Medical Student Evaluation using Augmented Standardized Patients: Preliminary Results

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Abstract. Standardized patients (SPs), individuals trained to realistically portray patients, are commonly used to teach and assess medical students. The range of clinical problems an SP can portray, however, is limited. They are typically healthy individuals with few or no abnormal physical findings. We have developed a functioning prototype that uses sound-based augmented reality to expand the capabilities of an SP to exhibit physically-manifested abnormalities. The primary purpose of this paper is to describe this prototype and report on its use in a study using medical students evaluated in a required annual Observed Structured Clinical Examination (OSCE). Presented is an overview of the prototype, a detailed description of the study, final results from the study, and conclusions drawn about the validity of using augmented SPs as a reliable medical assessment tool.

Keywords: Virtual reality, augmented reality, standardized patients, medical assessment, OSCE

Introduction

To become clinically competent physicians, medical students must develop knowledge and skills in many areas of both the art and science of medicine. Three areas are emphasized in medical students' early clinical training: doctor-patient communication, performing the physical exam involving auscultation, and clinical diagnostic reasoning about patient pathology. Standardized patients (SPs), individuals trained to realistically portray patients, are commonly used to teach and assess medical students in those three areas.

1. Background/Problem

Extensive research on the use of SPs shows this approach to be a reliable and valid teaching and assessment technique [4], with psychometric qualities sufficient for high-stakes professional examinations. The National Board of Medical Examiners and the National Board of Osteopathic Medical Examiners will each require an SP-based exam for licensure of physicians in the U.S. beginning with the class graduating in 2005, as the Medical Council of Canada has done for several years. Additionally, the Education Commission on Foreign Medical Graduates requires graduates of foreign medical schools to pass SP-based exams prior to entering North American medical residency programs.

Actually, SPs have been used as a teaching and evaluation technique in medical education for about 40 years [1] [2], and are used at all levels of medical training [3] [4]. They are also widely used in the other health professions. Their flexibility and adaptability allow SPs to change appearance, provide verbal nuances and non-verbal cues to their communication, and in other ways exhibit the wide range of interpersonal interactions found in real patients. Their realistic presentation of clinical problems has been a major factor in acceptance by medical educators, and allows learners to practice and receive feedback on their clinical skills in a safe context.

The range of clinical problems an SP can portray, however, is limited. They are typically healthy individuals with few or no abnormal physical findings. Augmented reality (AR) can be used to expand the capabilities of an SP to exhibit physically-manifested abnormalities. Augmenting SPs with the ability to simulate abnormal physical findings would expand the opportunities for students to learn more clinical skills, e.g., by finding abnormalities on a physical exam, in a realistic setting with a real person (SP) while practicing their doctor-patient communication skills.

We have developed a functioning prototype of the technology for this augmentation. The prototype allows the listener to hear pre-recorded heart and lung sounds when auscultating the human body. The primary purpose of this paper is to describe this prototype and report on its use in a study using medical students evaluated in a required annual Observed Structured Clinical Examination (OSCE). Using lessons learned from this study, we will test the improved system with students in future required OSCE examinations using an expanded suite of abnormalities. At this future point, we will answer questions relating to the realism as perceived by an experienced clinician of using augmented SPs (ASPs) as a reliable assessment tool.

2. Tools and Methods

Auscultation involves listening for sounds produced by the body at various locations. The primary auscultation tool is the stethoscope. As one might imagine, The SP actor can not normally present abnormal conditions via this ubiquitous medical instrument. During auscultation, the head of the stethoscope placed against the patient's skin and typically has both a diaphragm for detecting high-pitched sounds and a bell for hearing lower-pitched sounds. An examiner listens not only for presence of sound but also its characteristics: intensity, pitch, duration, and quality. Analysis of these qualities leads to an assessment of normal findings or abnormalities suggestive of a pathologic process.

To reproduce sounds that a medical student would hear at various anatomical landmarks probed during auscultation, initial steps were to record normal heart and lung sounds that the system would play when a stethoscope head was touched to any of the 28 "hot zones"[5] on a human (the SP's) torso. Using these anatomical landmarks, 3D hot zones were identified and adjusted for any body morphology using five calibration points.

We adapted an electronic stethoscope so that the examiner hears through the stethoscope earpieces the recorded sound when the stethoscope head (listening piece) is placed against the skin in one of the hot zones. The stethoscope includes a magnetic sensor and a contact switch attached to its head. Figure 1 shows an early prototype [5] of the system. A mannequin is shown for the human SP. In this early prototype we used a plastic stethoscope that has now been replaced with an electronic one. Essentially, the system operates as follows. The medical student would use the stethoscope (3) to place against the ASP and perform auscultation. As the student places the stethoscope head, its position is tracked via (5) using the movement of the attached sensor. When the system software running on the PC (6) detects that the sensor / stethoscope head is placed within an appropriate location, the software triggers the corresponding sound file which plays into the headphones (7), now electronic stethoscope, which the student is wearing.

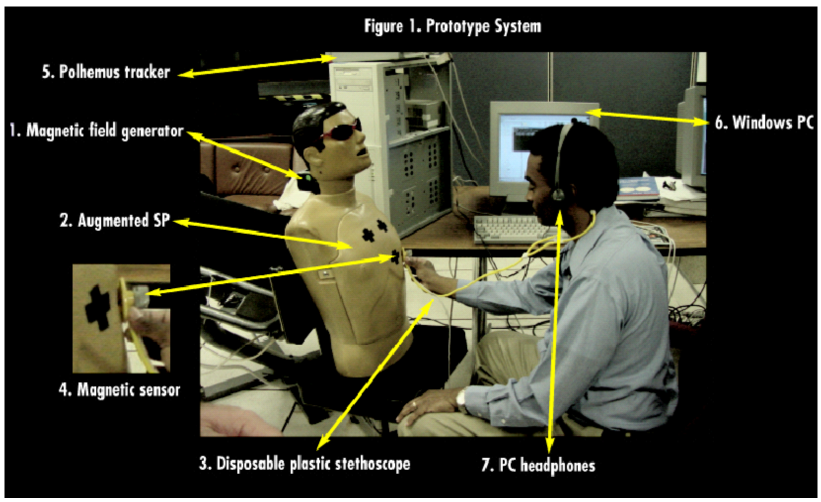

Figure 1: Augmented SP Prototype System

3. Results

In this paper, we report on a study of students testing in a required annual Observed Structured Clinical Examination (OSCE) that are provided an additional assessment using our ASP system. For this study we chose to have our subjects listen for a carotid artery bruit. When auscultating the neck of healthy patients no sounds should be heard. However, in patients with atherosclerosis one often hears a characteristic sound, or bruit, caused by restricted or turbulent blood flow in one or both carotid arteries. For this study we asked subjects whether they detected an abnormal sound as they auscultated the neck areas.

Forth year medical students were the study subjects. The study was completed in two halves with the first half taking place in July 2005 and the second in August 2005 for a total of 105 subjects over approximately 14 different days. The main objective of the study was to determine the validity of using augmented SPs as a reliable assessment tool by presenting abnormal pathology – a bruit.

This sound was chosen because the distinction between normal and abnormal heart and lung sounds is often more subtle than a carotid bruit, and thus may not be distinguished by inexperienced subjects using our current system. The bruit for this study was recorded from a patient. Two SPs were provided with the augmentation in two separate rooms; however, only one SP at a time had an audible bruit to keep students unaware of the purpose of the augmentation. Instead, students were told that we were evaluating a new type of electronic stethoscope and evaluations were performed in addition to normal SP OSCE assessments. Figure 2 shows the configuration of one of the ASP rooms. In the picture, the medical student listens to the neck of the sitting patient with the electronic stethoscope while progress is monitored by a student running the ASP system.

The study was performed at the Theresa A. Thomas Professional Skills Teaching and Assessment Center at the Eastern Virginia Medical School. The Center trains SPs to portray patients providing historical information, nonverbal cues, and physical findings, albeit mostly normal ones.

The students conducted a physical examinations on the augmented SPs, including an auscultation of the left and right side of the ASP's neck and reported whether they heard a carotid bruit or not. Of course, hearing no sound was the normal state for these healthy SPs but a preprogrammed sound of a carotid bruit was played on either the left or right side when desired. Students were instructed on the use of the electronic stethoscope, listened to the SP on both sides of the neck in the areas corresponding to the activated hot zones, and indicated on a form what they had heard.

Figure 2: OSCE ASP Assessment Configuration

Assumptions we made include the following:

1. Students would note that a bruit was heard if in fact they heard one in their exam.
2. The students' hearing was normal so they should be able to detect a bruit.
3. The bruit sound was played at an acceptable intensity and that the amplification on the stethoscope was appropriate.
4. That the sound actually played into the earpieces when it was supposed to.

Of the 105 students taking the OSCE, many were excluded for any one of the following criteria:

1. tracker did not indicate a stethoscope sensor in the hot zone,
2. student did not use the electronic stethoscope as the sole instrument for auscultation
3. bruit sound did not play (sound on or off) when sensor was in the hot zone, or the
4. student did not place the stethoscope in a correct anatomic position to listen for a bruit or failed to listen for a bruit (SP scoring)

Upon applying the above exclusions, data from 53 students were used and organized as follows:

Sound on and heard:	16
Sound off and not heard:	19
Sound off and heard:	1
Sound on and not heard:	17

A Chi-Squared test with 1 degree of freedom was performed using a 2x2 table of factors: (sound on, sound off) versus (heard, not heard). The Chi Square test of association gives a value of 10.808 which is equivalent to approximately a tenth of a percent (.00101) chance that the sample distribution can be attributed to randomness. Therefore, we are highly confident that using the ASP system in this case was a valid assessment tool showing that the students could be adequately tested in diagnosing the bruit.

4. Conclusions/Discussion

The study was successful in its attempt to evaluate medical students in their normal OSCE testing environment. Results, however, showed that about 1/3 of the students failed to diagnose the bruit appropriately. This may be because one or more of our assumptions was incorrect for some of these cases. An example may be the presence of partial hearing loss in a few of the subjects due to modern-day headphone speaker usage. Another factor may be the amount of exposure that some 4th year medical students have to carotid bruits. Additionally, comparison of failure rates in other non-augmented portions of the OSCE may shed light on approximately how many students can be expected to not identify such pathology. Nevertheless, the ASP system was shown to be statistically significant in providing a valid assessment tool for carotid bruits.

5. Future Work

Additional studies using more experienced trainees and clinicians as subjects will be done to assess the realism of the Augmented SP system and its continued validity for assessment. The next phase of our work will be: (1) Add additional abnormal sounds to our database, either through collecting them from individuals with abnormalities or modifying normal sounds; (2) Minimize the technology components to increase realism; (3) Explore other ways to augment SPs to display other abnormal physical findings; and (4) test the realism as perceived by an experienced clinician of combining selected abnormal auscultatory findings with pertinent clinical history information to resemble a clinical encounter between doctor and patient.

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