Introduction

Information and Communications Technology (ICT) is any application or communication devices such as: satellite systems, computer and network hardware and software systems, mobile phones etc. Those help to deliver services and improve the quality of life (Desai, 2010).

There are many technologies and computer based systems that collect, store, edit, analyze and display spatial data that help users in many purposes. The proliferation of sensor technology, along with advances in wireless communication and mobile devices, allow for context-aware applications (Desai, 2010).

In addition, the rapid convergence of ubiquitous computing technology, ICT and Location-Based Service (LBS) technologies such as Geographic Information System (GIS) and Global Position System (GPS) are raising the possibility of a dramatic transformation of the way we perceive and move about the urban environment, and how we interact with each other in an urban space (Cartouche et al. 2005).

GPS-based navigation systems have become very popular, mainly because they allow people to rapidly explore unknown areas, while Augmented Reality (AR) is a relatively new technology that combines imaginary information like a virtual object into the real world and in real time with interactive visualizations that allow the user to imagine a real 3D environment (Mulloni, Dünser and Schmalstieg, 2010).

However if we try to integrate AR techniques, we will find that the GPS system works only outdoors, because the required satellite links are blocked or are unreliable inside buildings, and

the GPS receivers require an unobstructed view of the sky. But in general, the GPS system has many real-world such as applications for location, navigation, tracking, mapping and timing (Alessandro, Daniel and Schmalstieg 2009).

There are many advances in software and hardware for mobile computing such as mobile workstation and wearable PC, Tablet-PC, Personal Digital Assistant (PDA) and Smartphone. In the past few years, mobile phones have become an increasingly attractive platform for augmented reality (Papagiannakis, Singh and Magnenat-Thalmann, 2007).

AR technology is being utilized in many areas such as medicine, manufacturing, visualization, path planning, and entertainment and military applications, but it has received a great deal of attention as a new method for displaying location-based information in the real world. This technology can be used to enhance the user's interaction and perform tasks especially when the virtual object shows real information that the user cannot detect using personal senses (Mulloni et al. 2009).

Endless possibilities for AR systems are currently being developed, which increased convenience, awareness, transparency, and access to information and social opportunities that break traditional power structures by receiving and delivering services anywhere and at any time (Azuma, 1997).

Interactive AR systems must also have some characteristics to allow a high degree of vision and utility to ensure that the virtual objects interact with the user in a natural manner. These characteristics include the registration of virtual objects in the augmented view, virtual and real objects being visually indistinguishable, virtual objects exhibiting standard dynamic behavior, and the user having unconstrained motion within the workspace. Also cost cannot be ignored, so

there is need to lower the cost to allow for broader usage and a minimal run-time setup (Vallino, 1998).

However, indoor and outdoor terms, which are usually used in AR technology, need to be differentiated. Indoor localization means the determination of a user's location taking place within a closed area or inside a building such as a campus, company, museum or exhibition (Mulloni et al. 2009). While outdoor localization means the determination of a user's location, the place in the open air, or through buildings such as a town, a street, or a city exhibition; there is a technology to achieve this, such as a GPS which works only outdoors because the required satellite links are blocked inside buildings (Nakazato, 2005).

1.1. City Overview

A city is a human settlement and social unit in a specific geographic location. The city's population growth increases demand on private and public services; leading to the emergence of urban sprawl (Kabbani and Abdeen 2007). As a result, cities suffer social and environmental problems. Consequently, the conflicts between the requirements of urbanization and the limited resources and vulnerable environments are increasingly fierce (Wang, 2008). When human settlements appear in a city, many complex environmental issues, living condition problems, and pollution, which need more planning and stronger management, begin to form (Layle, 1985). ICT facilitates in a city are open for public access and therefore the sharing of "complete and transport" information is available to everyone (Kabbani and Abdeen 2007).

A Knowledge City (KC) is defined as a city that depends on using technology to serve the growing human needs or where private or public services can be delivered and received anywhere and at any time (Kim, 2008). Many cities have adopted particular advanced

administrative systems to manage housing, land usage, transportation and more. Nevertheless growth of cities has been associated with many social and environmental problems (Abu-Anzeh and Ledraa, 2007). This mismatch between rapidly developing problems and outdated institutions has redirected attention to the mediating role of regional planning in meeting the needs of rapidly expanding regions and planning regions, focusing on developing and managing the physical, human, and financial resources required to solve problems and fulfill objectives (Abu-Anzeh and Ledraa, 2007).

Major cities all over the world encounter problems of human and traffic congestion due to a high population density such as Tokyo, Mexico city, Cairo and Makkah (Talukder, 2006). Moreover, many cities have problems in terms of space limitation, which lead to crowd concentration and traffic jams, Makkah is one of those typical cities and the major challenge facing urban planners and designers in the city of Makkah, is planning the movement of vehicles and mass transit during the period of Hajj. So, local authorities have worked on various solutions to resolve the problems and every year they provide many plans to avoid the congestion in order to alleviate the traffic and pilgrim mobility (Nishinari, 2010).

1.2. Crowd Management

Crowd management or crisis management are the strategies, processes and measures which are planned and put into force to prevent and cope with crisis due to crowding (Glaesser, 2006).

Crises usually happen as a result of unexpected situations, both men made or environmental. They may also be as a result of an inability to contain the situation by the parties concerned such as crowding (Al-Sharief, 2006). Therefore, crowd management is one of the most important requirements that help to find solutions and appropriate strategies for cities' management. Additionally, crowding and crisis management has become a highly studied science, which needs a high amount of knowledge and

powerful techniques to be implemented and quickly adapted whenever a negative situation occurs. But strategies such as planning, organizing, directing and follow-up are always needed (Glaesser, 2006).

1.3. Research Motivation

Makkah city is the center of the Islamic world. It has the Great Mosque (Al-Haram) and the Hajj ritual sites; it is located in the western region of Saudi Arabia.

Enhancing Makkah's image will reflect positively in the Muslim world regarding the facilities made available to pilgrims and citizens. Since Makkah is a destination for people of different nationalities, languages and culture, this prompts us to find appropriate and comprehensible methods to deal with these differences. In addition, the government and the local authorities are committed to control and guide the large influx of pilgrims. But unfortunately, many of their efforts are not full proof and problems occur. To overcome these problems it is essential for Makkah to catch up with technological city development due to its special status and unique problems.

Pilgrims come from most countries of the world but many are elderly and/or with a low level education and varied languages. Most of the problems and major tragedies occur due to the pilgrims' lack of knowledge and insufficient knowledge sharing techniques on how, when and where to move. The Saudi government is continuously looking for better procedures to protect pilgrims by deploying tens of thousands of security personnel to help organize pilgrims and direct their movement. However, this creates an additional burden on authorities to oversee their safety as well, along with educating them on pilgrims' needs and communication skills.

Most research emphasizes the need to serve the authorities and the bodies in charge of overseeing and supervising the steady flow of the pilgrims. The supporting companies which have carried out these pieces of research are trying to build independent hardware and software which have, as a basic function, to guide the individual pilgrim. This requires overheads for

training each pilgrim, hardware costs, the difficulty of meeting the hardware requirements and the distribution of software and regular for updates.

The main motivation for this research is to use technology to manage crisis situations, due to pilgrims' lack of knowledge during crowding.

1.4. Research Objective

With all the progress the Saudi government has achieved in terms of construction and expansions in Makkah city, it is human behavior during chaotic events that account for most of the injuries and fatalities that happen during overcrowding. Physical expansions of the ritual site buildings may increase problems and make management more difficult; educating pilgrims and citizens on exit and entry of buildings and structures is always challenging. Alternative solutions must be found that target the pilgrims themselves in an attempt to increase their knowledge by providing them with vital information to make accurate, timely and wise decisions for their own safety and the safety of others. This will reduce tragedies, delays and inconveniences. For Makkah to cope with a mass influx of people from different countries, incomes, ages, languages and educational backgrounds it must move towards being a KC utilizing ICT's to provide more efficient and cost effective solutions usable by most people. Such solutions should focus on pilgrims' direct interaction with their environment to make correct and sensible choices.

We need to provide high quality services to pilgrims to ensure their safety during Hajj by avoiding problems, and it is essential for Makkah to catch up with technological city development due to its special status and the annual crowding and congestion in the city.

One of the proposed solutions to solve human congestion is to provide an appropriate method to manage the crisis situations by providing essential information for pilgrims using LBS that are based on AR as a suitable technology through mobile phones.

Many cities around the world use ICT's to improve their citizens' lifestyles and try to reduce the congestion by providing the information that answer many questions such as 'where am I?', 'where can I go?', 'how should I behave?'. This can be accomplished by building a system that sends and receives information, utilizes, using a basic tool available to most citizens: the mobile phone, providing a sense of control.

The main objectives of this research is to introduce the Mobile Pilgrim Assistant (MPA) prototype by building a model of a mobile application that exploits emerging technologies such as LBS and AR delivered via mobile phones that could ultimately help in crowd management and reduce crowd congestion and provide visually oriented pilgrims on foot with self-control in terms of navigation through the holy sites during Hajj. This technology will reduce the burden on the authorities in terms of controlling and guiding the large number of pilgrims and may help overcome the obstacles of their different nationalities, languages and backgrounds, using mobile phones as the most common device used by pilgrims. Formally stated, this research will address the following questions:

1) Will the MPA provide Hajj pilgrims with an easy to use mobile application for Hajj related services such as real time graphical data during rituals?

2) How satisfactory was the MPA for pilgrims to use during a crowd situation while performing Hajj rituals.

1.5. Research Methodology

The methodology followed for this thesis was:

- Review of the literature for:
  - ICT based on LBS in terms of objectives, types and ways of implementation. Comparison between several types of LBS technologies according to their limitations, accessibility and usage.
  - Augmented Reality technology and its usefulness in determining the environment around the user and his navigation.
  - The concept of crisis management and methods used to solve congestion especially in the management of the annual pilgrimage and procedures taken in the event of congestion.
- Selecting an appropriate method of service localization technology and then selecting the most suitable method in term of user navigation and ease of use.
- Design the MPA prototype using Visual Studio by C# language.
- Test and evaluate of the prototype for reliability, functionality and usability.
- Collection data and analysis.
- Results and recommendations are discussed.

1.6. Thesis Organizing

Chapter I: Introduction to research, motivations, objectives and methodology

Chapter II: ICT examples, introduces the concept of Location Based Services, and the Augmented Reality concept based on outdoor localization tracking.

Chapter III: City planning overview and urban development, with an overview about city types, services, problems such as crowd managements is discussed.

Chapter IV: Crowd management strategies with Makkah city and the Hajj season as a case study.

Chapter V: MPA's architecture, specifications, design, and implementation.

Chapter VI: Results in brief and detailed tasks analysis.

Chapter VII: Conclusions and recommendations**.**

Appendix A: Google Map Tables.

Appendix B: GPS Function Code.

Appendix C: Test questionnaire.

Appendix D: Statics Scale.