Impact Objectives

- Introduce novel user interfaces and interaction experiences in workspaces where professionals are engaged in collaborative tasks around 3D medical images
- Ultimately, use this technology to make medical workspaces more productive, accelerate critical thinking and clinical decision-making, and in doing so accelerate care and patient outcomes

Medical interfaces of the future

Many aspects of healthcare are becoming increasingly entwined with 3D imaging as a means of diagnosis, surgical navigation and procedure planning as an alternative to expensive and invasive techniques. Here, ***Dr Daniel Simões Lopes*** *tells us about the* ***IT-MEDEX*** *project, which is working to make 3D medical images ever more powerful and usable on an array of devices*

Could you tell us a little about the role of imaging in medicine?

Healthcare has become immensely dependent on digital imagery. Virtually every medical speciality relies on images either for diagnosis, surgical planning, surgical navigation, education or patient-clinician communication. Nowadays, we cannot imagine healthcare practice without relying on image data, particularly 3D medical images. Several imaging modalities allow professionals to visualise the inner anatomy without disrupting tissue continuity and give us the possibility to extract faithful representations of a patient's anatomy. That is why planning complex surgeries, designing subject-specific implants or solving intricate diagnostic cases would not be possible without 3D imagery. It is also important to realise that whenever professionals exchange image data among themselves, they open interesting discussions to solve clinical cases, as medical images foster visual collaboration and promote greater anatomical insight, hence contributing to a boost in visual memory through collaboration.

Can you discuss a little about your background and how you arrived at the IT-MEDEX project?

I have a degree in biomedical engineering from the University of Lisbon, Portugal, and graduated in computational engineering under the framework of the University of Texas at Austin|Portugal Program from the same university. Currently, I am a postdoctoral scholar at INESC-ID Lisboa with interests in computer graphics and human-computer interaction applied to 3D modelling, radio-diagnostics, surgical planning, surgical navigation and physical rehabilitation.

My hands-on experience with conventional user interfaces for volume visualisation and image segmentation led me to ponder on new interaction possibilities which conventional interfaces do not promote. However, it was only as a visiting scholar in France that I had the chance to further elaborate on these possibilities. Together with very talented colleagues from Inria Lille, we developed an application to interactively visualise and explore volume data in real-time. So, the work initiated at Lille was indeed the 'seed point' of what later became the IT-MEDEX project.

The IT-MEDEX project will explore and evaluate healthcare areas where such technologies can add value over traditional assessment and intervention approaches. Have you identified specific areas of medicine that will benefit the most from this technology?

At its core, the IT-MEDEX project is about designing medical user interfaces and medical user experiences. In each interface, we build a bridge between interactive technologies and healthcare applications where 3D medical images are involved. Several healthcare areas have been considered, namely: radiodiagnosis, surgical planning, surgical navigation and medical education. Within each area, we have identified conventional workspaces that present serious limitations in the way healthcare professionals analyse and understand 3D medical images. The typical workspace confines the user to a desk with monitors in front of them, and restrains interaction with such rich and complex image data by relying on a mouse and keyboard. It is in these workspaces that interactive technologies promote more interesting forms of interaction. For instance, large interactive displays enable multi-touch interaction on a wide surface whether in a horizontal or vertical configuration. That way, we can have several professionals collaborating around the display to directly control and share digital content. Other interactive surfaces such as tablets and smartphones also have much more potential than their consumer oriented purposes. For instance, these devices can be converted into what we call a 'six degrees-of-freedom universal remote control': a tablet can be used to perform 3D rotations and 3D translation, change the opacity and colour maps, apply 3D clipping planes, share content, make annotations on the volume, measure distances and angles, etc.

To what extent will current technology limit what you can do with the IT-MEDEX project?

Even though we live in an amazing period where interactive surfaces, motion capture technology, virtual reality (VR) and augmented reality coexist in device ecosystems, there are still several technological bottlenecks that limit our research potential. For instance, all our radiology and surgical partners complained that current head-mounted displays have lower resolution than conventional medical imaging displays. This is an undesirable technical feature for radiodiagnosis and surgical practices, as medical imaging displays must allow the visualisation of subtle details that sometimes only become visible after performing many brightness and contrast adjustments to the image. Even so, we believe that head-mounted displays with higher resolution will become available in a couple of years. Another technical limitation we face is noise from depth cameras, as such devices provide skeletal tracking signals and gesture recognition output that lack precision regarding joint position and segment orientation, and do not track many people and their hands very well. Accuracy-controlled and high-precision skeletal tracking and gesture recognition are mandatory to perform adequate gestures in surgical scenarios, especially in surgical navigation. Regarding interactive surfaces such as tablets and smartphones, they do not have enough computational power to produce volume rendering imagery in real-time, much less images with global illumination realism (i.e., light and shadow effects). Even for relatively small volume data sets, these devices overheat and batteries drain too fast.

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Do you see this project as a springboard to introduce increasing levels of VR to medicine?

This is an excellent question. It is well known that medical professionals can be resistant to changes in their workflow. Nevertheless, once a few technicalities are fixed (see previous question), professionals appear to be very receptive to adopting VR-based diagnostic and VR-based surgical planning as work tools in everyday practice. Every single healthcare participant mentioned that VR is more than suitable for radiologic education and surgical training. Our healthcare partners also mentioned that it is very important to guarantee that each VR prototype consists of a plug and play, portable and cost-effective setup. These requirements have always been part of the IT-MEDEX project desiderata, which is why we truly believe that it will contribute to introducing increased levels of VR to healthcare. Furthermore, we have always received enthusiastic responses from clinicians, radiologists and surgeons when testing our VR prototypes.

Is the IT-MEDEX project likely to develop bespoke software to use in the project?

The development of all applications always follows good software engineering practices. All applications are made with Unity game development software, being mostly coded in C# and GLSL shading languages. In order to minimise integration problems, each software component is available in a web subversion repository SVN. All modules and prototypes, even those under development, remain in this same repository accessible to all researchers of the project. We also follow an open source and freeware philosophy by sharing part of our software to the community, and to date we have made available an interactive volume and surface rendering engine.

How do you plan to publicise this research and the technology used?

Dissemination of project outcomes is an imperative task in any research project. For this purpose, we organised a workshop on interaction in healthcare to discuss the crucial role that medical interface and interaction design play in healthcare. This workshop brought together actors with different specialities (clinical, academic or industrial) who shared their experiences on how human-computer interaction and interactive technologies can contribute to improving healthcare delivery. Several team members also give talks as invited speakers at international and national venues. It is always very satisfying to capture the reactions of the general public. That is why we showcase our prototypes at fairs and public events.

Project Insights

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CONTACT
Daniel Simões Lopes
Principal Investigator

T: +351 21423508
E: daniel.lopes@inesc-id.pt
W: http://it-medex.inesc-id.pt/home

PRINCIPAL INVESTIGATOR BIO

Dr Daniel Simões Lopes has a degree in biomedical engineering from the University of Lisbon, Portugal, and graduated in computational engineering under the framework of the University of Texas (UT) at Austin|Portugal Program. He was a visiting scholar at the Neuromuscular Biomechanics Laboratory of UT Austin where, under the supervision of Dr Richard Neptune, he focused his research on integrating detailed contact models and musculoskeletal modelling techniques to estimate joint loading during human gait. He was also a visiting scholar at Inria Lille where he contributed to the development of an application to interactively visualise and explore volume data in real-time. Besides IT-MEDEX, he is also a postdoctoral researcher and Head of Biomedical Research at the Visualization and Intelligent Multimodal Interfaces Group at INESC-ID Lisboa.