Validation of Mixed Reality Visualisation for Clinical Skill Development

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Introduction

Over the recent decades, minimally invasive surgery (MIS) has been introduced in various clinical specialties, such as general surgery, neurosurgery and interventional radiology and undoubtedly offers significant benefits to the patients(1) . However, the lack of direct interaction with the tissues, poor depth perception, fulcrum effect and the depiction of 3D anatomical objects into 2D screens are challenges for the clinicians, which may result in errors due to early mental fatigue. Mixed Reality (MR) visualisation is a promising technology and potentially may be utilised to overcome the above challenges. A considerable number of studies(2,3) demonstrated that from the commercially available Three-Dimensional Head-mounted display devices (3D HMD, there is technical and clinical superiority of Microsoft HoloLens, which is being used for the present project.

Objectives:

- A systematic review and meta-analysis of Microsoft HoloLens studies with direct and indirect clinical impact.
- Explore the intraoperative surgical navigation and visualisation framework, to support the user to perform a specific clinical task (Ultrasound-guided Common Femoral Artery puncture) with better accuracy.
- Clinical study including surgeons with varying level of expertise to validate the developed HoloLens framework.

Methods

Metanalysis

- A detailed systematic review of all the HoloLens-related studies and further categorization according to their focus.
- Statistical analysis of the accuracy results, using Rstudio statistical software and STATA.

Framework

- Perform ultrasound-guided Common Femoral Artery (CFA) puncture, recorded by HoloLens2 in a blue phantom ultrasound model (Simulation Suite, Paterson Building).
- Real-time dynamic streaming of the ultrasound imaging into the HoloLens' glasses using Unity applications (C# script).
- Surgical navigation of the position and orientation of the needle by using visualization tools.

Current work and project plan

- Completion of the statistical analysis for target error estimation.
- Development of the framework for real-time ultrasound streaming onto HoloLens
- Development of intraoperative visualised navigation for the correct position and orientation of the needle.
- Clinical study to evaluate the developed framework.

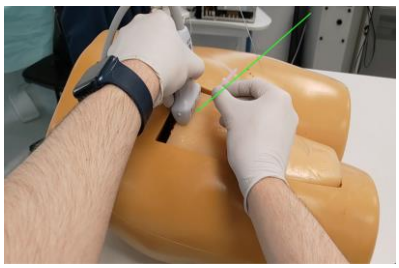

***Figure 1: Left:** : HoloLens surgical navigation regarding the desired position and orientation of 18G needle for the CFA puncture., **Right:** Rear-time feedback of the location of the needle in the ultrasound scan with navigation with the desired trajectory*

Preliminary Results

Metanalysis:

- 35 studies were selected.
- Considerable Heterogeneity (I^2 >75%), due to clinical and methodological diversity of the studies.
- Lack of standardised evaluation methods.
- Extremely positive feedback from the clinicians.
- Rapid and efficient learning curve even from inexperienced users.
- In most of the studies there is improvement of the accuracy by using HoloLens.
- Encouraging results with strong potentiality for clinical adoption in the near future.

Discussion

The CFA puncture is one of the most performed procedures, as it is the first and foremost step for many diagnostic and therapeutic interventions. Surgical navigation provided by MR would increase the accuracy and minimise the complications, resulting to better clinical practice. Despite the significant heterogeneity of the current studies, Microsoft HoloLens brings a new era in the medical MR, representing a novel, optimistic and promising technology for MIS. Further research for improved registration techniques, higher accuracy and even training for surgeons would encourage the introduction in the operative theatre in a regular basis.

References

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