Risk Management in Hospitals using Augmented Reality: the ANGELS Project

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ABSTRACT

Augmented Reality (AR) is starting to provide powerful tools that enable the creation of Smart Environments in many real world application domains. The paper provides an overview of the ongoing ANGELS Project (Augmented Network Generating Learning for Safety) co-funded by the European Commission. The ANGELS system is meant to support users to deal with risks in healthcare environments. Specifically, the system 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 in real time, and assess the understanding of risks and procedures by users and managers. The system is not restricted to any specific environment within a Hospital. Rather it can be employed in different departments. The assessment protocol will include measures of all dimensions of the learning model, usability measures, participants' satisfaction, and learning outcomes. Results derived from this study may provide important empirical data about the utility of the implementation of AR in the field of training in safety at work.

KEYWORDS: Risk Management, Healthcare, Smart Environments, Augmented Reality, Hospitals.

INDEX TERMS: H.5.1 [Multimedia Information Systems]: Artificial, Augmented and Virtual Realities; J.3 [Life and Medical Sciences]: Medical Information Systems

1 INTRODUCTION

Workers in the healthcare sector have to deal with a wide range of risky activities and environments every day. The nature of their work, whether delivering frontline care for the physically or mentally impaired, handling patients or providing cleaning services, makes health and safety a priority in this sector. It is essential for workers and employers to be aware of the risks they face and how to manage them. In this context, effective training programs are demonstrated to reduce the number of injuries and deaths, property damage, legal liability, illnesses, workers' compensation claims, and missed time from work [1].

On another account, Augmented Reality (AR) is demonstrated to be an effective learning technology in many applicative domains, especially when it is compared to other learning methods. Work described in [2] shows that AR technology allows training and access to large amounts of information in the context of industrial assembly and maintenance, whereas other studies [3][4] show that AR can improve spatial abilities while learning 3D geometry. In the context of healthcare applications, AR has proved to be a useful tool for the evaluation of AR instructions in Hospital settings [5][6] and for the creation of collaborative platforms supporting the execution of dynamic tasks [7]. Also it has proved to be useful for learning complex surgical techniques [8].

The main goal of ANGELS is to create a system based on Augmented Reality (AR) that provides training on the job, tutoring, retraining and updating about of safety and prevention related information within work environments in the healthcare sector. The system will be used to evaluate to which extent the proposed Augmented Reality interface will help users addressing and understanding risk management tasks in Hospital environments.

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2 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 users in identification and understanding of 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
- assess the understanding of risks and procedures by users and managers

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

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

2.1 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.

2.1.1 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.

2.1.2 User 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 that is 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 to keep track of use cases and provide data for performance evaluation. The Mobile client is implemented on Android Tablets and is updated through a 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,
- provide safety managers with information for performance evaluation.

2.2 System Tools

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

2.2.1 Users Profile Identification

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.

2.2.2 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 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 a 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 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.

2.2.3 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.

2.2.4 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 users in the execution of safety and risk management related tasks.

3 Assessment of Users Performance

ANGELS will include performance assessment tools that will basically provide information on the way each user has accessed 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 and so on. The system will be accompanied by a separate assessment tool, in the form of a set of questionnaires.

Basically, the system will collect information on how users access the available tools and this will be evaluated separately by means of suitable and independent performance evaluation metrics. The system also offers a basic Training mode that will allow managers to define different training paths including 1) a unstructured training path, 2) a semi-structured training path and 3) a structured training path.

3.1 Method

As explained in [9], in order to prove the utility of the learning program, the ANGELS project includes two experimental trials (pilot study and large scale trial) to test efficacy and effectiveness of the system. The initial version of ANGELS will be tested in the pilot study. This study will be focusing on eliminating technical problems and testing the didactical model and usability issues. This will take place on three sites (Italy, the Czech Republic and Spain) with approximately 5-6 nurses "friendly users"/sites working at a given Department of a Hospital. The users' feedback will be used to refine the methodology and the software which will then be tested in a large scale "summative evaluation" trial (approx. 25 nurses/sites), reaching a total of 100 users. In addition, 1 or 2 tutors/sites will be involved in the trials in order to support the training procedure.

The assessment protocol will include measures of all the dimensions of the learning model, usability measures, participants' satisfaction, and learning outcomes. Metrics include a measure of the sense of presence, a system satisfaction scale, a system usability scale and a comparative analysis with standard risk assessment documentation.

Contents of the learning path can include information about inhalation and contact (mucous membrane and skin), biological risks, manual handling of loads and patients, chemical risk, risk associated to the use of electric or electro-medical equipment, physical risk, and psychosocial risk.

4 Conclusion

Results derived from this study may provide important empirical data about the usefulness of implementing AR in the field of training in safety at work in Hospitals.

ANGELS system has also important advantages such as the innovation of the learning practice thanks to an interactive

methodology. It could increase the workers awareness of health and safety issues, and as the training is conducted while performing the tasks, it makes relevant information fully accessible directly in the work environment. Specifically, the system will allow participants to explore environments and get information, training and retraining experiences.

Additionally, as a result of the project, a free Starter Kit will be developed in order to offer an accessible service to workers and organizations interested in safety in the healthcare workplace.

Finally, according to the design of the system, the AR features will ensure that information will be provided to the user contextually where it is needed when it is needed, thus turning the Hospital Department into a smart environment where information is selectively available to different users according to their "needs" and in a way that directly relates to the involved risks.

5 DISCLAIMER

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