh* and *360 uh* represent the color red. Finally, the *UL* coordinate determines the luminosity of the color: dark and light colors are given an explicit name in QC_{LAB4} and QC_{LAB5}, respectively. The intervals of HSL values which define the color names ($QC_{INT1..5}$) have been calibrated to the images to be described, in this case the traffic sign images. And, for example, the colors names given to the sign in Fig. 1 is *red* for the boundary and *white* for the interior.

4 Qualitative Orientation Description (QOD)

In the recognition of a traffic sign, it is very important to take into account the orientation of the inner objects in order to correctly classify the traffic sign. Thus, in order to define the orientation of an object *A* with respect to (wrt) an object *B*, the centroids of both objects, named *a(x,y)* and *b(x,y)* respectively, are considered (A and B are oriented objects, with a front and a back, such as arrows). Hence, two orientation tags are established: the first one is defined in order to determine the horizontal orientation relation of *A wrt B* as follows:

If $b.x < a.x \pm t_1$ *then "left"*
Else if $b.x = a.x \pm t_1$ *then "equal"*
Else "right"

Analogously, it is defined in order to define the vertical orientation relation of *A wrt B*:

If $b.y < a.y \pm t_2$ *then "up"*
Else if $b.y = a.y \pm t_2$ *then "equal"*
Else "down"

where, the symbols t_1 and t_2 represent the thresholds used to compare the coordinates *x* and *y*, respectively. It is necessary to define these thresholds because it is very difficult to find two centroids perfectly aligned with the exact *x*, and *y* coordinates. The thresholds have to be established experimentally according to the image size.

5 Shape, Color, and Orientation Similarity

The approach to obtain dissimilarity values between qualitative parameters of shape, between qualitative colors and between qualitative orientation is based on Conceptual Neighborhood Diagrams (CNDs).

Freksa [1991] determined that two qualitative terms are conceptual neighbors if "*one can be directly transformed into another by continuous deformation*". Thus, for example, acute and right angles are conceptual neighbors since an extension of the angle acute causes a direct transition to the right angle. CNDs can be described as graphs containing: (i) nodes that map to a set of individual relations defined on intervals, and (ii) paths connecting pairs of adjacent nodes that represent the continuous transformations which can have assigned weights in order to establish priorities.

For each of the features given in the models for QSD and QCD, a CND has been defined by Falomir et al. [2010]. Then, dissimilarity matrices are defined to map the pairs of nodes in each CND to the minimal path distance between them.

As the qualitative shape of an object is described by means of all its relevant points (RPs), in order to define a **similarity measure between shapes**, first a similarity between relevant points has to be obtained. Hence, given two relevant points, denoted by RP_A and RP_B, belonging to the shapes of the objects A and B respectively, a similarity between them, denoted by $SimRP(RP_A, RP_B)$, is defined as:

$$SimRP(RP_A, RP_B) = 1 - \sum_{i \in \{KEC, A \vee TC, L, C\}} w_i \frac{dsShape(i)}{DsShape(i)} \quad (1)$$

where *dsShape(i)* denotes the dissimilarity between RP_A and RP_B with respect to feature i, obtained from the dissimilarity matrices constructed. *DsShape(i)* denotes the maximum dissimilarity in the dissimilarity matrix related to the feature i. The parameter w_i is the weight assigned to feature i, and it holds that $w_{EC}+w_{A|TC}+w_L+w_C = 1$ and $w_i \geq 0$.

Note that, by dividing *dsShape(i)* and *DsShape(i)* the proportion of dissimilarity between RP_A and RP_B related to feature i is obtained. Furthermore, let us considered that $w_{EC}=w_{A|TC}=w_L=w_C= 0.25$ as a baseline. The final value given in (1) is subtracted from 1 in order to provide a similarity between relevant points, instead of a dissimilarity.

In order to compare two shapes A and B, with n and m relevant points, the similarity between A and B (*SimQSD(A,B)*) is calculated from (1) as an arithmetic mean of the similarity between relevant points of both shapes in a clockwise direction. If $n \geq m$, then there are some relevant points of A with no corresponding points in B. In this case, the points with no corresponding pairs are compared to the *void* relevant point and the similarity between both points is zero. Therefore the similarity between A and B is:

$$SimQSD(A,B) = \frac{1}{n} \sum_{\substack{RP_A \in A \\ RP_B \in B}}^{m} SimRP(RP_A, RP_B) \quad (2)$$

With respect to the **color similarity calculus**, let QC_A and QC_B be the colors of objects A and B respectively, then a similarity between them, denoted by $SimQCD(QC_A,QC_B)$, is defined in function of their conceptual neighborhood as follows:

- 1.0, if both colors have the same qualitative label;
- 0.95, if the colors of A and B have a conceptual neighborhood distance of 1;
- 0.9, if they have a conceptual neighborhood distance of 2, and
- 0, otherwise.

For example, *red* has a distance of 1 wrt *red*, of 0.95 wrt *orange* and *pink*, of 0.9 wrt *green* and *purple*, and 0 wrt the rest of the colors. All the above values have been established experimentally.

With respect to the orientation similarity calculus, a CND for each orientation tag is also defined, and shown in Fig. 2.

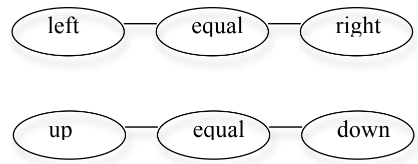


Fig. 2. CNDs for the QOD model

Given the above CNDs, $SimQOD(QC_A,QC_B)$ is obtained by the similarity matrices shown in Table 1 and 2. Also the values in the matrices have been established experimentally.

	left	*equal*	*right*
left	1	0.95	0
equal	0.95	1	0.95
right	0	0.95	1

Table 1. Qualitative similarity matrix for the horizontal qualitative orientation.

	up	*equal*	*down*
up	1	0.95	0
equal	0.95	1	0.95
down	0	0.95	1

Table 2. Qualitative similarity matrix for the vertical qualitative orientation.

6 Traffic sign description and recognition

The initial set of images considered in this paper is shown in Fig. 3. The set of images have been divided into four categories: warning, danger, prohibition and priority.

Fig. 3 Set of images considered.

In the system developed for traffic sign classification, first each traffic sign of the database is described as shown in the example of Fig. 4. For each sign, the QSD of the boundary is obtained, including also its number of vertices and its color. Then, the background color of the traffic sign is also stored qualitatively. If the traffic sign has inner objects, then the boundary, number of vertices, and qualitative color of

each object are calculated. If there is more than one object inside the traffic sign, the qualitative horizontal and vertical orientations of the objects are also obtained.
Then, when a new image of a traffic sign is introduced into the system, in order to determine which specific sign it is, it has to be described following also the same scheme.
After obtaining the description of all the images of the database and the description of the image to classify (*target sign*) the recognition process starts by calculating the similarity of the exterior description of the *target sign* wrt the ones in the database. Using only this similarity, the system can **determine the category of the sign** (warning, danger, prohibition and priority). The exterior similarity (SimEx) is calculated as follows:

$$SimEx(QC_A,\ QC_B)= 0.3*SimBoundCol(QC_A,\ QC_B) +\ldots$$
$$0.2*SimBackGrCol(QC_A,\ QC_B) +\ldots$$
$$0.5*SimBoundShape(QC_A,QC_B)$$

where *SimBoundCol* is the similarity between the boundary colors of both traffic signs, and *SimBackGrCol* is the similarity between their background colors. Both similarities are calculated as described in previous Section. *SimBoundShape* is the similarity between the boundary shapes of the images, also calculated as described in Section 5, following a cyclic comparison. The weights (0.3, 0.2, and 0.5) have been established experimentally to account for the importance of each feature for the traffic sign classification.

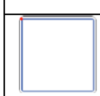
<table>
<tr><td>Graphic Representation</td><td colspan="5"></td></tr>
<tr><td>Interpretation</td><td colspan="5">Warning: Give priority to vehicles from the opposite direction</td></tr>
<tr><td>Boundary</td><td colspan="2">QSD</td><td>N. Vertices</td><td>Boundary C.</td><td>Backgr. C.</td></tr>
<tr><td></td><td colspan="2">[[line-line,right,sl,convex],[line-line,right,sl,convex],[line-line,right,sl,convex],[line-line,right,sl,convex]]</td><td>4</td><td>White</td><td>Blue</td></tr>
<tr><td>Nº</td><td></td><td>QSD</td><td>C</td><td>N V</td><td>O.</td></tr>
<tr><td>1</td><td></td><td>[[line-line,right,ml,convex],[line-line,right,msh,convex],[line-line,obtuse,ml,concave],[line-line,acute,msh,convex],[line-line,acute,sl,convex],[line-line,acute,ml,convex],[line-line,obtuse,msh,concave]]</td><td>Red</td><td>7</td><td></td></tr>
<tr><td>2</td><td></td><td>[[line-line,acute,sl,convex],[line-line,acute,ml,convex],[line-line,very_obtuse,msh,concave],[line-line,right,ml,convex],[line-line,right,msh,convex],[line-line,very_obtuse,ml,concave],[line-line,acute,msh,convex]]</td><td>White</td><td>7</td><td>equal and right wrt 1</td></tr>
</table>

Fig. 4. Example of the description of a traffic sign image.

SimEx is calculated for the target sign wrt all the categories of traffic signs in the database. Then, the type of the target sign is determined by choosing the categories that have the maximum (it can be one maximum or more) value of *SimEx*. Once the type or types are determined, the **final classification step** starts in which the specific traffic sign inside the category is specified.
In the last step, for each type selected, the target sign is compared with all the traffic signs inside a category by calculating also a the similarity between the inner objects. This similarity is calculated in differently depending of the number of inner objects. A traffic sign is only compared with other ones with the same number of inner objects. If the signs have no inner objects, the similarity between the signs is calculated as *SimEx (SimIn = SimEx)*. If they have only one inner object, the similarity is calculated as:

$$SimIn(QC_A,\ QC_B)=0.5*SimColor(QC_A,\ QC_B) +\ldots$$
$$0.5*SimShape(QC_A,\ QC_B);$$

where *SimColor* is the color similarity between the color of both inner figures, and *SimShape* their shape similarity, both calculated as in Section 5, but in this case, as orientation matter the comparison is not cyclically done.
If the traffic signs have more than one inner object, then the similarity is calculated as:

$$SimIn(QC_A,\ QC_B)=\frac{1}{N}\sum_{i=1}^{N}(0.15*SimVO(QC_A,\ QC_B) +$$
$$0.15*SimHO(QC_A,\ QC_B) +$$
$$0.40*SimColor(QC_A,\ QC_B) +$$
$$0.30*SimShape(QC_A,\ QC_B))$$

where *SimVO* and *SimHO* are the similarity between the qualitative vertical orientation and the qualitative horizontal orientation, respectively of both inner objects, and N is the number of inner objects. Again the weights (0.15, 0.3, and 0.4) have been established experimentally to account for the importance of each feature for the traffic sign classification.
Then, the final similarity between two traffic signs is calculated as:

$$SimF(QC_A,QC_B)=0.5*(SimEx(QC_A,QC_B)+SimIn(QC_A,QC_B))$$

Therefore, the target sign will be classified as the specific sign which has a bigger *SimF*. If several maximums were obtained, then the sign would be classified as all the signs with the maximum *SimF*.

7 Experimentation and results

In order to test the approach presented, the images in the database were digitally created using an image editor (Photoshop Elements), and the images to classify where obtained from photographs taken with a digital camera (Sony DSC-W290). From each photograph, only the sign was extracted and described. Fig. 5 shows an example of one photographed traffic sign, that was correctly classified as a as a “Warning: Give priority to vehicles from the opposite direction” sign with a 95.5% of similarity.

a) b)

Fig 5. (a) Traffic sign photograph; (b) its equivalent image in the database

Table 3 shows several real images, their classification result and the similarity obtained with the presented method.

Target sign	Classified as	Final Similarity
	Traffic light	64%
	Give priority to vehicles from the opposite direction	95.5%
	One-way traffic, two lane road	97.19%
	Danger	93.64%
	Parking area	88.63%
	Crossroads with right-of-way from the right	97%
	Crossroads ahead	99%
	Junction with a minor side-road right	98.75%
	Junction with a minor side-road left	99%
	Start of a third lane	96.25%
	Give way over oncoming traffic	85.81%

Table 3. Example of photographs successfully classified

The experiments were carried out on a Dell XPS m1330 portable computer, with a M1330 CORE 2 DUO T9500 2.60GHZ CPU.

With a set of more than 50 photographs to classify, the system has obtained a recognition rate of 87% with a temporal cost of 77.64 milliseconds as average for the classification of a traffic sign.

The recognition rate of traffic signs that have not curvilinear segments is higher, 91%, because the segmentation process followed to obtain the curvature information has to be improved in order to get better recognition rates.

An example of a traffic sign that has not been successfully classified is presented in Fig. 6. It represents a false positive. This sign is a *"humps"* sign but it has been classified as a "*Left Priority Intersection"* with a similarity measure of 92.81%. The reason is that the inner object has not been correctly described because of its curvature elements.

Fig. 6. Photograph of a traffic sign that has been classified incorrectly.

The images shown in Table 3 also demonstrate that the traffic signs in the photograph have noise associated (different shapes due to e.g. the angle of the picture, or color differences,) and the use of the qualitative method here described has been able to manage this problem.
Although the image database used in this experimentation is small and may not indicate the correct performance of the proposed method in more realistic settings, it shows the ability of qualitative theories to deal with the problem of traffic sign recognition. The comparison (Table 4) of the initial results presented in this paper with previous work demonstrates that they are promising enough to continue research in this field.

Method	Recognition Rate
Legendre moments	97.5%
Invariant features	94.5%
Fuzzy sets and shape measures	88.4%
Eigenvector based	96.8%
Color distance	93.5%
The proposed method	91.0%

Table 4. Comparison of the presented method with other methods in the literature.

The proposed method can be classified as a shape measures-based method, and the recognition rate is competitive with that obtained by other methods of the same kind.
An important point is that a good traffic sign recognition system has to be able to recognize signs that are rotated and/or partially occluded. An advantage of the presented method is that it is invariant to small rotations, and the recognition rate does not decrease with images rotated slightly with respect to the pattern sign. As future work, the approach will be extended and tested with partially occluded signs.
Finally, it is usual that traffic sign recognition methods, such as the presented method, get different rates in function of the type of segments of the objects (straight-lines or circular lines).

8 Conclusions and future work

This paper has demonstrated that it is possible to use qualitative representations of shape, color and orientation for traffic sign description and classification. The approach presented is also able to manage the noise associated to a real digital image of a traffic sign.
For the traffic sign recognition only a similarity measure is defined based on conceptual neighborhoods, which does not need training. As future work it would be useful to use this similarity as part of a learning process using neural networks or SVMs and test whether the recognition rate is improved.
If the sign has curvilinear segments, the recognition is less accurate because the segmentation process used does not obtain the all the curvature information needed. Therefore, another improvement would be to develop a new method to extract curvilinear information or to approximate the curves to small straight segments.
Also, the system has to be extended in order to recognize all legally defined traffic signs and test if the recognition rate is still the same.
Finally, using qualitative representations to describe and classify traffic signs allows the gathering of semantic information from the signs. Therefore, using the approach here described makes it possible to develop a learning system to support the teaching of traffic signs.

Acknowledgments

This work has been partially funded by the "Ministerio de Economía y Competitividad" with contract number TIN2011-24147, the Fundació Caixa Castelló project P1-1B2010-49, by the Spanish Ministry of Science and Innovation R&D project ARTEMISA (TIN2009-14378-C02-01), the Transregional Collaborative Research Centre on Spatial Cognition at the Universität Bremen, and the European Union under IEF Marie Curie project Cognitive-AmI, the Deutscher Akademischer Austausch Dienst (DAAD), Generalitat Valenciana (GV/2013/135), and by Universitat Jaume I (project reference P1·1B2013-29).

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Monitoring driving behaviour and biometric data to detect stress patterns

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Abstract

The Self-aware driver architecture is made in order to design a system using sensor technology that supports drivers to inform about their stress level during the driving process. Multiple advances in automobile technology are used to help and protect drivers in the road. However, the stress state is yet not considered as an important feedback data for the driver. This work takes into consideration the negative influences of stress on individuals and proposes a system designed to support drivers by providing them with information that can reduce the risky stress situations on the road, birding this information gap. As a starting print, biometric sensors are used to collect data associated with stress and open source drive simulation software is used in order to simulate the driving task

1 Introduction

Increasing automobile security is good researched and studied field. Most of these studies are focused on creating systems and technologies that are aimed to avoid accidents (passive security) or to reduce the consequences in case of accident (active security).

This research is based on our previous studies and models of stress level measurement technologies [M. Fernández *et al.,* 2012]. In current studies, we have used corresponding methods to develop instruments for measuring a driver's stress level. As the driver plays the main role in the driving process, his stress level can affect the driving process turning into one of the key risk factors. To help the drivers to be aware of their stress level, we have used the Self-Aware architecture that measures the stress level and reports it to the driver as a "passive security system", suggesting the driver to follow one of the risk decreasing scenarios (reduce the speed, make a pause, turn off the heating, etc.)

The growing availability of low cost sensor technology on the commercial market, enables the possibility to install a real time stress level informational from the driver and there are endless simulation possibilities of a driving environment [A. Hess *et al.,* 2012].

Furthermore, the system has been extended into supporting an external monitoring that could be widely used in the training simulators. Our research have shown that the simulation quality has a very important role for the data acquisition and the data quality [D. PUZENAT and I. VERLUT 2010]. It has to be taken in consideration that the simulation has to be realistic enough to cause lifelike reactions of the driver. As there is a large amount of the factors influencing the driver's actions as well as driver's stress level, the simulation has to be advanced enough to produce a real life effect on the Driver.

The continues section State of the art we will talk about the current technologies and compare them. In section 3 the architecture model is described and a use case is explained. The paper concludes whit a brief conclusion and a some future steps to take in consideration.

2 STATE OF THE ART

To be able to collect significant information for the measurements of stress and be able to make pseudo realistic risk alerts it's very important to consider that there are a loot variables that influences this process.

To make the simulation Process we have tested two driver simulations software. Each of them had some advantages and disadvantages.
The openDS simulator is an open source project for research. It is written in Java [R. Math, *et al.,* 2013]. The alternative simulation program is Vdrift [F. Kehrle, *et al.,* 2011]. Currently the advantages from openDS to Vdrift is that openDS is a driver simulator that is not lap based and Vdrift is currently more a video game that is track based.

The measurement of the biometric data from the driver and so acquire the drivers stress is also necessary and to accomplish this task we can use two different sensors.
The emWave sensor is from Institute of HeartMath. This sensor was used in a first approach used in [M. Fernández *et al.*, 2012]. This sensor allows measuring coherence/stress level in real time with only one sensor in the ear (allowing movements with the head). It is based on a USB Plethysmographic pulse sensor for ear (ECG and Heart rate), optionally for finger with a sample rate of 360 samples/sec. The gain (increase needed for the amplitude of the signal) setting adjusts automatically via LED duty cycle (ratio between the pulse duration and the period of a rectangular waveform). The photo diode operating range is 30 - 140 beats/sec
.
The E-Healt Stet is a sensor platform developed by the Libelium. The set consists of 10 different body sensors:
Pulse, Oxygen in blood (SPO2), Airflow, (breathing) Body temperature, Electrocardiogram (ECG), Glucometer, Galvanic skin response (GSR - sweating), Blood pressure (sphygmomanometer), Patient position (accelerometer), Muscle/electromyography sensor (EMG).

The main difference between the emWave and the E-health set is that the emWave gives us already a stress measurement and the E-health set gives us Biological data that can be used for estimating the stress level.
In the following section is going to be used to explain and describe the system architecture where the sensors and the simulator are used and how is expected that the system works.

3 System Architecture

This chapter is devoted to the architecture that are used in the architecture to collect biometric data (e.g. heart rate, EEG) the driving parameters/simulation data (e.g. speed, gear) and the interaction whit the driver as shown in figure 1.

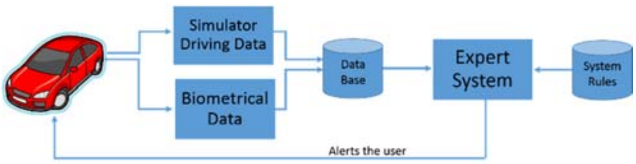

Figure 1 Self-Aware Model Architecture

The architecture enables to monitor the driver while using the simulator locally and/or remotely by an observer. All the data from the biometric sensor and the driving simulator can be computed together and stored on a local database. The information stored in the database is used by an expert system that is in charge of generating alerts to the driver. At the same time the data base can be used for an external monitoring. The expert system alerts the driver when one of the analysed parameters becomes critical.

The architecture is based on the client server model concept.
The main elements of the architecture are the driving simulator, the driving data collection, the biometric sensor, the biometric data collection, the data storage and the expert system.

- Driving simulation: In our studies we use OpenDS that is an open source driving simulator written in Java. The code of OpenDS has to be specifically modified so that the required driving data can be extracted.
- Biometrical sensors: We use the emWave sensor that was used in our previous studies of the stress measurement by traders [J. Martinez *et al.*, 2012] and the e-Health Sensor Platform V2.0.
- In a first approach the stored information can be analysed by two entities. The first entity is the local system that warns the driver in case of any of the key parameters are out of range so that the driver makes decision about his further actions aimed to ensure his safety. The second entity is an external monitoring that can be used by an observer. In the following subchapter we describe the use case for the architecture.
- In a second approach we could add a bigger sensor set to get more data that could be analysed.

In the following subsection we present a use case to see how this system can works.

Use case

A driver is placed in the simulator and his vital biological signals are collected by the emWave Sensor. While driving in the simulation software the driver is exposed to different stressful and complicated situations. This data obtained from the sensors is collected and stored together with the driving information as time, gear, gas/brake pedals position, etc. The expert system analyses the stored information in real time and gives the driver feedback; depending of the definitions of the rules the driver gets an alert and recommendation or just notification. Figure 2 shows a test user driving in openDS and whit an emWave.

Figure 2 Driver Simulator and emWave

Figure 3 shows us the Data gathering and visualisation of the collected data.

Figure 3 Driving Simulator Data whit Heart Rate

Figure 4 shows us the data dashboard. On the Left side we can see the Heart rate and the stress level being indicated whit different colours. When the bar becomes red the Driver is stressed, when orange then he is under some stress and if it's green the driver stress it's minimal or not stressed.

Figure 4 Observer Cockpit whit Sensor and simulator data

This is one of the possible use cases for this architecture whit the use of the emWave. Only in future Steps when we use a different sensor set e.g. E-health Kit we can do a more precise statement. The use case might be subject to changes in this case. In the following section Conclusion and future work we will discuss introduce to different possibility and steps that could be done next.

4 Conclusions and Future work

In this paper we presented a Self-Aware Model application in a driving scenario that tries to close the gap about the stress and tries to give useful information about the stress to the driver.

Now it's important to find and determine which information gives us the relevant information about stress and find the correlation. Not all sensor data will have a direct influence in the stress of the driver that can be measured directly.

In a second approach we will use the e-Health Sensor that connected whit Arduino board and will collected the data and sent to the simulator. The revised data can be computed and integrated with the data that is extracted from the simulator (e.g. speed, rpm, gear….) and stored in the database.

The comparison between both measurements emWave and a different sensor set can show and tell us which parameters and or biometric signal are closer and more relevant for an optimal estimation of the stress level.

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Comparing Energy Efficiency of drivers and vehicles using Data Envelopment Analysis

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Abstract

In this paper, we propose a new methodology to compare and promote efficient driving by providing feedback to the user. The proposed methodology uses Data Envelopment Analysis (DEA) to enable comparisons between drivers and vehicles, by including parameters retrieved from vehicle as inputs or output for DEA method.
Providing feedback to the user is essential in driving eco-systems for changing bad driving habits and not returning back to driving bad-habits. In our case, feedback is provided once the driver has finished some routes, by proposing which corrections or improvement has to deal with for future trips. The required vehicle's telemetry data is obtained through the OBD2 port using an OBD2 adapter.

1 Introduction

The driving style is has a direct effect on the energy consumption of vehicles. The more aggressive a driver is the more waste of energy makes. Energy-saving behaviors include: not exceeding driver speed limits, accelerating and decelerating smoothly, using appropriate gears depending on speed, and keeping constant speeds. These behaviors among others provide a positive contribution in saving fuel and reducing greenhouse gas emissions, up to 25% of fuel could be saved [1] [2]. Moreover, other benefits include improving comfort, reducing risks and increasing the life of vehicle components.

Motivation drivers to change driving style is crucial, but before automated systems should be able to detect these behaviors and compare drivers each other.
Smart cities should provide its citizens of smart information about their behaviors and the behaviors of the rest of the citizens, analyzing data in any form, from any source, merging the more information the better.
In this sense, authors propose the creation of Ranks for comparing citizens' efficiency in several fields such us residential environments, offices and buildings and of course travelling. Among others Ranks, we present in this paper a rank of drivers using their own vehicles by applying DEA to datasets including the parameters meaningful when analyzing driving and drivers efficiency.

2 Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a nonparametric method to provide a relative efficiency assessment (called DEA efficient) for a group of decision-making units (DMU) or for productive efficiency (aka technical efficiency) with a multiple number of inputs and outputs. DEA was first proposed in 1978 [Charnes, 1978] and is commonly used in operations research and economics to empirically measure productive efficiency of DMUs. In order to determine whether a DMU is efficient is as easy as checking if the DMU is on the "frontier" of the production possibility set. In this way, DEA identifies a "frontier" on which the relative performance of all utilities in the sample can be compared.
In recent years, a great variety of applications of DEA have appeared for the evaluation of the performances of many kinds of entities engaged in various contexts. DEA is especially useful when examining the nature of complex (often unknown) relations between multiple inputs and multiple outputs. DEA has been used both in private [Emrouznejad, 2008], [Eilat, 2008], [Amirteimoori, 2012], [Chian, 2010] and in public contexts [Gonzalez-Rodriguez, 2010], [Afonso, 2010].
Regarding energy efficiency studies, DEA is commonly applied for the study and comparison of the performance and efficiency of energy industries, above all in the electricity industry, see [Weyman-Jones, 1991], [Pombo, 2006], [Vaninsky, 2006], [Perez-Reyes, 2009] and [Tovar, 2011]. More recently, it has also been applied to IT companies in [Serrano-cinca, 2005] and [Fernández-Montes, 2012]. Recently, it has also been popularized in environmental performance measurement due to its empirical applicability.

In this work, DEA is used as a method to compare energy-consumption efficiency between each various drivers and between various vehicles, where productive efficiency is measured as the energy consumed to make some trips.

3 Inputs and outputs selected

DEA study can be done under two models: CRS and VRS. CRS assumes that the relation between inputs and outputs are constants. That means that relation between inputs and outputs is lineal and can be represented by a rect. On the other hand VRS assumes the relation between inputs and outputs is variable, which is a more realistic model.
Moreover DEA can be performed with three orientations: input oriented, output oriented and input-output oriented. Each of these orientations assumes that we are capable of modifying inputs, outputs or inputs and outputs respectively. Figure 1 shows orientations and models samples.

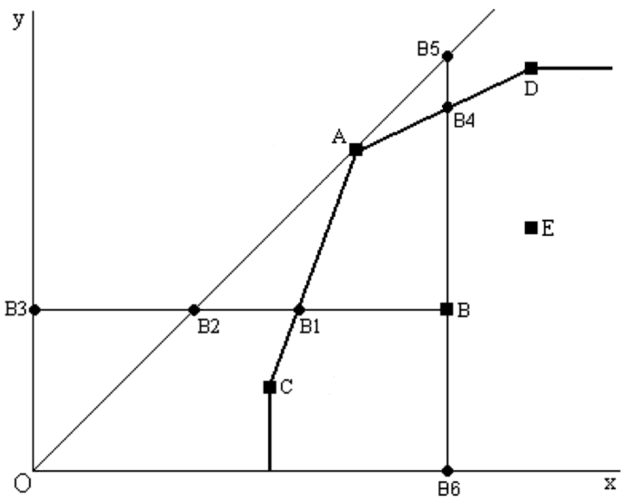

Figure 1: DEA models, orientations and frontiers

Once DEA is performed, it establishes the frontier whether the best efficient DMUs are, and less efficient DMUs has to tend to this frontier. In Figure 1, A belongs to the frontier for both models CRS and VRS. B should improve any inputs or outputs in order to be more efficienct. For example, in VRS, input oriented, it should decrease its inputs while maintaining its outputs in order to be projected in the frontier at B1 point.

In order to compare drivers and vehicles, about one hundred of trips where analyzed from the retrieving of parameters *sensed* by the car. Not every parameter should be taken into account for efficient study so the following parameters where selected:

- Inputs:
  - Number of hard accelerations (greater than 2.5 m/s^2)
  - Times a hard negative acceleration has been made (sharply breaks) (less than $-2.5 m/s^2$)
  - RPM. Revolutions per minute
  - PKI[1] (Relative cinetic power) which is computed by ($currentSpeed^2$-$previousSpeed^2$)/ space
  - Engine load
- Outputs
  - Average fuel consumption
  - Duration of the trip / consumption
  - Total time in movement

Acknowledgments

This research is partially supported by the projects of the Spanish Ministry of Economy and Competitiveness ARTEMISA (TIN2009-14378-C02-01) and Simon (TIC-8052) of the Andalusian Regional Ministry of Economy, Innovation and Science.

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An approach to a reference model for a sentient smart city

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Abstract

The interest about Smart City concept has increased in recent years. In fact, Smart Cities is expected to improve cityzens life experience by driving the next digital revolution, moving from the personal area (mobile computing, smart home) to the urban area (collective computing and collective intelligence). But the development of Smart Cities is not being as fast as expected. Several problems need to be undertaken in order to achieve the objectives of the paradigm. This paper presents an approach to address one of these problems: to orchestrate the platform that is required for gathering information about city, store it in a model and enable it for exploitation. The heterogeneity of the potential data sources available and the complexity of the information nature and structure, make it a non-trivial task that have to be solved before commercial solutions appear and provide specific and non-interoperable solutions.

1. Introduction

According to Unied Nations, more than 50 percent of all people, 3.3 billion lived in urban areas. By 2030 this number is expeted to be increased until 5.5 billion. This urban growth rate impulse goverments to look for solutions and smarter ways to manage and organize cities.

At the same time, evolution of electronics is increasing its capabilities and changing the way in which humans interact with technology. Computing devices are becoming part of our daily life.

But now, these devices jump from personal environment to the city area, improving the way in which humans and city interact, and creating smart cities.

Several definitions of smart city can be found in bibliography:

- The use of smart computing technologies to make the cirtical infrastrcuture componets and service of a city more intelligent, interconnected, and efficient.
- A city well performing in a formard-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens.
- A city striving to make intself "smarter" (more efficient, sustainable, equitable, and livable).
- A city that monitors and integrates conditions of all of its critical infrastructures, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens.
- An instrumented, interconnected and intelligent city. Instrumentation enables the caputre and integration of live real-world data through the use of sensors and other devices. Interconnected means the integration of those data into a computing platform and the communication of such information among the city services. Intelligent refers to the inclusion of complex analytics, modeling, optimization and vistualization to the operational business processes to make better operational decisions.
- A city where the ICT strengthen the freedom of speech and the accessibility to public information and services.

From these definitions, can be emphasized some key concepts related to smart cities: infrastructure, communications, computing, information, technology, services, efficience, citizens, sustainability, livable, quality of life, integration, resources, optimization and accesibility.

Smart Cities have been identified as one of the central topics in European Research Program because of its potential, and its decisive contribution to quality of life in coming years. The evolution of the paradigm will create also an emerging market around it, and provide an important impulse for economy.

European Commission affirms that there is a need to reach a high level of agreement at an industrial level to overcome the increasing market fragmentation caused by isolated partial or specific solutions (vertical), commercial oriented, that already exists in the smart city initiatives.

Smart City concept is expected to be an important economic engine in coming years, because of the implications that its development has for people, bussiness and administrations. In fact, the paradigm implies a joint effort between them.

The project *European Smart Cities* identifies six smartness dimensions for smart evaluation: economy, people, governance, mobility, environment and living.

The paradigm will improve cities in each one of these dimensions.

- Information and communicatinos networks
- Engineering
- Energy and cooling networks
- Responsible mobility
- Distribution of drinking water
- Smart building management
- Waste collection and recovery
- Public lighting networks
- Garden city
- Wastewater recovery
- Energy management

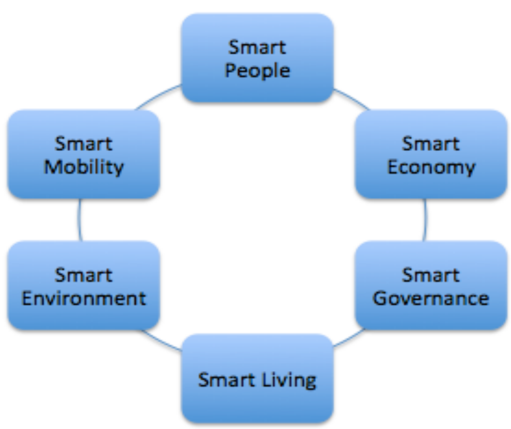

Figure 1 - Smart Cities dimensions

These dimensional developments will be translated in more concrete benefits for society as are the following facts:

- Reducing resource consuption: energy, water, hence CO_2 emissions
- Optimizing infrastructure utilization, and so improving quality of life
- Developing new services for citizens (collective, real-time city information, forecasting, health monitoring, bussines opportunities)
- Improving commercial relationships for providers and consumers

According to Gartner, in 2012 there were 143 smart city projects ongoing along the world. Distributed as follow: North America (35), South America (11), Europe (47), Asia (40) and the Middle East & Africa (10). But the number is growing.

Research programs are driving this trend and spend large amounts on this issue to encourage the creation of a market to strengthen business involvement and smart cities development.

Nevertheless, because of the early stage in which Smart Cities are, the challenges for a smart city are very general [Batty, 2012]:

- A new understanding of urban problems
- Effective and feasible ways to coodinate urban technologies
- Models and methods for using urban data across saptial and temporal scales
- Developing new technologies for communicatinos and dissemination
- New forms of urban governance and organisation
- Defining critical problmes relating to cities, transport, and energy
- Risk, uncertainty and hazard in the smart city

But not only exist challenge in smart city design, yet also about research in smart city:

- To relate the infrastructure of smart cities to ther operational functioning and planning through managemente, control and optimization
- To explore the notion of the city as a laboratory for innovation
- To provide portfolios of urban simulation which inform future designs
- To develop technologies that ensure equity, fairness and realise a better quality of city life
- To develop technologies that ensure widespread participation

The objective of this paper is to describe a reference model for the architecture of a smart city that develops interoperability (service composition thinking) and infrastructure integration (multiple-device platform, networks and integrated data center). This is, to orchestrate the information gathering, processing, publication and use.

2. Background

Several Smart Cities projects are presented, analyzing especially how their functinonality is organized.

The smart city development pyramid [Al-Hader et al., 2009] is an example of functionality organization for smart city. The reference model proposed in this paper uses a similar approximation in the low layers, but is significantly different in top layers.

A service oriented architecture, in this case, of smart city geospatial management can be found in bibliography [Al-Hader et al., 2009a]. It seeks an efficient resource planning, management and quality of service.

Other proposal for an integrated service management planform, called ISMP [Jungwoo et al., 2011], divides it in thre layers: Infrastructure component (sensors and actuators), Middleware (Gateway service, Mobility manager, Ubiquitous information, Operation management and Integrated database) and Service.

A low level architecture for monitoring public spaces is proposed in SOFIA project [Filipponi et al., 2010]. It follows an event driven architechture, collected form wireless sensor networks, and use two main building blocks: Knowledge Processors and Semantic Information Brokers. It has an aggregation and correlation system to create event of a high level abstraction. This way, an Interoperability Open Platform manages heterogeneous data sources.

3. Reference Model

The reference model proposed (Figure 2) is organized in four levels, which divide responsibility of functionality implementation.

In the first layer, called *Infrastructure Level*, resides the complexity of to manage heterogeneous sensors, and other real world information sources, deployed in the urban spaces.

There is a core feature in this layer, which is Urban Communications Abstraction. In other words, how to connect the huge number of elements deployed along the city (sensors, actuators, gateways, etc). The specification for a WSN, in example, will reside in this level.

The second layer, called *Information Level*, aggregates and consolidates information gathered. Data is generated andcollected have to be orchestrated in order to build a sustainable model that could be exploited by services and applications.

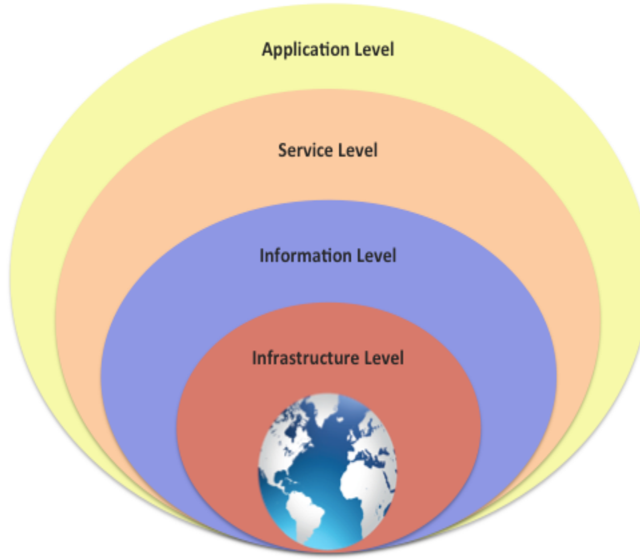

Figure 2 - Vision of the reference model proposed

Basically in this level resides a real world model to store the data in a useful way and the procedures to transform plain information, gathered from sources, in data. The sources for the information of each dimension are heterogeneous, and complicated to aggregate. It is necessary a process to enrich with semantic information the data gathered. The Unified Urban Information Model will store the enormous quantity of information generated, to be exploited by services in the next level. This level should be able to measure, optimize, control and monitor complex systems from urban life.

Open Data philosophy encourage guvermental transparency and open innovation for smart cities, giving free access to data retrieved along the city. It empowers user driven innovation through open data platform strategy. This set of data would be at this level.

The third level, called *Service level,* by following SOA architecture, defines a suit of open and standardized enablers to facilitate the composition of interoperable smart city services. This ecosystem allows providing services to high-level applications. This is, an open urban service development, which supply interoperability between applications and service levels, and thus another key feature in the platform design.

In the top, *application level* is ubicated. These applications, use services provided in the previous layer, for implements complex task over city environment.

4. Conclussions

Smart Cities are on the track. The paradigm is not yet totally defined, but smart cities are starting to implement it and are going to be very much more in next years.

The succesful development of Smart Ctites paradigm will require a unified ICT infrastructure to allow a sustainable growth.

The evolution of the paradigm will create a bussiness opportunity in an emerging market. It will impulse the economy, and will constitute a research opportunity.

Information will be in the heart of the city. Data adquisition and sharing will play a crucial role in the game. Data management will be a complex task and the urban information model is one key aspect in the design.

Whole people implicated: researchers, enterpises, citizens, goverments, etc, have to row in the same direction, providing horizontal and interoperable solutions. In fact, service interoperability is essential for the good development of applications.

A reference model is necessary to orchestrate how the responsabilities and functions are divided among the solution in a more efficient, scalable and suitable way, that support new generations of services that have not been defined yet.

5. Future Work

The Reference Model has to increase the detail specification level, by explaining levels separately and defining the characteristics and singularities of them.

A demostration implementation is also needed in order to validate and show the utility of the reference model.

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Stress map development reducing routing risks

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Abstract

There are different ways how to reach a destination. The fastest or the shortest are typical examples. However, a person's preference to approach in a convenient and less risky way is often neglected. This approach is going to add stress-level information before taking a decision and proposing route. The use case of an automotive environment can serve as an example to benefit from new technologies transferred from the medical domain. We restrict our attention to the automotive field of application and are interested in the stress level of a driver. Therefore, we will look on physical surroundings, e.g. the number of driving lanes, traffic signs, load of traffic, crossroads and roadwork apart from inadvertence caused by mobile devices (texting), sleepiness etc. We propose a system that indicates stress level like a map overlay and based on biometrical measurements from car drivers to improve health, a feel-good factor and avoid more accidents.

1 Introduction

The term 'stress' is used in very different context and the meaning of stress varies from content to context: Stress in work, stress while driving, stress caused by unstable working conditions, stress during vacation, stress during an exam etc. A further factor is the individual view on the term. While some people may consider to 'be under stress' when solving a new task for the first time, others may consider stress as a part of the daily life but nothing exceptional. However, the majority agrees that stress is something to be avoided as much as possible. Furthermore, the majority agrees that stress is something no healthy when present over a longer time frame. For sure, stress is not positive when a person misses the focus during decision taking, and, as a consequence, the decision increases the risk for an accident or even when the decision reduces the quality of life. In the case of this paper, the term stress should be related to a geographical area and not purely to a person, like it is typically assumed. The background is the following: We asking people to define conditions provoking stress, the condition is associated to a scenario, typically clearly related to a location. The location can be a room (in case of an exam), a shop (when hunting for Christmas gifts), the car (traffic) when driving etc. The last example is something we would like to investigate in more details because commuters report about a very different behavior when arriving to the workplace in the morning and when returning home.

From an objective point of view, the starting time in the morning is mostly fix and that means, the commuter feels a high pressure to arrive on time. In the evening, the situation varies (in most cases) because a delay does not have direct impact, like colleagues waiting to start the meeting etc. The exception might be the kid waiting to be picked up by their parents at a fixed time. However, it is notable, that some people prefer to select a return trip possibility not optimal with respect to driving time but less challenging or stressful. That means that preferences change comparing the arrival and return trip. Other criteria, like that you are more tired and you would like to have a more decent way back home are considered as well. Always assuming that there is a choice available to select from.

In summary, the decision can be taken on base of the knowledge whether a certain route will produce more or less stress on a driver at a certain point of time. Since routes can be associated to geographic areas, we would like to develop a stress map providing criteria to compose a route. Of course, this idea may be broadened to switch the point of interest: A city could provide a map showing zones clustered by stress parameters. A simple decision could be to enter or avoid certain areas or even to promote a low-stress city to potential visitors or citizens. Returning to the case under consideration for route detection, approximately 1.600.000 accidents per year are caused by texting, strengthens the accident possibility 23 times and slows the driver's reaction speed by 20 percent approximately [Raychelle Lohmann, 2013].

Since higher stress lowers a driver's attention, this paper focuses on reduction of stress situations in combination with route selection and it tries to lower some risky situations, and as a result, preventing accidents. The first navigation system developed for the automotive sector has been delivered in 1981 from Honda in cooperation with Alpine Electronics [Wikipedia, 2013] lacks this possibility due to the impossibility to gather the required data. However, today's systems still lack this feature.

2. State of the art

2.1 Analyze biometrical data

In general, a stressor is a stimulus that causes stress. Sometimes the stressor is easy to detect, repeat and tune. In the case of this study, the stimulus is something that occurs in our mind, spirit or activity[1]. The stressor can be an environmental condition that repeats every day (like to travel to the workplace). In order to restrict the parameters to a reasonable amount, it is assumed that we don't take into account general changes in life condition, like for example divorcement, workplace stressors, chemical stressors induced by drugs or social stressors.

In fact it is crucial to separate the different preconditions, cluster them and sort them according to the relevance of the current problem. The following cluster sets belong to the preconditions:

- Noise
- Colors, intensity of sunlight, daytime
- Air quality
- Insects
- Crowd
- Passengers
- Too much information (traffic signs, lights)

In out first attempt, we concentrated on individual characteristics/parameters of a single user. Just enough information should be gathered to detect a situation before an objectively stressful task is carried out. For example, measuring the blood hormone level during a stress situation would increase the cortisol, adrenalin and noradrenalin level within 1 to 2 seconds [Smyth et al., 1998]. Cortisol needs 1 to 2 minutes to pass the saliva [Smyth et al., 1998]. It is not the purpose of this paper to understand our biological system in detail but to indicate the possibilities to make a statement with only few data.

Nonetheless [Stevens et al., 2008] states that 'measurements of cortisol in saliva are as much as 100 times lower than in blood, it is thought that salivary cortisol and free cortisol in blood correlate more closely with stress than does total blood cortisol'. The system that considers this correlation is called SPR (surface plasmon resonance) Biosensor System. Another system developed by ETH Zürich measured the stress level with the discriminative power of electrodermal activity of fingers, heart- and breathing rate, cortisol in saliva. Measurements with 33 test subjects showed 83% hits of the proper stress level [Setz et al., 2010].

2.2 Geo information and routing

Information for routing support can be obtained from several sources. Google maps could initially be used because of its simple directions service and widespread available geographical data. However, it has limitations with respect to requests (2500) where transit requests costs 4 and walking up to 8 requests.

Thus we look for open source solutions that provide landmark information to combine our biometrical data. For example, OpenStreetMap and GeoNames. MapQuest offers a free routing service with maps from OpenStreetMap or the commercial product NAVTEQ. A brief comparison of some (web) map services is given in Table 1[2].

Besides differences in the license model, the way in which the location is identified doesn't vary fundamentally. OpenStreetMap differs slightly from the two others, when looking for walking routes, multiple directions or the incorporation of online traffic information. The missing API is assumed the most relevant limitation for our approach.

Feature	**Google Maps**	**MapQuest**	**OpenStreetMap**
License	Proprietary	Proprietary	ODbL
Location	Post Code, Street Name, Town, Neighborhood, City, Long/Lat	Post Code, Street Name, Town, State	Post Code, Street Name, Town, Neighborhood/Suburb, State/Region, City, Country, Long/Lat
Walking/ Bicycle Directions	Yes	Yes	Yes, third-party
Multiple Directions	Yes	Yes	No
Live Traffic Information	Yes	Yes	No
API Available	Yes	Yes	No

Table 1: Comparison of web map services

[1] Webster's Third New International Dictionary, Unabridged ISBN-13: 978-0877792017.

[2] http://en.wikipedia.org/wiki/Comparison_of_web_map_services (last accessed 29/01/14)

2.3 Navigation systems

There are several navigation systems on the marked. Some of the known manufactures are: Falk, Becker, TomTom, Navigon, etc. They usually work with a device for positioning, visualizing geo information like street cards and if needed an Internet can be associated. Users of these systems enter a destination and may be several intermediate stops. Besides simple optimization criteria like the *fastest* route or the *shortest* route, some devices allow individual profiles to be defined and applied. However, not all systems provide the same functionality, besides the basic routing. For example, TomTom [TomTom, 2013] uses a system called HD Traffic to provide traffic information or IQ Routes using anonymous travel time data from other users when looking for the fastest route. In this case the current situation (like traffic jam etc.) can be taking into account when calculating the route. In this case, an Internet connection is mandatory.

3 Model of the stress map

According to the additional service mentioned, other data like the one we are proposing to track could be added as well. That means, each volunteer participating can collect data and push it to a centralized server. The server can apply an algorithm to 'draw' a map characterizing an area (or a street on a route) with a certain stress value. Due to the large amount of data, a database (like MySQL) should be used on the server side. Of course, individual data can be associated also to clusters (areas) in case these areas exist in advance.

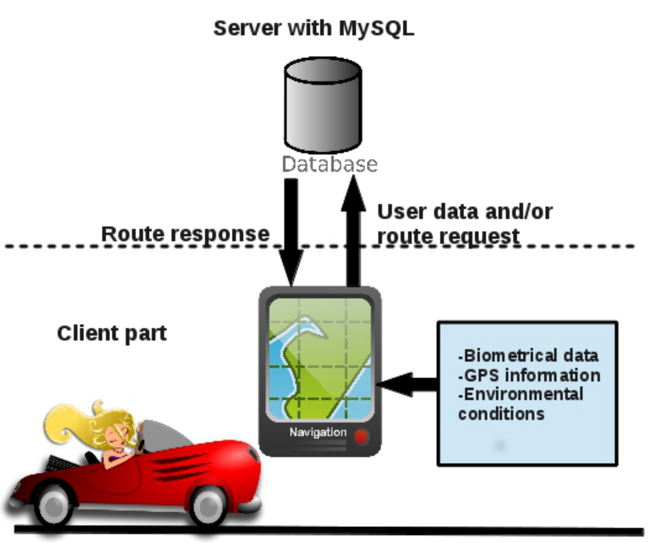

Figure 1: Stress map model

These two possibilities can be further subdivided. The current work leaves open this fact and does not investigate pros and cons at this stage. In the first prototype, the server will provide the maps attributed with stress values as specific weights and it will also calculate the route. The result will be passed to the client (typically a smartphone). In a second step, routes can be revised when server data changes, like for example, in case the stress level change causes a re-calculation of the route providing a different result. The principle architecture is sketched out in Figure 1.

As a new option, our proposed system would offer a service, like for example 'low-stress' routing. This option might be the only relevant or it will be combined (and weighted) together with others (like the *distance*), in order to define a user's profile. Profiles may depend on the *time of the day* or the *mode* of the user (*catch a flight* or *drive a safe route* – with less accidents). Biometrical data from the user and traffic situation together with other values of environmental conditions are considered in the computation.

In a first approach, we assess the stress level of a user from 1 to 10 where one is the lowest and ten the highest level. A person can enable to upload biometric data to the server database. It should be mentioned that the current system does not consider a protection of user personal data; a requirement to be considered in future versions. As well as other external factors occurring and influencing the condition of streets, like winter condition, daylight etc. The influence can be measured via biometrical data and other external data like weather, speed etc. and calculates the route.

4 Scenario in a city

It's 3 p.m. Sally sits in her car and wants to drive to her boyfriend. The car is equipped with a navigation system including our stress map system. Sally has no time constraints, so she clips the biometrical sensor to her ear. Sally's stress level, which is an individual one, is compared to her profile and matched to her preferences for this travel.

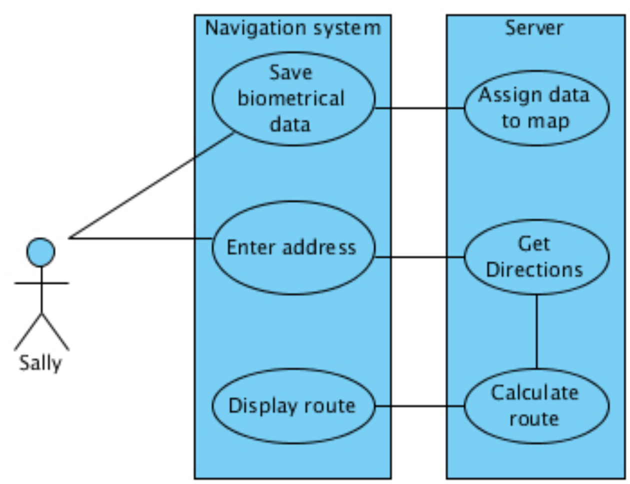

Figure 2: Use case for Sally's route

As a result, we might consider to select a route imposing less stress on Sally and allowing her to drive relaxed and safe (less risk for accident) to her boyfriend. Her boyfriend lives on the opposite side of town. In principal, Sally had two choices: drive along the ring road or meander through the city centre. Her navigation system with stress level map knowledge would select the first one, while it would propose the second option in case not taking into account her personal stress level and preference. Figure 2 shows the players in the use case. Besides the upload of her biometrical data and the mapping on the route from the start to the destination, the system does not look different to a traditional navigation system with server-side calculated routing. The collection of Sally's biometrical data could be done as a permanent process removing a separate *save of biometrical data* in the very first step.

5 Conclusion and next steps

The proposed system helps a driver to select a navigation route based on biometrical data and personal preferences. The system can be extended by external data to provide a more accurate decision, not only based on experience but on online data. The key component is a stress map derived from multiple user input. The user input is not a recommendation but a stress level indicator, individual to each user but generalized from many input values. As a result, areas can be clustered or streets can be attributed with a *new* parameter characterizing the stress imposed on a user entering the zone or selecting a road. With small extensions, the information can be added to traditional navigation system flows. Also from the opposite position, the information could be valuable: A city could detect areas of more or less stress. A citizen or visitor could be guided to areas of lower stress, in case they are looking for a relaxing walk but also for a (more) relaxing shopping zone. In general, the level of stress over all zones might be considered to rate a larger area. The stress levels quality, the effort to capture them and the protection of data for individual volunteers pushing stress-level data, is a future step to be investigated.

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A collaborative standard-based mobile telemonitoring platform

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Abstract

Telemedicine is becoming an increasingly important approach to diagnostic, treat or prevent diseases. However, the usage of Information Communication Technologies in healthcare results in a considerable amount of data that must be efficiently and securely transmitted. Many manufacturers provide telemedicine platforms without regarding interoperability, mobility and collaboration. This paper describes a collaborative mobile telemonitoring platform that can use the IEEE 11073 and HL7 communication standards or adapt proprietary protocols. The proposed platform also covers the security and modularity aspects. Furthermore this work introduces an Android-based prototype implementation.

1 Introduction

Cardiovascular disease is one of the most common causes for deaths in Germany, representing 43% of the cases (status 2007). Statistically one out of two adults suffer from hypertonia (high blood pressure), more specifically, 44% of the female and 53% of the male population, in an age group from 18 to 79. [Jahnsen *et al*., 2008]

Hypertonia is economically one of the most important diseases in Germany, with a cost of about 8.6 billion euros in 2006 [Jahnsen *et al*., 2008].

In most cases the persons who are concerned, especially elder people, need to visit a physician, either in his or her office or in a medical center, to be examined. This scenario results in jammed anterooms and medical staff busy measuring blood pressure and the already limited healthcare resources cannot be deployed efficiently [Sufi *et al*., 2006].

In this context telemedicine is becoming a more and more important approach to this problem [Bärwolf *et al*., 2006]. By the interconnection of patients, physicians, medical centers and health insurance funds, virtual medical rounds are already reality [Bärwolf *et al*., 2006]. TEMPiS[1] is a telemedicine project started in 2005 that provides provision for apoplexy patients in Bavaria [Bärwolf *et al*., 2006].

Telemedicine can be used to diagnostic and treat diseases or even to prevent them [Lehmann, 2005]. A further benefit of telemedicine is distance overbridging for elderly and disabled people [Lehmann, 2005]. Besides, this approach gives them the opportunity to stay in their homes (Ambient Assisted Living) and be with their family [Sufi *et al*., 2006].

However the use of Information Communication Technologies in healthcare produces a huge amount of information that needs to be exchanged and accessed from many heterogeneous systems [Iroju and Soriyan, 2013]. The current market situation presents developers with a challenge: many healthcare device manufacturers offer complete systems (hardware and software) without considering the aspects of interoperability, since most of the available devices for vital parameter measurement use proprietary data formats and protocols [Ibánez *et al*., 2011]. As a consequence, interoperability between stakeholders (users, physicians, hospitals and other medical institutions) is barely possible.

An example is the telemonitoring system of the medical device manufacturer I.E.M. GmbH in Germany[2]. The company provides various monitoring devices, which transfer vital parameters using proprietary protocols via Bluetooth to a terminal. After that, the terminal sends the data within a SMS in PDU mode to a Short Message Service Center (SMSC). The SMSC transmits the short message to a national Remote Operating System (ROS), which forwards the information to the eHealth database server. Physicians are now able to fetch the data and manage it using the company's Hypertonia Management System (HMS Client-Server software) [I.E.M.]. Fig. 1 illustrates this data management concept.

This paper describes a model for a collaborative standard-based mobile telemonitoring platform to provide interoperability in information exchange in healthcare. Tough it is based on communication standards, the platform can also modularly adapt proprietary protocols to interconnect non-standard devices.

As a first step, a prototypic home based blood pressure monitoring scenario, from the admission of a new patient to

[1] TEMPiS project, www.tempis.de
[2] I.E.M. GmbH, www.iem.de
[3] Health Level 7 Standard, www.hl7.de

[2] I.E.M. GmbH, www.iem.de

data transmission, has been designed. The endpoint will be a hospital, which will store and analyze the measurements.

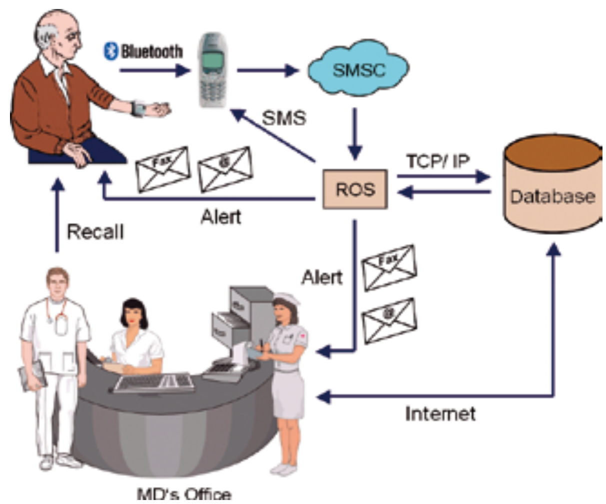

Figure 1: I.E.M. GmbH telemonitoring design [I.E.M.]

In this prototype, the mobile gateway will be a smartphone receiving measurements via Bluetooth in different data formats (proprietary or IEEE 11073) and forwarding them within an HL7[3] message to a server.

This paper is organized as follows: Section 2 describes the state of the art and introduces the technologies used for implementation. Section 3 presents the proposal for a mobile-based telemonitoring platform and its architecture. Section 4 gives a short description about the implemented features in the current version. The last section gives a conclusion of this work and some future outlook.

2 State of the art

This section presents similar telemedicine work followed by a short introduction to the technologies and standards used for this paper.

2.1 Related work

A similar approach to a mobile phone based telemonitoring platform is described in [Sufi *et al.*, 2006]. There, a telemonitoring system is presented, which uses mobiles for patients and healthcare service providers. The mobile devices run Java[TM] software and do the core communication. The system pursues a generic solution and provides different functions, like acquired biological signals submission, emergency notification, or a detection algorithm for abnormal situations. However there is no use of any healthcare communication standards as IEEE 11073 or HL7.

Another example is presented in [Ibánez *et al.*, 2011]. It suggests to put the measurement submission functions into a Residential Gateway. The data processing is unitized in OSGi[4] bundles. This system proposes a standardized telemonitoring system, which uses UPnP (Universal Plug & Play) standardized and non-standardized medical devices and the HL7 standard to transmit all gathered vital parameters. But this example does not cover any mobility or security aspects.

2.2 Technologies

This section describes the technologies used and required for implementation.

These technologies are the Android platform, the healthcare messaging standards IEEE 11073 and HL7, and the I.E.M. proprietary protocol and OSGi.

2.2.1 Android

In November 2007 Google announced the first version of an Android SDK. This was the first time when developers could implement Android applications and test them in an emulator. [Künneth, 2012]

Since then the Android platform is constantly improving and has the largest share of smartphone operating systems in the US [Llamas *et al.*, 2013].

Android applications are run on a virtual machine called Dalvik, which was designed for mobile devices and is different than typical Java runtime environments [Künneth, 2012]. Dalvik is register-based and has its own bytecode format and instruction set [Künneth, 2012]. Therefore all compiled Java bytecode must be transformed into Dalvik Executables (.dex) [Künneth, 2012].

2.2.2 Health Level 7

HL7 is a widely used standard for data exchange in clinical domains [Martín *et al.*]. In this work HL7 version 2.5.1 is used for exchanging blood pressure measurements and patient information.

An HL7 message, which is the basic data unit, is hierarchically structured and consists of segments, fields and components [Lu *et al.*, 2010]. Further, an HL7 message is generated after a specific event occurs. An event means that there is some new data available which needs to be transmitted amongst different systems [Lu *et al.*, 2010]. Another important HL7 feature is that the exchange of information needs to be done asynchronously. Following this, all relevant HL7 elements are introduced…

- Segments: A segment (see Fig. 2) is a group of fields segregated by a "<cr>". Every segment begins with a three-character code, which identifies the segment: MSH (Message Header), PID (Patient Identification) or OBX (Observation Result). [Lu *et al.*, 2010]

```
PID|||2||Kolesnik^Maksim||1987-11-20|M
PV1||I||L|MK12910742021987
```

Figure 2:HL7 PID and PV1 Segments

[3] Health Level 7 Standard, www.hl7.de

[4] OSGi Alliance, www.osgi.org

- Fields: Fields are strings, which represent the content of a message. The strings within a field are called components. Each field has its specific order and can be optional or obligatory. These attributes can be found in the HL7 specification tables. Fields are separated by an arbitrary character (defined in MSH Segment). But the HL7 authority recommends to use "|" for field separation. Figure 3 illustrates the date of birth and patients name fields.

```
PID|||2||Kolesnik^Maksim||1987-11-20|M
```

Figure 3: HL7 Fields

- Components: As mentioned above, components are strings representing the data within a field. There can be zero or more components within a field. Its order can also be taken from the specification. Fig. 3 illustrates the patient's name field consisting of two components (first name and last name).

2.2.3 IEEE 11073

The goal of the ISO/IEEE 11073 standard is to enable interoperability and interconnection between medical devices [Martín *et al*.]. Therefore it provides a set of different device specializations for any kind of medical devices like 11073-10407 for blood pressure monitors. However there are hardly monitoring devices implementing the standard *[Ibánez et al*., 2011].

2.2.4 I.E.M. blood pressure monitor protocol

The Android application discussed in chapter 4 has the ability to process blood pressure measurements gathered by the Stabil-O-Graph (see Fig. 4) blood pressure monitor. The device was manufactured by I.E.M. GmbH and uses a proprietary protocol to exchange information.

Figure 4: Stabil-O-Graph blood pressure monitor

After a successful measurement the following parameters are transmitted: Systolic value, Diastolic value, Heart rate, time of acquisition, time when the measurement was transmitted and the serial number of the device.

2.2.5 OSGi

OSGi is a component-oriented framework for networked devices. Deploying the framework gives the ability to manage the lifecycle of a software component (bundle) (install, uninstall, start, stop) remotely. [OSGi Alliance, 2007]

There are a few different OSGi frameworks available. For this work Apache Felix[5] OSGi will be used.

There are a few steps that need to be done before Felix can be started in Android, as Android does not run a standard Java Virtual Machine but a special Virtual Machine called Dalvik [6]. Dalvik cannot deal with Java Bytecode but with a special format called DEX [Apache, 2009] so any classes within a Jar bundle need first to be formatted into DEX files.

3 Design of the mobile telemonitoring platform

The goal of this work is to design a telemonitoring system where the central component is a smartphone gateway. The advantages of such a system are wireless data transmission, mobility and interoperability due to the fact that we can implement the wireless-based proprietary protocols and healthcare standards introduced in section 2.2.

3.1 Architecture

The architecture shown in Fig. 5 uses a mobile gateway, which will permanently receive measurements, save them temporarily and send an HL7 message to any given health data server within a medical center. The measurements can come from telemonitoring devices compliant with the IEEE 11073-X protocols, but also from devices with proprietary protocols and from other type of home-located or personal devices like biometric or AAL sensors.

Using mobile devices gives also the patient more mobility and freedom as both the monitoring device and the gateway can be carried anywhere. Many modern smartphones can transmit the collected measurements both via WiFi or via cellular networks. This is an important feature if a patient, for example, needs to be monitored around the clock (mobile ECG).

A major issue, especially for elderly patients, is to reach a good acceptance of the platform by considering several aspects of usability. In this scenario, a tablet that provides a user-friendlier graphical interface could also replace the smartphone.

Implementing well-known healthcare standards makes this telemonitoring system very flexible and interoperable since any wireless medical device can be used. It is also possible to transmit the information to any medical facility if their systems are able to manage Health Level 7 Messages.

Once the data has been stored persistently, physicians or care service staff can access and evaluate the measurements.

---

[5] Apache Felix OSGi Framework, http://felix.apache.org

[6] Dalvik Technical Information, http://source.android.com/devices/tech/dalvik

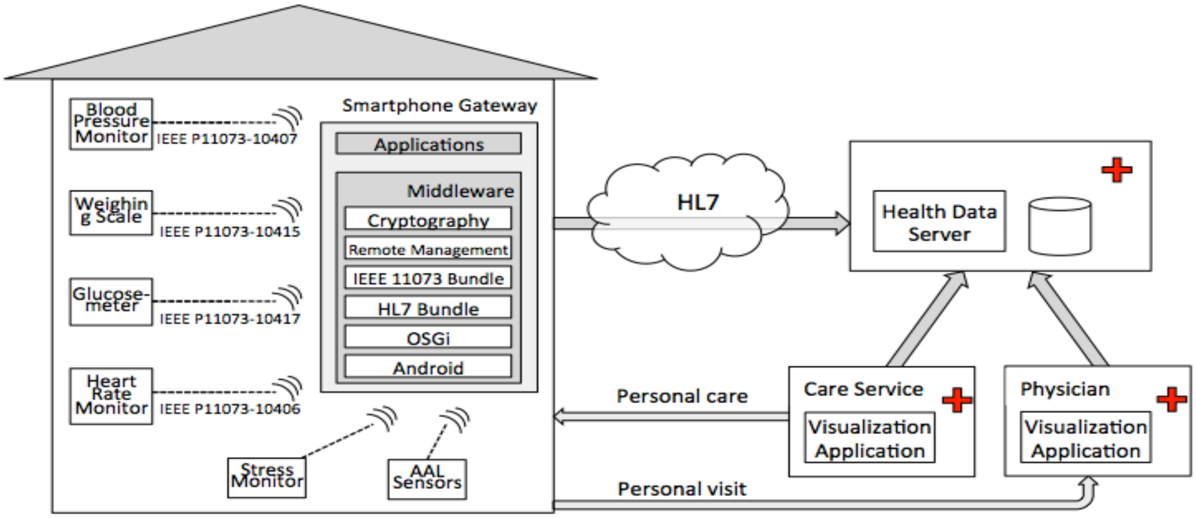

Figure 5: Telemonitoring platform design

Therefore, a mobile visualization application will be developed. This ensures the permanent access to health information for medical staff either at the patients home or at the physician's office.

3.2 Security

The collected patient information is very sensible and needs to be protected. It is very important that a patient or its address cannot be identified by the collected data [Fong *et al.*, 2011].

In general, security is characterized by the following concepts:

- Integrity: The information should stay in its original form.
- Privacy: Only authorized personal can access the data.
- Confidentiality: All critical information must be handled with confidence.
- Availability: The system must be available all the time.

Hence we need to apply security at patients home (Bluetooth data transfer, secret PIN usage for device pairing process), cryptography and certificates for secure information exchange from gateway to health data server and within medical centers (unauthorized access, health data manipulation).

Furthermore, we need to deal with problems like loss of mobile devices containing critical information, electricity failures or fire [Fong *et al.*, 2011].

4 Current Status

In the context of a Bachelor Thesis a first version of a prototype has been implemented. Figure 6 shows the available features. This system provides a module for parsing proprietary protocols developed by I.E.M. GmbH. The current version implements only the Stabil-O-Graph protocol.

For this implementation we decided to use an Android smartphone running API level 14 (Ice Cream Sandwich) and above. This requirement must be fulfilled since older Android APIs do not implement the IEEE 11073 Bluetooth Profile[7], which will be used in an advanced version of the application. During the implementation process a Samsung GT-N7100 Smartphone was used (1.6GHz Quad-Core Processor, 2GByte RAM). Another benefit of using Android is that it is based on the widely used programming language Java and therefore it is possible to deploy OSGi bundles.

The following sections describe the workflow from the addition of a new patient to the transmission of blood pressure measurements to a file server.

4.1 Application Features

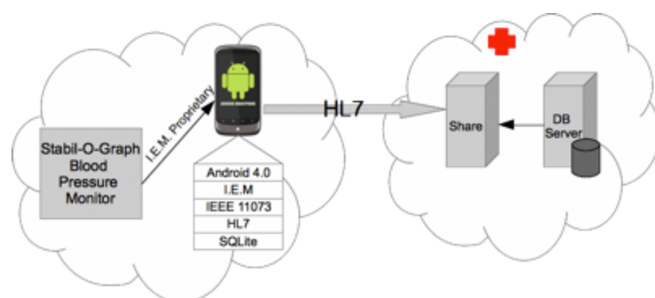

Figure 6: Prototypic Android monitoring application

Before starting the monitoring process, a new patient needs to be acquired (see Fig. 7).

[7] Android BluetoothHealth profile, developer.android.com /reference/android/bluetooth/BluetoothHealth.html

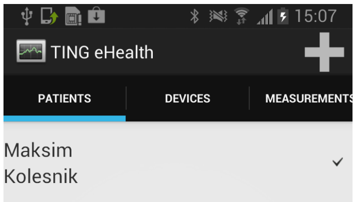

Figure 7: Selected patient

In order to generate an HL7 PID segment, the following information is needed: first and last name, date of birth and gender. The next step is to assign monitoring device. This can be done by selecting them from a list of all paired and available devices. Another click on the device will start an Android Service[8] (see Fig. 8).

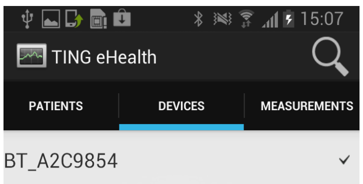

Figure 8: Selected devices

The service now runs in the background and waits until a new measurement is available. After the measurement has been successfully received, it will be temporarily stored in an SQLite database (see Fig. 9). Otherwise the data would be lost if no connection with the file server could be established. The last step is to generate an HL7 message (see Fig. 10), containing all measurements and patient information, and upload it to a file server.

Figure 9: Received measurements

```
MSH|^~\&|AndroidMonitor|Reutlingen-University|SomeShareServer|
SomeHospital|2013-11-06 21:58:43.958||ORU^R01^ORU_R01|||2.5.1||||
DEU|UNICODE UTF-8
PID|||2||Kolesnik^Maksim||1987-11-20|M
PV1||I||L|MK12910742021987
OBX|1|CE|8480-6^Intravascular systolic^LOINC||111|8480-6^mm
HG^LOINC|||||||2013-11-06 21:59:11||||61102X4K
OBX|2|CE|8462-4^Intravascular diastolic^LOINC||68|8462-4^mm
HG^LOINC|||||||2013-11-06 21:59:11||||61102X4K
OBX|3|CE|8867-4^Heart rate^LOINC||58|8867-4^/min^LOINC|||||||
2013-11-06 21:59:11||||61102X4K
```

Figure 10: Generated HL7 Message

[8] Android Started Service, http://developer.android.com/guide/components/services.html

5 Conclusion and future work

A mobile-based telemonitoring platform concept and a prototypic implementation have been introduced. To face the interoperability problem, the platform complies with the presented well-known healthcare standards IEEE 11073 and Health Level 7. The system is also able to deal with proprietary protocols developed by I.E.M GmbH and receive measurements from all their monitoring devices. Google's mobile operating system Android was equipped with Bluetooth Profile in the version 4.0 and is a good choice for an interoperable gateway because it supports both the needed wireless communications and the modular execution environment OSGi.

In future work the functionality of the application will be extended. At this point only a parser for the Stabil-O-Graph blood pressure monitor has been developed. Beyond that, some security techniques like cryptography and certificates must be implemented. But there are also a lot of non-technological issues that must be researched in future. Aspects like acceptance or usability are very important for both sides of the target audience, namely patients and physicians.

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Helping sales managers to understand their business environment

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Abstract

Within a business framework, one of the challenges of marketing and sales departments is to ensure that sales managers of the company have updated information about their customers' interests. In order to help commercial representatives in their day-to-day work, it is important to offer them technologies able to identify opportunities for each of their assigned points of sale.

Such technology should be based on proactive and context aware systems, i.e. these systems should automatically warn sales managers when an opportunity in a close point of sale is detected. In addition, these systems should be personalised (to the profile of the commercial representative) and should show adaptive features, i.e. providing an adequate response to changes in the environment (such as the adaptation of thresholds according to some economic data). Finally, these technologies should be naturally integrated and embedded into the devices used by sales managers to interact with the information system of the firm, i.e. employing both digital and physical sensors (by continuously taking into account updates of the sales data for adjusting the definition of opportunity, or by detecting the location of the sales manager for the system to provide information about the nearest shops).

Having this in mind, in this paper a system allowing the commercial representatives to obtain an automatic description of the different groups of points of sale is introduced. This will permit the sales manager to rely on a quick and updated overview of the environment in which s/he is placed. Specifically, the project refers to the design of a natural language generation (NLG) system to qualitatively describe the most important characteristics of each class, cluster or segment of points of sale previously defined. An adaptation of a generic architecture for data-to-text systems consisting of four stages is proposed. It includes the detection of the most relevant patterns of the data and the definition of a grammar that generates the natural language description of the considered clusters. A case study addressing a challenge in a marketing environment is included. The study takes place in a business-to-business (B2B) environment, in which a firm distributes its products via other firms.

Designing a qualitative human-machine interaction framework based on the cloud for robot learning about the environment

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Abstract

This paper introduces the concept of cloud robotics, a recent trend in robotics research, which uses all the advantages of Internet as a resource for massively parallel computation and real-time sharing of vast data resources. A design of an application based on cloud robotics is also presented, which consists in combining the user's knowledge and the knowledge provided in the cloud to enable a NAO robot learn about its context.

1 Introduction

In 2010, James Kuffner at Google introduced the term *Cloud Robotics* to describe a new approach to robotics that takes advantage of the Internet. *Cloud robotics* is an emerging field of robotics rooted in cloud computing, cloud storage, and other Internet technologies centered around the benefits of converged infrastructure and shared services. It allows robots to benefit from the powerful computational, storage, and communications resources of modern data centers. In addition, it removes overheads for maintenance and updates, and reduces dependence on custom middleware.

The Google autonomous driving project [Thrun, 2010] exemplifies this approach: the system indexes maps and images that are collected and updated by satellite, Streetview, and crowdsourcing to facilitate accurate localization.

The Cloud has been used as a metaphor for the Internet since the inception of the World Wide Web in the early 1990's. As of 2012, researchers are pursuing a number of cloud robotics and automation projects ([Guizzo, 2011; Tenorth *et al.*, 2012]). New resources range from software architectures ([Arumugam *et al.*, 2010; Du *et al.*, 2011; Hu *et al.*, 2012]) to computing resources [Hunziker *et al.*, 2013]. The RoboEarth project [Waibel *et al.*, 2011] aims to develop "a World Wide Web for robots: a giant network and database repository where robots can share information and learn from each other about their behavior and their environment"[1].

As it is stated by Goldberg and Kehoe [2013], Cloud Robotics has potential to improve performance by means of: (1) providing access to global libraries of images, maps, and object data, eventually annotated with geometry and mechanical properties (Big Data); (2) offering massively parallel computation on demand for costly tasks such as optimal motion planning and sample-based statistical modeling; (3) robot knowledge sharing of outcomes, trajectories, and dynamic control policies, 4) human knowledge sharing i.e. open source code, data, and designs for programming, experimentation, and hardware construction, and (5) on-demand human guidance ("call centers") for exception handling and error recovery.

Big Data involves data sets with sizes beyond the ability of commonly used software tools to capture, curate, manage, and process the data within a tolerable elapsed time. Therefore, big data could include the growing library of images, maps, and many other forms of data relevant to robotics and automation on Internet. The robots can acquire information and knowledge to execute tasks using these databases in the cloud. They may avoid dealing with the creation and maintenance of such data.

Therefore, cloud robotics, and specifically big data, offers interesting opportunities and challenges to some traditional robotic problems, such as the *SLAM* (Simultaneous Localization And Mapping) task*, grasping* objects and planning in *navigation*.

The SLAM problem [Durrant-Whyte and Baikey 2006] involves the building by a robot of a map of the environment without a prior knowledge, and its simultaneously localization by itself in the unknown environment. SLAM is data- and computation-intensive. The steps of data fusion and filtering for state estimation can be processed in parallel and in a cloud, as showed by the DavinCi project [Arumugam *et al.*, 2010] which implements the SLAM problem in the Hadoop[2] map-reduce framework.

Robotic navigation refers to the capacity of the robot to determine its own position with respect to a certain reference and then to plan a path to reach a desired location. Inside this field, most of the approaches rely on a map,

[1] http://www.roboearth.org/what-is-roboearth.

[2] http://hadoop.apache.org/

which construction requires large amount of storage space and is computationally intensive. Therefore, once again, cloud robotics and big data provide a very promising solution to these problems. Moreover, using the cloud it is possible to extract information from commercially available maps that can facilitate the task. **Planning** algorithms usually involve complex heuristics and/or reasoning depending on the context. Those methods can be computationally intense, but they may be solved quickly by parallel computing in the cloud and so that the robot could obtain the most appropriate route to its goal.

Robotic grasping has been an active research topic over the last few decades, but there are still challenges to solve such as obtaining creative object affordances and graspings. Inside the grasping field, now there are online datasets which can be searched to determine suitable grasping points of known objects [Goldfeder *et al.*, 2009; Kasper *et al.*, 2012]. In addition, the knowledge acquired by robots when graping objects can be shared in the cloud for future usage by other robots. This knowledge can also be used to inspire different object affordances to other robots in order to develope creative task-problem solving, such as: what to use to get water if there is not a glass available?

The use of online datasets may help robots learning when getting knowledge from vision data, because it is possible to store in the cloud data related to objects images, affordances and tasks. Moreover, managing data sets in the cloud can allow the application of human skills and experience to help in usual robotic tasks, as for instance to label the objects in an image acquired by a robot.

In this paper, we propose to take advantage of these latter features of cloud robotics, that is: (i) using the common knowledge about grasping found in the cloud, (ii) adding user-provided expert knowledge to the cloud and (iii) using the online datasets (big data) to develop a robot able to continuously learn from these data

Our purpose is to develop a platform that allows a NAO robot[3] to communicate with a tablet PC in order to retrieve user knowledge to identify an unknown object in the environment. Using the information provided by the user, the robot will search the cloud to find information about the object (i.e. semantic knowledge, affordances, grasping information, and even social information) and semantically annotate the object as learned. The spatial and topological situation of the object in the scene can be also qualitatively described using the approach by Falomir *et al.,* [2013] and then this description can be used not only to compare the object against others but also to describe it in natural language [Falomir *et al.,* 2012] to improve human-robot communication and also to get the user confirmation regarding the suitability of the object for the task to carry out.

[3] http://www.aldebaran-robotics.com/en/

2 Designing the Framework

So that robots could perform tasks cooperating with humans, they must be able to access and manage a broad set of contextual knowledge about the environments in which they operate.

One unachieved goal of robotics is to develop an inexpensive robot that can tidy rooms, floors, dinning tables, and desks by identifying the objects in these scenes, grasping them accurately and transporting them to their suitable "tidy" place. This task implies that the robot should recognize and grasp common household objects. The challenge here is that this set of objects is an unbounded set which depends on the context (i.e. house, office, school, bank, supermarkt) it is dynamically growing always due to fashion trends, the appearance of new inventions, new gadgets, and so on.

We believe that the cloud is a vast potential source for computation and data storing about objects, their semantics, and how to manipulate them and, therefore, the main objective of this paper is to develop an architecture (Figure 1) that allows a robot to learn about unknown objects in the environment using the cloud and human interaction.

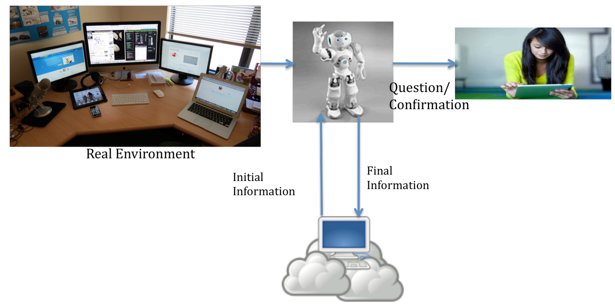

Figure 1. Framework of the application

Figure 1 shows the robot in a real environment, such as an office. If it finds an unknown object, first of all, it will ask to the cloud about information about it. Two situations may happen: (i) if the robot finds reliable information about the object, then it can ask to the user whether the unknown object is what the user guesses (using the information from the cloud); (ii) if the robot does not find reliable information about the object in the cloud, then it can ask the user about all the information that the user have about it.

Consider the following scenario, based on the image in Figure 1 which shows a desktop in an office. The robot does not know what is the circled object signed in the image. Therefore, it looks for something about it using Google Googles, Google Images and Web Catalogues about household objects. Then it can guess that it may be a microphone, and therefore it asks the user: "Is the object at the bottom-left of the image and left of the tablet a microphone?"; alternatively, if the robot does not find reliable information to make a guess then it can ask "What is the object at the bottom-left of the image and left of the tablet?". Moreover, the user can not only answer with textual information (a "yes/no" response and the name of the object) but also he/she can use the tablet in order to delimitate the boundary of the unknown object, which will improve the process of shape description.

Once the robot has the confirmation of the class of the object, then it can use the cloud again to get more information about it, such as information about its qualities, affordances, grasping points, and so on. Therefore, by using the cloud, the image of the object will be semantically annotated and the robot can learn more about the specific object. Finally, the result (the annotated object with all its relevant features) will be stored again in the web catalog of the robot (as the long term memory of the robot) so that the robot can use the knowledge acquired later and create ontologies of the objects of its environment.

Therefore, the robot will use the web or the information in the cloud and the feedback provided by the users to learn about the real environment. All the acquired knowledge will enable the robot to intelligently perform tasks such as, for instance, assisting a person by grasping objects from a place (home, office, etc.) and do something with them for the user. Moreover, this system also allows that the environment in which the person/user is, can be different from the one in which the robot is, and then the person can ask the robot a find-and-deliver task to a desired place of a common office object.

3 Conclusions and Future Work

This paper outlines an approach to such a cloud robotic system, which involves developing a human-machine interaction framework based on the cloud so that a robot could acquire knowledge about the environment. This framework would apply qualitative methods because they are suitable to develop a good human-computer interaction.

In order to be able to build such a system, at least we have to be able:

1. To segment an image and locate an object in it, as we have demonstrated in [Falomir *et al.*, 2011b]. These methods will be customized for the desired application and will be improved by applying methods to remove the background of the image [Rother *et al.,* 2004], and by studying methods of geometry simplification [Luebke 2001], and therefore improve boundary detection;
2. To create software which allows a user to sketch the boundary of the object in order to help the process of shape detection and description. In order to develop this software we plan to use our experience in Museros et al., [2013].
3. To describe the objects in an image and relate them with respect other objects in the image, as it is done inby Falomir [2011];
4. To classify an object in an image as a specific class of object (for instance "a table", "a chair") using similarity measures between objects (as the one in [Falomir *et al.,* 2013]) and other clustering and learning techniques. We plan to develop Support Vector Machines (SVM) techniques as the ones developed in [González Abril *et al.*, 2013] to try to solve this problem;
5. To semantically annotate the images, using techniques as the one presented in [Pérez-Catalán *et al.*, 2013].
6. To implement methods to describe the image, and the objects in it in natural language, which are good enough to be comprehensible by the user, as the one presented in [Falomir, 2013].
7. To use and create an ontology for objects present in the intended robot environment, as the one in Falomir *et al.* [2011], which will be increased with new types of household objects;
8. To exploit resources such as a furniture web catalog, as the one presented in [Martinez Mozos *et al.*, 2011], which has to be dynamically and continuously uploaded.

Therefore, this is a position paper of a challenging system, for which there are still a lot of steps to carry out, some of them, detailed before.

Acknowledgments

This work has been partially supported by the Spanish Ministry of Economy and Competitiveness (under project number TIN2011-24147), by Universitat Jaume I-Fundació Bancaixa (under project number P1-1B2010-49), by Universität Bremen and the European Union under IEF Marie Curie actions (project Cognitive-AmI), by the interdisciplinary Transregional Collaborative Research Center Spatial Cognition SFB/TR 8, and the Deutscher Akademischer Austausch Dienst (DAAD), Generalitat Valenciana (GV/2013/135), and by Universitat Jaume I (project reference P1·1B2013-29).

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Social Skills Training with Robots for Children's Education*

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Abstract

This article is about a project proposal of using robotics as a facilitator to create a context suitable to train social skills among children for educational purposes, as well as use them with children with needs of these social skills (mainly Autistic children). As a result, a compendium of robot based activities should be delivered in which the main working tool and interaction is a social robot. Finally, activities will be evaluated in real environments to assess the quality of the interaction with the robot, satisfaction, motivation, engagement with the activity and the improvement in the intended social skills.

1 Introduction

This article is about a project proposal of using robotics as a facilitator to create a context suitable to train social skills among children for educational purposes [Heerink *et al.*, 2012], as well as use them with children with needs of these social skills (mainly Autistic children) [Albo-Canals *et al.*, 2013a]. Robotics is itself something that is easy to be accepted by children, even those with Autistic Spectrum Disorder (ASD). Robotics as a tool can contribute to collaborative work, adapting the level of the sessions according to the children's educational performance [Díaz *et al.*, 2011].

Besides, robots can support teachers/therapists collecting data that can be useful to better evaluate and monitor the level of success acquired during educational activity. As a result, a compendium of robot based activities should be delivered in which the main working tool and interaction is a social robot. Three platforms has been chosen to take advantage of the capabilities from two different robotic concepts, in one side the NXT MINDSTORMS LEGO [Behrens *et al.*, 2011] robot and the Innvo Labs Pleo rb robot [Fernaeus *et al.*, 2010], and in the other hand the humanoid NAO robot from Aldebaran Robotics [Pardo *et al.*, 2012].

Designing activities with different robotic platforms is currently possible thanks to the standardization process that has undergone robotics in recent years, as in the field of household or industry. This process has opened the influence of educational robots to educational centers.

Finally, activities will be evaluated in real environments to assess the quality of the interaction with the robot, satisfaction, motivation, engagement with the activity and the improvement in the intended social skills. The activities are going to take place in the Special Unit for Developmental Disorders (UETD) at Sant Joan de Déu Hospital. This unit is specifically dedicated to the diagnosis, counseling to individuals and families affected by ASD.

2 Objectives and Expectations

Previous studies completed by the team have proved that robot features and behaviors can induce social behaviors in children. Furthermore, customizing and setting up robots that interact to complete a collaborative task reinforce social interaction and facilitates cooperative and collaborative behavior between peers and between children and the therapist or educator.

2.1 Previous Work

These previous studies include:

- A comparison US-EU about first experimentation in robotics-based interventions for social skills training with children with ASD [Albo-Canals *et al.*, 2013a].
- Analyzing human-robot interaction in interventions for social skills training with children with ASD
- Introduction of a study to compare different treatments within a program of counseling and education directed to parents with a cognitive rehabilitation program aimed at children through robotics - TBI's children (traumatic brain injury) [Barco *et al.*, 2013].
- Analyzing emotional factors in HRI. The studies would be extrapolated to children [Díaz *et al.*, 2013; Heerink *et al.*, 2013].
- Defining instruments for measuring HRI. They would be employed in our project.
- Examples of experimentation to be developed in deep along several sessions during the project [Angulo *et al.*, 2011; Pardo *et al.*, 2012].

*This work has been partially supported by the Spanish Ministry of Economy and Competitiveness under the project PATRICIA (TIN2012-38416-C03-{01,02,03}).

- Analyzing what it means to introduce robots in an hospital context, from the point of view of professionals [Chang *et al.*, 2012].
- Early experimentation with children at school. Studies of social presence in order to improve educational skills [Heerink *et al.*, 2012].

The motivation of the project proposal is based on the following points:

- Inclusion of ASD (Autistic Spectrum Disorder) Children in the Society. Although there is no treatment that eliminates the impairments on communication, socialization and behavior, it is demonstrated that the training of strategies, techniques improve global performance and adaptation to real life. One reason that more strongly interferes with the quality of life for people diagnosed with ASD is its inability to communicate effectively and respond appropriately to social situations.
- Increase of Children with ASD worldwide. At epidemiological level, there has been a gradual increase in the prevalence of ASD. The Centers for Disease Control and Prevention (CDC, 2012) estimated a rate of 1/88 people within ASD.
- Adaptation of the activities to regular schools [Wakeling, 2008]. The advantages of this kind of activities are that its problem-based learning bridges the gap between the classroom and the real-life experiments in laboratory.
- The impact of robotics in our society in coming years. In 2006, Bill Gates published that the current state of robotics was equivalent to that of the 80's with computers, and that soon we would live the boom of the robot as long as we will have a robot in every home and a robot in every working place. Moreover, in December 2013, Google completed the acquisition of robot-maker Boston Dynamics, as well as 8 robotics companies in the last 6 months.

These robots will be tools, colleagues, and superiors with the skills to help humans with a performance more efficient that human in their working areas. Robotics concepts have revolutionized the manufacturing processes in industries since the industry revolution. Now, they begin to be integrated into everyday life environments such as vehicles, homes, offices and schools. Living with Robots is already a reality, as happened with the interaction with computers.

The teams that participate in this project have proven experience related to Robotics and Education:

- In 2012, the team composed by La Salle, UPC and HSJD presented the early results obtained from a session using the LSMaker Robot with Autistic Children.
- In 2012 the same team, together with researchers from the Adaptive Systems Group at the University of Hertfordshire, United Kingdom, carried out a series of tests with children patients of HSJD to observe and assess the interaction with the robot NAO in the context of the development of a coach robot for educational purposes for children suffering from diabetes.
- In 2013 the same team, together with Tufts University from US, presented recommendations to set-up this type of intervention for children with ASD with LEGO robots.

2.2 Objectives

The main objective is to design and implement a therapeutic and educational program of robot based activities with the group of Social Skills Intervention (GHS) to encourage social interaction and improve social skills in children with ASD. Robot based activities provide an educative environment that facilitates enjoyable play, exploration and discovering, collaborative and cooperative activities, social interaction, (i.e. joint attention, sharing material, negotiate plans) discovering learning challenges.

Intended objectives of this robot-based program are:

1. Provide a complementary tool in the therapy-room to establish an understanding of the content provided.
2. Increase social skills like following instructions, turn taking, asking for help, and sharing resources.
3. Facilitate the task of teaching and, at the same time, equalize the level of the different participants.
4. Evaluate the quality of interaction with the robot and with the programming interface.
5. Obtain empirical data to better design effective robot-based program to improve social skills of autistic children.

2.3 Expectations

The robot should act as a facilitator of social interaction. The robot itself is an element that interacts with the environment and with the children. Furthermore, to fulfill the proposed activity, children would have to exercise social skills. Children following the program of robot based activities would improve in attention and other therapy related variables, as well as in educational objectives.

Optimizing the cost of ICT resources in therapy classrooms is a second expectation. The advantage of use a multipurpose reconfigurable device becomes obvious in terms of saving resources, as far as the same educational material is used among different sessions. The same example exists with computers, whit which I can process a document or a complex equation, but also I can play or watch a video.

3 Working Plan

The experience acquired in the LSMaker project with TBI children [Albo-Canals *et al.*, 2013b; Barco *et al.*, 2013] induces to imitate the methodology and timing for the project schedule. So the different project phases are structured as follows:

1. *The pre-screening and baseline evaluation. Selection of participants.*
   In this phase of the project the tasks are: 1) to contact to the centers and institutions, 2) to introduce the project, 3) to visit centers and to get informed consent letters, 4) to confirm the ASD diagnostic, 5) to select families and

centers that collaborate with the project, and 5) to establish a base-line for the project (pre-intervention measures).

2. *Interface adapted to ASD*.
   Analysis of School Curriculum seeking more appropriate activities to work with a robot. Implementation of the robot programming and configuration interface adapted to children with ASD based on previous studies.

3. *Beginning of the sessions and data collection*.
   Implementation of the robot programming and configuration interface. Since not all activities will consist of programming the robot by teachers or students, but also there will be activities that consist on setup and interact with the robot, will need to make a platform based on a graphic environment such as LabVIEW, on which it will download the applications, while high-level interactions will be done with the robot.

4. *Robotic activities set-up*.
   Study the requirements and configuration necessary for robot to carry out the activities. Design the activities using the Robots. The activities are the so-called ecologic activities, what means that are mapped in real life challenges or festivities. Those ones that require a more social interaction are done using NAO Robot, while those ones that require building, planning, etc. are performed with the LEGO NXT.

5. *Processing samples and preliminary results*.
   Activities test.

6. *Data analysis and dissemination*.
   Data analysis of the results obtained with the methodology based on the robot. The results obtained will be presented in scientific forums.

7. *Activity collection and Good manners guide*.
   Data analysis of the results obtained with the methodology based on the robot. Write a documentation of activities so that therapists, doctors,... could have a guide that allows them to use resources in a completely autonomous and independent mode, making unnecessary the technician/engineer intervention during the activity.

4 Outputs

There are different experiences in different parts of the world in the use of robots to improve the social skills of children with autism. Projects like AURORA, IROMEC... (http://www.autistec.com) show promising results in the use of robotics for improving the symptoms of children with ASD.

Our expectations are focused on the use of the robot as a facilitator of the game with others, and at the same time, sharing the center of attention, respecting turns, and creating teamwork and imitation games. So if children with ASD improve their social skills will have higher expectations of success in social interactions, decrease conflicts, improve their self-esteem and this will become a protective factor against possible comorbidities such as anxiety disorders or depression. In summary, we will improve their quality of life.

As a result of the project we will develop a collection of Robotic Activities to elicit social behavior. Also, we hope to generate a "good practice guide" for professionals working in the field of treatment for people with ASD using these tools and make the most possible from an educational, clinical and social, through a study based on efficiency and supported by professionals in ASD.

The activities planned in this project may be used in all Spanish and international institutions, providing the transformations aspects listed above. This extensive distribution service to marginal areas where the level of treatments is not adequate to provide an optimal training. As an example we are running a similar experience in Panama.

As we work with textbooks, digital or paper, these activities can be distributed as part of their own teaching materials in schools.

The content will be protected by the copyright of all materials created within the framework of the team's institutions. Being possible agreements with other educational entities to use them.

5 Conclusions

Robotics concepts have revolutionized the manufacturing processes in industries since the industry revolution. Now, they begin to be integrated into everyday life environments such as vehicles, homes, offices and schools. Living with Robots is already a reality, as happened with the interaction with computers. This article is about a project proposal of using robotics as a facilitator to create a context suitable to train social skills among children for educational purposes, as well as use them with children with needs of these social skills (mainly Autistic children). As a result, a compendium of robot based activities should be delivered in which the main working tool and interaction is a social robot.

Future research lines include (i) Parent Training Courses, which are offered information, resources and strategies on using technological supports to implement specific applications at home to improve learning, communication and leisure opportunities and relationship of the children with ASD; (ii) Using FAROS, a portal to health from the Sant Joan de Déu Hospital.

Acknowledgments

Authors thank medical and management support provided by the Sant Joan de Déu Hospital. We would like especially thank Dr. Jaume Pérez Payarols, Director of Innovation and Knowledge Management, for his research coordination.

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A Holistic Approach to the Sustainable Empowerment of the Ageing Society·

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Abstract

This paper presents a new European initiative to support the sustainable empowerment of the ageing society. Empowerment in this context represents the capability to have a self-determined, autonomous and healthy life. The paper justifies the need of such an initiative and highlights the role that telemedicine and ambient assisted living can play in this environment.

1 Motivation

The demographic change has profound effects on societies, due to alteration in age, birth rate or migration movements. One effect is the ageing of societies, which challenges societies either to enlarge institutional care or to find alternative solutions to care the elderly. One of the biggest current challenges is to sustainably empower the individuals and communities of the ageing society. For us, empowerment characterizes the strategies and the process to enable individuals to have a self-determined, autonomous and healthy life and additionally to support communities by incorporating new technological and management approaches in integrated home care to better provide for its (elderly) people.

Considerable hopes are placed on Ambient Assisted Living (AAL) and e-health (telemedicine) technologies to cope with those emerging confronts. The new technologies are expected to withdraw pressure from health and social care systems by assisting elderly people in independent living. However, most of these new technologies currently address a narrow spectrum of daily needs for elder citizens with dysfunctions: security (e.g. red buttons); health monitoring; extending certain functional capacities (e.g. different technical aids); social ties (e.g. various communication platforms). Comparing this technical status quo with the hierarchy of needs of individuals as well as of collectives reveals obvious gaps between available technologies and crucial aspects of quality of life. Activities and demands of daily living are not completely manageable by technical assistance but also need human capacities and contributions (e.g. support in dressing, feeding, household activities). Particularly rural communities envisage an extraordinary challenge: Local resources are often diminished due to migration of professionals and young people to cities, leading to the deterioration of services and assistance formerly provided by professionals or neighbourhood and family networks.

Several components influence a satisfying and healthy life. The World Health Organization (WHO) formulated in 1948: 'Health is a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity'[1]. This definition has been recently enlarged, and characterizes a healthy life first of all with the prevention of diseases and secondly, in the case of the presence of disease, with the ability to adapt and self manage [Hub11], a concept also known as resilience. Resilience in our understanding leads to empowerment, thus enabling systems to better cope with its challenges. This work adopts the concept of resilience to the context of an ageing society. It focuses on the individual or unit (such as a household or family), living in a certain community/society. To enable such a unit to gain and reach empowerment is the ultimate goal. To our knowledge, resilience as a strategy has not been implemented on a unit/household level nor exits a way of indexing to measure "empowerment" in such a context.

The ageing society refers not only to elderly people. Ageing is a process that begins at conception and goes on throughout life. We develop while ageing and interact with the environment thus shaping and influencing our own health and wellbeing. Yet the environment also shapes our health and wellbeing, it is a circular process. Declining functionality has a close relationship with healthy lifestyle and ageing. Elder people may suffer some physical or mental dysfunctionality as a consequence of ageing. People with other capacities grow older today than ever before in history, thus also profiting from the overall ageing of the society. Handicapped people suffer additional illnesses as a consequence of the duration of their dysfunctionality and of age.

This paper presents the goals and background of a new research initiative (TING-NET) on empowerment of the ageing society. It takes a holistic approach to empowerment and considers the infrastructure and systems that provide not

This work has been supported by Internationale Bodensee-Hochschule (IBH) under contract no. WTT-2013-004.

[1] http://www.who.int/about/definition/en/print.html

only health and household services, but also therapeutic-pedagogical and trustees services in the different participating countries. The research will apply the locality principle to bring the services close to the citizens and help them stay as long as possible in their area, their city/village and their private living space.

TING-NET aims to:

- Analyse how health, household, therapeutic-pedagogical and trustees services are implemented and interrelated in the different countries
- Analyse how new ICT technologies may be combined with care and home management services to improve both the services and their integration in a given community
- Find a European or international consensus on how to define and measure 'empowerment' in face of different practices
- Establish 'best practice' models as to how to integrate and personalize services and sets (international) defacto standards or guidelines for a sustainable service model with transferable structures and technologies
- Develop examples of transferring the best practices model to concrete, local user communities joining together professionals and practitioners, relatives, friends, neighbours and volunteers. The Action calls this local user community a TING.
- Consider how local user communities (cf. Figure 1) interact, help and learn from each other, building a network of communities (TING-NET).

The word "TING" has two meanings: in Germanic and Scandinavian countries, it represented the people's assembly in a community and it also denotes an ancient Chinese vessel. It symbolizes therefore both the community and the integration ideal.

The rest of this paper is organized as follows. Section 2 comments on the state of the art of research on AAL, telemedicine or therapeutics pedagogy applied to the empowerment of ageing societies. Section 3 presents the detailed objectives of the TING-NET research initiative. Section 4 shows initial ideas on a possible mapping of a TING in a rural community. Finally, Section 5 closes the paper with some conclusions.

2 State of the Art

The WHO European Centre for Environment and Health identified the unequal distribution of health and wellbeing as a major challenge for health governance. Environmental (health) inequalities exist in all regions and countries. Different population groups may face a wide range of inequalities within one country and the results are very diverse between countries. The WHO recommends a general improvement of environmental conditions, and they recommend to share experiences and case studies on successful interventions [WHO1]. This research initiative will address these recommendations by integrating key expertise from different domains, countries and disciplines.

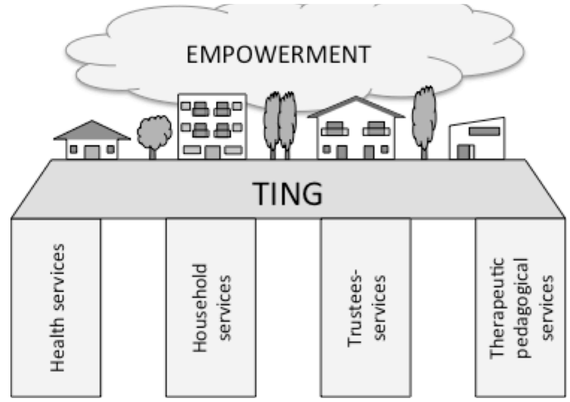

Figure 1: A TING is based on a set of basic services

Several classical research areas are related to this research: Firstly, Ambient Assisted Living (AAL) focus on providing support for a population group with disabilities, representatives are JADE (FP7 no. 266422), Synergy-COPD (FP7-ICT-2009-270086), ARMOR (no. FP7-287729) or REACTION (no. FP-7248590), which focus on chronic diseases or HAPPY AGEING that focuses on ICT support for home care (AAL no. AAL-2008-1-113). AAL with focus on advancement of social interaction: CONNECTED CO-LIVING (AAL no. AAL-2009-2-097) or USEFIL (no. FP7-ICT-2011-7) focusing on addressing the elderly social interaction or ALIAS with focus on adaptable ambient living assistance (AAL no. AAL-2009-2). All mentioned cluster examples have a narrow, typically ICT driven focus. This research initiative will exploit links with the European Regional and Local Health Authorities (EUREGHA) to contribute towards the creation of sustainable synergies and policies between regional and local authorities and EU stakeholders in the field of health care systems.

A second area strongly related to this research area is telemedicine, ranging from remote recommendation, chronic care management up to telemetric devices. Example projects are MOMENTUM (no. CIP-ICT-PSP.2011.3.4), a thematic network focused on telemedicine, or DECIPHER PCP (no. FP7–288028) that focused on mobile EHR, national hospital cooperation networks like national telemetric projects or networks of telemedicine centers in some countries. Furthermore, implemented patient care via telemedicine care management in other countries or a project like United4Health (no. CIP-ICT-PSP-2012-6) are also related to this challenge. Pilot projects like SMARTCARE (ICT PSP no. 325158, a telemedicine platform to deliver care services for older citizen neglect the effect of population ageing and other projects are too narrow and more dedicated to a specific disease like dementia in VPH Dementia Research Enabled by IT (FP7-ICT no. 601055) or rehabilitation from strokes like in CONTRAST (no. FP7-ICT-2011 ID-287320). The Virtual Physiological Human network of excellence offers a roadmap named DISCIPULUS (FP7/2007-2013) that plans for personalized treatment focusing on healthcare prediction and GRANATUM (ICT-2009.5.3) providing limited focus how to bridge information among biomedical researchers; both are not covering the objectives of this research initiative.

A third area is the non-medical therapeutic intervention. This is particular important to enhance the possibility of

communicating in high age. Associated with medical challenges is a loss of functions for mastering tasks of everyday life. These losses can be prevented or improved through medical rehabilitation such as physical therapy but also through the knowledge gained with therapeutic pedagogy. There are useful inventories for assessment of functioning for independent living for various groups with special needs, which have been developed by occupational therapists and nurses in the USA [Hor13]. Further examples are the EHLE project promoting health education for older citizens (GRUNDTVIG no. 134023-2007-IT-GRUNDTVIG-GMP) and the initiatives to promote healthy nutrition for the group 50+ (in age) by the Association for Health Promotion (ARGEF, Austria) both without integrating trans-domain relevant knowledge; furthermore, the project Empowering Socially Excluded Elderly within Russian Minority (NTERREG IV A project SFE1) with focus on the integration on minority groups at the age of 65 and over.
Finally, the household service and care service area is related to this initiative. As reported in [Ang11, Ang12] two processes are not in line: supporting services professionalization and formalization. As a result illegal employment rises. Two years later, there is no general movement in formalization visible. Regional initiatives try to focus only on specific groups like 'Elderly Men Homely in Kitchen groups' supported by the project Active Ageing in Tampere Region (www.piramk.fi/aip) or like in the project Design-led Innovations for Active Ageing (DAA a Interreg IVC project) on elder people living in larger cities and developing sustainable solution for senior care but neglecting crucial zones like rural areas.
One important technique to tackle the large set of open issues yet not covered in documented projects is the application of CASE management. Case Management is a collaborative process which assesses, plans, implements, coordinates, monitors and evaluates the options and services required to meet an individuals health, social care, educational and employment needs, using communication and available resources to promote quality cost effective outcomes [Cms13].-

3 Objectives

The first objective of TING-NET is to create a (meta-) model for empowerment. The goal of the meta-model is to provide the scientific community with a possible standard ('ideal') to which against 'real'- local models- can be compared and improved.
The meta-model will extract the best practices from the participating countries in terms of organisation of their health (system), household and therapeutic-pedagogical systems and the current application of technologies. The meta-model can be mapped as an empowerment model in the countries/regions/communities, taking into account the different contexts in terms of legal, political, ethical, cultural and financial differences. Therefore the meta-model will also be an instrument for the stakeholder community to deploy their changes leading to empowerment.
Beyond the innovation aspect, i.e. development of new technologies to facilitate independent living in a community setting, the issues of technology acceptance and financial affordability play a major role. The existence of suitable technologies is a necessary, but not a sufficient condition for achieving an improved quality of life for citizens and increased efficiency of health and social care systems. There are currently significant gaps between advances in technology and the actual adoption of these technologies by social and health care systems as well as by (older) citizens in their home settings. Several barriers exist at various levels and need to be overcome to achieve actual technology acceptance and penetration into social and health care systems. As authors of technology acceptance models have indicated [Dil96, Ven08], one of the core issues is use-friendliness of various technologies themselves. Across many European countries, there is still a significant scope for 'translating' and transferring the various new technologies into the social, cultural and institutional context of given countries. At the level of users (or potential users), technology acceptance is a function of age, gender and prior experience of the users. This is partly influenced by a digital divide, which is both economic (affordability of respective technologies) as well as cognitive (willingness to adopt respective technologies). At the level of social and health care service provision systems, the challenge is mainly related to costs and financial efficiency – whether the adoption of new technologies helps to constrain costs or at least prevent these from accelerating. Additional complication relates to the fragmentation of institutional set-up of service delivery in several countries (additional spending on new technologies of some service providers may entail savings for other service providers, which are under a different administration or financing system) and the lack of active coordination to facilitate the transfer of new technologies into those systems.
The second objective of TING-NET is to allow sustainability and resilience. Resilience describes the tolerance of a system against perturbations and is meant as an 'outcome' of empowerment, since it makes systems more prone to sustain and function. This process involves technologies and services.
The core issue is to empower citizens and facilitate their independent living through the new technologies. Technologies have to transfer innovations into the daily practice of citizens and into the regular practice of social and health service providers. Sustainability is therefore reached by keeping the stakeholders in the loop, sending the necessary input to them and receiving their feedback
The two cornerstone elements for sustainability have already been taken into account in the meta-model: user acceptance and financial affordability. Developments at very different fronts are needed, both at supply and demand side:

- Continuing innovation of user-friendly ICT enabled products and services to address the daily needs of people;
- Adaptation of such products and services into the widely varying contexts of community settings across many European countries;

- Advancing technology acceptance in the relevant customer groups with due consideration to the social and cultural contexts and needs;
- Addressing financial affordability to customer groups and financial efficiency for service providers;
- Addressing fragmentation of institutional (administrative and financial) set-up of service provision and providing for effective brokerage of ICT enabled services and products.

Referring to Roger's theory of diffusion of innovations [Rog03], the practical question is what are the possible strategies to win the early majority to adopt the ICT enabled services and products. On one hand we may expect that the following generations of older persons are more apt to use new technologies as they have used similar technologies earlier over their life course. On the other hand, as the speed of technology advancement increases, adaptation to state-of-art technologies remains an issue for each cohort of older citizens.

The final objective of TING-NET is to establish and consolidate a (European) community for sustainable empowerment of the ageing society.

Ageing society urges for a seamless fusion of different types of services that aim at enhancing the empowerment of individuals and decrease the need for institutionalized support. In fact three communities are envisioned. The goal of establishing these communities is to achieve a long-term basis for research and deployment.

In the first phase, a scientific community will be established to further develop the transdomain, user-centred research on empowerment integrating, harmonizing and possibly standardizing the developments ICT, health, household and therapeutic pedagogics. The knowledge created in TING-NET will be expanded in a second phase to a stakeholder community. The stakeholder community can be further hierarchically organized in two categories. On the one hand, stakeholders can be organized in user stakeholder communities, consisting of directly associated organizations and individuals, who locally map and implement the created meta-model, and their direct users. These communities need to be involved in all partner countries and future joining countries. They have very different situations to address. This needs to be evaluated, before planning networking activities. The situations depend on the development of the individual societies with regard to macro economic and demographic conditions.

On the other hand, stakeholders can also be organized in a planning stakeholder community, composed of government and non-government organizations, but also manufacturers in the different countries, who are involved in planning the application of the resulting model. Currently, critical gaps reside between non-scientific stakeholders. For example, the engineering solutions with advanced capabilities suffer from a lack of awareness at the medical organizations, as well as lack of interest of the manufacturers to develop a wide market for these solutions affordable for all people in need. The question of finances arises and is a crucial inhibitor for a faster empowerment of people to be able to improve their independent living. The establishment of this planning stakeholders community can show, through focused communication, how to importantly reduce healthcare expenses by applying the created knowledge (the best-practices meta-model). At the same time, it can draw attention of policy-makers across national frontiers. The TING-NET specially aims at contributing with this community to speed up the development of the health and care systems of some of the emerging European countries.

4 A TING Prototype Model

As stated in the previous section, TING-NET aims at developing a meta-model, a kind of guideline on how to assess the citizen and combine different services to support empowerment of the ageing society. This meta-model will later on be mapped to concrete models for specific countries or regions, taking into account their differences and possibilities both in terms of infrastructure and of social and cultural habits. One possible prototype model for a TING in a rural environment is presented in this section.

The process of empowerment is incremental. A self-determined, autonomous, healthy life is not a status reached at some point, but a continuous process of improvement.

The first thing that needs to be done is to capture the current, subjective quality of life of a person and his/her needs or improvement wishes. Very different circumstances may lead to the desire or need to capture the current quality of life; examples are (sudden) dysfunction, decreasing potential or performance or temporal absence of certain abilities (cf. Figure 2).

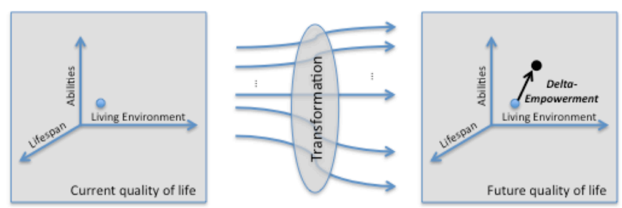

Figure 2: Delta-empowerment

The current quality of life depends on the abilities (sensorial, motoric, intellectual capacities or chronic diseases), the lifespan (i.e. the age) and the living environment (rural, cities, alone, in family, retirement home).

In order to increase empowerment, the desired quality of life has to be stated. Individual subjective preferences are combined together with objective measured potential. The result will be the future quality of life. The distance between both points is the delta empowerment. The target state can be achieved by applying suited transformations. The selection and parameterization of the proposed transformations will be supported by a recommendation expert system. This empowerment improvement process can be iteratively applied. The research activities in this part will address:

1. Definition of a measureable model for (subjective) quality of life.

2. Definition of empowerment as a distance in the quality of life space.
3. Formalization of transformation actions considering their impact on the quality of life model.

The abstract transformation actions will be mapped to instruments offered by the infrastructure. The classical instruments are personal care at home by members of a care service and personal visits of patients to physicians. This project proposes to extend this infrastructure by an integrated e-health platform. The research activities in this phase will be:

1. Definition, implementation and evaluation of the e-health platform.
2. Mapping of the transformations to the infrastructure instruments.
3. Definition of a usability concept for the platform based on user-friendliness and trust to improve the acceptance of the system by its users (patients and health-professionals).

The planned infrastructure can be seen in Figure 3.

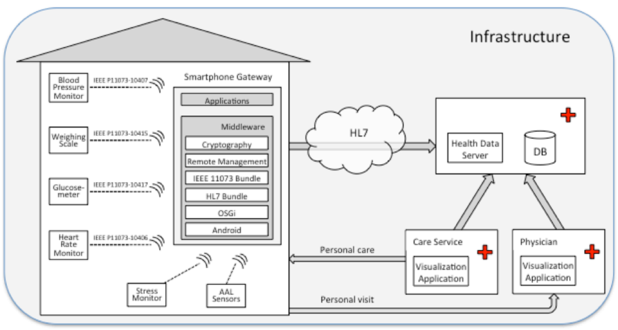

Figure 3: Telemedicine infrastructure

The requirements for this part are: (a) trust and security through encryption, (b) lower-cost through integration of standards and open interfaces for HW and SW, (c) mobility through the use of wireless solutions, (d) scalability and flexibility through a modular architecture (e.g. OSGi), and (e) application of standards (e.g. IEEE11073 for telemedicine devices and HL7). The home infrastructure will also integrate other biometric sensors like stress sensors and AAL-sensors. These sensors should be used to profile and predict the behaviour of the patient within the common living environment. This profile together with the health measures will be used to characterize the current quality of life, support recommendations and evaluate the achieved empowerment. The necessary profiling and behavioural description algorithms will be developed in this project.

The infrastructure mentioned serves as a typical installation that is locally available and provides e-health services to each individual. This service is considered to be only one competence needed for an aging society. Other services are for instance domestic services, trustee services and therapeutic pedagogy services.

Currently, some of these services are partially offered to individuals by different providers. For these individual persons, it is quite difficult to sort out and decide the need of support and the provider. It would be desirable to link service providers and citizens through a local service centre that is called TING (cf. figure 1). TING can on the one side collect the information of local/regional professional and non-professional service providers (cf. Figure 4).

On the other side, it can help to analyse the level of service

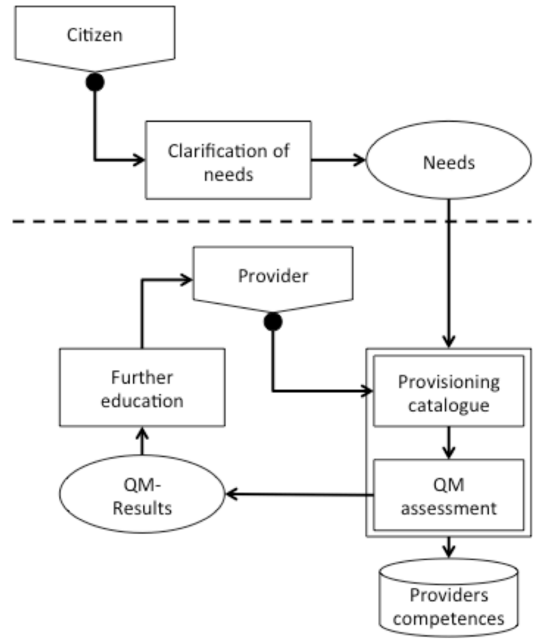

Figure 4: Assessment of providers' competences

needed by the citizens and support them to find the adequate measures and providers. TING provides a case-management for a whole (rural) community incorporating a network with all stakeholders.

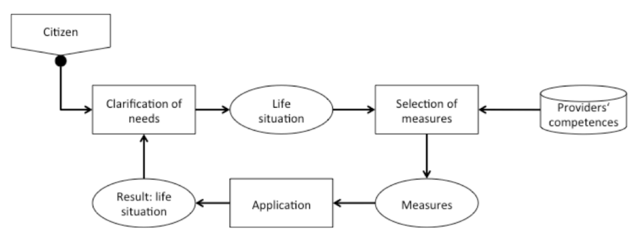

Figure 5: Citizens advice process

Finally, the idea of a TING can be spread to other communities as well, so that, in case of telemedicine, it can form a cluster of TINGs interconnected for service provisioning and data derivation. In the latter case, statistical measures can be taken on a large range of cases, and therefore, help to provide general support to health management and prevention. A possibility that nowadays is not available even in areas of intensive medical research like oncology and its statistical data used for empiric derivation of prognosis.

5 Conclusions

This paper presents the basic research objectives of a new European initiative to support the sustainable empowerment of the ageing society. Empowerment in this context represents the capability to have a self-determined, autonomous and healthy life. The complexity in coping with empowerment comes from the fact that it is an extremely heterogeneous field. Several disciplines play a major role and have to be joined together: medicine, ICT, social sciences, therapeutic pedagogics up to legal aspects. Furthermore, different countries/regions/communities have different levels of deployment of infrastructures and also different cultural habits in integrating the ageing society. The current situation in the different countries will be analysed and out of the best practices, a meta-model to support empowerment will be generated. This meta-model will be mapped to the different requirements of the particular real communities. For this meta-model to be sustainable, two main aspects have to be explicitly tackled: user acceptance and political and administrative support, therefore it is very important to create the appropriate stakeholder communities.

An example has been given of a mapping of this meta-model to a concrete model for rural communities, where the community would be organized as a kind of service brokerage centre that would both assess the providers' competence and the citizens' needs and accompany the citizens in a process of recommendation, application and evaluation of measures.

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