A Mobile Ultrasound E-Learning System

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Abstract
Ultrasound diagnosis is an important skill for gynecologists. However, there is no routing ultrasound course for medical students during pre-clinical stage, and no enough chances to practice ultrasound diagnosis during clinical stage for interns at the department of gynecology in Taiwan. This objective of this study is to develop an ultrasound diagnosis e-learning system for medical students and interns to enhance the skills of ultrasound diagnosis. When an experienced gynecologist performs an ultrasound examination, the synchronized videos, including : ultrasound images and operational procedures of ultrasound, are shown on mobile phones of medical students with less delay. This real time e-learning system provides interns with comprehensive learning scenes, including continuous operational procedures of ultrasound, and corresponding changes of images. This system provides interns with more chances and more flexible ways to practice ultrasound diagnosis while patients refuse to allow the interns be present in the ultrasound examination room.

Introduction
Medical ultrasound is widely used in clinical medicine since 1940s. As a noninvasive, cost-effective tool, it provides multi-disciplinary and multi-system applications. In obstetrics and gynecology, physicians use real-time ultrasound imaging to enhance the assessment and treatment. Experienced clinical physicians and sono-graphers act important roles on correct ultrasound examination for diagnosis and treatment. However, there is no routing ultrasound learning course for medical students during pre-clinical stage, and no enough chances to practice ultrasound during clinical stage for interns at the department of gynecology in Taiwan. How to promote the education of ultrasound has become an important issue [1]. Based on the evolution of ultrasound and information technology, tele-ultrasound will act as a more and more important role in telemedicine services for remote areas. Additionally, videoconference technology develops successfully and works efficiency for experts' consultations and surgical intervention supports. According to the study results, store-and-forward images have been proved its better quality and improved diagnostic accuracy than hard-copy images. A real time video-conference system which can provide feedback simultaneously has competitive advantages on diagnosis, education and training [2]. Some studies focused on expert visual guidance (EVG) systems, and which demonstrated that an inexperienced sono-grapher can be significantly assisted by EVG as compared to verbal instruction alone [3].

Generally, medical students can learn the skills of ultrasound examination in clinical environment. However, most of patients refuse medical students involving in their medical ultrasound examination procedures, especially in the department of gynecology. Therefore, it is difficult to learn the skills of ultrasound examination from practices for medical students. It is on great demands to setup a real time tele-ultrasound videoconference system for the mobile learning of ultrasound examination.

Methods
The medical images of an ultrasound device were captured in real time with refreshed rate 25 pictures/sec and the images were synchronized with a real-time ultrasound manipulation video recorded by a mobile phone when an experienced gynecologist was performing an ultrasound examination. The two videos were then streamed into a video stream server and delivered to the mobile phones of interns or medical students. This real time e-learning system provides comprehensive learning scenes, including continuous operational procedures of ultrasound, and corresponding changes of images. As shown in Figure 1, this mobile e-learning system is composed of three-layered infrastructure based on private cloud computing. The top layer is the hardware for video storage and processing. The middle layer is the virtual machines for video streaming and display services. The bottom layer is the setup for video capturing and transferring.

Results
As shown in Figure 2, a practical ultrasound examination workflow can be recorded as real-time teaching materials. The medical students can ubiquitously learn the skills of ultrasound examination prior to clinical practice. When an experienced gynecologist is performing an ultrasound examination, two videos, including: (1) ultrasound manipulation, and (2) corresponding changes of images are streamed into a video stream server and delivered to the mobile devices. Interns or medical students can learn the ultrasound skill via mobile devices apart from ultrasound examination unit. It can also leave a private space for patients. This mobile e-learning system provides medical students with a new learning way to practice ultrasound examination. Additionally, two synchronized videos with physician’s comments can make the learning easier as compared to lecturing on class.

Conclusions
When a physician is performing the ultrasound examination, the final diagnosis making is strongly dependent on combination the information of examination position and image. This system provides learner with more chances and more flexible ways to learning ultrasound skills and leave the patients with a more comfortable environment in the ultrasound examination room. There are many factors that can influence implementations of this e-learning system, such as curriculum design, technology awareness, motivation, and changing learners’ behavior [4]. With the advance of modern communication technology and popular mobile devices, it is possible for us to set up a high quality real-time mobile videoconference system to promote medical education. These are no barrier for medical students using this system. Although this system is mainly designed for medical students, it also could serve as a medical consultation system to improve tele-ultrasound services on clinical practice.

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References