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SMART INDUSTRIES

SARA

Surgical Augmented Reality Assistance

Computer-assisted surgery (CAS) is becoming an essential tool for surgical planning and guidance, as well as a tool to train for surgical procedures. Existing CAS solutions provide surgeons with anatomical references as well as with planning information such as cutting lines and resection boundaries. In addition, they may automatically update the images based on the positions of tools or pointers. However, with these solutions, the surgeon must still look away from the patient to a nearby display and then mentally align the visualized 2D structures with what they see on the table.

Augmented reality (AR) promises to overcome this shortcoming by projecting information directly onto the surgeon's field of vision through AR glasses. That way there is a visual one-to-one relationship between the information and the patient or task at hand. The SARA project investigated the use of AR to improve the CAS experience. More specifically, it examined overlaying a 3D rendering of medical images and planning information onto the patient's anatomy during neurosurgery and orthopedic surgery.

FRAMING THE RESEARCH OBJECTIVE

Augmented reality solutions that want to provide accurate information and overlay it on a patient, need 3D models of the relevant anatomical structures, a means to accurately align the 3D models with the patient's anatomy, as well as advanced visualization techniques.

The SARA project made advances for all three of these requirements. It developed (semi)automatic image segmentation tools to easily generate the required 3D models, innovative and accurate real-time marker-based alignment methods, and intuitive visualizations for the surgeon.

THREE MAIN OUTCOMES

The SARA project resulted in a pipeline procedure to enable the accurate separation of anatomical structures in neurosurgery and orthopedic surgery. It mainly focusses on the intuitive and accurate (semi) automatic segmentation of the brain and spinal anatomy based on state-of-the-art deep learning methods. These methods allow to convert medical images in a fast and convenient way into high-quality 3D models that are then easily transferred to the AR glasses.

Whereas conventional on-board methods in AR glasses for visually overlaying AR content onto the physical world are accurate up to a few centimeters, the project developed methods with a validated accuracy of less than 2mm, an accuracy comparable to commercial surgical navigation systems. This allowed the SARA solution to use existing surgical infrared markers and toolsets to provide a surgical navigation solution that is comparable to what is commercially available, albeit using off-the-shelf all-in-one AR glasses.

As part of the SARA project, there was a clinical validation for both neuro and orthopedic surgical use cases, including phantom, pre-clinical, and clinical trials. The use of AR for intracranial drain placement has shown that not only is the learning curve of the procedure reduced preclinically, but also that clinical accuracy in placement is improved by providing surgical navigation at the bedside where freehand techniques have traditionally been used. In addition, it has been demonstrated that outcomes in long-bone drilling are improved compared to traditional proprioceptive techniques at non-normal incident angles. Lastly it has been shown that AR provides a real-time solution for the determination and reconstruction of the functional rotation centers of femoral heads and acetabulum during hip arthroplasty, with results showing <5mm accuracy in phantom trials (10mm is conventionally considered as good).

In general, the SARA project has demonstrated that off-the-shelf AR hardware allows a more intuitive, lightweight, and mobile solution when compared to conventional navigation systems. We found that the best use of AR for surgical navigation are those applications where surgical navigation is currently not yet used but could be of benefit. This is for example the case with drain placement where commercial hardware has mobility limitations. A second use are those applications that are too specific and limiting to build a general application, as in the case of orthopedic navigation.

NEXT STEPS

The technology of the SARA project is currently being patented, and the options for commercialization are explored. In addition, a follow-up icon project AIM aims to update the 3D visualizations during the surgical procedures so that they take into account the anatomical changes induced by the procedures. Additionally, we want to automate the collection of a variety of clinical measurements as for instance angles, distances, and rotation centers in orthopedic procedures. Thirdly, additional clinical studies are running to further validate the technology, its positive impact on surgical procedures, and its application in training novice surgeons.

TRENDIFY project partners:

The SARA project was co-funded by imec, with project support from Agentschap Innoveren & Ondernemen

FACTS

NAME	**SARA**
OBJECTIVE	To improve surgical procedures by means of AR technology
TECHNOLOGIES USED	AR, deep learning, 3D models, surgical planning
TYPE	imec.icon project
DURATION	01/10/2018 – 30/09/2021
PROJECT LEAD	Pieter Slagmolen, Materialise
RESEARCH LEAD	Bart Jansen, imec – ETRO-MIT – VUB
BUDGET	1,846,333 euro
PROJECT PARTNERS	Materialise, eSaturnus, Orsi Academy, De Cronos Groep
RESEARCH PARTNERS	VUB - C4N – Neur, VUB - BEFY - ORTHO
RESEARCH GROUPS	imec – SMIT – VUB, imec – ETRO-MIT – VUB

WHAT IS AN

IMEC.ICON PROJECT?

The imec.icon research program equals demand-driven, cooperative research. The driving force behind imec.icon projects are multidisciplinary teams of imec researchers, industry partners and/or social-profit organizations. Together, they lay the foundation of digital solutions which find their way into the product portfolios of the participating partners.

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