Monitoring and Enhancing Nurse Emergency Training with Wearable Devices

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Abstract

In this paper we outline work designed to improve and understand the resuscitation skills of student nurses undertaking medium- fidelity simulation emergency scenarios. We describe the educational and clinical context of the simulation with a particular focus on how the supervision, analysis and feedback on student performance can be augmented by the use of sensors and other devices. Furthermore, we present initial findings from the use of sensors during video captured student scenarios.

Author Keywords

monitoring, nurse training, smart devices

ACM Classification Keywords

J.3 Computer Applications [LIFE AND MEDICAL SCIENCES]: Health.

Introduction

Nurses form the largest component of the healthcare workforce within OECD nations [1]. During their preparation to become nurses, students are expected to acquire a range of competences, including those related to caring and communication skills, assessing patients, and

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[1] http://www.oecd.org/health/health-at-a-glance-europe-23056088.htm

responding to their needs. Learning to effectively respond and manage emergency situations is a crucial part of their education. Emergency situations are often fraught with the potential for error, with students needing to manage uncertainty. Individual and team performance are critical in these high risk situations. Learning to assume responsibility, maintain a high standard of care and understand their role within the team is a key part of their educational experience. At the University of Southampton Faculty of Health Sciences, a purposely designed skills-based training facility is equipped like a 6 bedded hospital ward. A computerized mannequin SimMan provides numerous multi-sensory physical outputs that enable real life patient scenarios to be developed ([16], [4]). Through simulation experiences, students engage with a range of clinical situations within a safe, controlled environment. They then receive feedback on their performance from the supervising nurse educators.

The vision behind our work is to augment the above training scenario with near eye computing devices and body worn sensors in order to (1) be able to automatically asses the performance of the students and (2) in a later stage actively support the nurses in being more effective during the incident. Of particular interest (both for the recognition and the support) are the degree of group cooperation and coordination.

Related Work
The combination of head mounted displays with sensing and multi-modal input has been investigated in domains such as maintenance, production and emergency response (see e.g. [15, 7, 10]). Modern Smart Glasses such as the GoogleGlass system are much less obtrusive than traditional wearable systems, much previous work was based on. They have been analyzed in fields such as medical documentation [2] and surgery [11]. There has also been significant interest in using the technology for education purposes [8, 9]. Initial ideas for educational use were also discussed (see e.g. [13, 12]). Moreover, augmenting teaching in school-classes has been investigated, e.g. in [18].

In terms of detecting hospital and care activities, work has been described with using smartphones as unobtrusive sensors [3]. Recognition of group activities solely wearable sensors was introduced by [5]. [1] describes a prototype context aware preoperative information system to capture and interpret data in an operating room of the future. The captured data is used to construct the context of the surgical procedure and detect medically significant events.

Nurse skill training is specified in in-class single task mobile context-aware systems [17].

Contribution
In this paper we describe the initial experiments designed to verify the general viability of supporting teams of nurses in learning and performing emergency procedures by the means of near eye computing and on-body sensing. To this end we have collected several data sets from real life training runs in which the nurse students were equipped with Google Glass and a variety of sensors. In total we recorded 7 runs with 3-4 nurses each plus a supervisor present in the ward. Every run lasted 15-20 minutes. In this paper we describe the experiments and discuss some initial data.

Need for Augmentation

SimMans are highly sophisticated (medical) training dummies. They resemble a person of average height that can be programmed to have a heart-beat and breath. It is possible to measure pulse and apply arterial infusions.

Moreover, SimMan can simulate organ failure, heart attacks and have other crises. In a close-by control room the situation during a training session is influenced (e.g. SimMan's heart stops, crisis can occur, etc . . .) for learning purposes and in order to see how different trainees react to a crisis and training becoming "real".

Depending on the degree of skills (years of being taught) a common teaching lesson in the skill-center looks as follows:

1. The skill-training room is equipped like a standard hospital room, including lines for oxygen and nitrous oxide, a screen for monitoring the patient, a telephone to call specific clinical departments, an emergency trolley, a sink and an alarm system.
2. In this room 3-4 nurse-students have to attend a patient (SimMan). Here no roles are given to the nurses. One of the interesting aspects is understanding if and how roles come to them naturally.
3. A trainer is also present in the room, playing the role of an assistant.
4. The scenario / the health of the patient (SimMan) is controlled by a health care professional in control-room next-door.
5. After adding an emergency the simulation is continued based on the way the trainees deal with it.

During the training the sessions are monitored by educators, who afterwards analyze them and evaluate the competence of the trainees. In order to answer further research questions - e.g., how can training be enhanced, how do trainees learn, how do educators determine competence - the learning environment has been augmented further, so far mainly with microphones and cameras. Nevertheless, analyzing a training session after completion is limited as e.g. it is hard to determine who is referred to when a mentor is explaining something.

Aspects of Augmenting the Nurse Students
One of the main research questions is understanding how the complex process of rating a situation/behavior works and how a machine, be it a smart-phone, a smart-glass, a smart-watch or other devices, could help them.

On the road to build such a system this scenario provides a number of aspects worth analyzing:

- How do people interact with machines/devices specifically in emergency situations, and is a machine/device able to support the human dealing with an emergency (make them feel safer)? E.g. by displaying regulations or "what-to-do-lists" on a smart-glass.
- How do people interact with each other (often without talking)? How are roles naturally distributed?
- What paths are the students walking? Could the system help them to shorten paths? For example by determining what is needed and make them aware of it. So they can fetch on the path, eliminating the need to walk twice.
- Who looks in which direction, who looks to the areas where things happen (is concerned), is there someone trying to look away or to be unconcerned (which would be a strong sign that more training is

required for them), etc... All these questions require the machines to understand a situation!

- How could a machine influence the situation? E.g. give contextualized advice, check regulations and inform about them, detect false activities and warn, detect if a nurse needs assistance and inform an optimal helper.
- How do people react to the machine's attempt to influence?
- Could the help/influence of machine help trainees to learn faster?

Data Collection

We show in this chapter that the currently available wearable sensor systems like smart-watches or head mounted displays provide enough motion information to answer some of the questions mentioned in the previous section. Therefore we recorded data from different sensor modalities while the nurse students had to perform a typical nursing task. Although one could argue that working with a "training puppet" is not comparable to human patients, the trainers take care that the nurses treat the manikin as if it was a living patient. During the run the condition of SimMan gets worse resulting in an cardiac arrest. To save the patient, the nurses have to perform resuscitation. This process consists of several steps including cardiopulmonary resuscitation (CPR), administering adrenalin, attaching an automated defibrillator which detects ventricular fibrillation and applies shocks to the patient.

We equipped the nurses with Google Glass (see 1) and Android based mobile phones. Two of the four nurses were also equipped with our magnetic field based localization system [14], gathering location information of these nurses. We record raw acceleration, gyroscope and earth magnetic field information of the head (the intention is to determine in which direction the nurse is looking). The mobile phone stored in the nurse's pocket provides information about the body posture and modes of locomotion (stand, kneel, walk). Both sensor positions provide information about specific motion features to detect the CPR motion (depth, frequency). Although nurses are not allowed to wear watches due to hygienic reasons, we additionally gathered hand motions with LG Watch R smart watches. We define several regions of interest (Figure 4), e.g. the patient's bed, the nurse's ward containing communication equipment, emergency trolley storage room and a hygienic area for disinfecting the hands and storing protective clothes. Additionally a more fine grained grid is defined at the patient's bed to determine the position of the nurses relatively to the patient. As already mentioned, several cameras record the scenes and provide ground truth information for activities and position estimations.

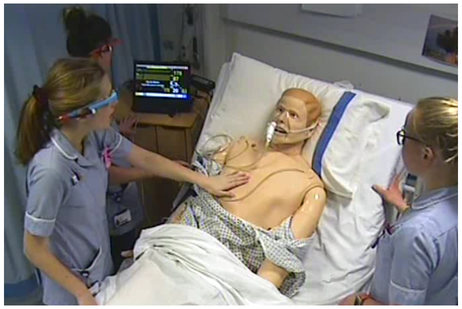

Figure 1: Nurse students wearing Google Glass while attending the SimMan-patient

First Analysis

Our first analysis focuses on, whether the used systems are suitable to detect specific activities like CPR or the movements of the nurses during the data recording.

CPR-Watch in Action

Wrist worn sensors provide information about the current hand related activities. In these scenarios the watch detects CPR related movements [6]. Our algorithm determines the depth and frequency of the compressions, directly linked to the quality of the resuscitation. In a future step, the algorithm should also be able to determine if it is necessary to switch the person doing the CPR they gets tired. It should be possible to detect exhaustion by monitoring compression depth and frequency trends.

Figure 2: CPR Watch can either be worn at the wrist or placed on top of the chest to estimate the quality and frequency of the compression.

Although all nurses had extensive CPR training, they started to rely on the CPR Watch. This is a clear indicator that people are willing to use augmenting devices and feel safer in stressful situations (life can be depending on correct CPR) when they are guided by a device. Figure 2 depicts a situation in which the watch is placed on the chest of the SimMan patient. As that nurses normally are not allowed to wear a watch they invented a new way to use it, by placing it on the patient's chest! Feedback of the nurse student and a present doctor was strongly in favor of extending their standard emergency equipment with such a watch.

CPR with the Smart-Glass

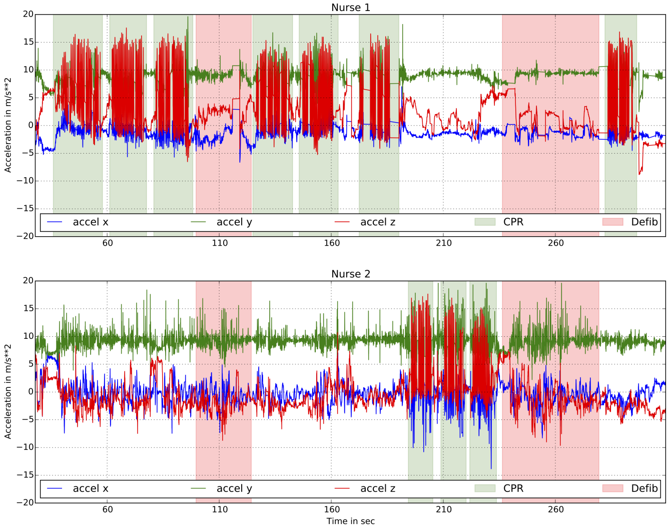

Figure 3: Nurse Glass Streams of two nurses. The trajectories indicate the recorded accelerations of x, y and z axis, the colored areas indicate CPR processes performed by nurse 1 and nurse 2 and the red area indicate the time when the defibrillator examines the heart rhythm, first red section is shorter as there is no shock applied, the second red section marks when the defibrillator applies a shock to the patient.

Google Glass provides information about the motion of the head and its current orientation ("In which direction is the person facing?"). Additionally, specific motions encompassing the complete body are visible in the sensor data stream. As depicted in figure 3, the acceleration information of the head clearly indicates the CPR process. The quality of the gathered information is comparable to the data quality of the wrist worn watch.

Tracing the Nurse

The data recordings showed that there are no fixed roles related with a specific nurse. Figure 4 depicts the estimated positions (in blue) and the reference positions which have been manually estimated using the videos of the cameras. Although the estimated positions seem to be off, a trend is visible (e.g. clusters around the bed and close to the sink). One has to keep in mind that the environment is demanding for localization systems.

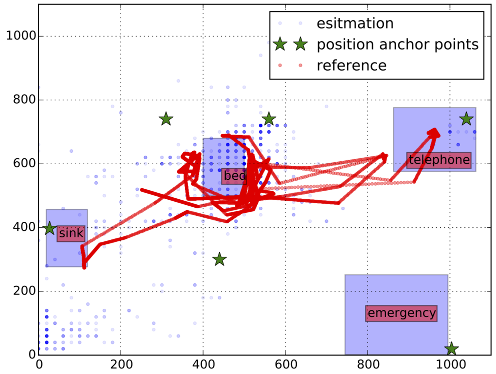

Figure 4: Overview of the room with reference positions of the nurse(red) derived from video material and magnetic field based locations (blue).

Conclusion

The experiments have clearly shown the viability of using near eye devices together with simple on-body sensors in emergency training scenarios. Initial inspection of the data indicates that a significant amount of information about relevant activity and cooperation patterns is contained in the data. We are currently working on developing automated recognition methods for key actions and quality parameters.

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