International Journal on Islamic Applications in Computer Science And Technology, Vol. 5, Issue 2, June 2017, 37-44

Bluetooth Based Holy Places Crowds Control System

Lamia Berriche [a], Monirah.S.AlOrf [b], Banan.A.AlHadlaq [c], Dalal.A.AlZeer [d], Nouf.A.AlMutairy [e], Hessah.S.AlHarbi [f]

Computer and Information College, Al-Imam Muhammad Ibn Saud Islamic University, Kingdom of Saudi Arabia

[a] lberriche@ccis.imamu.edu.sa , [b] Alorfm@yahoo.com , [c] Banan.Alhadlaq@gmail.com, [d] Dalal-Alzeer@hotmail.com , [e] Nouf.Mutairy@gmail.com , [f] Hessah.S.1990@gmail.com

Abstract

One of the main problems that still exists in the Holy places and causes lots of damage and danger to the pilgrims is the crowd. Crowds are essentially caused by the performance of the religious duties by millions of Muslims in a unique place in short period of time. Image processing techniques for crowds' detection is limited by camera coverage and need of continuous light. Positioning systems based on wireless technologies such as GPS, Bluetooth and WiFi are another alternative for crowd detection. In this work, we developed a Bluetooth Based Holy Place Crowds Control System (BHPCC) for controlling the crowds in holy places. This system is able to find lost pilgrims and control crowds by detecting them and recommend less crowded places for pilgrims.

Keywords: Crowds Control, Positioning, Bluetooth.

1. INTRODUCTION

Large numbers of pilgrims come to Makah and Madinah every year and according to the statistics, pilgrims are increasing yearly. One of the main problems that still exist in those places that causes a lot of damage and danger to the visitors is the crowd. Crowds in religious places are caused by many factors. One main factor consists in the performance of the religious duties in a common place and common time e.g. stone throwing and tawaaf. Another reason is that the instructions and guidelines issued by the security agencies are not followed. These two reasons are enough to cause the crowds. Some of the crowding effects that happen in these places are; getting pilgrims lost and the difficulty of determining the residence place, difficulty in moving from one place to another, delay of health and emergency services, delay of the arrival of services and food for pilgrims, thefts possibilities and difficulty in communicating with security agencies and guiders.

In order to eliminate these difficulties and preserve the safety of pilgrims and visitors, crowd must be controlled. There are many technical studies nowadays on finding solutions for the crowds. Crowds are mainly detected by means of people density measurement. Crowds detection techniques could be classified as: device based and device free techniques. Device free techniques do not require people to hold any device. Some emerging device free solutions are based on image processing techniques (M, Li, et al 2008). Major disadvantage of this technique is the cameras coverage and the need of a continuous source of light. Recently, a device free method was proposed by (Xi, W, et al. 2014). This method is based on counting crowd based on the wireless Channel State Information (CSI). This solution shows good accuracy and reliable results. Device based techniques are based on positioning systems (Y, Yuan 2014). A positioning system enables a device to determine its position, and makes the position of the device available for position-based services. Some of the current wireless technologies used for positioning are GPS, RFID, wireless sensors and Bluetooth. Complexity, accuracy, and environment, are among the factors that play a role in determining the type of wireless technology to apply for a particular use (A, Bensky 2008). Yuan and all presented a method to estimate crowd density using wireless sensor received signal strength in (Y, Yuan, 2013). Bluetooth and WiFi were used in (Y, Yuan 2014) for crowd density estimation and they showed that the system accuracy achieved 92%. In (Mohandes, M 2010), RFID technology is used to identify and track pilgrims. Tests were conducted on 1000 pilgrims for the identification purpose using passive RFID. And 6 pilgrims were tracked using active RFID. Authors mentioned that the system needs further improvement to allow crowds detection accurately. RFID based system was also used in (R. O, Mitchell, et al., 2013), were authors concluded that RFID signal weakness makes the pilgrims location inaccurate. In this work, we developed a Bluetooth based positioning system for controlling the crowds in holy places. Bluetooth is chosen in our work due to its low cost, high availability and accuracy (Hallberg, 2003). BHPCC provides features such as positioning pilgrims, counting people density to find out crowded places and sending messages to a selected set of pilgrims recommending less crowded places for them.

In section 2, we give a survey of positioning methods used for crowds' control. Then, in section 3 we compare wireless technologies used for positioning purpose. In section 4, we describe the pilgrims positioning Bluetooth based system, crowds' detection and crowds control methodology. After that, prototype results are given in section 5.

2. LITERATURE REVIEW

2.1 Positioning methods

Positioning based crowd detection is based on the use of positioning systems and so crowd detection accuracy depends deeply on the later ones. A positioning system is a network of devices used to locate an object indoor or outdoor. Positioning involves estimating how far one terminal is from another, or where that terminal is located. The methods used for getting location information from a wireless link are different. Complexity, accuracy, and environment, are among the factors that play a role in determining the type of distance measuring system to apply for a particular use (A, Bensky 2008). Positioning method can be generally categorized into network-based, device-based and hybrid methods (A, Brimicombe and C, Li. 2009).

Device-Based Positioning

In device-based positioning, such as Global Positioning System (GPS), the mobile device determines its position using the signals it receives. In other words, signal measurements and the computation to determine a position are performed by the receiver located within a mobile device. No network connection is required and so more privacy is guaranteed. However, device based positioning is power consumer and positioning is impossible in case the signal is not received. So, this makes indoor positioning not possible or inaccurate.

Network-Based Positioning

Network-based positioning uses the transmitter base stations of a mobile telecommunications network to locate a mobile device by measuring the signal travelling to and from a set of base stations. Through signal measurements, the direction and length of an individual radio path can be computed and the position of a mobile device can be derived using computational geometry. Network-based positioning is a low power consumption system and it does not require extra software or hardware to be installed in the mobile device. On the other hand a connection to a server-side service is needed. Also, in case high accuracy is required, there can be high costs in terms of signaling and processing overhead and thus reduced capacity for voice/data transmission. Some commonly used network-based positioning methods are:

- Network Cell Identification (Cell-ID): where device position is given through base stations coverage areas.
- Angle of Arrival (AOA) : where received signal angle of arrival is used to determine the device position.
- Triangulation: where the device position is computed by finding its distance from static stations. Distance to static station is computed by time delay methods such as Time of Arrival (TOA), Time Difference of arrival (TDOA), Round Trip Time (RTT) and Enhanced-Observed Time Difference method (E-OTD). Also Received signal strength based method (RSS) are used for distance computation (A, Brimicombe and C, Li. 2009).

Hybrid Positioning

Hybrid positioning approaches aim to take advantages of different types of positioning methods by integrating them. One main hybrid positioning approach is to incorporate device-based and network based positioning technologies. Device-based positioning, such as GPS positioning, offers high accuracy. However, it has a relatively long position fix time with high battery consumption and poor signal reception indoors and in dense urban environments. On the other hand, network-based positioning can work indoors and in dense urban areas across a broad range of devices. However, it has lower accuracy. The hybrid positioning approach of incorporating these two technologies aims to provide increased accuracy and availability. This is commonly referred to as Assisted-GPS (A-GPS) (A, Brimicombe and C, Li. 2009).

2.2 Wireless Technologies for Positioning

Some positioning systems make use of wireless communication technologies. In addition to their ultimate task of transferring information from one terminal to one or more remote ones a wireless communication system could be used for positioning. Wireless technologies most widely used are GSM, WLAN, Bluetooth, infrared, wireless sensors and RFID. The characteristics of signal accuracy and deployment cost for the positioning technologies are quite different from one technology to the other. Table 1 gives comparison between these technologies from the point of view of deployment range, data rates, power consumption and hardware cost (Clarinox Technologies Pty Ltd, 2009). It is important to understand that the use of a particular technology should be closely related to the purpose and scope of the specific application. The deployment of different types of positioning technologies depends on many factors such as: mobile telecommunications network technology, the type of mobile devices being used, operating environment, the requirements for services and applications, and the cost.

Table 1: Wireless Technologies Comparison (Clarinox Technologies Pty Ltd, 2009).

	RFID-passive	RFID-active	Bluetooth	WiFi	GPS
Power Usage	None	Low to Medium	Medium	High	Medium
Data rate	Low	Low to Medium	Medium to High	High	Not Applicable
Coverage	Low	Medium	High	High	Very High (outdoor)
costs	Tags-low Readers-medium to high	Medium	Medium	High	High

3. METHODOLOGY

In this work, Bluetooth was selected for its high availability, low cost and good accuracy for indoor positioning (Y, Yuan 2014). One Bluetooth devices is working as base station whereas other devices are used as static stations.

3.1 The Static Station

Bluetooth static stations are distributed such that their coverage areas are overlapping. Consequently, an improved Network Cell Identification positioning method is proposed. A cell in this improved algorithm is not the overall coverage area of a Bluetooth device but the intersection areas between Bluetooth devices coverage areas. Crowd density is computed for each cell see Figure 1: Bluetooth Stations Distribution.

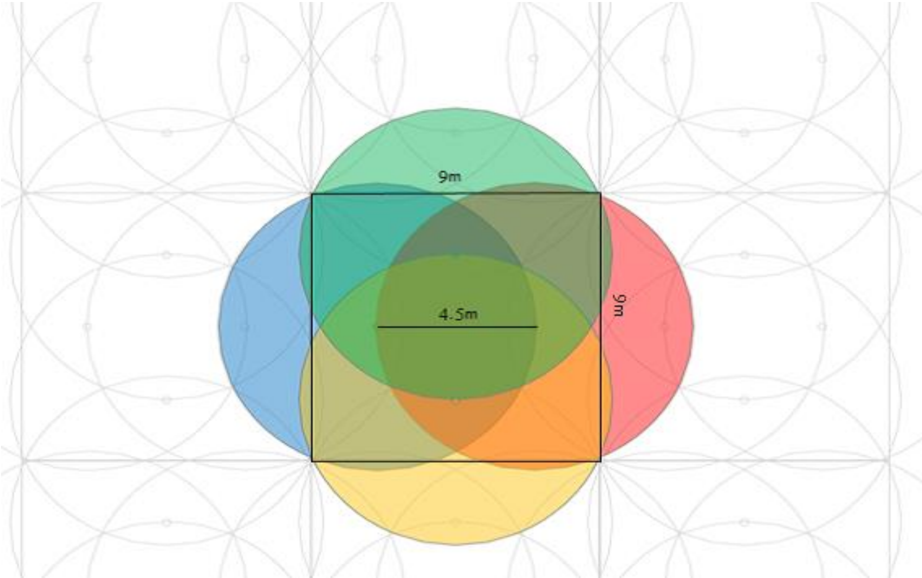

Figure 1: Bluetooth Stations Distribution

3.2 The Base Station

The base station provides the following three functionalities:

a) Managing both pilgrims and static stations information such as adding a static station coordinates, deleting it or modifying it.

b) Crowd control: gathering information from static stations, identifying crowded and un-crowded areas and redirect pilgrims based on that. The crowds control is done through two stages :

- **Stage 1: Crowds detection**
  This stage is responsible of positioning pilgrims holding Bluetooth devices. The Bluetooth static station finds all devices within its coverage using a simple device discovery operation. After that, the static station sends the Bluetooth IDs of these devices to base station. The base station gets pilgrims positions from all the static stations. Afterward, the base station computes people density per cell. Crowded and un-crowded cells are then identified.

- **Stage 2: Crowds management**
  After the identification of crowded and un-crowded places, Bluetooth messages are sent to some pilgrims advising them to go to un-crowded places. These messages are sent exclusively to young pilgrims who are not accompanied with babies and old people.

c) Search pilgrim: This functionalities enables the search of lost pilgrims by using their Bluetooth devices IDs.

4. SYSTEM IMPLEMENTATION AND RESULTS

In the prototype, static stations are distributed such that each block sizing 9*9 m^2 is covered by four static stations. Transmission is direct from static stations to the base station with no intermediate stations. The distance between two static stations is almost 4.5m.The Bluetooth

Device Discovery Profile was implemented for the device discovery operation at the static stations. The Object Push Profile was implemented for the messages multicast operation done from the base station to the Pilgrims devices. Both Bluetooth Discovery Profile and Object Push Profile are described in the Bluetooth specification (https://developer.bluetooth.org/TechnologyOverview/Pages/Profiles.aspx). At the base station an officer is able to manage pilgrims' information and manage static stations see Figure 2. The agent is also able to find lost pilgrims and manage crowds through the interface in Figure 3.

Figure 3: Crowds Management Interface

The system was tested for different crowds' situations. To simplify testing, crowd threshold assumed to be 5 pilgrims per m2. Some testing situations with their results are given in Table 2. As shown in Table 2, the system detects crowds in places where the number of pilgrims exceeds 5 and if the crowd is detected in one floor and not the other, messages are sent to appropriate pilgrims to redirect them to empty areas. In test1, people density is less than crowd threshold, so, no crowd is detected and no messages are sent to pilgrims. Also, as shown in test 3, when crowd is everywhere, both first and second floor people density exceeds crowd threshold value, the system detects crowds and cannot control it. In this prototype, it takes almost 9s to detect crowded cells and send messages to pilgrims.

Table 2: Testing Results

	Number of Pilgrims in Floor 1	**Number of Pilgrims in Floor 2**	**Result**
Test 1	4	1	No Crowds
Test 2	12	1	The crowd was controlled partially, there are still crowded areas.
Test 3	10	5	Cannot control the crowds, all the floors all full.
Test 4	8	1	Crowd controlled successfully

5. CONCLUSION & FUTURE WORK

In this paper, BHPCC system was proposed for solving crowd problems in the holly mosques of Makah and Madinah. The system controls the crowds leading to prevent their damages. BHPCC considers the positioning principle for controlling the crowd and was implemented through the deployment of a Bluetooth wireless network. Such system could be connected to billboards at the entry gates of the mosques to inform pilgrims about the overcrowding degree and to direct pilgrims to non-crowded places. In addition, the pilgrims' position could be exploited by a proximity service system to advice and guide pilgrims during their Nusuks (Al-Zunaitan, et al, 2011). In our test cases, Bluetooth technology shows good results for pilgrims tracking and crowds detections unlike RFID, in (Mohandes, M 2010), and (R. O, Mitchell, et al., 2013), which suffer from inaccurate results in presence of obstacles between the tag and the reader. Less intrusive solution such that in (Xi, W, et al. 2014) may be more accurate but they don't provide pilgrims tracking and proximity services deployment possibility. Further studies on the proposed prototype should be conducted such as expanding it to Al-haram space, which may lead to increasing the time needed to find a pilgrim or to solve a crowd. Also, further studies should be conducted to give the impact of people moving speed on the system accuracy.

6. REFERENCES

A, Bensky. Wireless Positioning Technologies and Applications. ARTECH HOUSE, 2008.
A, Brimicombe and C, Li. Location-Based Services and Geo-Information Engineering. s.l. :

Wiley, 2009.
Al-Zunaitan, A, M, Al-Helan and L, Berriche. Bluetooth Based Tadhkir Messages Broadcasting System. 11th Hajj and Umrah Symposium, Makkah, 2011.
Clarinox Technologies Pty Ltd, Real Time Location Systems. 2009.
Hallberg, J, Nilsson, M and Synnes, K. Positioning with Bluetooth. 2003. 10th IEEE International Conference on Telecommunication. Vol. 2, pp. 954 - 958 .
M, Li, et al., Estimating the number of people in crowded scenes by mid based foreground segmentation and head-shoulder detection. 2008. IEEE ICPR. p. 1C4.
Mohandes, Mohamed. A Case Study of an RFID-based System for Pilgrims Identification and Tracking. [book auth.] Cristina Turcu. Sustainable Radio Frequency Identification Solutions. s.l. : intech, 2010.
R. O, Mitchell, et al., Hajj crowd management and navigation system: People tracking and location based services via integrated mobile and RFID systems. International Conference on Computer Applications Technology, 2013. pp. 1-7.
Xi, W, et al.,: Electronic frog eye: Counting crowd using WiFi. INFOCOM, 2014. pp. 361-369.
Y, Yuan, C, Qiu and W, Xi. Estimating Crowd Density in an RF-Based Dynamic Environment. 10, 2013, IEEE SENSORS JOURNAL, Vol. 13, pp. 3837-3745.
Y, Yuan. s.l. Crowd Monitoring Using Mobile Phones.: Sixth International Conference on Intelligent Human-Machine Systems and Cybernetics, 2014. pp. 261-264.