CONFERENCE PROCEEDINGS

SEVILLE, SPAIN
18-20 NOVEMBER 2013
AN AUGMENTED REALITY SYSTEM FOR RISK PREVENTION IN HOSPITALS: PRELIMINARY USABILITY DATA

S. Quero1,6, M. Pérez-Ara1, G. Terenzi2, M. Fiorese3, D. Campos1, R.M. Baños4,6, M.A. Vicent5, D. Reina5 & C. Botella1,6

1 Universitat Jaume I (SPAIN)
2 Inglobe Technologies Srl (ITALY)
3 Entropy Knowledge Network Srl (ITALY)
4 Universidad de Valencia (SPAIN)
5 Hospital La Magdalena (SPAIN)
6 CIBER de Fisiopatología de la Obesidad y Nutrición (CIBEROBN) (SPAIN)

Abstract

In the health care sector, workers have to deal with a wide range of activities and environments that put them at risk of occupational disease or work-related accidents. In this sense, around 40% of health care workers suffer an accident at work. Information and Communication Technologies (ICTs) have shown their utility in the application of education programs in medicine training, medical diagnoses and, also for safety at work in the health care sector. Regarding the use of Augmented Reality (AR), some examples about its application can be found in the medicine sector. However, in the specific case of safety at work training, no studies have been found so far. In order to test the utility of this tool, the project ANGELS (Augmented Reality Network Generating Learning on Safety) has emerged. It is a European Project (Lifelong Learning Program: 518015-LLP-1-2011-1-IT-LEONARDO-LMP) funded by the European Commission and formed by a Consortium of public and private organizations in Italy (Fondazione PTV Policlinico Tor Vergata, Entropy KN (ENT) e Inglobe Technologies), France (Hopital Broca), the Czech Republic (National Centre of Nursing and Other Health Professions), and Spain (Universitat Jaume I) with the aim of creating a training system based on Augmented Reality about safety and prevention within work environments in the health sector. This paper presents the description of the ANGELS System as well as the preliminary results about the usability perceived by participants in the pilot study carried out in Spain. Results obtained showed acceptable usability for the ANGELS system with a mean score of 67 (SD = 4.81). Although preliminary data about the first version of the ANGELS System revealed acceptable usability, some modifications aiming to improve its usability would be desirable before the next large scale trial is conducted.

Keywords: Augmented Reality, European Project, learning program, safety at work, health sector.

1 INTRODUCTION

The ANGELS project (Augmented Reality Network Generating Learning on Safety) emerged with the aim of testing the utility of Augmented Reality (AR) for training in risks prevention at work in the health care sector. It is a European Project (Lifelong Learning Program: 518015-LLP-1-2011-1-IT-LEONARDO-LMP) funded by the European Commission and formed by a Consortium of public and private organizations in Italy, France, the Czech Republic, and Spain with the aim of creating a training system based on Augmented Reality about safety and prevention within work environments in the health sector [1].

ANGELS - Augmented Network GEnerating Learning on Safety idea starts from two different main needs.

The first one is probably the “never ending” need to innovate the learning methods to develop a training path in line with new skills and new perception habits, now massively popular in everyday life. By this we mean the use of technological devices to carry out normal day to day operations, for instance from shopping to travel bookings, from listening to music to reading books. Because of this, the Augmented Reality (AR) was selected. AR is a term for a live direct or an indirect view of a physical, real-world environment whose elements are augmented by computer generated sensory input, and the view of reality is modified by a computer. As a result, “technology functions by enhancing one’s current perception of reality”. Several studies have shown that immersing in a digital environment can enhance education in at least three ways: by allowing multiple perspectives, in situ
learning, and transfer of the results." [2] Starting from the key goal of the Life Long Learning Program to “address the modernization and adaptation of educational training systems in the participating countries” ANGELS proposes a Technology enhanced and immersive learning system whose aim is to experiment a new tool but also a new learning paradigm. Indeed we know that changing technology or updating tools means above all changing the learning framework. This is one of the main issues of ANGELS: developing an innovative tool and methodology and also a new learning approach. The ANGELS system allows participants to explore environments and get information, training and retraining experiences. At least the ANGELS system will allow participants to add more input and information based on personal previous experience in the environment (“See risks through the eyes of those who live on the front line”).

The second need is one of the most strategic and urgent issues in our modern society and it is still a big challenge at a European level: Workplace Safety and Health. In the health care sector, workers have to deal with a wide range of activities and environments that put them at risk of occupational disease or work-related accidents. In this sense, around 40% of the health care workers suffer an accident at work. Giving effectiveness and attractiveness to learning path in this field it is crucial to promote the culture of Safety at work, develop awareness, personal commitment and responsibility. It is a big challenge for the ANGELS Consortium because traditionally, such training is very focused on regulatory issues such as rules and law articles and it is often perceived as boring and low appealing. Information and Communication Technologies have shown their utility in the application of education programs in medicine training [e.g., 3, 4], medical diagnoses [e.g., 5] and, also at safety at work in the health care sector [e.g., 6, 7]. Regarding the use of AR, some examples about its application can be found in the medicine sector. This tool is demonstrating to be an effective learning technology in many applicative domains, especially when it is compared to other learning methods. In the context of healthcare applications, AR has proved to be a useful tool for the evaluation of AR instructions in Hospital settings [8, 9] and for the creation of collaborative platforms supporting the execution of dynamic tasks [10]. However, in the specific case of safety at work training, no AR-based studies have been found so far.

Thanks to the Augmented Reality and a new methodology that reverses the learning paradigm, the environment becomes proactive and interactive, allowing the integration between site and human behavior.

The expected impact is mainly to provide innovation to learning practice thanks to an original and interactive methodology, to increase the workers awareness about health and safety issue, to ensure the effective valorization and exploitation of the project results and products, and to build an original methodology framework usable on other content such vocational skills relevant to labour market.

Indeed ANGELS wants to introduce the following key innovations:

- The first one concerns technology. ANGELS will focus on innovative practices and technologies (“Augmented Reality and immersive technique), not usually considered in “practical” treatments of learning. During the two experimental cycles (pilot study and large scale trial) ANGELS teaching staff will test the learning model developed for this project, measuring participants’ satisfaction, the level of retention of the content, and usability.

- The second derives from the first one and from a realistic assessment of 21st century teaching environments. The ANGELS program will be designed to accommodate constraints deriving from participants’ heavy workloads making education accessible directly in the work environment. In particular in the health care context, not taking time away from the staff at work and at the same time providing them with the right information and training about safety is a crucial challenge.

- Third will be the field of application, addressing the issues of safety at work in the health care settings. In this context it is so fundamental the adoption of instruments of training/updating on the job deeply integrated within work settings that, thanks to the development of didactical technologies, it can provide users with localized information and training aids about right safety and prevention procedures (environments, employment of technical devices, etc).

- Finally, rather than producing “guidelines” for academics and decision-makers, ANGELS will produce a Starter Kit that directly appeals to organizations in need of Safety on Work training, university teaching staff, and professional trainers. The ANGELS Starter Kit will include multimedia content and documents (also to be released on the web) and free DEMO software allowing safety managers at the organizations and individual workers to try and deeply understand the ANGELS System. The
multimedia content will adopt “a narrative style”, in which the trainer tells about the practices they have developed and the way they have tested them, and the participants testify their experience.

So far the analysis of the different risks and populations involved in this area, as well as the analysis of the availability of training programs on safety at work has been conducted [11]. The aim of this work is to present the description of the ANGELS System as well as the preliminary results about the usability perceived by participants in the pilot study carried out in Spain.

2 METHODOLOGY

2.1 Participants

The recruitment procedure of the sample consisted of contacting potential participants by e-mail and telephone in order to invite them to participate in the pilot trial. Once they reported their interest in participating in the study, a meeting was conducted in order to clarify the study requirements and reach an agreement with the hospital. After contacting several hospitals in the Valencian Community, finally, the internal medicine department of the public Hospital La Magdalena (Castellón, Spain) agreed to participate in the study.

A total of 5 participants composed the final sample of the pilot study carried out in Spain: 3 of them were nurses, 1 of them was a nursing student and the fifth one was the nurses’ supervisor. There were 4 women (80%) and 1 man (20%; the supervisor). The mean age was 31.8 (SD = 9.68), and ranged from 21 to 47. The average age of seniority in the role of the sample was 61.40 months (SD = 52.69), that is, around 5.12 years.

2.2 Assessment

To assess the usability of the ANGELS System, the System Usability Scale (SUS; [12]) was used. This questionnaire assesses the main features of the system functioning (e.g., “I think that I would like to use this system frequently”; “I thought the system was easy to use”, etc.) in a Likert scale ranging from 1 (“strongly disagree”) to 5 (strongly agree). The total score ranges from 0 to 100 (where 0-60 = “no acceptable usability” and 61-100 = “acceptable usability”).

Quartile ranges and acceptability ranges of the SUS are showed in Fig.1.

![Fig.1 Quartile ranges and acceptability ranges of the SUS.](image)

2.3 The ANGELS System

In this section a short review of the features of the ANGELS system is offered. Basically, the system is capable of recognizing and identifying users’ profiles, thus providing contextual information about the risks in the environment. The system supports the users in identifying and understanding the risks in the indoor navigation of the hospital environment. The system also provides tools to:

- help users manage specific risk situations by means of AR guided procedures using mobile devices,
- update data related to the risks in the environment, and
- assess the understanding of risks and procedures by the users and managers.

The system is based on an Augmented Reality interface that enables:

- contextual semantic information on risks and procedures,
- indoor navigation, and
- access to different kinds of content at the same time using AR.

2.3.1 System Architecture

To achieve the goals of the project, a simple architecture has been conceived. The ANGELS system relies on a Client/Server application architecture with multiple clients communicating with one or more Servers (possibly a Cloud Server). There are two kinds of clients, including a Web Client (Administration Client) and a User Client (ANGELS Application) running on an Android mobile device.

Server

The server hosts the database and data structures and provides all the required communication services to make the system effective. This component provides information to the Application Clients and information can be updated by means of a web-based interface by a principal administrator/operator of the system.

Users Client

The User Client contains all the features and tools enabling the navigation in the environment and the accessibility of information by each user profile. It includes a suitable navigation tool based on augmented reality methods to contextually trigger information about risks and procedures where and when they are needed. The system will make use of suitable augmented reality tags applied in correspondence of meaningful items in the environment (like patient beds, equipment etc.). Another feature of the system is the recording of the user's navigation history. This will allow keeping track of use cases and providing data for performance evaluation. The Mobile client is implemented on Android Tablets and is updated through real-time communication with the Server.

Based on what we have said above, the purpose of the client app is to:

- provide navigation tools for locating risks in the environment,
- identify risk tags with their associated meaning,
- provide users with useful information in order to deal with the identified risk,
- provide tools to assess the understanding of risks, and
- provide safety managers with information for performance evaluation.

2.3.2 System Tools

A number of interdependent tools allows users to achieve both the learning and operative tasks.

Users Profile Authentication

Recognition of users' profiles is done in two steps:

- Active scanning of the environment to detect QR Codes that identify users.
- Once a QR code is scanned, the system identifies it as being associated to a given user ID.

The identification process is a filter that provides general information about the risks in the environment as well as the related risk management procedures.

AR Guided Procedures

Once the user has been identified and he/she has accessed the Application on his/her Tablet, as a first step, a specific feature informs the user about the risks in the environment that are relevant to his/her profile. The information is provided in different ways (e.g. a categorized list of situations, tagged department map, AR labels in AR view) in the context of the chosen Department.

Alongside with the risk related information, specific procedures will be provided to the users in order for them to understand and perform their tasks more effectively and efficiently. By means of a suitable user interface, specific risk situations (e.g. a patient affected by an infective disease to be treated with special care) will be associated with specific risk management procedures that will be prompted to the user's view using Augmented Reality technology.

Basically, the Augmented Reality interface of the system allows the users to access the information while inspecting the risk situation by means of the mobile camera. Suitable AR tags will be included in
the environment and will be associated to specific areas of the Department to encode specific risk situations. This way, AR tags are used as “identifiers” for specific risks and procedures. They will provide the contents needed in the specific risk situation.

Information and Data Update
As risk situations may change unpredictably in Hospital Departments, ANGELS has been conceived as an open system. Indeed, an important feature of the system is the possibility to update information when it is required. Based on this idea, enabled users are allowed to update the risk database in their department both with risk-related information and with suggested operative procedures.

Support for Indoor Navigation
The system provides support for the identification and understanding of risks in the indoor environment. Specific locations in the department are encoded by means of QR codes. This information is employed in association with the gyroscope and compass data from the mobile device to create an augmented reality view of the risks that surround the user. The idea is that the mapping of the environment with risk labels will support the users in the execution of safety and risk management related tasks.

2.3.3 Assessment of users performance
ANGELS includes suitable performance assessment tools that basically provide information on the way each user accesses the application. This information can be employed by Safety Managers to understand if the system actually helped users to achieve better scores in their daily activity, as it can be plotted onto other relevant data, such as the actual number of accidents or injuries that occurred during a given time interval. The system is also accompanied by a separate assessment tool, in the form of a set of questionnaires.

The system also offers a basic Training mode that will allow managers to define different training paths including 1) an unstructured training path, 2) a semi-structured training path and 3) a structured training path.

This way, the system collects information on how users access the available tools during the training process and the learning outcome is evaluated separately by means of suitable and independent performance evaluation metrics.

2.4 Procedure
A pilot study was carried out where participants were asked to participate in the testing of the ANGELS System application in order to detect the usability problems encountered and give us their opinion.

The trial consisted on testing the different features of the training assigned to each participant. The training was based on 4 different learning modules according to the type of risk to learn and the measures to prevent it. The modules were: 1) biological risks; 2) handling and mobilization of loads and patients; 3) chemical risk, and 4) risks derived from an inadequate use of Personal Protective Equipment (PPE). The training lasted for 15 days. After these 15 days, the opinion about the usability of the system was collected.

3 RESULTS
Results obtained showed an acceptable usability for the ANGELS system with a mean score of 67 (SD = 4.81). This result is placed in the 2nd quartile (see Fig. 1). Therefore, preliminary data about the first version of the ANGELS System revealed a good usability.

Regarding the specific answers reported by the participants to the questionnaire, the mean scores of each item are shown in Fig. 2 (positive aspects) and Fig. 3 (negative aspects).
As we can see in Fig. 2 and Fig. 3, the participants had a good opinion about the ANGELS System with respect to the facility of use, the consistency of the system, and integration of the different functions. On the contrary, participants reported that they would not use the system frequently; they considered they would need support to learn as well as they would have to learn a lot of things before using it. Finally, they found the System moderately unmanageable.

Regarding the qualitative data reported by the participants about the usability of the system, participants reported the following problems:

- They found it difficult to find the target codes in the environment.
- When the training was complete, a small message appeared down the screen and participants could not see it. Using a bigger print would be desirable.
- Participants considered that the System should mark the environment targets with a check sign when they read the information related to that target.
- It would be useful to limit the characters of the TAGs titles in order to achieve an adequate visualization (e.g., titles too long did not appear complete).
- Poor quality of the videos.
- They thought that it would be better if the images could expand.

Despite these problems, participants also considered the System “easy to use”, “a quick way to find the necessary information” and “an attractive format to learn”.
4 CONCLUSIONS

Preliminary data about the first version of the ANGELS System revealed acceptable usability, however some modifications aiming to improve its usability would be desirable before the next large scale trial is conducted. Specially, it is necessary to improve the perceived difficulty to learn how to use of the ANGELS System.

Results derived from this study provide preliminary data about the usability of the first version of the ANGELS System in the field of training in safety at work in the health care sector. As it was mentioned in the introduction, the ANGELS system has important advantages such as the innovation to learning practice thanks to an original and interactive methodology. A system like ANGELS could increase the workers awareness of health and safety issues, and as the training is conducted while performing the tasks, it will make education to be fully accessible at their work environment.

DISCLAIMER

This project has been funded with support from the European Commission.

This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

REFERENCES


