# EXPERIENCES USING AUGMENTED REALITY ENVIRONMENT FOR TRAINING AND EVALUATING MEDICAL STUDENTS

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**ABSTRACT**

The process of medical training and evaluation in Brazil has been supported by several resources in order to graduate more qualified students. These resources include atlas, photos, movies, cadavers, animations, real patients, standarized patients(actors) and anatomical manikins, among others. For the reality of medical schools in a developing country as Brazil, high-end manikins are too expensive. This paper describes the validation of the Augmented Reality Environment for Life Support Training (ARLIST) system, built on the top of conventional manikins, used in cloth shops, during three editions of the Selection Exam for the Medical Residence Program of São Lucas Hospital, reaching a total of 450 users of this system. The use of manikins in these exams has showed that there is great potential for using this kind of technology in this process in medical schools, since the results were promising and resources as cadavers and experimental animals are increasingly scarce.

***Index Terms— augmented reality; medical training***

## 1. INTRODUCTION

The process of medical training in Brazil has been supported by many resources in order to graduate more qualified students. These resources include anatomy atlases, high definition pictures, care of real patients, simulation systems, sessions with actors simulating real patients, movies, cadavers, anatomical manikins, among others. However, the images, despite their quality and the possibility of being reused, do not allow the proper interaction of the student. The contact with real patients is what generates very rich learning experience, but the exposure of these patients to unprepared students, represents a serious risk to the patient's health and involves important ethical issues, that also happens with the use of cadavers. Moreover, sometimes it is not possible to find patients or cadavers with diseases appropriated to the level of student knowledge.

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The use of films and actors, in turn, suffer from the limited availability of these resources, plus the impossibility to simulate all desired situations. Because of these limitations, the use of manikins, equipped with simulation capabilities, has been quite interesting. However, for most of medical schools in a developing country like Brazil, this kind of equipment cannot be supported due to its high costs of installation and maintenance, and small number of configuration alternatives. A low end manikin, for example, costs between US$ 30,000.00 and US$ 100,000.00.

From these findings, the Augmented Reality Environment for Life Support Training (ARLIST) project[5] has evaluated the resources available in existing manikins, compared them with the needs of training programs for medical education in Brazil and planned, built and tested a patient simulator based on a conventional mannequin, used in cloth stores.

After these studies, simplified versions of the manikin have been used in three editions of the selection exams of the Medical Residency Program of São Lucas Hospital at PUCRS University, reaching a total of 450 users of this system. This paper describes the results of these tests.

This paper is organized as follows: Section II presents the main features of the ARLIST project. Some related projects for supporting medical training are described in Section III. Section IV describes the protocol and results of the validation tests. Conclusions and future work are presented in Sections V.

## 2. THE ARLIST PROJECT

The main goal of the ARLIST project was to enhance the training process of LS courses, allowing the trainee to be more autonomous during medical attendance, and providing the instructor with easier control over the trainee's actions during the simulation. A detailed description of this project can be found at [5].

The most relevant visual and sound clinical responses that should be analyzed during emergency were developed. In the sound category some the developed aspects were: cardiac, pulmonary, and endotracheal sounds, beyond short sentences as complaints about lack of air and pain, and responses to the evaluation of the alert state. In the visual signs category we developed the following issues: facial

expressions representing pain and level of consciousness (unconscious or alert); body injuries and skin color changes.

A manager software called Patient Simulation Control Tool (PSCT) was also build to allow the instructor to configure all signs and feedbacks provided by the manikin and to easily register all the trainee actions during the training session.

In order to keep the original anatomical manikins currently used during the LS training sessions and represents the sound signs, ARLIST uses a waistcoat with EVA (ethyl-vinyl-acetate) and instrumented it with push buttons and audio connectors that emit sounds when pressed. These buttons which are connected to the computer, are for cardiac auscultation, pulmonary auscultation and intubation checking. When the PSCT receives the signal it plays the appropriate sound on an adapted stethoscope.

On the visual side, ARLIST implemented aspects such as facial expressions, skin color (visible on the manikin's face) and body injuries. These images are one of the main aspects that differentiate this project from the commercial training manikins. The image exhibition is performed using a projector mounted on a metal structure especially designed for the project

## 3. RELATED WORK

In simulations of medical emergency care, in which feelings of tension and stress must be present to give realism to the exercise, virtual and augmented reality environments [3] [4][7] fulfill the role even more efficiently when compared to simulations based only on interactive software using conventional devices and static or animated 3D models [6][3].

## 4. CASE STUDY

In order to test the ARLIST project in a real situation, the manikin has been adapted to be used in the selection exams for the Medical Residency Program of São Lucas Hospital at PUCRS University.

The tests were done in three steps. First we perform a pilot study with specialists in LS training in order to ensure that the system was free of implementation bugs. Then the system was tested by a group of physicians from the LS area, and later by medicine students. After, a new manikin, featuring only the auscultation mechanisms, was built to be used for the selection exam for the Medical Residency Program of our University Hospital. The testing protocols, as well as the obtained results are presented in the following sections.

### 1.1. Pilot Study

For the initial tests we invited three experienced physicians who work both in daily emergency care and train medical students in the Advanced Life Support in Cardiology courses [1]. During these tests, one of the physicians acted as a supervisor, while the others played the roles of students. Later, they exchanged these roles. Three undergraduate students from the medicine course also made an exercise with the system. After evaluation the physicians and the students pointed out some suggestions for improving the training system, such as: the quality of lung and heart sounds; the framing of the facial image on the mask; the quaity of the lesion image projected onto the manikin chest. However, they classified the set of features available on ARLIST as very satisfactory and considered the project to be very useful for medicine classes, enabling more realistic simulation and facilitating repetitive training.

### 1.2. Validation Tests

After the implementation of these changes, we started the formal tests with students of the medicine course of our University. The group was formed by thirteen final year students. These students had already had training in emergency care and had already had experience with the traditional training manikins.

The tests were conducted in three homogeneous groups formed by: last year medical students; resident physicians and post-resident physicians. To ensure that the information transmitted to the participants were uniform, i.e., that all receive the same information and do the same preliminary exercises, a protocol has been established for the project presentation and the simulation execution. The description of this protocol and some detailed results concerning resource quality and existence are presented in a previous work [5].

Some suggestions for improvement were reported, indicating that we still need to improve the quality of the projected injuries and some heart sounds, which justify the opinion of 22% indicating little contribution.

Considering the presence of resources, 80% of the students indicated that the resources were important for the realism of the simulation. In the general comments, the students have reported that there were more autonomy, accuracy and objectivity in the simulation running comparing to other trainning sessions they had participated, mainly due to the possibility to evaluate some patient characteristics, as the alert state (waked up/unconscious), the skin color and the auscultation of heart and lung sounds directly on the manikin. Only one subject reported that the existence and quality of the resources makes no difference to the training session. None of the descriptive answers reported worsening in the training process due to the use of computer resources.

In descriptive remarks, the students suggested the addition of new resources, such as pulse palpation and greater variety of lung and heart sounds. As improvement proposals, the suggestions included the use of children images (regarding facial expression) and the displaying of more realistic images for the body injuries.

The participants of the first tests session made in their evaluation a comparison of the ARLIST system with systems that they had already used for the practice of first aid care. The main comments were about the following aspects:

- The need for imagination is considerably decreased through the possibility to see a facial expression or an injury over the manikin;
- The ease of pulmonary and cardiac auscultation allowed greater autonomy during simulation, and increase the overall level of realism;
- The recording of the trainee's actions alloes for a more detailed analysis of each performance, enabling both self-evaluation and comparison of results among the members of the group.

All students have expressed concern about the raising of stress levels during simulation, compared with the traditional systems, especially because of the constant vocalized patient remarks, such as complaining of pain or shortness of breath. This, according to the instructors, is positive because it brings more realism to the simulation. Comparing to existing systems, we could say that this is an important novel feature provided by ARLIST.

### 1.3. Medical Residence Test

In order to test the project in a real situation, the ARLIST has been adapted to be used in the selection exams for the Medical Residency Program of São Lucas Hospital at PUCRS University. For this exam we have removed the image features and preserved the auscultation resources and the log file from the original project. The PSCT interface was adapted to present only the aspects that were relevant for the exam, such as the identification number of the candidate, time elapsed and a start/stop button. The system was used in 2008, 2009 and 2010, with a total of 450 students.

This exam is based on Objective Structured Clinical Examination paradigm [2] that comprising a series of clinical stations for "hands-on" examination that simulates typical clinical scenarios. Candidates are assessed for language usage and proficiency as well as basic knowledge of therapeutic management of common complaints. The examinations were always divided into five rooms, called "stations" that were arranged side by side, so that the displacement between one room and another could be done in less than 30 seconds. On each station one medical specialty was evaluated.

Besides the use of the manekins, the candidates executed four different activities:

- interact with actors that pretended to be patients;
- perform some specific task like sutures in an animal skin model in a setting that simulates a surgical room;
- perform microscopical analysis of a body secretion or fluid smear like urine or vaginal discharge;
- assembly or prepare material for a medical procedure.

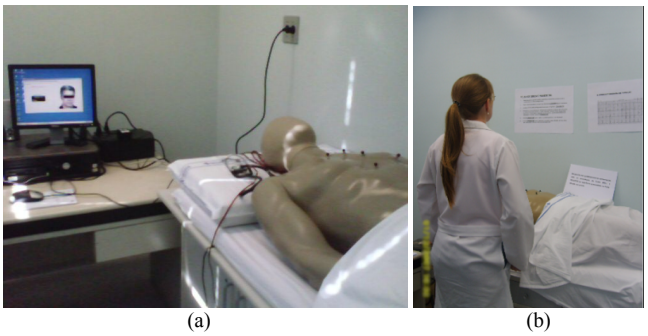
The evaluation protocol for this exam was done the following way: initially, the candidates were received in a waiting room in which an evaluator read a description about how the evaluation would be performed at each station/room. In these instructions the candidate was informed that:

- In each room, one of the medical specialties defined for testing will be evaluated;
- The total time to perform each activity will be 15 minutes;
- The begining, as well as the end of the period available to perform the activity at each station, is signaled by a siren;
- At the door of each room there are specific instructions for the activities to be performed inside the room. Reading and understanding these instructions are part of the evaluation process and should be done within the 15 minutes reserved for the activity execution;
- The candidate cannot communicate with the evaluators;
- Upon completion of the activity, the candidate must remain in the room, sitting at the indicated location, and wait by the sound signaling.

In this case study we also have used common mannequins, sold in clothing stores. However, instead of using the EVA waistcoat, these mannequins were drilled in the chest (Figure 1a) for installing eight push-buttons, allowing for the complete auscultation process. Since these mannequins have the proper dimensions and anatomy for the exam, we choose for not using the waistcoat. The adaptation of the auscultation resource directly on the mannequins chest, proved to be a feasible, more practical and very low-cost solution if compared with the waistcoat for auscultation.

Our manikin was used always in the Internal Medicine station, in which a candidate, as the one shown in Figure 1b, should perform the manikin auscultation, properly identifies the sounds and presents her diagnosis. The station was equipped with a computer, a manikin with the instrumented stethoscope, two sound boxes and the computer application that controls the simulation. The available instructions for the candidate in this station explain how to activate the buttons that allow the realization of auscultation. But is also made clear that not all the buttons available were valid and it was expected that, from its position in the manikin body, the candidate knew which one should emit a sound or not. The aim here was to evaluate whether the candidate had clear at which anatomical points he/she should auscultate the patient.

On each year the manikin has been configured to mimic a different disease. In the first edition it simulates an adult male, approximately 60 years old, suffering from arrhythmia. A recording presented the case to the candidate, instructed him about the patient clinical condition and informed about the availability of an electrocardiogram, which should be requested orally when he judged appropriate. According to the evaluation requirements, the candidate should first auscultate the patient and only after analyze the electrocardiogram.



(a) (b)

Fig. 1. Manikin with auscultation buttons fixed to the body.

In the second year, a young man (20-25 years old) with a mild pneumonia was simulated. The stretcher was placed in the middle of the room, so that the candidate could choose the side whereby the patient would be examinee. This was also an aspect evaluated on the station.

In the third edition it simulates a middle-aged woman with lung emphysema. The candidate listened to a recording of the patient's case and, as in the first year, the candidate was alerted to the existence of an X-ray exam of the lungs, and when desired could request it. The expected action was the request of this exam after patient auscultation.

In the stations of the first and the third years, full body mannequins have been used lying on a stretcher with the body partially covered. In the second year, to simulate a patient with pneumonia we used a half-body mannequin, as can be seen of the right side of Figure 2. In the third year the station we makeup the mannequin using a lipstick to simulate a female face.

After the exam, the students were requested to fill out a specific evaluation questionnaire. One question was related to the level of perceived realism of the stations with actors and other about the station with the manikin. The students were requested to rate the realism on a five-level Likert scale, considering 1 as no realism and 5 as very high level of realism.

The mean rate for the manikin was 4.16, with a standard deviation of 0.44. The mean rate for stations with actors were 4.26, with a standard deviation of 0.51.

In a similar way, we asked the students if the presence of the manikin has increased or not the difficulty of the task. 25% of the students declared that there were no additional difficulty, while 35% pointed out that the presence of the manikin in the Internal Medicine station has turned the station into a more difficult experience. 27% of them declared that the stations with the actors were more difficult.

## 5. CONCLUSIONS AND FUTURE WORKS

The use of computer resources for helping in medical education has been demonstrated to be a useful tool for supporting new ideas to improve the current educational process. The use of manikins in medical residency exam, which have a low cost of installation and maintenance compared with very expensive professional anatomical manikins, showed that there is great potential for using this type of technology in the evaluation processing at medical schools, both because the results were promising and also because resources as cadavers and experimental animals are increasingly scarce.

Besides that, the three different situations simulated during the selection exams for the Medical Residence Program has proved the flexibility of the apparatus developed for ARLIST.

As can be seen from the evaluation, the level of realism perceived in the station with the manikin is very similar to realism perceived in those stations that had actors performing as patients. Taking into account that these actors have a very long experience in this type of work, the results can be considered positive.

In the future, we intend to add some new features, in order to improve even further the simulation. Some features that have been considered are the use of a patient simulator, the replacement of push buttons by sensors mounted inside the manikin body, in order to allow the student to interact more naturally, implementation of eye drops, bleeding and pulse palpation.

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