Augmented Reality as a Tool to Deliver e-Learning based Blended Content in and out of the class-room

Marius Erdt[1], Jason Maroothynaden[2] , Junming Peng[1], Wolfgang Mueller-Wittig[1] , Paul Gagnon[2]

[1]Fraunhofer IDM@NTU, Singapore
[2]Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore

Abstract

In this paper, we present a mobile Augmented Reality application that can be used for undergraduate anatomical education. It can be used in and out of the classroom. In the classroom, the application can track and augment 3D objects such as a cadaveric solid organ (e.g. heart) specimens as well as 3D plastic anatomical models without the use of observable markers. Out-side the classroom, virtual representations of the hearts were computed and added as an offline version to the application allowing students to self-learn. To allow students to "sense-make" concepts and add additional educational value to offline content, the application can also track 2D content like printed posters. Augmentation in 2D and 3D views via various digital content modalities supports students in learning and "sense-making" anatomical terms and concepts.

Categories and Subject Descriptors (according to ACM CCS): K.3.2 [Computer and Information Science Education]: Computer Science Education—

1. Introduction

The complete spectrum of education has now evolved into student active learning. Recently the World Health Organization has identified "eLearning as likely to be as effective as traditional methods for training health professionals" (http://whoeducationguidelines.org). This is particular true for anatomy education which is undergoing significant changes due to curricular time constraints, limited availability of cadavers and technological developments in the areas of three-dimensional modeling and again e-learning. With no prescribed template for anatomy tuition, most modern undergraduate courses use a range of methods including imaging, classroom teaching, problem based learning and now flipped classroom approach to provide a solid foundation in general anatomy. The use of cadavers is mainly utilized for postgraduate training where detailed knowledge of regional anatomy is required. However, both student types struggle with learning and "sense making" anatomical terms and concepts, 3D arrangements of organs and structures in the body systems, and their clinical contextual relevancies. For undergraduates, the use of 3D stylised plastic and virtual 3D computer models is common for learning initial terms and concepts pertaining to general anatomy (http://www.visiblebody.com). Zhu et al. [ZHM*14] provide an extensive literature review about the use of AR in healthcare education. Blum's et. al. [BKB*12] magic mirror system which augments the users own body image that is seen on a TV screen represents a good example of the technological development of AR in/for anatomy sciences. However, these standard models do not show natural variation in specific organ structures, tissue textures, and colours. Where perceptual knowledge of 3D organ size and arrangements in the body systems is required, it is best to use cadaveric specimens. However, due to storage cost and logistics this is not always possible. Plastinated models are ideal because they are real anatomical specimens, which have been preserved with reactive polymers. However plastinated models are expensive. Their availability is also limited in the classroom, with learners often crowding around models. It would be ideal to digitise the plastinated models and view them via a mobile device inside and outside of the classroom. Furthermore, augmented 2D posters via flipped-book-style overlays offer the content creator (i.e. course leads) "value-added" educational content via the ability to present a specific topic via a self-contained package of threshold terms and concepts for both undergraduate and postgraduate audiences. In this work, a mobile AR solution for anatomical education in- and outside the classroom is presented that works with 2D and 3D content.

DOI: 10.2312/eged.20151025

2. Technical Overview

Two AR scenarios were implemented, a poster tracker and a 3D object tracker that can track plastinated heart specimens or plastic heart models on mobile devices (iPads). In the first scenario, a 2D tracker recognizes a 2D poster printout in the video stream of the mobile device, reconstructs the pose of the camera and augments the video stream with media like PDF lecture notes, video links, and image overlays. An example of such an augmented overlay is a flip book style overlay where the user can browse through different images by touching the image shown on the poster. The second scenario is a 3D object tracking where text labels associated to anatomical parts of heart specimens are shown in the video stream after recognition of the 3D pose. A precomputed 3D reconstruction of the tracked specimens can also be viewed in order for the students to learn at home. The instantAR [EBW*13] framework is used for creating the AR application. instantAR is a webkit based browser supported by a native X3D renderer and a computer vision engine known as VisionLib. The native backends are wrapped in JavaScript, providing an easy access and control of the rendering and tracking engine. Implementation can be done using HTML and JavaScript and the GUI can be defined by CSS stylesheets. Furthermore, various types of formats for documents and media such as PDF, AVI, MP4, MP3, JPEG, PNG are supported making AR overlays and 3D HTML annotations easy. The annotations of each heart model can be shown/hidden one by one or shown/hidden all at once as per users' selections. The flip book style feature for multiple image page views is defined using the X3D setAttribute node where the frame sequence number and a rotation interpolator is specified for each page. The flipping action is visually as smooth as a CSS3 transform function. The 3D tracking approach contains an offline training step where a feature map is created from an initial image sequence and a 3D point cloud is reconstructed. The 3D models of the specimens to be tracked are manually aligned such that the 3D annotations will be shown accurately at the correct position in both virtual and augmented views during the online tracking. Fig. 1 shows the online tracking on an iPad. A problem during the design and implementation stage of annotations is to create a large number of 3D annotations for several heart specimens and views (interior and exterior). To reduce the annotation workload, an Annotation Manager using the JavaScript Prototype property was created to sort and dynamically generate HTML labels for the annotations. The various attributes and aspects of the annotations with or without occlusions can be easily adjusted. This greatly reduces the work of generating and updating new annotations. In order to avoid a repetitive training with the same anatomical specimens in case the annotations change and in order to allow occlusions of labels by body parts, a 3D model of each heart is reconstructed from the training video stream using Autodesk 123D Catch (`http://www.123dapp.com`). Annotations and occlusions are then computed relative to the created model.

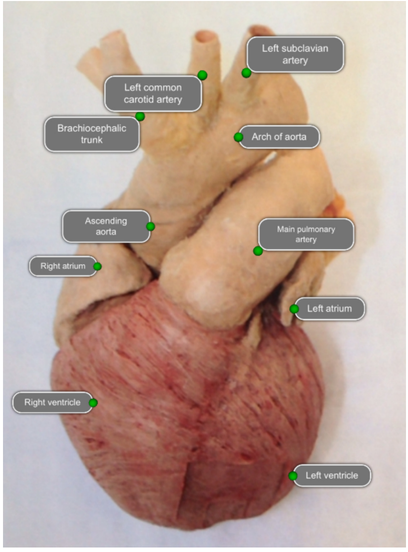

Figure 1: *A plastinated cadaveric heart specimen augmented on an iPad.*

3. Conclusion

We have presented a mobile AR application for undergraduate and potentially postgraduate anatomical education that can augment 3D plastinated cadaveric specimens of the human heart as well as 2D printed posters. The application can be used in the classroom as well as at home where anatomical terms can be introduced via 3D virtual representations of solid organs. Augmented 2D posters have been designed to facilitate deep "sense-making" of anatomical concepts by providing different viewpoints that constructively dovetail into the 3D real and virtual specimens. In future work, we will empirically explore the actual educational merit of AR for medical education.

Acknowledgement Special thanks to Dr Dinesh Kumar from LKC Medicine of NTU for providing anatomical content and expertise in this project. This research is a cooperation between LKC Medicine of NTU and Fraunhofer IDM@NTU. Fraunhofer IDM@ NTU is funded by the National Research Foundation (NRF) and managed through the Interactive & Digital Media Programme Office (IDMPO).

References

[BKB*12] BLUM T, KLEEBERGER V, BICHLMEIER C, NAVAB N. MIRRACLE: An augmented reality magic mirror system for anatomy education. *IEEE virtual reality*, (2012), 115–116. 1

[EBW*13] ENGELKE T., BECKER M., WUEST H., KEIL J., KUIJPER A.: Mobilear browser - a generic architecture for rapid ar-multi-level development. *Expert Syst. Appl. 40*, 7 (June 2013), 2704–2714. 2

[ZHM*14] ZHU E, HADADGAR A, MASIELLO I, ZARY N.: Augmented reality in healthcare education: an integrative review. *PeerJ PrePrints*, 2 (2014). 1