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Analysis of Survey Tools for Recommender Systems in the Selection of Ambient Assisted Living Technologies

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Abstract

This work is a study about a comparison of survey tools and it should help developers in selecting a suited tool for application in an AAL environment. The first step was to identify the basic required functionality of the survey tools used for AAL technologies and to compare these tools by their functionality and assignments. The comparative study was derived from the data obtained, previous literature studies and further technical data. A list of requirements was stated and ordered in terms of relevance to the target application domain. With the help of an integrated assessment method, the calculation of a generalized estimate value was performed and the result is explained. Finally, the planned application of this tool in a running project is explained.

Keywords: survey tool; smart home; assisted living

1. Introduction

With the recent advances in medicine, people live longer and healthier compared to previous generations. Approximately 20% of the world population will be age 60 or older by 2050 [1]. The increasing aging population results in many challenges for the healthcare system, and society needs to discover new ways of caring and monitoring people's health to reduce the burden of healthcare workers and shortage of nursing home spots [2]. Technological advances, along with cost reduction in computing devices and network solutions, are some of the main requirements in enhancing the independence of elderly and ill people at home [3].

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The Germany Federal Government's Demography Strategy[1] has been in existence since 2012, and the results of the working groups were published in 2017. Chapter 4 of the working group 'Self-determined life in old age' recommends a lifeworld approach to the design of health-promoting structures. It goes on to explain: 'Housing that is suitable for the elderly also supports sick people and families with children. 'Smart homes' help in the care of the elderly and children. It should be noted that availability must not be limited to specific points but must offer the same level of living conditions in the regions, as this is the only way to ensure that medical care is tailored to need and easily accessible. Furthermore, comprehensive accessibility is of particular importance, as this concerns not only physical barriers but also technical and non-technical barriers. The Home Health Living Lab of the Lake Constance University of Applied Sciences is currently investigating this last point in particular, and the study will be completed in 2021 [4].

The successful implementation of such systems requires the introduction of various modern technologies, such as hardware engineering, mobile development, database management, frontend, and backend development. Despite the work on taxonomies for Assisted-Living technologies (AAL), such a smart homes [5, 6], one of the most considerable drawbacks of their implementation is the optimization of techniques to select individual functions determined by specific users' requirements [2, 12]. Every person who needs assistance has their health personal issues and particular living conditions [7]. The functionality of domestic smart technologies, as well as the users' role with the technology in different household situations, should be clarified through the consideration of householder's understandings, choices, and habits [8, 9].

The design of technologies that support decisions in smart homes within the context of AAL has been widely applied [10]. Recommender systems are an accepted and widespread technology used by many market leaders of various industries [11]. However, there is a lack of literature on recommender systems to help users select the proper AAL technology products for setting up their smart home based on users' preferences. These kinds of recommender systems could aid in selecting the best alternative among the overwhelming amount of home health monitoring technology available on the Internet [10, 12]. A critical part of developing a recommender system for the selection of AAL technologies is to get insight into users' requirements. Therefore the need for survey systems arises. The trend of the increasing popularity of web technologies, low cost, and the possibility of interactive interaction between users and online surveys contribute to the implementation of recommender systems for the AAL technology election [13]. In some research, an online survey has already been conducted to get insights into user's smart home perspectives. In the REFIT project, an online survey is conducted with the long-term objective of creating a step-change in uptake rates of retrofit technology measures in UK homes [14].

Survey systems in AAL and smart home technologies can be used in a variety of ways. They allow us to collect statistical information for a study, collect customer feedback on the purchased product or provided service. Survey systems can help with individual assessments of the customer requirements in smart homes and AAL technologies. Surveys can be a way to collect the AAL user's information that is not mentioned in the conversation. And since the patient may doubt whether to provide any information personally, the polls will provide an opportunity to do this confidentially.

Large companies, manufacturers, and suppliers of AAL technologies can create web forms on their own if it is a part of their commercial product. However, the creation of such own platforms for non-commercial organizations, medical organizations, start-ups, and companies where it is not the central part of their product can be costly in terms of money and time. Using online survey tools can significantly reduce set-up and administration costs. Since creating and providing the survey do not need skills in computer programming and web-designing.

Currently, there is a wide variety of available survey tools on the Internet, which allow to implement different surveys in web products and process the gathered data in little time. However, AAL technologies have some technical requirements, which will be explained in the following sections, and as a consequence, not the whole survey tools offered can match them. There are still very few publications in the scientific literature based on this topic. Even though some studies of survey tools are available on the Internet, these are neither scientific research nor part of the

[1] http://www.bmfsfj.de/bmfsfj/aktuelles/alle-meldungen/gleichwertige-lebensverhaeltnisse-in-ganz-deutschland-schaffen/137220

recommender system for AAL selection. They draw different conclusions and, in most cases, reflect the subjective thoughts of the authors. This fact means the need for research on this topic.

This study's objective is to provide a comprehensive analysis of survey tools that can be used in recommender systems to advise prospective users and smart home companies on selecting the right AAL technologies based on user's preferences. The paper is structured as follows. In section 2, the features of survey tools for AAL are addressed. In sections 3 and 4, the selection process and method for survey tool comparison are presented, respectively. In section 5, the results of the survey tool that best fits the requirements for AAL recommendations are drawn along with their characteristics. The last section concludes, and remarks are presented.

2. Requirements definition

To successfully determine the requirements for a survey system for AAL, we first tried to determine the main purpose of using a survey system in AAL and smart home technologies. Studies show that online survey systems can successfully replace traditional paper surveys in medicine and AAL technologies, as they have such advantages as lower cost and faster collection of user responses compared to paper surveys [15]. Online survey systems also can help to solve one of the biggest problems of implementation AAL technologies is the individual adjustment of technology for each user [10]. It can be possible with specially created questionnaires and a survey of potential users of AAL systems to determine the characteristics and needs of each user. Therefore, the collection, processing of responses from potential users, and the possibility of their subsequent processing to solve the problems of implementation AAL and smart home technologies and assessing their needs are determined as the main task of the survey tool in these technologies.

Based on this task, the main requirements of a survey tool for AAL were identified. These requirements were divided into two categories. In the first category are the requirements for implementing the basis of the questionnaire. Without them, it would be impossible to implement most of the survey systems for AAL and smart home technologies. In the second category, not essential requirements for implementing the survey framework are included. However, these requirements could provide additional functionality and affect usability for both developers and the survey users. It can also affect the time and cost of developing a survey, which is essential for implementing AAL and smart home technologies.

2.1 Requirements definition

The following requirements of survey tools for AAL and smart home technologies were identified:

- **Requirement 1 (R1): Question administrations.** To enable administrators to create and delete questions. The primary function of survey tools is the ability to create and delete questions. The ability to create variants of questions could be important for questionnaires with changing questions based on previous user's answers. The ability to create questions with pictures and checklists also could be useful for AAL and smart home technologies.

- **Requirement 2 (R2): Answers administration.** To allow administrators to delete users answers.

- **Requirement 3 (R3): Hierarchical questions and skip logic.** A possibility to change the following questions and to skip some depending on previous answers. This fact allows us to ask only relevant questions individually for each user and thus collect more data for fewer questions compared to traditional linear types of survey.

- **Requirement 4 (R4): Adaptive question rules for navigation between questions.** Possibility for administrators to create rules for changing questions during the survey. In order to minimize the involvement of additional staff, questions should be changed automatically according to the administrator‘s rules.

- **Requirement 5 (R5): API**. Availability of functions for communication between survey tools and additional programs. Additional programs may be required to process survey results and possibly return results. The survey tool should have the availability of functions and rules for communication with other programs.

- **Requirement 6 (R6): Results management**. Possibility of returning results data in web-window after finishing the survey. After the survey, it may need the possibility to process responses and display the results (for example, to offer some products or services) or subsequent processing after accumulating a sufficient number of user responses.

2.2 Additional requirements of survey tools for AAL and smart home technologies

As stated at the beginning of section 2, some requirements are not considered necessary for the survey framework. However, these could provide extra functionality to the tool. The following additional requirements of survey tools for AAL and smart home technologies were identified:

- **Requirement 7 (R7): Continue later.** This feature allows for saving the survey session for each user in an automatic way. So the user can continue the survey after sometime later when it is more comfortable. This function is very comfortable for use from the point of users and shows the advanced level of the project. It can be useful, especially for long questionnaires, where premature termination of the survey can may data loss.

- **Requirement 8 (R8): Template editing.** To allow developers to control the look and feel of pages during a survey. A survey administrator can select the template to use for each survey to personalize the look and feel of the survey. Modifying a template can be as adding images to the home page, changing background colors, or maybe new text colors for specific questions.

- **Requirement 9 (R9): Installation option for the server.** This feature allows developers to install the survey system on their servers. It can be an option for projects that want to be independent of the additional software for data protection. As well as survey services in this category usually free because the providers do not have to provide hosting. At the same time, these survey tools allow making more deep settings with the system but need more time for installation and adjustment.

- **Requirement 10 (R10): Supportive community.** A supportive community is a variety of resources for discussion, information retrieval, and problem-solving for this survey tool. It can be specially created customer support resources from the manufacturer (questions, search answers, and feedback forms, including by phone), as well as forums, discussions, and guides for this tool.

- **Requirement 11 (R11): Entry barrier.** The entry barrier is a term that comes from programming. It describes the existence of high start-up time costs or other obstacles that prevent new developers from quickly entering a tool or programming area. Ordinary time costs to entry include reading particular documents, technical peculiarity, and depends on the technical background of the developers.

3 Selection process

At the beginning, a search was conducted by using Google scholar with the goal of gaining insight into the online survey application's current status. The keywords ‘survey tool’, 'survey application’, ‘survey system’, ‘online-survey’, ‘web-based survey tool’, and ‘web-based survey application’ were used. No relevant articles were found. A second search was performed in IEEE Xplore and ScienceDirect databases using the same keywords. No remarkable literature

was selected as none of the scientific publication was directed related to the requirement description of online survey tools stated in section 2. Since no significant matches on this topic were found, a comparative study of survey tools was conducted with a particular focus on the requirements stated in section 2.

Five online survey tools were selected among a large number of solutions available on the Internet: Google Forms too[2], SurveyMonkey[3], LimeSurvey CE[4], JD eSurvey[5], and TellForm[6]. LimeSurvey has two versions of a tool: paid (LimeSurvey) and free (LimeSurvey CE), which do not differ in functionality, except for the installation feature on the server in the free version. In the paid version, access is provided to a server; here, all necessary software is already installed. However, in this article, we do not consider this version.

3.1. Comparison method

A comparison of survey tools was made. The result, based on the technical functionality of each tool, is shown in Table 1. Apart from the requirements, the price of the survey tools was also taken into account. Selected survey tools are in the first row, and the requirements from section 2 are placed in the first column. Correspondence of each requirement to each tool is found at the intersection of tools and requirements.

Requirements	Grade	Google Forms	SurveyMonkey	LimeSurvey CE	JD eSurvey	TellForm
R1: Question administration	5	Yes	Yes	Yes	Yes	Yes
R2: Answers administration	5	Yes	Yes	Yes	Yes	Yes
R3: Hierarchical questions	5	With limitations	Yes	Yes	Yes	Yes
R4: Adaptive question rules	5	With limitations	Yes	Yes	Yes	Yes
R5: API availability	5	Yes	Yes	Yes	Yes	Yes
R6: Results management	5	Yes	Yes	Yes	Yes	No
R7: Continue later	3	Yes	Yes	Yes	Yes	No
R8: Template editing	3	No	Yes	Yes	Poor	Poor
R9: Installation option for own server	3	No	No	Yes	Yes	Yes
R10: Supporting community	3	Yes	Yes	Yes	Poor	Poor
R11: Entry barrier	3	Low	Middle	High	High	High
Price*	4	Free	39-99 €/month	Free for own server	Free	Free

Table 1. Comparison of survey tools.

In the selection of the best survey tools for AAL and smart home technologies, two aspects were addressed: the number of requirements that cover each tool and the weight of these requirements. Consequently, we used a weighted

[2] Google forms website: https://www.google.com/forms/

[3] SurveyMonkey website: https://www.surveymonkey.com/

[4] LimeSurvey website: https://www.limesurvey.org/

[5] JD eSurvey website: https://www.jdsoft.com/jd-esurvey.html

[6] TellForm website: https://www.tellform.com/

sum method. The method is based on the calculation of a generalized estimate (taking into account estimates by all criteria) [16]. The method consisted of the following stages:

Stage 1. Weights of the feature were identified by using technical requirements, which are numerical estimates of their importance (Table 1). Here, the highest degree of importance corresponds to grade '5'. Grade '5' is assigned to all the requirements stated in section 2.1. Grade '4' of importance corresponds to price attribute, as this is a considerable but not critical parameter. All other additional requirements stated in section 2.2 are assigned to grade '3'.

Stage 2. Estimates of objects according to criteria are reduced to a dimensionless form. This conversion is performed differently depending on the type and orientation of the criterion:

- For the criteria to be maximized, all object ratings for this criterion are divided by the maximum rating.
- For the criteria to be minimized, the minimum is selected from the ratings for this criterion, and it is divided into all object ratings for this criterion.
- For substantive (verbal) criteria, a transition to numerical evaluations is performed.

Criteria that take the values "yes" or "no" are replaced by the numbers 0.67 and 0.33, respectively [16]. All dimensionless estimates have values ranging from 0 to 1. The larger the value of the dimensionless rating, the better the survey tool (by any criterion).

Stage 3. Weighted estimates of objects (E_{ij}) were found (dimensionless estimates (P_{ij}) were multiplied by the weight of the corresponding criteria (W_i)):

$$E_{ij} = P_{ij} \cdot W_i \tag{1}$$

Stage 4. Comprehensive estimates of each object (E_j) were found (sums of weighted estimates(E_{ij})):

$$E_j = \sum_{i=1}^{N} E_{ij} \tag{2}$$

Where N is a quantity of criteria (in this case, it is 12).

The best tool is considered with a more extensive comprehensive assessment. The result of the computation is shown in table 2.

3.2 Results and characteristics

Once the requirements of the survey tools for recommender systems in the selection of AAL technologies has been presented and weighted by the grade of importance, the overall results of the study are shown in Table 2. For each selected tool in this study, the main advantages and disadvantages are stated, as well as the punctuation that each survey tool has obtained in the evaluation method in section 3.1. The max comprehensive assessment equals to 1. LimeSurvey's solution obtained a more significant evaluation compared to the other tools. The outcome shows that the selection of a survey tool depends on the technical requirements of each particular project. In the case of this study, the LimeSurvey tool is the one which best accords with the basic requirements for a recommender system for the selection of AAL and smart home technologies.

Survey tools	Advantages	Disadvantages	Assessment (E_j)
Google Forms	Admins can connect the created survey to Google Spreadsheets, which enables them to process the retrieved data. This solution's capabilities can also be expanded through third-party add-ons or its integrated script suite (for smaller feats). Free	Limitation in creating hierarchical question Adaptive questions rules	0.525
Survey Monkey	Skip logic and question branching Data analysis tools Data reporting and presenting Complete and detailed basic reporting for the data analysis	Pricing Software variety options are hidden behind a paywall No installation option for its server and not available for offline surveys	0.575
LimeSurvey CE	Open-source license (GNU) Multiple capabilities and non-existing cost of the solution 80 different languages supported Skip logic, adaptive questions rules, and template editing API allows the developer to develop plugins for multiple purposes	Relatively high entry barrier inherent in all polling services that can be installed on its server	0.59
JD eSurvey	Open-source web application Branching and randomization to piping for survey control of a long list of question types, including video questions. Creation of statistical, charts and graphs, export survey data to Excel and SPSS. Possibility of downloading survey statistics as PDF files. The disadvantages include the relatively poor supporting community, high entry barrier, and poor template editing.	Relatively poor supporting community High entry barrier Poor template editing.	0.54
TellForm	Open-source application with quite simple functions. Up to 11 different types of surveys It has analytics attached to its surveys. It is easy to customize the look and feel of surveys, and the application's interface is clean and straightforward.	No option for data export. No continue later function. Poor supporting community and high entry barrier.	0.49

Table 2: Characteristics of the survey tools and assessment.

In Figure 1, the punctuation of the survey tools in the assessment are summarised in a bar graph. LimeSurvey tool has several advantages such as price and a set of functions required for the election of AAL and smart home technologies. Nevertheless, the scores obtained by the other tools are not far away from LimeSurvey ones.

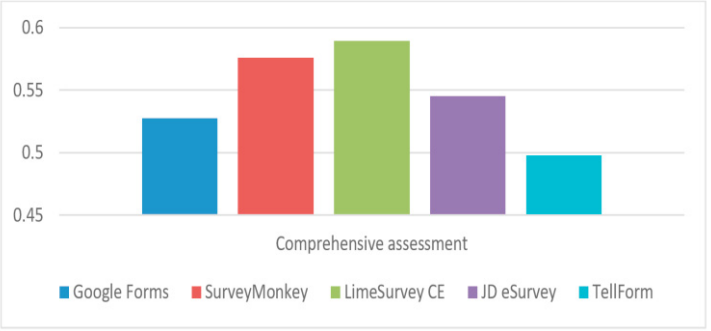

Figure 1. Comprehensive assessment.

Given the vast selection of survey tools, the focus was on the simple principle of selecting candidates. Therefore, only a subset of all survey tools was presented in this article. The comparison was made by dimensionless estimates, that was multiplied by the weight of the corresponding criteria and added in the total assessment. Some features of survey tools, like data security, are beyond the scope of this article.

Since the primary goal of this article was to research existing survey tools that can match with the requirements needed for a recommender system for AAL and smart home technologies selection, other requirements and characteristics of the tools were not deeply studied and should be considered in prospective studies.

4. Conclusions and Outlook

In the beginning, the work presents the definition of a set of requirements for survey tools applied in the domain of AAL technologies. Based on these requirements, a comparison study was conducted. Therefore, a set of tools was identified and selected. In the next step, the tools were evaluated according to the weighted requirements. As a result, the LimeSurvey tool received higher punctuation in the assessment compared to the other survey tools. Although the other tools received lower scores, they could also be used with a recommender system in AAL technology selection. As a result of the documented selection process, the tool mentioned will be used as a survey platform for the recommender system in the domain of AAL technologies. The tool will guide a user during an interview-like process to identify all needs. In a second step, the recommender system will propose a solution for an AAL technology.

The basic requirements for the survey tool used for recommender systems in the scope of AAL and smart home technologies were defined and presented. A comparison was conducted among different survey tools, and the requirements that each survey tool should cover were selected. The features that are defined in the technical requirements for AAL received higher priority. The comparison is based on technical data of these survey tools, other articles, or comparisons. As calculations showed, the LimeSurvey tool has higher punctuation in the assessment compared to the other survey tools that were proposed.

LimeSurvey has proper documentation and a big support community. Installation options for own servers can make data handling safer and fully controlled by administrators. Although the other tools have lower scores, they could also be used with a recommender system in AAL technology selection. The selection of the survey tool is the first step in the creation of a recommender system for giving advice on AAL technologies. Further steps will take place under the possibilities offered by the survey tool.

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