Med Ultrason 2021:0, 1-5 Online first
DOI: 10.11152/mu-3139

A prototype of a handheld augmented reality application to get familiar with ultrasound equipment knobology

Christian Kollmann[1], Lukas Santner[2]

[1]Center for Medical Physics and Biomedical Engineering, Medical University, [2]University of Applied Sciences Technikum Wien, Biomedical Engineering, Vienna, Austria

Abstract

Aims: A prototype application has been developed that is adapting modern augmented reality technology to support learning in ultrasound skills-labs or at home. The application enables students to get in real-time an orientation and information about the knobs on an equipment´s control panel that is available in the lab. **Material and methods**: The Augmented reality (AR) application for smartphones or tablets was created in Unity (San Francisco) with the software development kit Vuforia (Vuforia PTC Inc., Zurich) to support students with their own devices to learn the knobology of an ultrasound equipment. An interface was modelled, which is superimposed on the live camera image and provides information about the displayed knobs and sliders on the control panel. **Results:** The smartphone or tablet app is able to detect the specific ultrasound equipment in real in the skills-lab, as well as from a hardcopy photo or displayed by a monitor and to provide further detailed information. The application can be used therefore as preparation of a practical course or for orientation within the lab at the equipment.

Conclusions: The flexibility of the app is optimal for students to become familiar with the equipment before they are having their skills-lab lecture and might help to reduce time for introduction to orientation at the equipment´s console.

Keywords: ultrasound; teaching; augmented reality; education; equipment

Introduction

Augmented reality (AR) applications (i.e. applications that layer virtual information over actual real images) are becoming familiar to a wider audience due to the developments in image-based technology and software. By using so-called head-mounted displays [1] or a smartphone camera, the observer can see-through glasses or the smartphone camera to the real scenery that is overlayed with different kinds of additional information. Originally developed for performing manufacturing and assembly operations [2], the healthcare-related applications are now numerous, ranging from visualizations of organs [3], head-mounted display of patient data during surgery [4-6], treating psychiatric disorders [7-9], training and educating personnel [10-12], to procedure planning and biopsies [13-15] or 3D printing applications [16-18].

The ongoing miniaturization and implementation of faster hardware chips make it possible now to use AR-health-care applications in modern tablets and smartphones. Although there are only a few medical applications described [14,16,19], the offered AR-tool kits from different companies enable users to design new versatile AR applications for handheld operating systems of iOS (Apple Inc.) and Android (Google Inc.) with less programming effort.

Today, most students are equipped with a modern tablet or smartphone for e-learning purposes. They are familiar with its handling and frequently search the needed information adhoc on the internet instead of spending time looking into course books or literature. The accessibility of special information is easy to obtain and, especially in ultrasound skills-labs, the hands-on training can be improved and accelerated if individual help comes adhoc with one´s own smartphone. The integration of

Received 04.03.2021 Accepted 05.05.2021
Med Ultrason
2021:0 Online first, 1-5
Corresponding author: Christian Kollmann
Center for Medical Physics & Biomedical Engineering, Medical University Vienna,
Waehringer Guertel 18-20, 1090 Vienna, Austria
E-mail: christian.kollmann@meduniwien.ac.at

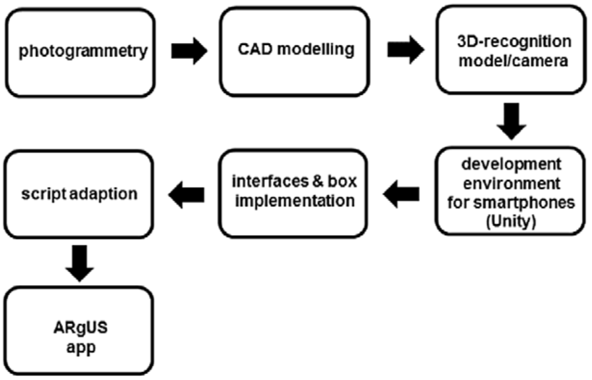

Fig 1. Schematical view of the different developing steps for the Augmented reality application

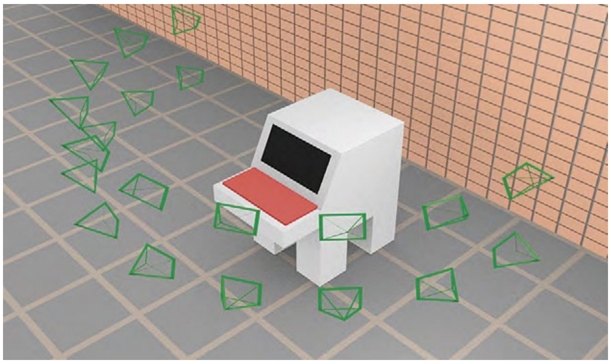

Fig 2. Illustration of the chosen method to acquire images for photogrammetry, repeatedly circling around the equipment at defined angles and positions with a camera

problem-oriented solutions might lead to support teaching of technical basics in skills-labs [20,21] .

For this purpose, we have developed an AR prototype application for Android-based smartphones and tablets to learn the handling and explain the frequent knobs and sliders by scanning the ultrasound equipment with a handheld device. Free available programming tool kits have been used to keep the development process short and inexpensive for our prototype and to demonstrate that this kind of educational application can be realised without too much effort. The prototype app has been offered to students for getting individual feedback after working with it in a realistic representation in- or outside the skills-lab (e.g. at home).

Material and methods

AR programming

The prototype application has been developed in Android (Android Studio 3.3.1, Google Inc.) which simplifies different module implementation and prototype testing of the app on various smartphones or tablets. Before live camera images are overlayed with AR information, several different working steps are necessary (fig 1).

First, the real ultrasound equipment has been modelled in 3D by photographic scanning (photo-grammetry) because no digital computer aided design (CAD) model was available. The free 3DF Zephyr lite version of 3DFLOW (vers. 4.353, 3Dflow SRL Verona) has been used with a capacity of up to 50 camera images. These digital images were taken manually in a semicircle around the ultrasound equipment (fig 2). Considering the front view as the origin (0°), it was started on one side at approximately 80°. When the image was recorded one step to the side (approximately 10°) was taken and the process repeated until the other side was reached (-80°). Then the whole procedure was repeated at a new angle. This resulted in 3 semicircles of images and the remaining ones were used to take close up images of areas of interest or in case something was rendered poorly. Then all images were imported to the 3DF Zephyr lite program to generate out of a spatial point cloud a textured mesh model of the equipment with highest quality output settings.

The CAD model of the ultrasound equipment could be constructed with this mesh model using Blender (vers. 2.79b, Blender Foundation) and acts as a reference model to optimize the final designed CAD model together with the knobs and sliders of the console in 3D.

The next step has been the recognition of this 3D CAD model from the live camera video stream of the real equipment. The toolbox Vuforia and the Model Target Generator (both vers. 8.0.010 Vuforia PTC Inc., Zurich) are chosen to implement the detection of the equipment acquired from different spatial positions (fig 3). Both toolboxes generate models that can be used with Unity (vers. 2018.3.11f1, Unity Technologies, San Francisco), a software development kit to combine all previous toolboxes and models for the smartphone app available for Android Studio.

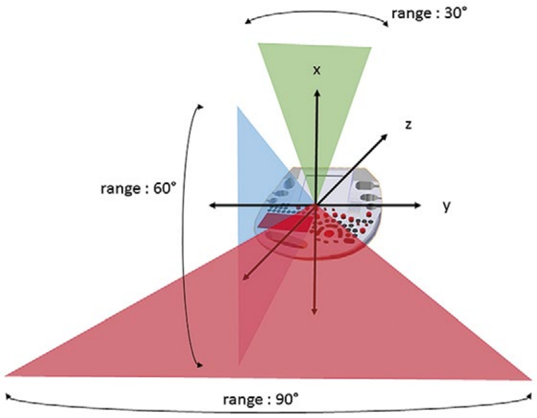

Fig 3. Illustration of the possible recognition planes, angles and dimensions of the modelled CAD console

Table I. Feedback questions with 4 rating categories

Question	Rating results: mean (range)
Q1. Can interactive augmented reality apps be helpful in the education of students?	4 (4)
Q2. Is this app easy to install & use?	3 (2-4)
Q3. Is the information from this app helpful for you?	4 (4)
Q4. Would you use such apps as preparation for a skills lab at home?	4 (4)
Q5. Would you prefer AR apps over traditional learning materials?	2 (2)
Q6. Do you think that such apps help to learn the handling of the device faster?	3.5 (3-4)
Q7. Do you think that you will be able to find your way around the real device better after using the app?	3.5 (3-4)
Q8. Would you recommend this AR app to other fellow students?	4 (4)

Answering possibilities: not the case (1 point) | not really the case (2 points) | possibly the case (3 points) | definitely the case (4 points)

Additionally to the automatic detection of the equipment, an interface is needed to offer real functionality and interaction within AR. Blender has been involved to show additional information within boxes, knobs and sliders at the console while marking the object in the real camera image with the touch screen or adapting scripts to operate the app. In the final step the code has been adopted as suitable for 2D photo or 3D camera recognition before the software app was finalized for Android (Version 4.4. and above).

App integration in the teaching course

The app was uploaded together with an installation guide and digital photos of the different ultrasound consoles to the internal Moodle platform to be available for the students of a basic ultrasound course. Additionally, a questionnaire (Table I) was created in Moodle to get a first feedback about this prototype acting as a pilot for further extensive AR apps planned.

Results

Two versions of the app have been created, a 2D version (called ARgUS lite) that can be used to recognize the ultrasound console features from a hardcopy photo (fig 4a) or digital by a monitor (fig 4b) and a 3D version (called ARgUS), suitable for detecting and interacting with the real equipment in the skills-lab (fig 5). In total 5 different types of ultrasound equipment (CX 30 Philips, Logiq E9 GE, Voluson E6 GE, X300 Siemens, Xario200 Canon) were implemented in this way to support teaching and learning with the present imaging equipment in our skills-labs.

After starting the app, the smartphone or tablet camera is activated and depending on the position of the user the whole console (fig 5a) or only a part of it (fig 5b) is automatically detected and knobs and sliders are highlighted that are in view of the camera. Additionally, all console elements are identified with names in an overlayed text box (fig 6), that is clickable and shows more information about the special function (fig 7). On the main window of the app a help function can be selected to get familiar with this AR software or to get a list of the implemented ultrasound equipment. The app works on different handheld devices and has been tested to be operational from Android version 4.4 up to version 9.

A first feedback from the radiotechnology students, who could download this app optionally with other

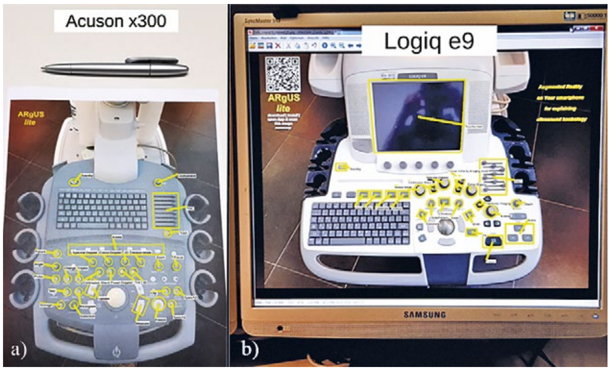

Fig 4. Augmented reality representation using a hardcopy photo (4a) or a digital one on a monitor (4b)

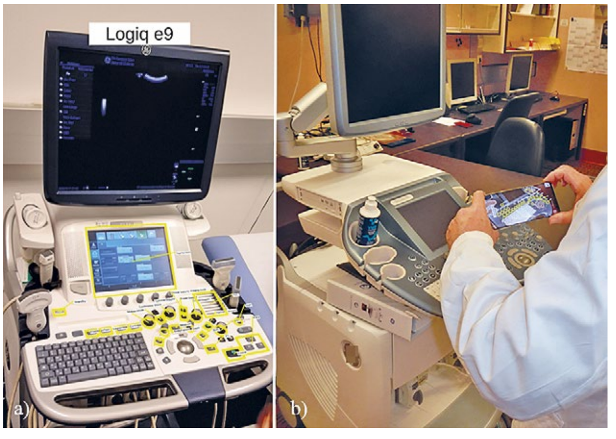

Fig 5. Augmented reality representation on real equipment (5a) using a smartphone (5b)

course documents mainly showed that these kinds of application can support teaching (4/4 points, Q1), the information offered has been helpful (4/4 points, Q3) and usable at home (4/4 points, Q4) to get a faster understanding of the handling and orientation of the equipment (3.5/4 points each, Q6,7). All testers would recommend the app to their fellow students but would prefer installation from an official app store (3/4 points, Q2) and would use it together with classical teaching materials (2/4 points, Q5).

Discussion

The ultrasound equipment is detected once the camera is placed on the photo, monitor or real equipment and the overlay of the control knobs are displayed. On older handheld devices with earlier Android versions installed, there could be a latency time of a few seconds due to slower computer processing unit (CPU) speed and suboptimal internal application programming interfaces (API). Ambient light conditions can influence the recognition speed, too. Due to the fact that the Vuforia toolbox relies on optical and inertial sensors it was possible to obstruct the camera view by e.g. pressing buttons on the device without losing the correct user interface position. The correct spatial position of the overlays is a crucial item and does not come out of the box. Depending on the position of the handheld camera to the console the overlayed information can be shifted a little bit and is not fully superimposed sometimes but this can be omitted by using a wider distance or a position in front of the equipment.

A lot of working time was spent on the photogrammetry and remodelling process to get a digital CAD object of the special equipment. Different sizes and positions of the console´s knobs and sliders of the equipment types needed to be adopted individually. A CAD model from the manufacturer or high-resolution 3D scanning of the equipment might lead to a reduction of this working load for obtaining a mesh file for further processing.

The feedback of this pilot application has been limited because only 3.8% of the course participants were willing to test this app and send back their opinion. This is mainly due to the fact that it was optional to use and the download could not be managed from the Google app Store or app store of Apple because no application has been programmed for iPhone at the moment. However, an AR application is valid to support basic learning of console functions and a faster orientation at the real equipment. Adding more special equipment features and supporting information from the internet might lead to AR applications being used in skills-labs regularly or as a preparation.

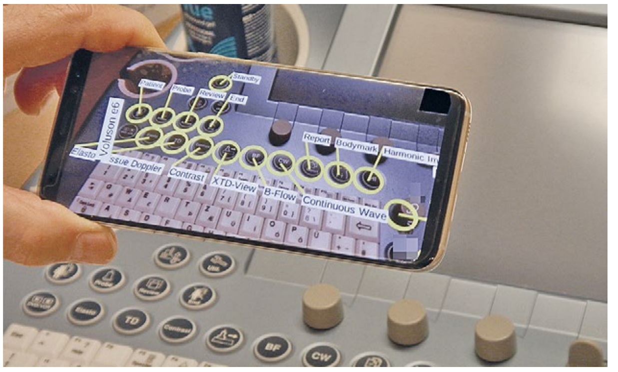

Fig 6. Augmented reality representation on the smatphone shows different knobs on a console with clickable text boxes.

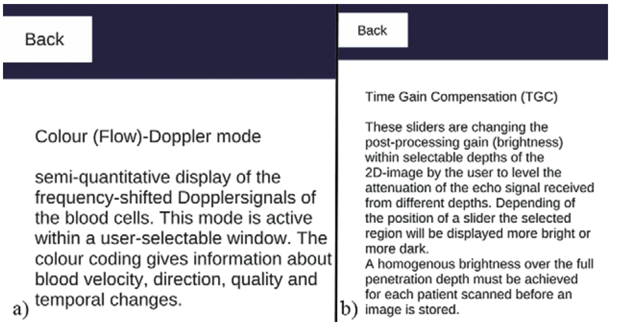

Fig 7. Examples of additional information displayed if the text boxes are clicked

Conclusion

Realizing a handheld augmented reality application for teaching students the ultrasound knobology of an equipment with overlaying additional information is possible with already free accessible tool kits and not too great an effort for developing and costs. The developed software app is stable in use and flexible to the needs of students for their individual studies. These kinds of AR-applications supporting basic ultrasound teaching are becoming more attractive if they are available for different operating systems. AR provides new possibilities and features that have not been available until now for this special educational purpose.

The app, equipment photos and a video demonstration are downloadable under a creative commons license (CC BY-NC-SA) from our university server (https://cloudius.meduniwien.ac.at/index.php/s/cCdikZ5qLfVSuzp).

Acknowledgement

The authors gratefully thank the responsible persons for their support from the skills-labs of Centre for Anatomy & Cell Biology (Medical University Vienna) & Radiotechnology (FH Campus Wien)

Conflict of interest: none

References

1. Eck U, Winkler A. Display technologies for augmented reality in medical applications. Unfallchirurg 2018;121:278-285.
2. Caudell TP, Mizell DW. Augmented reality: an application of heads-up display technology to manual manufacturing processes. Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences 1992:659-669. vol. 2. doi:10.1109/HICSS.1992.183317.
3. Rancati A, Angrigiani C, Nava MB, et al. Augmented reality for breast imaging. Minerva Chir 2018;73:341-344.
4. Lang H, Huber T. Virtual and Augmented Reality in Liver Surgery. Ann Surg 2020;271:e8.
5. Quero G, Lapergola A, Soler L, et al. Virtual and Augmented Reality in Oncologic Liver Surgery. Surg Oncol Clin N Am 2019;28:31-44.
6. Vávra P, Roman J, Zonča P, et al. Recent Development of Augmented Reality in Surgery: A Review. J Healthc Eng 2017;2017:4574172.
7. Botella C, Bretón-López J, Quero S, et al. Treating cockroach phobia with augmented reality. Behav Ther 2010;41:401-413.
8. Chicchi Giglioli IA, Pallavicini F, Pedroli E, Serino S, Riva G. Augmented Reality: A Brand New Challenge for the Assessment and Treatment of Psychological Disorders. Comput Math Methods Med 2015;2015:862942.
9. Juan MC, Alcañiz M, Monserrat C, Botella C, Baños RM, Guerrero B. Using augmented reality to treat phobias. IEEE Comput Graph Appl 2005;25:31-37.
10. Ebner F, De Gregorio A, Schochter F, Bekes I, Janni W, Lato K. Effect of an Augmented Reality Ultrasound Trainer App on the Motor Skills Needed for a Kidney Ultrasound: Prospective Trial. JMIR Serious Games 2019;7:e12713.
11. Weiner E, Gordon J, Rudy S, McNew R. Expanding Virtual Reality to Teach Ultrasound Skills to Nurse Practitioner Students. Stud Health Technol Inform 2019;264:893-897.
12. Wu HK, Lee SWY, Chang HY, et al. Current status, opportunities and challenges of augmented reality in education. Comput Educ 2013;62:41-49.
13. Ameri G, Rankin A, Baxter JSH, et al. Development and Evaluation of an Augmented Reality Ultrasound Guidance System for Spinal Anesthesia: Preliminary Results. Ultrasound Med Biol 2019;45:2736-2746.
14. Deng W, Li F, Wang M, Song Z. Easy-to-use augmented reality neuronavigation using a wireless tablet PC. Stereotact Funct Neurosurg 2014;92:17-24.
15. Tang R, Ma LF, Rong ZX, et al. Augmented reality technology for preoperative planning and intraoperative navigation during hepatobiliary surgery: A review of current methods. Hepatobiliary Pancreat Dis Int 2018;17:101-112.
16. Moreta-Martinez R, García-Mato D, García-Sevilla M, et al. Combining Augmented Reality and 3D Printing to Display Patient Models on a Smartphone. J Vis Exp 2020. doi:10.3791/60618.
17. Wake N, Bjurlin MA, Rostami P, Chandarana H, Huang W. Three-dimensional Printing and Augmented Reality: Enhanced Precision for Robotic Assisted Partial Nephrectomy. Urology 2018;116:227-228.
18. Wake N, Rosenkrantz AB, Huang R, et al. Patient-specific 3D printed and augmented reality kidney and prostate cancer models: impact on patient education. 3D Print Med 2019;5:4.
19. Hou Y, Ma L, Zhu R, Chen X. iPhone-Assisted Augmented Reality Localization of Basal Ganglia Hypertensive Hematoma. World Neurosurg 2016;94:480-492.
20. Spehlmann ME, Eden M, Frey N, Lüdde M. Integration of problem-oriented learning into skills lab of echocardiography: A successful tool to enhance comprehension of internal medicine. Med Teach 2017;39:1202.
21. Kollmann C. Teaching Technical Basics in Ultrasound for Medical Students – Outline of the Viennese 'Teach Us Sound' Concept. Praxis (Bern 1994) 2018;107:1273-1278.