USE OF GPS-AIDED NAVIGATION TO ASSIST GHANAIAN PILGRIMS DURING HAJJ

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INTRODUCTION

Global navigation satellite systems such as the Global Positioning System (GPS) have now become a widely used aid in navigation. GPS is commonly used in many applications such as land surveying, shipping, piloting, route guidance, map making, study of earthquakes, precise time reference and hobbies and games such as geocaching. This system was initially implemented for military purposes to provide navigational data. In 1995, the system became fully operational, and was also made available to the civilians with a lesser accuracy. GPS now provides many advantages for civil users, in terms of availability, reliability and accuracy. Its applications can be extended into all facets of life; including religious activities.

The annual Hajj is unquestionably one of the most remarkable spiritual undertakings in the life of Muslims. Each year during the months of Hajj (Shawwal, Dhul-Qi`dah, and Dhul-Hijjah), millions of pilgrims from all over the world begin pouring into the Kingdom of Saudi Arabia by land, sea and air. Together with the pilgrims from within the Kingdom, the rich and poor, young and old; the faithful answer to the call of their Creator.

Problem Statement

Most of the pilgrims arriving for Hajj each year are doing so for the first time and as such need to be guided throughout the performance of the rituals. Finding your way in an unfamiliar environment always poses challenges, and pilgrims are always at risk of getting lost.

Ghanaian pilgrims are no exception, and each year numerous incidents occur where pilgrims get missing during the Hajj, sometimes for weeks. Usually, it is women and elderly pilgrims that suffer this mishap. Also, buses transporting pilgrims most often lose their way, creating delays and bringing discomfort to pilgrims (Ghana Hajj Mission).

This situation is disturbing, thus a convenient and workable solution is required to address it. Paper maps are helpful in finding places; however they might be difficult to read, are difficult to update and also could be easily thrown away. GPS aided navigation systems provide better position determination and location information and thus, could prove useful in helping to significantly reduce the numbers of pilgrims that get lost.

Objective

The aim of this paper is to propose an approach that employs GPS to address the navigational challenges faced by Ghanaian pilgrims during Hajj. This is intended to be achieved by taking

measures that would ensure that pilgrims are at all times aware of where they are and also are able to locate where they are going.

LITERATURE REVIEW

Global Positioning System

Global Positioning System (GPS) is a satellite-based navigational system that provides reliable positioning, navigation and timing services to users worldwide, on a free and continuous basis. It consists of a network of satellites orbiting the earth, with each transmitting a time signal. Using these satellites as reference points, a GPS receiver can decode the time signals and convert them to a position on the earth's surface. GPS was developed by the United States Department of Defense (DoD) in the 1970's, and was opened up for civilian use about a decade later (Clarke, 1997; www.gps.gov).

GPS Segments

GPS is comprised of three segments: the space segment, the control segment and the user segment. The space segment is made up of the satellite constellation that orbits the earth and sends signals. As of March 2008, there were 31 actively broadcasting satellites in the GPS constellation. With the increased number of satellites, the reliability and availability of the overall system has been improved (Dogan, 2010). The control segment consists of a worldwide network of tracking stations which determine satellite locations, system integrity and behaviour. A master control station, which is the central processing facility, is located in the United States. The tracking station in the Middle East region is located in Bahrain.

The third segment consists of the user GPS receivers. A commercial GPS receiver is a small battery operated portable device that receives signals from the GPS satellites and then displays the user's position, altitude, speed and several other navigational parameters. Some sophisticated receivers also incorporate street-level maps where the position of the user is shown dynamically in real-time on a map. (El-Rabbany, 2006; Dogan, 2010).

Figure 1. A Magellan GPS receiver (Source: Google Images)

How It Works

GPS is a passive system; users can only receive the satellite signals. At any given time, at least four of the satellites are above the local horizon at every location on earth, twenty four hours a day. When a GPS receiver is activated, the nearest satellites are located and signals are received from each visible satellite. The time difference between the signals from each satellite and data from the satellites' orbit are combined and used to solve the three unknowns of latitude, longitude and elevation (Clarke, 1997). GPS also provides time information as well.

The accuracy of the data acquired depends on the type of receiver, methods used to collect the data, amount of time data are collected and what, if any, post processing is done on the data with more advanced software. Ground-based GPS receivers can be used to obtain accurate surface coordinates for all kinds of geographic information systems (GIS), mapping and surveying data collection. GPS systems available today can give locational accuracies ranging from 100 metres down to between 3 and 6 metres (Harmon and Anderson, 2003)

To keep the military advantage, the US DoD provides two levels of GPS services:

- The precise positioning service (PPS)
- The standard positioning service (SPS)

The PPS, as its name implies is the most precise of the services and is available to only authorized users. Its accuracy is at the centimetre level. The SPS, also known as the civilian GPS service is less precise. However with development of new augmentation techniques, accuracy has significantly improved.

Sources of Error

There are many error sources that can affect the accuracy of information provided by GPS receivers. A few are enumerated below.

- Refraction in the atmosphere can delay the signal and cause ranging errors
- Reflecting or bouncing on tree trunks, buildings and other structures causes signals not travel directly to the antenna, thus causing ranging errors. This is known as multipath interference.
- Bad satellite geometry can result in weak positional solutions known as Dilution of Precision (DOP). These DOPs can be separated into Vertical, Horizontal, Positional (3D) and Geometric (with time).
- Selective Availability carried out by the US military; which is the intentional degradation of positional accuracy by introducing noise into the satellite's clock and orbital data. The rationale behind this is to prevent hostile forces from gaining precise GPS readings. Selective Availability was switched off on May 1, 2000, but can be reinstated at any time.
- Encrypted data that can only be demodulated by special hardware. (http://www.directionsmag.com)

Applications

Although military applications drove the construction of the system, civilian use far outstrips military use of GPS around the world today. Military applications include:

- Missile guidance
- Target tracking
- Search and rescue operations

Civil uses include:

- transportation systems (navigation for aviation, ground and maritime operations)
- disaster relief and emergency services (accurate and timely response to distress calls)

- natural environmental systems (accurate tracking of environmental disasters such as fires and oil spills)
- recreation (trailblazing, mapping by hikers and cyclists)

Future applications can only be limited by one's imagination

GPS enables automatic vehicle location and in-vehicle navigation systems that are widely used throughout the world today. By combining GPS position technology with systems that can display geographic information or with systems that can automatically transmit data to display screens or computers, a new dimension in surface transportation is realized. (www.gps.gov). Most of the GPS receivers currently on the market allow the upload of map data; this allows the display of location relative to streets, buildings and other features rather than just giving coordinates.

Recent availability of location awareness for mobile phones, particularly internet-enabled mobile phones is broadening the potential applications of GPS. Mobile phone manufacturers are making advances in GPS-enabled handsets, as well as developing their own GPS-centric applications and services. The free mapping product from Nokia, Ovi Maps, has maps for over 180 countries that include voice guided navigation for both pedestrians and drivers for 74 countries in 46 different languages. Ovi Maps can work offline, thus have the advantage of not requiring an active data connection or even network coverage on the mobile phone to function (www.wikipedia.org).

Figure 2. A Nokia phone that supports GPS-enabled navigation (Source: Google Images)

Figure 3. An iPhone 4 equipped with Magellan RoadMate GPS navigation system (Source: www.magellangps.com)

Hajj

The organization of Hajj is a daunting task for the officials in charge. Millions people must be provided with shelter, food, water, security, sanitary facilities, medical care and en masse and on time transportation. The Ministry of Hajj (authority that is charged with the organization of Hajj and Umrah), the Hajj Missions of all the participating nations, Hajj guides (mutawwifs) and other relevant stakeholders are responsible for providing these services. To cope with the logistical issues, the Ministry of the Hajj has increasingly turned to the mutawwifs to provide the personal attention that so many pilgrims require. They arrange primarily for transport, accommodation and other vital services. Mutawwifs also see to it that the pilgrims get to where they are supposed to go and give guidance to the pilgrims with regards to Hajj rituals. So important is this role that the Hajj Mission of every single nation

must register its pilgrims with one or another of these guides upon arrival in Saudi Arabia, and must have the guide's approval to leave.

Additionally, the Ghana Hajj Mission sets up a Task force group, comprising of volunteers from Ghana as well as Ghanaians resident in Saudi Arabia. This group is the backbone of all operations of the Hajj Mission. They are the foot soldiers who coordinate all activities to ensure that everything runs smoothly according to schedule.

METHODOLOGY

Over the past few years, an average number of about 2,500 pilgrims from Ghana respond to the call of Hajj each year (Ghana Hajj Mission). It is based on the number of pilgrims that arrangements for accommodation, transport and other services are made. The main strategy is to have a leader with a GPS receiver to guide each group of pilgrims.

Choosing the right GPS

The following are features that would be considered when acquiring GPS receivers:

- Easy to operate (graphic interface) – the people to use the receivers are not professional thus a simple and easy to use device is required.
- Data input Connectivity (Bluetooth or wireless transfer) – to make the transfer of maps possible.
- Route planning – ability to create routes from start to finish point and remember stored locations.
- Longer battery life – requires low energy to operate
- Cost – value for money

An online search for receivers with at least three of the preferred features revealed that the cost ranged between $250 - $400 (www.garmin.com and www.magellangps.com). Acquiring 25 receivers at a mean price of $350 will sum up to $8750.

Maps of the Holy cities of Madinah Al- Munawwarah and Makkah Al- Mukkaramah will be obtained from Google maps and inputted in the receivers.

Action plan

With regards to transportation, the number of buses provided by the mutawwif is dependent on the total number of pilgrims. Most of the buses in service now can seat 50 people. The bus

schedule is usually designed such that each bus runs a particular route twice. So if there 2500 pilgrims, 25 buses will be provided, with each making two trips.

Prior to the arrival of the first batch of pilgrims from Ghana, the Task force team already present in the Kingdom will visit all the installations that would host the pilgrims and take GPS coordinates of the places. These locations generally are:

- Hotels or places of residence in Madinah Al- Munawwarah (secured by the Ghana Hajj Mission)
- Hotels or places of residence in Makkah Al- Mukkaramah
- Campsite or tents in Mina
- Campsite or tents in Arafat

These coordinates would be entered into the GPS receivers. Test runs would then be conducted to see the effectiveness of the receivers as navigational aids.

Madinah Al-Munawwarah

Prince Mohammad Bin AbdulAziz International Airport in Madinah is the preferred first point of call for pilgrims arriving from Ghana to the Kingdom. Upon arrival, buses provided by the mutawwif convey pilgrims to their places of residence within the city, which is located about 15 km South-West from the airport.

About two hundred pilgrims arrive per flight, and generally two flights arrive each day till all the pilgrims are ferried from Ghana. Thus eight buses would be required each day. An additional bus to serve as backup would be needed. A member of the Task force team with a GPS receiver in hand will be on the bus from the airport; helping to direct it to the intended destination. Barring any operational setbacks such as failure of flights to arrive, this would be repeated until all pilgrims have arrived.

While in Madinah, pilgrims also visit the Holy Prophet's Mosque, the Quba' Mosque and the Baqi graveyard. With a GPS receiver in hand to help navigate buses from the hotels to these sites and back, incidents of getting lost and delays will be minimized.

Prior to leaving Madinah for Makkah, some paper work has to be completed by the mutawwif to enable pilgrims travel. After this is done, the green light is given to head towards Makkah.

To begin the Hajj rituals, pilgrims set off to Makkah from Madinah. On board each bus would be a member of the Task force team with a GPS in hand to direct the bus to the place of lodging in Makkah.

Mina

On the eighth day of Dhul-Hijjah all roads lead to the tent city of Mina, located about 6 km from Central Makkah, for the actual commencement of the Hajj. In order to control the heavy vehicular traffic, buses are usually not allowed into the dwelling areas in Mina. Several parking areas are created away from the dwelling areas where buses can drop pilgrims off. From these points, pilgrims then proceed on foot to their designated tents. Only ambulances and official vehicles are permitted to drive within the inhabited areas.

Figure 4. Photograph of tents in Mina (Source: Google Images)

It is therefore imperative that buses conveying pilgrims to Mina drop them off at points not so far from their tents, so as to save them from the trouble of having to trek long distances before reaching the tents. Over the years, many Ghanaian pilgrims tend to get lost during this, sometimes long, walk to reach their tents. Since all the tents are of the same make and colour, as shown in Figure 4, distinguishing between them is sometimes a problem. Making a single wrong turn could lead one to a completely different zone. The hoisting of national flags only helps in identifying tents once a person is close; from a distance it is difficult to discern.

Thus, with the coordinates of the tent location already inputted in a GPS receiver, navigation from the pilgrims' residence in Makkah to tents in Mina would be easy. Buses would first of all proceed to the drop-off area closest to the tents assigned to Ghanaian pilgrims. Once pilgrims alight, they will be guided by a member of the Task force team with a GPS in hand to the tents. Since positional accuracy is not very precise, but rather within a given radius, hoisted flags would be very useful in identifying the precise location of the tents once the pilgrims get close.

Arafat

Standing on the plains of Arafat on the ninth day of Dhul-Hijjah is a pillar of Hajj, the omission of which renders the Hajj invalid. The Prophet Muhammed (peace be upon him) is reported to have said that "Hajj is Arafat"; signifying the importance of this ritual. Pilgrims need to be within the boundaries of Arafat between the hours of sunrise and sunset.

To ensure that pilgrims are comfortable enough to carry out this very important act of worship, shelter are provided to accommodate them during this period. Thus, from the camp-site in Mina, pilgrims need to be transported to the tents in Arafat. Here also, locating these tents has been problematic during past years. There have been occasions where Ghanaian pilgrims have had to wander in vain in search of these tents. Proceeding from Mina to Arafat would therefore also require the use of a GPS receiver to help in locating the assigned tents.

After sunset pilgrims would be transported to Muzdalifah to pass the night, then head back to Mina after Fajr prayers on the morning of the tenth of Dhul-Hijjah.

Makkah Al-Mukkaramah

Upon return, pilgrims spend two or three nights in Mina before proceeding to Makkah to complete the remaining rites. Once the rituals are over, the Hajjis then take the opportunity to do some sight-seeing and shopping before they return home. This is also another period in which pilgrims tend to get lost. The main issue here is that pilgrims at this stage venture out by themselves and not in groups as they used to do during the performance of the rituals. This therefore presents a huge challenge in ensuring that pilgrims return safely. The suggested approach here is that those with smartphones will be aided in installing coordinates of the place of residence so that in the event of tem losing their way, they could rely on their phones to help guide them back.

Challenges

Sourcing for funds to implement this approach could be an issue. The Ghana Hajj Mission is a non-profit making body and so all the payments made by pilgrims must be used in provision of services they would enjoy directly. However, it is hoped that the Ghana Government as well as philanthropists would buy in to this idea and help finance it.

Finding the right people with knowledge on GPSs and to operate the receivers could be an issue of concern. To better help in the functioning of this approach, people with at least some basic knowledge about GPS would be very useful. Otherwise, members of the Task Force team need to be taken through a brief orientation on how GPS works and how to use the receivers. This would require some investment of resources which might not be available.

Also, a significant proportion of the pilgrims from Ghana fall into the category: 'technology migrants'. These are people generally not so in tune with modern technology. Thus, this method could face rejection from pilgrims unfamiliar with the workings of GPS.

RECOMMENDATIONS AND CONCLUSION

It is worthy of note that movement or commuting during the performance of the rituals (from Makkah to Mina and from Mina to Arafat and back) is organized in groups. This approach thus seeks to utilize this already existing arrangement of group activities; so that group leaders with GPS receivers in hand will be better guided, and thus minimize the number of pilgrims who get lost. To ensure the smooth implementation of this approach, the following actions are recommended:

- Inclusion of at least two individuals with GPS knowledge in the Task Force team.
- Commitment and co-operation among officials is key in the success of this approach.
- Sensitizing pilgrims is very essential.

Employing GPS could help in easing the navigational challenges faced by Ghanaian pilgrims. This approach by no means the only solution to this problem. Ideas such as GPS equipped wrist bands have been suggested, so that any missing pilgrim can be tracked and rescued. These approaches though laudable will cost more at this moment. Thus, as a short term remedy to the situation, the use of GPS receivers will suffice, until a better alternative is found.

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