Assessing nurses' acceptance of a serious game for emergency medical services

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***Abstract* - Serious games can help in training medical first responders by providing emergency simulations which are always available, safer and possibly cheaper than real-world simulations. However, serious games for training emergency medical services (EMS) nurses must take into account the familiarity of the users with 3D videogames, which could be very low. In this paper, we present a prototype of the serious game we are developing for training EMS nurses in decision making and the results of a user study we have carried out with its intended users. The main purposes of the study were to assess nurses' acceptance of this kind of application, as well as to collect suggestions and requirements from nurses.**

Keywords: serious games, training, emergency medical services, evaluation, human-computer interaction

I. INTRODUCTION

Recent years have seen an increased interest in serious games and virtual reality applications to train emergency medical services (EMS) professionals (see, for example, [1-3]). This paper particularly focuses on training EMS nurses (i.e., nurses working in ambulance services) in decision making, employing 3D serious games (hereinafter, serious games). When EMS nurses face an emergency, they have to correctly analyze the situation, assess conditions of people involved, choose the appropriate procedures and perform them. Moreover, they typically need to operate under strict time constraints. Training of EMS nurses includes classroom lessons, case studies and live simulations. Emergency procedures are often described by flowcharts that have to be memorized by nurses. During live simulations, nurses operate on mannequins or actors under the supervision of an instructor, who guides them and evaluates their performance. More rarely, larger live simulations (reproducing, for example, mass disasters) involving many people are organized, with actors playing patients and emergency situations recreated in every detail. Simulations are necessary for EMS nurses, to test concepts and procedures they learned before having to handle real emergencies, where errors or delays can have serious consequences. These live simulations require time, money and organizational effort, each time they are carried out. On the contrary, once modeled, the situations presented by a serious game can be rehearsed without additional costs, the game can be used at any time and anywhere, including at home, while live simulations have to be organized in specific places on specific dates. Training sessions need to be periodically repeated during nurses' careers, mainly because: (i) emergency procedures are regularly updated, as a consequence of progress in medicine (e.g., new knowledge or changes in medical devices); (ii) some kinds of emergency situations occur rarely, and they have to be rehearsed through training, to maintain the ability to effectively handle them. Thus, nurses need training tools which can be frequently, conveniently and easily accessed and used, to reduce time needed and increase opportunities for training. Although serious games are promising to this purpose, some difficulties may arise from the fact that nurses may not be familiar with 3D videogames. Thus, the serious games development process must include a careful design and evaluation that involves the intended users , to identify and solve possible usability issues, which could hinder the effectiveness of training. In this paper, we present a prototype of the serious game we are developing for training EMS nurses in decision making and the results of a user study we have carried out with its intended users. The purpose of the study was to assess nurses' acceptance of this kind of application, as well as to collect suggestions and requirements from nurses.

The paper is organized as follows. In section 2, we describe previous work relevant for this paper. In section 3, we introduce the proposed application and the motivations for its development. Section 4 illustrates the user study we carried out and discusses its results. Finally, section 5 describes future work.

II. RELATED WORK

In this section, we consider previous work concerning desktop VR applications and serious games to train medical personnel supporting the development of non-practical skills (e.g., decision making or interpersonal skills). Kizakevich et al. [5] propose a system for multicasualty triage training, employing a commercial virtual patient software, simulating the physiology of casualties, and a learning management system implementing the FAPV (Familiarization, Acquiring the skills, Practicing the skills, and Validating the skills) method for self-paced learning. The system has also been employed for pre-deployment training of Army medical staff, for military sustainment training and for civilian disaster response training. A user evaluation of the latter application was carried out but the results have not yet been published. The Xbox 360 has been used as the platform for training triage skills in disaster situations in the "Triage Trainer" game,

developed by TruSim [6], a division of Blitz Games Studios. Jarvis and de Freitas [7] carried out a preliminary evaluation of this system, comparing two groups of users: the former using "Triage Trainer", the latter using a tabletop game. Users in the first group were more accurate in prioritizing casualties, suggesting that the serious game could be a more effective training tool than traditional methods, but, as highlighted by the authors, more investigation is necessary, since the small size of the sample and the different quality of instructions given by different evaluators could have affected the results.

Sliney and Murphy propose JDoc [8], a serious game with the purpose of familiarizing junior doctors with the day-to-day stress of a hospital. This system aims at reducing the time senior doctors have to devote to training junior doctors. It provides a CMS to manage resources like characters, questions and answers that can be made in the game, user data and so on. A graphical interface allows senior doctors to create scenarios by adding patients, together with some related data (e.g. blood test results), nurses and doctors to the game. Users can then go through the environment and assess patients. A usability test with junior doctors showed that interaction with the system was easy and that doctors perceived it as a useful tool for training. Unfortunately, the paper does not describe how the behavior of characters with which the player can interact and the assessment procedure are modeled.

Finally, the Medical Media and Design Laboratory [9] developed a scenario-based medical simulation in the 3D virtual world of Second Life, called Second Health [10]. This project aims at providing a new training method for nurses and medics from any speciality. A single scenario is currently available. Its main purpose is to teach nurses working in a hospital ward how to use medical devices. Users of the system can explore a virtual hospital, retrieve documents about patients, reach their beds and interact with medical devices, setting their parameters. A scoring system keeps track of users' performance. The scenario was tested with nurses from different specialties pointing out that 82% of them would recommend it as a training tool to nursing students and colleagues.

III. OUR PROPOSAL

The application we propose has three main training objectives:

- given an emergency medical procedure composed of tasks, teach the trainee what tasks to perform, in what order and with what timing, to correctly carry out the procedure;
- show the trainee how the tasks are performed, through realistic animations of game characters;
- allow the trainee to experience also infrequent emergency situations. In particular, we are focusing on emergencies involving disabled persons.

A. Application Description

The application has been developed with NeoAxis [11], a game engine programmable in C# and built on the Ogre rendering engine [12].

Nurses can freely explore an environment in which an emergency is taking place. Non-player characters (NPCs) provide information about the emergency or about patients through conversations triggered by proximity. When nurses want to carry out tasks on a patient, they have to choose what task to perform among a list of possible ones, belonging to the appropriate emergency medical procedure (Fig.1).

We have modeled medical procedures by using ConcurTaskTrees (CTT), a task modeling formalism proposed by Paternò [13]. We produced CTT models during the design phase, starting from scenarios written together with an emergency medicine expert, describing the details of an emergency situation and of the medical procedure to be performed in that situation. Our application retrieves tasks from CTT models to propose them to the player and tests player's actions correctness with respect to the constraints imposed by the CTT model. We provided a detailed description of how we use CTT to model and access medical procedures in [14].

The selection of a task by the player triggers events in the environment, for example the execution of animations or the appearance of visible effects on the patient. Animations of nurse characters reproduce real EMS nurses' actions (Fig.2). Virtual models of the medical devices actually employed by EMS nurses are available in the environment and are used during the procedure. When these devices have a display, the corresponding information is shown on a 2D plane for a convenient reading (Fig.3 shows an example where a medical monitor has been connected to the patient). An NPC representing a second nurse can take part in those tasks which have to be performed by two nurses (Fig. 4).

B. Design

The involvement of domain experts in the design of serious games is fundamental to guarantee an effective training [4]. To produce the prototype of the application, we defined a first emergency scenario and the associated medical procedure (one of the authors of this paper is an EMS doctor), which was then translated into a CTT model. In the scenario description, we identified the actions which had to be presented through animations and the medical devices used by nurses during the procedure. We then recorded nurses' movements for those actions through motion capture and took pictures of the real medical devices to be able to faithfully model them and their behavior. A preliminary version of the prototype was then reviewed by to the medical co-author of this paper, together with two doctors experts in physical disabilities (since the emergency scenario involves a disabled patient), and an emergency nurse. Their opinions allowed us to refine the prototype, making it more adequate to its intended users and to its purposes.

Figure 1. Choosing an action

Figure 2. The animation for the "Put oxygen mask on" action

Figure 3. Reading vital signs in the 2D plane

Figure 4. The nurse NPC helps in a step of the procedure

In the following part of this section, we illustrate the most important design decisions which guided the development of our application. They were based on particular requirements which mainly depended on the intended users of the application and on the application main purposes.

1) Navigation and Controls

To allow for a straightforward interaction with the application, giving users the possibility to better concentrate on the training task, we decided to employ only control devices they are already familiar with, i.e. mouse and keyboard. To the same purpose, we limited the number of keyboard commands, often required by commercial videogames. Thus, we implemented a point-and-click navigation control. Moreover, we chose third person perspective over a first person one, since the former allows the player to see more of its surroundings and can contribute to increase situation awareness. The camera (i.e. the point of view) is placed just above the head of the player character. To rotate the camera over the three axes, users have to move the mouse, while to reach a destination in the environment, they have to click with the right mouse button on it. The direction in which the player is looking is indicated by a crosshair (see Fig. 2 and Fig. 3). After a right click, the player character automatically moves towards the chosen destination and stops when it reaches it or when it hits an obstacle (e.g. a table) in between. Beside the mouse, only two keys are necessary to interact with the application: the "Enter" key toggles between navigation mode and task selection mode, in which users can select tasks to perform the procedure, while the "Esc" key goes to the main menu which contains the usual game functions such as load and save game. To maintain similarity with the interfaces of the applications to which nurses are used (office applications) we integrated in the GUI an always visible panel proposing the list of tasks still to be performed (see Fig. 1 and Fig. 3). In task selection mode, users can choose a task from the list by double-clicking it.

2) Patient Symptoms

A fundamental aspect of a serious game for training EMS nurses is how the patient character is modeled. We provided the simulation of patient symptoms to give feedback to users' actions (i.e. to tell if performed actions are correct) and to allow to evaluate patient conditions. The credibility of the simulation was validated by the already mentioned medical panel. For our first implementation, we employed a very simple patient model, to quickly produce something nurses could evaluate. In this model, patient states are identified by a set of symptoms and correct users' actions trigger transitions among states. Consequences of wrong actions are not currently considered: if users select the wrong task from the list a text message is shown, telling them they have to select another task.

3) Animations

During a medical emergency procedure, nurses have to perform various actions which require precise sequences of physical actions. The scenario employed in the user evaluation included the detailed animations of three different parts of the procedure, namely putting the oxygen mask on the patient's face, cannulating a vein, moving the patient to the stretcher. All three animations tried to accurately reproduce the actions performed by nurses during real emergencies, but they differed in the way they were created and presented to the user of the application. The first animation was created using motion capture data, while for the other two keyframing was employed. Keyframing is a technique through which the animator creates a subset of the frames required for an animation, while the remaining frames are created by the software, which interpolates between subsequent key frames in the handcrafted set, creating a smooth transition. The second animation was presented in the form of a rendered video overlaid on the 3D scene, focusing only on important details (e.g. the hands of the nurse character) and showing only the most significant movements. The other two animations, were instead performed by characters in the environment and all the movements involved were shown to the user. Motion capture requires more effort than keyframing, but should produce more realistic animations. Making virtual characters perform actions in the environment is more difficult than overlaying a rendered video on the scene, but should provide a more compelling experience, since virtual characters move in the same environment in which users are immersed, helping to maintain their sense of immersion.

We included these three animations in the application, to test if nurses had strong preferences for one technique over the others and receive indications for the future development of the application.

IV. EVALUATION

We carried out the user study with a sample of EMS nurses from Udine Hospital, Italy. The emergency situation we presented in the evaluation is based on a scenario concerning a tetraplegic person with high fever and respiratory difficulties in his bed at home, assisted by a relative. Patient's respiratory difficulties in the simulation are indicated by a cyanotic complexion, the sound of heavy breathing and the animation of the patient abnormally bending his chest. EMS nurses must initially concentrate on patient's breathing, putting an oxygen mask on his face. Then, they must measure some vital signs(heart rate, blood pressure,…). Finally, the patient must be transferred to a stretcher.

A. Procedure

The evaluation took place at the EMS center from which ambulance runs start. Each nurse carried out the test during her work shift change or during a planned break. This way, it was possible for nurses to devote their full attention to testing the application without being subjected to time-pressure or interruptions (such as having to leave for an ambulance run) and distractions. Nurses were initially asked to fill in an anonymous questionnaire containing demographic questions (age, sex, computer experience, videogame experience, etc.). The computer use questions (Table I) were inspired by those proposed in [15]. After having been instructed about the navigation controls, nurses went through a familiarization phase, in which they were allowed to spend unlimited time in a generic non-emergency environment until they felt familiar with the controls. This environment was made of two rooms connected by a corridor. Nurses started in the corridor and were asked to reach the room in front of them, which had many boxes in its centre, forcing them to move along the walls to explore the room. Nurses were asked to fully survey the room around the boxes and to go back to the corridor. Then, if they were not yet familiar with the controls, they were asked to reach the other room at the opposite end of the corridor. This room was larger and contained several big fantasy objects. Nurses were free of moving around the room as long as they liked.

When nurses felt acquainted with the controls, the actual evaluation phase (involving the emergency situation) started. First, nurses were told that they had to move in the game and choose the appropriate tasks from the proposed list to handle the emergency situation. They were instructed about how to interact with the list of tasks and about the fact that tasks in the list would appear in random order. No other information was given, but nurses were invited to ask any question in case of difficulties or make any remark about the whole experience (following a think-aloud protocol), since we were interested in evaluating how quickly all the aspects of the application could be understood. Then, interaction with the application started.

Initially, a text window, introducing the emergency situation and the main goal, was shown to the nurses. After they read the introduction, they could click on an OK button and start the test. The virtual experience initially places nurses on the front door of the patient's house where they are met by a relative of the patient, who engages them in a brief conversation about what happened. Then, the relative invites nurses to follow her to the patient's bedroom. Once they reach the room, the relative informs nurses that the patient is tetraplegic and they can also see a wheelchair on the patient's bedside. Then, nurses can choose tasks from the proposed list to perform the procedure. When a correct task (i.e. a task satisfying the constraints imposed by the CTT model of the procedure) is chosen, an event is triggered in the environment (e.g. an animation). After executing all the proper tasks, when the patient is transferred to the stretcher to take him to the ambulance, a message informs nurses that they have successfully handled the emergency.

After the test, nurses were administered a questionnaire (Table II), with questions about overall player satisfaction, specific application details, such as the patient character or animations, and the perceived usefulness of this kind of applications in training EMS nurses. Most questions were presented in the form of statements to which nurses had to indicate their level of agreement on the following five-item Likert scale: "Strongly agree" (1), "Agree" (2), "Neither agree nor disagree" (3), "Disagree" (4), "Strongly disagree" (5). Some statements were taken from questionnaires proposed in the literature. In particular, statements 2, 3, 5, 6, 15, 16 and 17 were taken from the Presence Questionnaire proposed in [16]. Statement 12 was instead taken from the EGameFlow [17] questionnaire, developed to evaluate games for e-learning,

TABLE I THE COMPUTER USE QUESTIONNAIRE.

1. How long have you been using a computer?					
I have never used a computer	Less than a year	About a year	1-2 years	2-5 years	More than 5 years
2. How often do you use a computer?					
I do not use a computer	About once a month	A few times a month	A few times a week	Every day, for less than 1 hour	Every day, for 1-3 hours	Every day, for more than 3 hours
3. What is the main thing you do when you use a computer?					
I do not use a computer	e-mail	Web browsing	Videogames	Document editing (Word, Excel, etc.)	Other (describe)
4. How much do you like using a computer?					
Not very much	A little	Very much			
5. How often do you play videogames?					
I do not play videogames	About once a month	A few times a month	A few times a week	Every day, but for less than 1 hour	Every day, for 1-3 hours	Every day, for more than 3 hours
6. Did you ever play 3D videogames?					
Yes	No				

while statement 1 comes from a questionnaire to evaluate navigation control in VEs [18]. To have more opportunities to collect subject's opinions on the experience, we read the statements together with them and interviewed them to elaborate on their ratings. The number of items in the questionnaire was intentionally kept as low as possible, since we wanted to avoid nurses getting tired by the evaluation.

B. Participants

We circulated a call for volunteers among the nurses working for the EMS center of Udine Hospital: 12 of them, 8 female and 4 male, answered positively. Subjects did not receive any compensation for participating in the test. Moreover, their supervisors were not involved in the recruitment, to avoid any pressure to participate in the study. The average age was 38.6 years (youngest 28, oldest 50). Answers to question 2 in the computer use questionnaire (Table I) were almost equally distributed among the last 3 responses: all subjects use computers daily, although the numbers of hours differ. No nurse indicated playing videogames as his/her most frequent computer task: the main computer tasks were almost equally distributed among email, web browsing, editing documents and using computers at work. Most of the subjects said that they like to use computers very much. Use of videogames (2D or 3D) is rare: 7 nurses play videogames a few times a month, 4 nurses play about once a month, only one nurse never played videogames. Finally, 7 subjects never played 3D videogames.

C. Results

In this section, we report the results for the two phases of the evaluation and the questionnaire (Table II, Chart I), together with some observations.

1) Familiarization Phase

The purpose of this phase was to allow nurses to familiarize with navigation controls. The average familiarization time was about 2 minutes. However, seven nurses took 90 seconds or less to get used to the navigation controls. The two slowest nurses took about 5 minutes to familiarize with the controls. They both did not have any experience with videogames and one of them did not like to use computers while the other one liked it only a little. A particular case is represented by a nurse having experience with some console games, who took nearly 4 minutes to familiarize with the controls. Because of the control system she was used to, she would have preferred to use the arrow keys to navigate the environment rather than the mouse. Overall, the control system we adopted turned out to be easily learnable by users with no or very little experience with 3D videogames, as confirmed by questionnaire results. The first 3 statements, concerning the difficulty of familiarizing with the controls, received positive ratings as shown in Fig. 5. Altogether, 83% agreed or strongly agreed and 17% disagreed with statement 1; 91% agreed or strongly agreed, while only 9% disagreed with statement 2; 75% agreed or strongly agreed, 17% neither agreed nor disagreed and 8% disagreed with statement 3.

2) Test Phase

The test phase was completed in an average time of nearly 7 minutes (mean: 419 seconds, standard deviation: 83.38 seconds). During this phase, nurses did not show particular difficulties with the controls or the interface. Statement 4 obtained very good ratings (50% strongly agreed, 42% agreed, 8% neither agreed nor disagreed). This result was predictable, considering that computer use questions pointed out that the main computer tasks carried out by the subjects usually involve traditional 2D interfaces with menus.

3) Specific Application Details

Statements 5 to 11 investigated the satisfaction of the subjects about some specific aspects of the application. The provided view proved adequate to the task, allowing nurses to completely survey the environment and objects and characters in it (identical results for statements 5 and 6: 58% strongly agreed, 42% agreed). During the demonstrations of the preliminary version of the prototype, the expectations of the medical panel on the simulation of the patient were

TABLE II EVALUATION QUESTIONNAIRE

Interaction	
1	Moving through the virtual environment was simple
2	I quickly learned how to move through the environment
3	I could always concentrate on the actions in the game rather than the commands I had to give to activate them
4	I quickly learned how to select tasks to perform the procedure
View	
5	I had a complete view of the environment
6	I could observe well objects and characters in the environment from various points of view
Specific application details	
7	The sound of the shortness of breath of the patient is realistic
8	The cyanotic complexion of the patient is realistic
9	List virtual patient's aspects you liked or disliked (open question)
10	The application shows three animations, listed below, related to actions belonging to the procedure. Order them from 1 to 3 based on your subjective preference (1 best, 3 worst). Oxygen mask application. Vein cannulation. Patient's transfer to the stretcher.
11	The characters helped me understand what was happening in the environment and what I was supposed to do
Usefulness and effectiveness as a training tool	
12	This kind of application could increase my knowledge
13	This application would integrate well with the training methods currently employed to train EMS nurses
14	In what phase of the training should it be employed? (open question)
Global satisfaction	
15	I felt involved in the experience
16	I liked the graphics of the application
17	I liked the audio of the applications
18	I would be willing to use this kind of application
19	Additional comments (open question)

demanding, so we used statements 7 to 9 to collect nurses' opinions about the patient character. The number and the level of detail of nurses' comments stress how a credible simulation of the symptoms and of the reactions of the patient to the procedure is crucial for this kind of applications. To assess nurses' subjective preference about the three animations, introduced in section III, we asked them to put animations in order of preference, from the best to the worst (question 10). We assigned a score of 1, 2, 3 respectively to the first, second and third condition. The average scores for the three animations were 1.92 (standard deviation 0.96) for the rendered animation, 1.83 (standard deviation 0.8) for the animation created through keyframing, 1.75 (standard deviation 0.72) for the animation created with motion capture. Friedman's test pointed out that the small differences among these averages are not statistically significant. The obtained ratings highlight how there was no clear preference among the considered animations, although we expected the rendered video to perform worse than the other two, since the overlaid video could have created a break in the sense of immersion.

4) Usefulness and Effectiveness as a Training Tool

There was a substantial agreement about the usefulness of the game as a tool for training nurses: 50% of the nurses strongly agreed and 42% agreed (8% disagreed) with statement 12 ("this kind of application could increase my knowledge"). They also thought that this kind of training could be easily integrated with current training procedures for EMS nurses (statement 13, 50% strongly agreed, 50% agreed). In particular, we received the following comments and suggestions, as spontaneous remarks or answers to question 14 (the first two suggestions were given by almost all nurses, while the others came from single nurses):

- the application could be used to train novice EMS nurses who still have to learn all the emergency the application could be used during retraining, which occurs periodically during a nurse's career to refresh previously acquired knowledge;
- the need to concentrate on the patient during real emergencies could prevent nurses from paying attention to each possible detail of the procedure, so the application could be used to analyze emergency

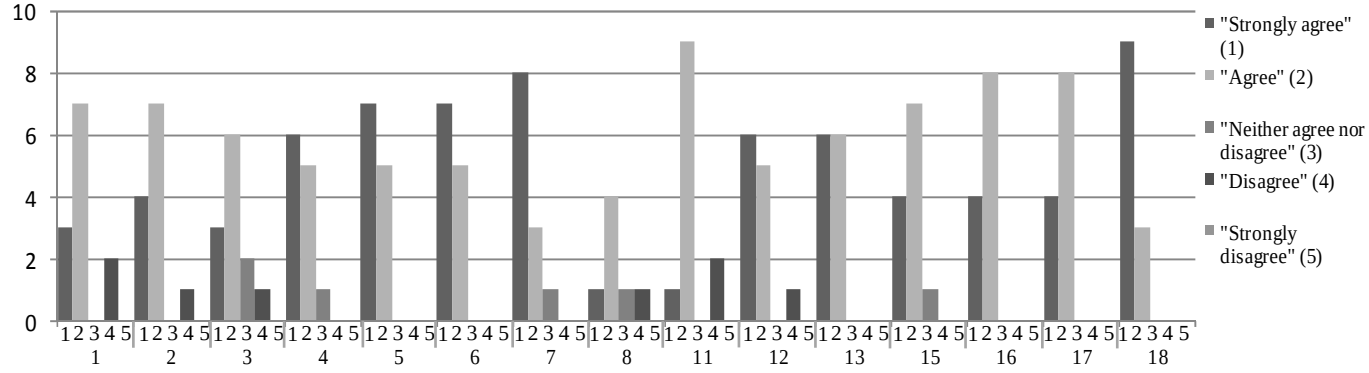

Figure 5. Percentages of responses (vertical axis) for each statement (horizontal axis)

situations and the corresponding procedures more carefully;

- the application could always be available to nurses at the workplace to refresh procedures when there is some time available (e.g., waiting for an emergency call), and it could also be used at home;
- the application could be used to teach procedure updates;
- the application could be used to test nurses' knowledge, substituting written exams;
- a multi-user experience could improve collaboration among the different roles involved in the emergency, such as nurses, ambulance drivers and possible volunteer rescuers, by allowing them, to communicate and cooperate applying their peculiar skills.

In the well-known Technology Acceptance Model [19], which concerns also prospective use of a system, perceived usefulness and ease of use drive the acceptance of a new system or technology. Under this light, the high ratings in perceived ease of use and usefulness obtained in our study are an indication that training with serious games could be well accepted by nurses.

5) Overall Satisfaction

Statements about realism of graphics and audio (number 16 and 17) received the same high score (33% strongly agreed, 67% agreed). It is interesting to note that subjects appreciated the fact that nurse characters uniforms and medical devices had been modeled after the real ones. This brought the simulation closer to their everyday life experience. Although the graphical and audio quality of the application does not reach the level of the best commercial videogames, the high level of satisfaction from the nurses' side indicates that it is more than sufficient for the specific training application.

Almost all nurses reported a high or very high involvement (statement 15, 33% strongly agreed, 58% agreed, 8% neither agreed nor disagreed). This happened despite the fact that no particular interaction devices for immersive VR were used and an observer was present.

Finally, statement 18 tests if nurses would willingly use this kind of application for training. The score was the highest of the whole questionnaire: 75% strongly agreed and 25% agreed. In particular, some of them were really enthusiastic about the possibility of having such applications always available for training.

D. Nurses' Feedback

During the evaluation, we invited nurses to share their thoughts about the application, whether they were questions, critiques or proposals. Many of them were related to minor improvements we should implement, but some identified new requirements for the application or important desired features. In the following, we report the most significant of them.

In the game, users can see a nurse NPC which remains passive most of the time. It was included into the environment for two reasons: (i) to make the presented situation more realistic, since actual ambulance runs do not involve less than two nurses; (ii) to take part in moving the patient to the stretcher, an action required by the considered emergency medical procedure. One of the nurses wished it was possible to give orders to the other nurse, since in real situations different nurses deal at the same time with different aspects of the emergency. This is an improvement which could increase the complexity of possible actions in the environment and pose more challenges to the user, providing more learning opportunities.

We were expecting nurses to generally require more verbal interactions with characters than we provided in the application. However, only one of them said it would have been good if he could ask free questions to the other characters. Similarly, another nurse pointed out that questions asked by the main character to the relative of the patient were not the ones she would have asked in a real situation, so the possibility of choosing questions would have made conversations more useful.

Making the application adaptive to different professional levels was suggested by one of the nurses. Since, in real emergency situations, people with different skills and goals are involved (e.g. nurses and volunteer rescuers), the application should be aimed at training all these different kinds of first responders and automatically adapt to different users. For example, the set of tasks a user can choose from should change with respect to the role she has.

Some nurses had previous experience with other multimedia applications for training, usually in the form of

hypertexts, integrating videos and animations, which presented emergency situations and asked trainees to select the correct procedure or just showed it. Nurses compared the serious game with these applications or with the traditional non computer-based training methods. In each case, the application was seen as a better way to convey knowledge, mainly because of the immersive elements it introduces.

Finally, by observing nurses while they navigated in the game, we noticed that several of them tended to collide with walls or other obstacles, forcing the camera to positions that made it difficult to move away from those obstacles. This problem could be overcome, for example, by optimizing the way camera handles proximity with large obstacles or making these obstacles exert some force on characters, to keep them away. Moreover, camera control has also to be optimized for situations like narrow passages or low ceilings, since they often make it difficult to locate destinations while moving through the game, slowing down users.

V. Conclusions and Future Work

This paper has presented a serious game for training in emergency medical procedures and the results of a user study carried out on nurses. Since the subjects involved in the study are the intended users of the application (i.e., professional EMS nurses), we think that the results we collected (requirements, opinions about particular design decisions, overall acceptance of a serious game for training in decision making), could be generally helpful for the development of systems with similar purposes targeted to the considered category of users.

Following feedback received during the evaluation, we will proceed in two main directions. First, we plan to employ the CTT formalism not only to model the medical procedure, but also NPCs behavior and patient health state evolution and the interactions among them, exploiting the fact that scenarios which predefine all the events are available from traditional EMS nurse training. We intend to use CTT, possibly proposing extensions to it, to support the definition of a sequence of patient states at design time and to employ a patient states ontology for run-time retrieval of details about the current patient state. We will also exploit CTT to represent NPCs actions and temporal relations among them. We will then use a cooperative tree (a feature of CTT) to connect player's actions to patient state changes and NPCs actions. The game engine will thus be able to execute NPCs actions as a consequence of player's actions. Second, we will develop, together with domain experts, a scoring system to give players the possibility to evaluate themselves with the game and keep track of their progress.

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