Multi-Dimensional Presentation State – Towards a DICOM Mechanism for Consistent Presentation of Higher Dimensional Medical Imaging Data

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Abstract. Multi-dimensional patient data, such as time varying volume data, data of different imaging modalities, surface segmentations etc. are of growing importance in the clinical routine. For many use cases, it is of major importance to replicate a certain visualization of a data set created on one machine on a different computer using different software tools. Up until now, there exists no standardized methodology for this consistent presentation. We propose an extension of the Digital Imaging und Communications in Medicine (DICOM) called “Multi-dimensional Presentation State” and outline scope and first results of the standardization process.

Introduction

Recent developments in visualization techniques of medical imaging data promoted an increasing usage of three dimensional visualizations of patent data for diagnostic, medical planning, intra-operative or therapeutic assistance and documentation. In many applications, such visualizations are generated on one workstation (e.g. the radiologist’s PACS workstation) and reviewed on a different system, e.g. the referring physician’s desktop computer. It is crucial, to replicate the viewing parameters defining the appearance of the model on the creating workstation as closely as possible on the reading workstation.

Nowadays, patient models not only consist of three dimensional imaging data but also of surface models, multi-dimensional imaging data sets, e.g. time series, and other measurements which shall be visualized in a consistent way.

Up until now, there is no standardized approach to replicate the appearance of a higher dimensional patient model defined on one system on another one. The only option would be to create DICOM Secondary Capture [1] snapshots of a certain view. This guarantees for a good replication, but interaction with the model, e.g. rotating it by a certain angle, is impossible. Therefore, practical application of this workaround is limited.

Within the Digital Imaging und Communications in Medicine (DICOM) standard [2], there exists a concept of so called “Presentation States” which aim on a consistent presentation of two dimensional images, e.g. radiographs or slices of a three dimensional volume, independently of the presenting system. They have been introduced by Supplements 33 (Soft Copy Presentation State, 2000), 100 (Color Presentation State, 2004) and 120 (Extended Presentation States, 2009) [3]. Since DICOM is the prominent standard for medical image storage and handling in the medical environment, it seems natural to add an additional Presentation State describing the visual appearance of higher dimensional patient data. We called this a “Multi-dimensional Presentation State”.

Methods & Materials

DICOM is extended by so called “Supplements” which describe the additional objects and services introduced to the standard. The DICOM statutes require a Working Group taking the lead in the creation of a new Supplement. For Multi-dimensional Presentation States, DICOM WG-11 “Display Function Standard” is the lead. It closely collaborates with WG-02 “Projection Radiography and Angiography”, WG-07 “Radiotherapy”, WG-12 “Ultrasound”, WG-15 “Digital Mammography and CAD”, WG-16 “Magnetic Resonance”, WG-17 “3D”, WG-21 “Computed Tomography”, WG-22 “Dentistry” and WG-24 “Surgery”. This group will work closely with the clinical organizations, such as the ACR and AIUM as well as the Web3D consortium to develop this standard. Up until now, almost 70 individuals from industry, universities and different clinical specialties actively participated in meetings and discussions.

Clinical use cases were collected to have a profound understanding of the applications the Multi-dimensional Presentation State might have in the future. The use cases were brought in by the respective DICOM WGs, by companies having products for a particular market which might make use of the Multi-dimensional Presentation States and clinical practitioners. The use cases are to be reviewed by clinical associations within the summer / autumn 2011. After the review, the technical specifications will be refined based on the use cases.

In parallel to the use case collection, the WGs involved have compiled a glossary defining all terms and concepts needed to describe the visual appearance of a patient model from a technical perspective. This was to ensure that all stakeholders use the same terms to describe certain concepts and to avoid misunderstandings in the standardization process.

Based on the use cases, the desired features and the particular scope of the Supplement are negotiated among all stakeholders. Attributes are defined which store the input and describing parameters needed for a particular visualization.

Results
The Work Item "Proposal for New Work Item for Multi-dimensional Presentation State" has been granted by the DICOM Standards Committee has been granted.

The glossary is completed, but since it serves as a working document, contents may change as the standardization process proceeds. It defines all inputs like (multiple, maybe time varying) volumes and 3D surface meshes, 2D images for fusion with 3D volumes, fiducials, waveforms etc. Rendering parameters and features such as cropping and multi-planar reformatting, rendering algorithms, opacity maps lightning models and view point orientation. Blending and fusion of different models shall be supported. Annotations are defined as graphical or textual decoration which may have clinical significance. Animations, e.g. Endoscopic Cine or Multi-Volume Animation are included as well. The glossary also identifies proprietary features which will most likely not be covered by the future presentation state since they are hard to be described in a standardized manner. Examples are specific algorithms used for rendering, slicing, segmentation, etc. User navigation and the definition of GUI elements are out of scope of the Supplement. The current version of the glossary is available at [4].

Up until now, use cases from CT, MRI, PET, Ultrasound, Angiography, Surgery, Interventional Radiology, Education and Training and Informed Consent are available. Use cases from additional areas such as Dentistry, Oncology, Pathology, Mammography, Diffusion Tensor Imaging are in the pipeline. All use cases are accessible via [4].

From the use cases, it was already possible to derive several prototypic discipline-independent workflows (WF) which might result in Integrating the Healthcare Enterprise (IHE) Integration Profiles:

- Diagnosis Workflow
- Intervention/Surgery Procedure Support Workflow
    - Planning (see Diagnosis WF)
    - Intra-procedural assistance
- Documentation and long term storage

The Diagnosis Workflow (see fig. 1) is as follows:

- Physician or technician acquires volume data and creates MPR and volume render views on the imaging device. He/she might optionally create segmentations or fuse/blend image series of different modalities. The views supporting the radiologist's opinion are saved as presentation states.
- Reviewing physician displays Views on a review device. Data and view (in form of the presentation state) are loaded independently from each other.
- Views may be changed or added during review. The new views might be saved as presentation states, again.
- Measurements may be taken on the image Views or calculated algorithmically from the volume data
- Annotations may be made on the Views and new Views saved as documentation of the diagnosis
- A report is created, which may reference one or more Views
- The visualizations might be used for clearer patient understanding for informed consent.

The Intervention/Surgery Procedure Support Workflow is a multi-staged process:

- Planning is performed according to the Diagnostic Workflow
- Additional planning information such as selection and sizing of implants, size of a lesion, position of a tumor, definition of a work or ablation area, access strategies etc. can be performed. They result in additional data objects generated during the planning process. The whole scene can be stored as presentation state.
- During the procedure, views are dynamically updated based on previously defined presentation states to guide the work.
- Additional patient data might be acquired and fused with pre-procedural views
- Views are stored for post-procedural documentation.

From the work up until now, it is evident that it will be impossible to fully replicate the visual appearance of a higher dimensional patient model on two systems since it is impossible (and not practical) to standardize all algorithms or all interpretations of attributes. Therefore, we identified a continuum of interoperability for Multi-dimensional Presentation States. It goes from most objective and therefore most interoperable features like input definition or clipping planes towards most proprietary and therefore least interoperable features (see fig. 2). The work will first focus on the features on the most interoperable section. Based on the use cases, the stakeholders will decide which of the proprietary features shall be included and to what extend they should be formalized. The clinical relevance of each feature will be the guidance for this decision process. It will always be possible to add private (and therefore non-interoperable) elements, which are proprietary attributes defined by each vendor, to the Multi-dimensional Presentation State.

Conclusions & Discussion

The Multi-dimensional Presentation State has the potential to fill a gap in the process chain of medical image processing and usage. Since it relies on clear clinical use cases, a wide adoption within the hospital is anticipated. By early 2012, we plan to have the “First Read” in front of DICOM WG-06 “Base Standard”. In 2012, the “Public Comment” phase shall be finished. “Final Text” is estimated for the end of 2013.

The development process is open to everyone; we would appreciate any input from the visualization community.

Acknowledgments

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References

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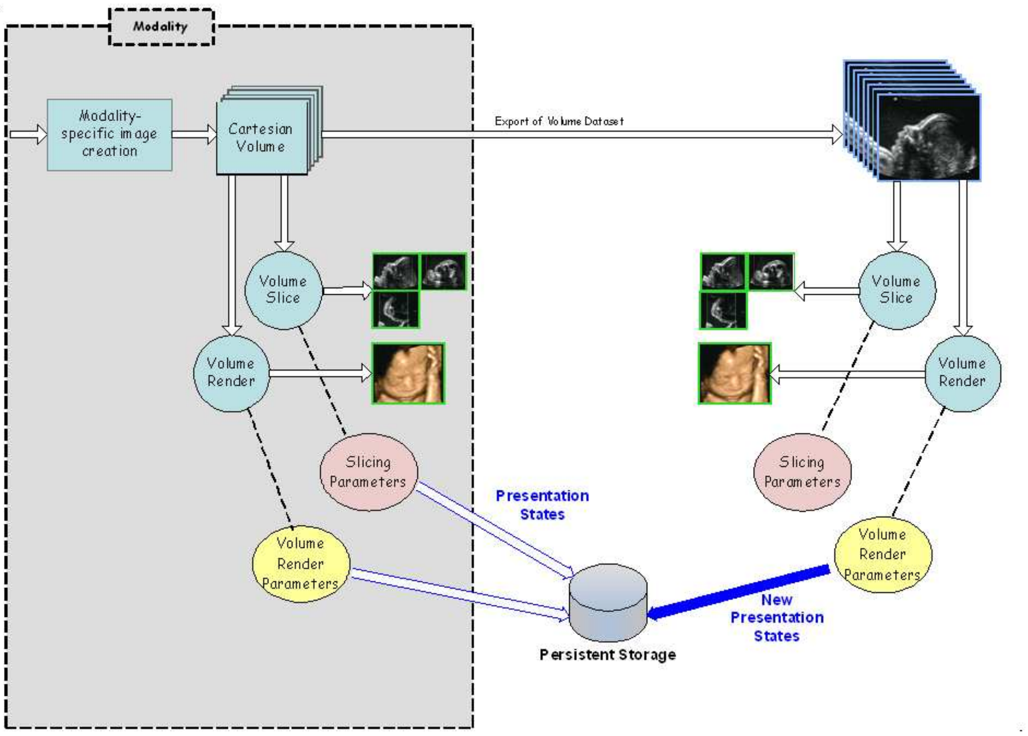
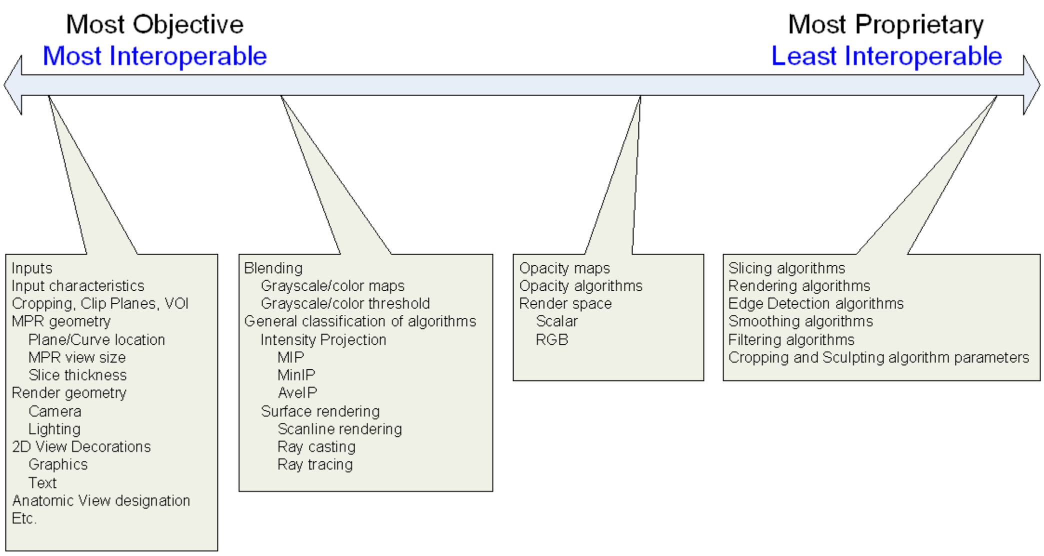
Illustrations



#1. Illustration of the Diagnostic Workflow .



#2Continuum of interoperability for Multi-dimensional Presentation States.