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The Use of Personal Learning Simulators to Improve Doctors' Clinical Decision Making skills

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Abstract

This paper discusses the use of personal simulation within medical learning. Our objective is to show that personal simulators can be used to realise all datasets needed to fully represent medical situations. We developed a high fidelity personal simulator test framework titled JDoc. The paper outlines the construction process and the functionality of the personal simulator. We present a small scale post-test usability study with junior doctors from which we can assess the benefits of personal simulation within a small subcategory of medical users.

1. Introduction

The medical domain consists of a substantial body of knowledge, which is continually increasing in size and complexity. The visualisation of medical data can be anything from the representation of a patient's anatomy, models of molecular structures, spatial navigation of medical volume data, to complex permutations of medical diagnosis protocols.

Personal simulators are moving to the forefront of medical training. Within medical education the use of visualisation is becoming commonplace. It is within these sectors of medicine that there has become a need for adequate visualisation. One of the key issues being researched within designing personal simulators is the difficulty representing the vast amount of different data types; realism, cognition, haptic feedback, interpersonal and communication skills, emotion, acquiring correct medical information, etc.

These dynamic datasets are required to make an effective simulation for end-users. The user needs to be surrounded by the relevant information through internal visualisation and imagination, be it consciously or subconsciously.

According to Beaubien simulation is a powerful training tool [1]. It allows the user to choose their own practice schedule. They can review feedback when required and all actions are free of environmental distractions within a safe, controlled learning environment.

Binstadt [2] asserts that medical simulation provides an immersive environment that, by replicating actual critical patient encounters, provides residents with the opportunity for the pursuit of multiple core competencies concurrently: (simulated) patient care, practice-based learning, interpersonal and communication skills, and the acquisition of new medical knowledge.

Personal simulation is a subcategory simulator defined by the use of an interface, typically computer, based software, to allow a learner to interact with a modelled patient and environment. This type of simulator requires solid technological implementations through usability engineering and concise HCI methods to bring them to a level of satisfactory realism. These simulators suffer from the disadvantages of not being able to operate in association with specialist instrumentation. It is not feasible to expect each doctor in training to possess, or have access to a standalone machine for each type of training module.

By using a well-structured personal simulator, it is possible to elicit different types of emotion and behaviour. This can be achieved by design for high levels of visual and behavioural realism and by incorporating multi modal forms of interaction. This in turn can be used at a cognitive level to condition the learner to be more effective at clinical medical decision making. Hence medical learning can be assisted by personal simulation in the form of training simulators. An example of a personal simulation prototype of this kind is JDoc.

2. What is the purpose of the Junior Doctor Simulator (JDOC)?

The purpose of the JDoc is to familiarise junior doctors with the day-to-day stress of a hectic hospital. By simulating patients and creating scenarios using basic parameters provided by senior doctors, JDoc supplies junior doctors with valuable (virtual) experience, which otherwise would be unobtainable.

It both immerses the player in the believable world of a busy hospital at night and educates them as to the diagnostic procedures and medical criteria required while working on-call in a hospital ward.

As the need for doctors continuously increases, the ratio of junior doctors to senior doctors also increases. The junior doctor simulator addresses some of the associated problems. Instead of every senior doctor having to continuously teach while working with a trail of junior doctors, they will input interesting cases into JDoc. Using this method the senior doctor can concentrate more on his or her patients without compromising the quality of learning of the junior doctor. The simulator goal is expressed in terms of the effect that it will have on the player. JDoc establishes what the player will learn through prior research with many experienced doctors who have first-hand experience and knowledge of the relevant areas for junior doctor education.

Medical simulation has a key role to play in training all medical fields [4]. Medical simulation training programs have resulted in improved performance, shorter response time, and less deviation from practice standards than non-simulator training. Medical simulators increase trainee confidence, competence, and improve patient safety. Medical simulation training can also yield cost and process efficiencies.

3. JDoc

JDoc is an interactive, computer-based 1st -3rd person junior doctor simulator prototype. It is used to train and teach junior doctors interpersonal skills, communication skills, medical information, decision making skills etc. It is a simple, cheap and easy-to-use development model, where people are assisted by information technology [5]. It can be installed on any home computer that meets the minimal required specification (e.g. any PC less than 3yrs old). The users' actions are continuously logged for reviews and revision by either the user by comparison or by a senior doctor dependant on which situation is preferred. Interactive prototypes of specific fidelity enable a better understanding of end-users and their tasks, lead to a better collaboration and make it possible to produce better software faster [6]. Realistic prototypes help resolve detailed design decisions in layout, visual presentation, and component selection, as well as

finding points in interaction design and interface behaviour [7].



Figure 1. JDoc intro screen; from here they can begin the simulator, change the video/ audio setting or exit the simulator.

Once the user has installed JDoc onto their personal computer they can run it anytime by double-clicking on the desktop shortcut. As the simulator boots up, the various entities (Bots, tables, beds, buildings, etc) are loaded up. These entities are given predefined mass and position. Each static object (for example a chair model) has their given co-ordinates and rotation. All triggers and audio emitters are programmed to react to specific events. Each "bot" (Non-Player Character) and the one player character are then spawned to their specified location. They either have static orders or dynamic orders called upon from a tripped trigger. When the simulator is fully loaded, the user has to attempt to go from waiting on call to assessing the patient (Fig. 2.). When the user has finished using the simulator, all actions can be reviewed either by themselves or their supervisor in an individual txt file. Once a junior doctor logs onto JDoc they take control of a doctor model (an on call junior doctor). JDoc creates a file under the doctor's name in which all their actions will be documented.

The user must make their way to the hospital and then find and assess the patient. To accomplish this they must talk to other doctors and nurses (Non-Player Characters (NPCs)) ask questions and follow the correct protocol in assessing the patient. Each assessment and every reaction from the in-game doctors and nurses, and factors like ECGs, blood test results and patient history can differ as the senior doctors create a new scenario.

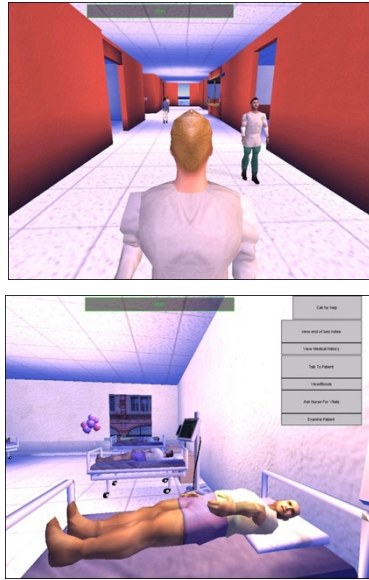


Figure 1: A selection of in game shots from JDoc

4. The Output

For each user of JDoc an individual Xml file is created. The file named after the users' log-in name records every movement and decision the user makes. Dependant on how JDoc is set up by the senior doctor this Xml file can either contain the correct procedure for each step so the junior doctor can compare his/her own mistakes or it can be setup so only the senior doctor can assess each users' decision making skills and how well each user diagnosed the patient.

5. How was the JDoc built?

For the purposes of developing the JDoc prototype, the popular game engine, Torque Game Engine (TGE) from GarageGames was used. 3DS Max 8 was used for modelling. The game engine itself is coded in C++. These factors will all remain hidden from end users' of JDoc. Any new scenarios created by senior doctors shall be done through a simple Content Management System. Within this CMS will be a series of simple questions with either tick boxes or text boxes that will edit the underlying code and will ultimately create new unique scenarios.

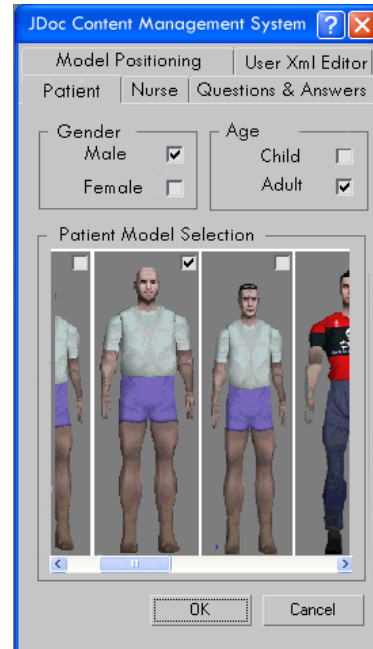


Figure 3: Using the JDoc CMS the senior doctor is able to create new scenarios.

It is with the use of this Content Management System (CMS) that JDoc becomes infinite. Once the senior doctor has completed building his scenario he can save it and make it assessable to other senior doctors or ever other hospitals. The likelihood of scenario sharing would increase significantly with the addition of a simple database website accessible to all users' of JDoc.

6. Usability aspects of JDoc

JDoc input devices are constrained to tactile (keyboard or mouse) and the output devices are constrained to visual (monitor) or aural (speakers). Any action the user wishes to carryout, be it simply unconstrained user movement or assessing a patient, is made by inputting their choice by keyboard (actions bound to a specific key) or by mouse (button click). The predefined response to the users' choice is then relayed back through the monitor, through the speakers, or both. The first and most important usability aspect we looked at was the user's avatar itself. How would the user move the character? How would the user know he/she moved the character? Given our input devices constraint, we felt that the use of the arrow keys would be the easiest means of character movement. JDoc generally uses the 3rd person model but in any instance where the blind spot behind the model causes an obstruction the view changes to first person. This method still detracts from the realism of the game; however, user feedback has shown that it is adequate, especially when one considers the lack of sophisticated output devices.



Figure 4: Here we see the view the user gets in first person while interacting with others.

Assessing the patient is another area in which good usability practices are essential to extend the fidelity of JDoc. This area differs from the first as it is dynamic. Again taking the available basic input devices, it was decided to use on-screen buttons and drop-down menus for the users to input their actions. This method is sufficient as it leaves the user thinking about what action to undertake rather than how to undertake it. Where responses cannot be predefined in button or text boxes we use input boxes for the user can explain their actions by writing an explanation. Good usability practice plays a vital role in JDoc. It is these practices that differentiate JDoc from a simple text based simulator. The use of good audio, camera positioning etc, creates an atmosphere inside JDoc that brings the users state of mind somewhat near the level needed in a real life scenario.

7. The Usability Test

To evaluate our implemented framework from an end-users' perspective, a rapid usability test was performed. A test group of N junior doctors ranging from age 21-32 and mixed sex, N = 24, from Cork University Hospital participated.

Table 1. Results from the junior doctor usability questionnaire

Question	Yes	No	50%
Would the simulator benefit junior doctors?	100%	0%	0%
Do you think the data was represented appropriately?	90%	0%	10%
Did you think the sound effects were realistic?	100%	0%	0%
Do you think the model of the hospital was realistic and captured the feeling of a real hospital?	80%	10%	10%
Did you find the player character easy to control?	60%	20%	20%
Did you find the button interface easy to follow?	100%	0%	0%

To further understand some of our results we performed another rapid usability test this time on a control group, M = 14 "gamers" again of age 21-32 and mixed sex.

Table 2. Results from the control group usability questionnaire

Question	Yes	No	50%
Do you think the simulator would benefit junior doctors?	70%	0%	30%
Do you think the data was represented appropriately?	70%	0%	30%
Did you think the sound effects were realistic?	100%	0%	0%
Do you think the model of the hospital was realistic and captured the feeling of a real hospital?	50%	50%	0%
Did you find the player character easy to control?	100%	0%	0%
Did you find the button interface easy to follow and use?	100%	0%	0%

From these initial tests we are able to infer that the simulator will benefit junior doctors; the data and sound was acceptable, realism was acceptable for junior doctors but in the gaming world only adequate. The main point taken from these tests is the movement of the character. Gamers who have used these controls found them excellent therefore allowing us to presume, although some doctors struggled with these controls, with minimal experience they would become more proficient. The simulator was also tested on a hallway group but the tests were deemed invalid as the users' within this group kept becoming distracted by medical terminology unknown to them.

The hi-fi prototyping had the advantage that end-users both participated and were studied in a realistic setting. [6]

8. Evaluation

When evaluating JDoc and the use of personal learning simulators, comparing them to other medical simulators, like the use of mannequins for example is meaningless. The purpose of these simulators is to improve doctors' clinical decision making skills. Little to no emphasis is put on patient simulation or patient conditions. The consultants and student doctors that have used JDoc all returned positive feedback and felt that a fully completed JDoc could become a good addition and

another learning method. These personal simulators are built, not with the purpose of replacing old technology or becoming a front runner in new technology. They are built to hopefully keep the master apprentice model going between different levels of doctors.

9. Future Works

Future work on JDoc has numerous possibilities. Many new scenarios could be built and new models and characters can be continuously added. The big forward step for this project would be to add a Content Management System (CMS) screen for the senior doctors to continuously edit and update the scenarios (Fig. 2.). Each new scenario built in each hospital can then be added to a database and then made accessible to any user of JDoc over the internet making the amount of scenarios potentially endless. Critical pedagogy Scenarios will also be built to expand teaching strategies and to prevent the scenarios from becoming static e.g. having actions return incorrect results and letting the user have the option of flagging these inconsistencies. The data should adapt to individual needs and levels of expertise in order to enhance cognitive performance. It should learn with the user [8].

Also updates for JDoc could be periodically built and downloaded to each copy of JDoc adding better functionality and diversity to JDoc.

10. Conclusion

The personal simulator prototype JDoc proved to be very effective as a clinical decision learning system as a training simulator. When Medical professionals need to make decisions it is important that they have access to all required information (data). JDoc, as a training program, gives the users' experience with all the required information (except haptic) to make an informed decision. This decision making training will then, in theory, aid the user in any relevant real life situation.

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