Transforming Medical Education and Training with VR using M.A.G.E.S.

George Papagiannakis
ORamaVR
Foundation for Research Technology Hellas
University of Crete, Department of Computer Science, Heraklion, Greece
george.papagiannakis@oramavr.com

Nick Lydatakis
ORamaVR
nick@oramavr.com

Steve Kateros
ORamaVR
steve@oramavr.com

Stelios Georgiou
ORamaVR
stelios@oramavr.com

Paul Zikas
ORamaVR
paul@oramavr.com

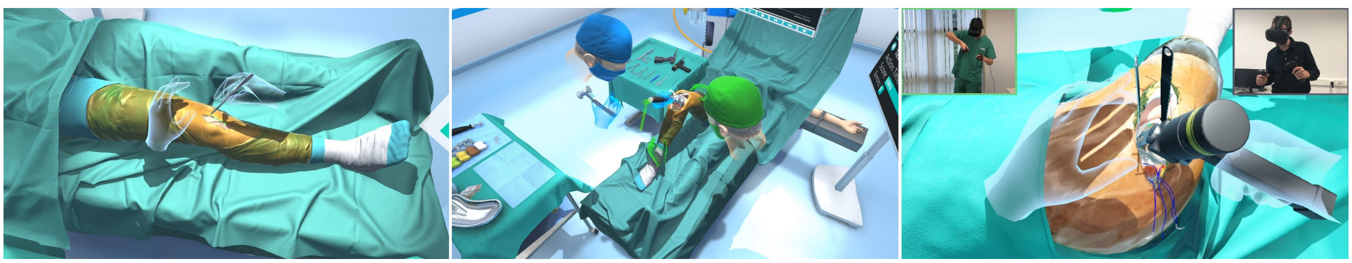

Figure 1: Different medical scenarios and functionalities of our system: a) Initial incision in Total Knee Arthroplasty simulation based on the medial parapatellar approach, b) Cooperative Total Knee Arthroplasty in which the main surgeon inserts the femoral implant, c) Femoral Hip resection performed by the main surgeon in Cooperative Total Hip Arthroplasty.

ABSTRACT

In this work, we propose a novel VR s/w system aiming to disrupt the healthcare training industry with the first Psychomotor Virtual Reality (VR) Surgical Training solution. Our system generates a fail-safe, realistic environment for surgeons to master and extend their skills in an affordable and portable solution. We deliver an educational tool for orthopedic surgeries to enhance the learning procedure with gamification elements, advanced interactability and cooperative features in an immersive VR operating theater. Our methodology transforms medical training to a cost-effective, easily and broadly accessible process. We also propose a fully customizable SDK platform able to generate educational VR simulations with minimal adaptations. The latter is accomplished by prototyping the learning pipeline into structured, independent and reusable segments, which are used to generate more complex behaviors. Our architecture supports all current and forthcoming VR HMDs and standard 3D content generation.

SA '18 Posters, December 04-07, 2018, Tokyo, Japan

ACM ISBN 978-1-4503-6063-0/18/12.
https://doi.org/10.1145/3283289.3283291

CCS CONCEPTS

• **Computing methodologies → Virtual reality**; • **Applied computing → Interactive learning environments**; Collaborative learning; Distance learning;

KEYWORDS

Virtual Reality, Surgical training, Psychomotor simulation

ACM Reference format:
George Papagiannakis, Nick Lydatakis, Steve Kateros, Stelios Georgiou, and Paul Zikas. 2018. Transforming Medical Education and Training with VR using M.A.G.E.S.. In *Proceedings of SA '18 Posters, Tokyo, Japan, December 04-07, 2018,* 2 pages.
https://doi.org/10.1145/3283289.3283291

1 INTRODUCTION

Since the beginning of surgical education, there has not been much improvement on the apprenticeship-training model. Cadaver models are mostly used to train apprentice surgeons in addition to books, videos and on-the-job learning. However, cadavers dramatically increase the cost of training and lead to limited real training sessions per surgeon. In addition to the commonly used training mediums, the current course of a training surgeon requires the transfer of knowledge and skills from a master surgeon through tasks during a real surgery. Although this master-apprentice teaching method is nowadays standard, the learning-on-the-job demands are high

[Papagiannakis et al. 2018]. In recent decades, robotic simulations have been introduced to enhance training by offering reusable, technological alternative solutions. However, due to the cost of such simulators it is difficult for independent surgeons to afford them on a large scale resulting in the use of alternative solutions including AR/VR platforms for advanced training [Vacchetti et al. 2004]. Our system offers a great supplementary tool for VR medical training. We can massively prototype and deliver a variety of simulated surgical operations in a fail-safe environment due to our fully customizable platform - SDK.

2 OUR M.A.G.E.S. METHOD

2.1 Multiplayer with Geometric Algebra Transformations

Our innovative networking layer, allows multiple surgeons/assistants to perform cooperative operations while extending the current educational model. To support a large number of participants in the virtual Operating Room (OR), we implemented our custom Conformal Geometric Algebra (CGA) GPU interpolation engine to reduce the data transfer on the network. Dual Quaternions provide a smoother and more reliable interpolation between the transformation values [Papagiannakis 2013] while reducing the network traffic by compressing the broadcasted values. Such innovative cooperative system supports the simultaneous training of multiple apprentice surgeons within the same VR operating theatre. Interpolating between two positional values using our own system has a major impact in performance [Papaefthymiou et al. 2016], in network utilization and finally in the visual output.

2.2 Analytics Engine

At system s/w level, we present our own Analytics engine with cloud-based user assessment to track, monitor and present important feedback regarding each gamified operation. VR environments provide a variety of tracking capabilities, from hand movement tracking to measuring an unexpected approach; we utilize a variety of means to generate a surgical profile for each user that will be used for evaluation. Real-time error tracking with visual indications, completion time of each step and global leaderboard are also supported. We also offer various error types, which augments the real-time operation with additional challenges. Gathered analytics data from users is used to improve the scoring system based on average performance. Finally, the operation's difficulty level adapts according to participant's skills offering a learning tool for beginner specialist and a challenging simulation for experienced surgeons.

2.3 Gamified Rapid Prototyping

Another novelty our system exhibits, is the rapid prototyping of surgical operations using our custom visual scripting editor. Medical operations can be modeled, modified and generated through scriptable nodes to speed up the content production while offering a user-friendly, coding-free SDK environment. Since surgical operations contain clearly defined steps, we utilize a classification method to extract and break down complex surgical patterns. This segmentation offers great flexibility in the content creation while enables the development of a prototyped platform architecture.

2.4 Educational Curriculum

The majority of VR simulators primary provide training [Gallagher et al. 2005], neglecting the educational factor. Training refers to the acquisition of skills whereas education refers to the acquisition of knowledge and information. Our products integrate an educational curriculum [Kateros et al. 2015] to enhance knowledge and skills. Through our platform, we highlight the critical parts of each simulation, prioritizing and inform our users about the learning elements of each operation. Gamification elements [Zikas et al. 2016] linked with narration are also integrated for additional challenges as a key motivational factor for users to repeat their training.

2.5 Semantic Representation of Medical Operations

For rapid operation adaptation to variations, we implemented a semantic representation of medical operations to replicate each surgery in a directed acyclic graph. By prototyping commonly used patterns and surgical techniques we managed to create a customizable platform able to populate new content with minimal changes. More specifically, a surgical session consists of several repetitive actions that can be modelled and used repeatedly through operations. Such custom surgical action prototypes support a variety of commonly used interactions and procedures of a real surgery offering great flexibility in the development of VR surgical metaphor.

3 FUTURE WORK

We already have two extra operations undergoing. In the future, we aim to implement image recognition machine learning for real-time suggestions on optimal surgical approaches. Finally, we also target to extend our visual scripting editor into a VR editor in order to create content directly from the virtual environment.

REFERENCES

Anthony Gallagher, Ritter E. Matt, Champion Howard, Higgins Gerald, Fried Marvin P., Moses Gerald, Smith C Daniel, and Satava Richard M. 2005. Virtual Reality Simulation for the Operating Room: Proficiency-Based Training as a Paradigm Shift in Surgical Skills Training. *Annals of Surgery* 241 (2005), 364–372. https://doi.org/10.1097/01.sla.0000151982.85062.80

Stavros Kateros, Stylianos Georgiou, Margarita Papaefthymiou, George Papagiannakis, and Michalis Tsioumas. 2015. A Comparison of Gamified, Immersive VR Curation Methods for Enhanced Presence and Human-Computer Interaction in Digital Humanities. *International Journal of Heritage in the Digital Era* 4, 2 (2015), 221–233. https://doi.org/10.1260/2047-4970.4.2.221 arXiv:https://doi.org/10.1260/2047-4970.4.2.221

Margarita Papaefthymiou, Dietmar Hildenbrand, and George Papagiannakis. 2016. An inclusive Conformal Geometric Algebra GPU animation interpolation and deformation algorithm. *The Visual Computer* 32, 6 (01 Jun 2016), 751–759. https://doi.org/10.1007/s00371-016-1270-8

George Papagiannakis. 2013. Geometric Algebra Rotors for Skinned Character Animation Blending. In *SIGGRAPH Asia 2013 Technical Briefs (SA '13)*. ACM, New York, NY, USA, Article 11, 6 pages. https://doi.org/10.1145/2542355.2542369

George Papagiannakis, Panos Trahanias, Eustathios Kenanidis, and Eleftherios Tsiridis. 2018. *Psychomotor Surgical Training in Virtual Reality*. Springer International Publishing, Cham, 827–830. https://doi.org/10.1007/978-3-319-64177-5_41

Luca Vacchetti, Vincent Lepetit, Michal Ponder, George Papagiannakis, Pascal Fua, Daniel Thalmann, and Nadia Magnenat Thalmann. 2004. *A Stable Real-time AR Framework for Training and Planning in Industrial Environments*. Springer London, London, 129–145. https://doi.org/10.1007/978-1-4471-3873-0_8

Paul Zikas, Vasileios Bachlitzanakis, Margarita Papaefthymiou, Steve Kateros, Stylianos Georgiou, Nikos Lydatakis, and George Papagiannakis. 2016. Mixed Reality Serious Games and Gamification for smart education.