Standards in Augmented Reality - Towards Prototyping Haptic Medical AR

Panagiotis D. Ritsos, Nigel W. John and Jonathan C. Roberts

Bangor University, UK

{p.ritsos, n.w.john, j.c.roberts} @bangor.ac.uk

Abstract

Augmented Reality technology has been used in medical visualization applications in various different ways. Haptics, on the other hand, are a popular method of interacting in Augmented and Virtual Reality environments. We present how reliance on standards benefits the fusion of these technologies, through a series of research themes, carried out in Bangor University, UK (and international partners), as well as within the activities domain of the Research Institute of Visual Computing (RIVIC), UK.

Keywords: *Medical Augmented Reality, Haptics, Standards*

Augmented Reality (AR) technology is used in various research fields, with different context and requirements. This mosaic of AR flavours spans from simple, 'core' use cases, such as tour guides [20] to more complex medical applications [16]. The complexity of such systems is often increased through the fusion of AR with various interaction technologies, such as haptics or gesture recognition.

The variety of use cases, coupled with the frequent misuse of the term AR leads to confusion about what the field entails, what AR truly means and whether some of the aforementioned use cases are, indeed, AR. Bearing in mind the variety of AR examples that the AR Standards community investigates, revisiting definitions may be worthwhile.

Barba et al. [2] follow a modern approach, taking into account how technology has evolved in the current era of the smartphone and almost ubiquitous internet access. They emphasise that AR must be treated as a subset of Mixed Reality (MR), as defined by Milgram and Kishino [15]; specifically as the technique for visually aligning interactive virtual content, spatially superimposed and registered on the physical world, as defined by Azuma [1]. Furthermore, they argue that MR must be broadened to include other forms of reality augmentation, as discussed by Mackay [14]. We feel notions related to Weiser's ubiquitous computing [25] can be also included.

Azuma's definition pinpoints the need for AR to be interactive, despite the fact that AR applications, predominantly, focus on visual representation. We believe that by enhancing interaction in AR the remaining senses complement vision, resulting in systems that offer a more organic perception of the synthetic (physical and computer-generated) space.

This paper presents a view on how haptics can be used as means of interaction in medical AR applications. Our approach is based on research carried out in the School of Computer Science, Bangor University, UK[1] along with international partners, as well as within the domain of activities of the Research Institute of Visual Computing (RIVIC), UK[2]. We highlight how these research themes can be fused together through standards, such as X3D.

Importantly, reliance on standards ensures that implemented systems can be built, combined,

[1] `http://www.cs.bangor.ac.uk`

[2] `http://www.rivic.org.uk` – A collaborative amalgamation of research programmes between the computer science departments in Aberystwyth, Bangor, Cardiff and Swansea Universities

maintained, distributed and enhanced with greater ease [21]. In particular, in the academic domain, where research themes are persistent as student cohorts come and go, reliance on standards offers a certain continuity and allows mature prototypes to be easily adopted by the industry. After all, “conformance supports progress since all science must be repeatable” [23].

The structure of the paper is as follows: Section. I describes how web technologies, in particular X3D, are being employed in medical visualisations to enhance interoperability and accessibility. Section. II presents how a haptic prototypic toolkit can be used to fabricate haptic interactions and how these can be used with ‘built-on-standards’ medical AR. Finally, Section. III offers some concluding remarks.

I. X3D in Medical AR

AR technology can be used *in situ*, in medical settings, to visualize patient scan data [16]. Such data can be obtained from medical scanners, which include support for MRI, CT and Ultrasound modalities. Nowadays manufacturers of such devices provide workstations that support 3D visualisations of patient data. To enable easier storage, handling and transfer of medical data between devices, the Digital Imaging and Communications in Medicine (DICOM) standard has been adopted [10].

Nonetheless, in order to increase interoperability and accessibility of medical data, one could rely on the use of web technologies. Towards this effort, the Web3D consortium has formed a Medical Working Group, which acts towards the development of MedX3D, an extension of X3D, the ISO standard for using 3D graphics over the internet [6]. MedX3D supports the functionality and interoperability required in medical visualization systems and allows various improvements in medical care, including surgical planing, medical education and accessibility [11].

Currently, four key tasks have been completed, including the specification of the X3D Volume Rendering Extensions (VRE) and the MedX3D

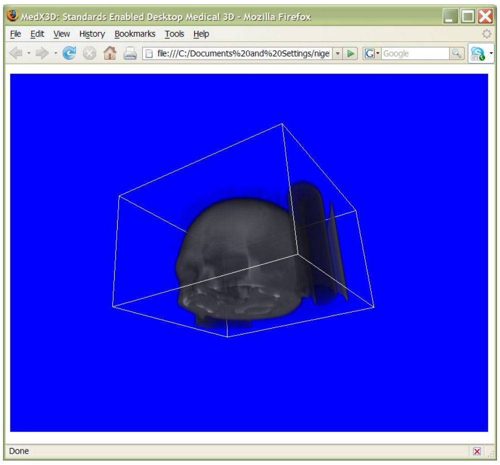

Figure 1: MedX3D browser plugin, displaying data from a CT Scan.

profile, segmentation and ontology support, an import/export library and a web browser plugin (see Fig. 1) that can read DICOM data and provide 3D visualization through the VRE. Further information can be obtained from [11, 23]. An effort to overcome the requirement for specialised plugins, which may be limiting in mobile systems [4] is MEDX3DOM [7], which is using the X3DOM [3].

Building on the above standards, medical simulators benefit from increased fidelity, as hardware develops, becomes cheaper and more accessible. An example of this is the use of H3DAPI[3] in ImaGiNe-S Imaging Guided Needle puncture Simulation [5]. H3DAPI is an open-source haptics software development platform that uses OpenGL and X3D. It extends X3D with support for haptic interaction and volume rendering [23] and allows users to build applications for various haptic devices, combining X3D, C++ and Python. H3D also has support for physics engines such as PhysX and SOFA. The latter is specifically designed for surgery simulation.

A similar effort of a haptic extension of X3D, albeit not strictly for medical visualisations, is that from Kurmos et al. [13], who present a partial implementation of a Java wrapper to the HAPI open-source C++ haptics library, named JHAPI.

[3] `http://www.h3dapi.org`

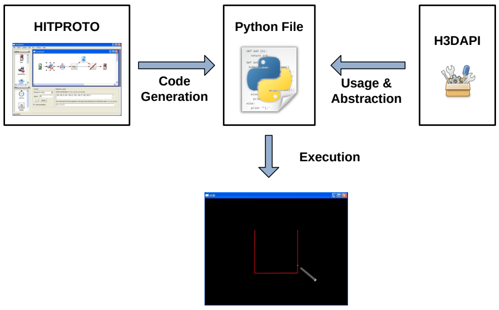

Figure 2: HITPROTO toolkit architecture. Haptic interactions are modelled using HITPROTO. The produced interactions, (saved in Python) are interpreted by H3DAPI and can be integrated in larger systems

They provide a demonstration of its use within the Xj3D browser through the Scene Authoring Interfacer (SAI). The JHAPI has proven to work effectively with static objects and future work will investigate the creation of a similar wrapper for CHAI3D[4].

II. Prototyping Haptic Interactions for Medical AR

Haptics have been used in the past to interact with computer generated objects in AR/MR environments [8, 9, 24]. We suggest an architecture for fabricating haptic interactions for AR, based on the use of the toolkit HITPROTO [17, 18].

HITPROTO enables users to quickly create haptic interactions through a graphical programming interface. The toolkit uses a modular approach where the developer drags and drops components into a design area (canvas), assembling diagrams that translate into haptic interactions. Each component, called 'Block', maps to elements and functions of the H3DAPI. Creating a haptic interaction with HITPROTO is a three step process (see Fig. 2): (a) The developer builds an interaction diagram by connecting modular blocks together, referencing objects in an X3D scene, (b) the diagram is saved in an intermediate .hit XML file (c) HITPROTO outputs a H3D Python file. The H3DAPI viewer is then used to execute the scene.

[4] `http://www.chai3d.org/`

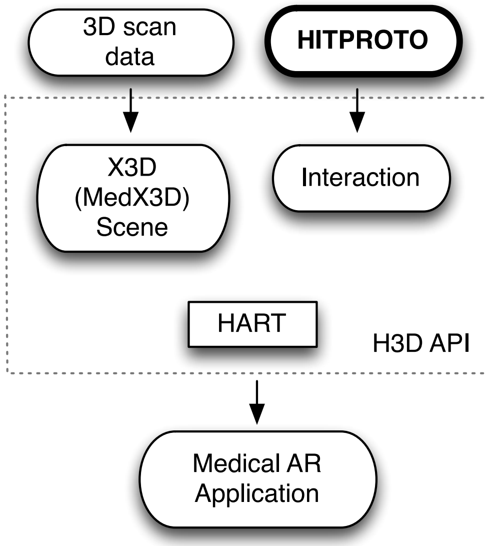

Figure 3: Due to its reliance on standards the HITPROTO toolkit can be combined with popular APIs to produce AR scenarios (such as medical AR with the use of 3D scan datasets), allowing the developer to quickly prototype haptic interactions with those objects.

In theory, the toolkit could be used with any device supported by H3DAPI; however the current system has only been tested with the PHANToM Desktop, with support for more devices planned for the future. Moreover, outputting interactions as components written in an established language like Python ensures easier integration with existing systems. The Python code can be used as is or modified and integrated within systems using the H3DAPI.

HITPROTO's reliance to standards enables it to be part of a larger development process that creates AR demonstrations. Our hybrid architecture builds upon X3D and H3DAPI (see Fig. 3) and abides to Azuma's definition of AR. It combines MedX3D/X3D for displaying 3D medical data (virtual), HITPROTO for prototyping haptic interactions (interactive in real time), and HART [22][5], a bridge handling the connection between ARToolkit [12] and H3DAPI (view of real world and 3D registration).

At the moment HITPROTO has been used pri-

[5] `http://webstaff.itn.liu.se/~karlu/work/HART/`

marily in haptic data visualization [19]. It has, however proven to be usable, even from users with no or very little programming. We believe it can be a useful tool in implementing haptic interactions in AR. It offers a powerful abstraction mechanism for haptics and its reliance on standards promotes a modular approach, allowing its synthesis with other systems to create more elaborate medical AR investigations.

III. Conclusion

This paper suggests an approach into prototyping haptic interactions for medical AR systems, based on the use of the HITPROTO toolkit and established APIs and standards, used for medical visualization and haptics. X3D is the foundation upon which our architecture is built on. The goal of our approach is prototyping haptic interactions using a visual programming toolkit, allowing developers to add an advanced form of interaction in their medical AR application. We believe that this use case is a prime example of how standards assist researchers and developers in implementing complex AR systems.

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