Mosque Tracking on Mobile GPS and Prayer Times Synchronization for Unfamiliar Area[1]

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Abstract

The GPS has been applied in many fields of knowledge. The sophisticated technology on GPS has contributed many findings of new alternative and facilitating the end-user many of ease, specifically on position tracking matters and its accuracy is also utilized to navigate a path of directions of travel's destination. Usability of GPS to track coordinates of places precisely is also able to be utilized to assist a Moslem traveler who goes on a trip which has not been visited yet to find the nearest mosque to perform the prayer. However, not many techniques have been proposed for a Moslem traveler for Mosque tracking system and how to resolve the geometrics dilution of precision problematic on signal retrieving while tracking the mosques is still an issue. This paper presents development GPS on tracking nearest mosque surrounding visited area with geometric dilution solving and optimization of GPS track using mobile application software embedded with prayer time's synchronization on the mobile application. The proposed technique could not leave 5 times prayer and somehow confronts many difficulties to seek the nearest mosque to perform the worshiping in new areas.

Keywords: *Mosque Tracking; Mobile GPS, Mobile Application.*

1. Introduction

Finding a particular location at a particular time is a common task to everyone. Recently, with the advance of technology especially with the development of the Global Positioning System, locating certain location or building is no more a daunting task. It has been made easy with the navigation and mapping application and these applications are also available on mobile phones, making the application more accessible for everyone.

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The work on a mobile hot-spot navigator for instant POI finding in an unfamiliar area (a case study of restaurant findings in Da-an District, Taipei city, Taiwan) has been presented by Wei-Shen Lai et al. [1]. Such work which focused on location-based services is getting more popular. On-the-go consumers require dynamic information. Therefore, to improve user experience on mobile POI finding in unfamiliar area, their study proposed a brand-new POI database comprising information extracted from User Generated Content (UGC) and a refined POI finding module which better equips the mobile of the major tasks in tracking algorithm, including optimizing memory.

In this paper, a mobile GPS system is proposed with time reminder synchronization interface to remind Muslim travellers of their daily prayers with mosque locations to be new POI. We applied on-line GPS track optimization algorithm using mobile platform, embedded with 5 prayer times which will be alerted to the traveller 15 minutes prior to praying.

This paper is organized as follows. Section 2 describes the fundamental concept of how GPS works. Section 3 describes the framework of proposed technique. Furthermore, section 4 describes result of implemented technique. Finally, the conclusion of our work is described in section 5.

2. Preliminaries

2.1. General Global Positioning System

Global Positioning System (GPS) is a technology introduced to track by the United States of Defense (DoD), for spaced-based positioning, navigation, and timing system. It its currently working on 24 satellites, located at various locations and collaborate with several ground monitoring stations. It provides geo-location signals, measurement between different objects e.g., vehicles, people and provide efficient roaming between different locations. The tracking can cover from the earth's surface to geosynchronous orbit in space. A less-known element omitted from many descriptions is the embedded timing that serves as an essential element in its navigation services. Precise time and stable frequency signals available from GPS are at least equal in importance to its navigation and velocity determination functions. They are the synchronization sources for global communications, electronic transactions of all types, power-distribution networks, and innumerable other applications.

2.2. How GPS Works

GPS implements the time-difference-of-arrival concept using precise satellite position and on-board atomic clocks to generate navigation messages that are continuously broadcast from each of the GPS satellites. These messages can be received and processed by users anywhere in the world to determine their position and time accurately within a few meters and nanoseconds, respectively. The operation is based on the triangulation of satellite signals, using the radio signal travelling time [3]. Its location and time transmission of the signal will be sent by each satellite. After receiving the data, GPS receiver will computer the position and calculated distance using signals from four different satellites, as shown in Figure 1 [4].

As described in [4], we can assume that satellites and receivers have perfect internal clocks, which is never the case. Each satellite will transmit a coded signal. Consider this signal to be like the peaks and ridges along the edge of a super long key. This code is generated as a function of time. The receiver can also generate the same code. It matches the incoming code to the internally generated code except that there is a delay caused by the signal‘s travel time between the satellite and the receiver. The receiver measures how much it has had to shift the timing of its code to match the incoming code. Since the receiver knows how much time it takes the signal to reach the receiver and the travelling speed of the signal, it can then calculate the distance from the satellite. If you know how far you are from one satellite then you know that you are somewhere along an imaginary sphere around that satellite.

If you know how far you are from two satellites, then you are somewhere along the intersection of these two spheres, which is a circle. If you add another satellite, then you are somewhere where this third sphere intercepts with the circle created by the intersection of the other two spheres. The sphere will most likely intercept the previous circle at two points. One of these points is where you are, and the other is not a reasonable solution – somewhere in the outer space. Thus by knowing where you are relative to these three satellites the receiver with a perfect clock can identify its location. Although no clock is perfect, the satellites have atomic clocks that are very accurate – one second in one million years. Light travels at 186,000 miles per second. If the receiver time was off by 1/100 of a second, the calculated distance would be off by 1,860 miles [4].

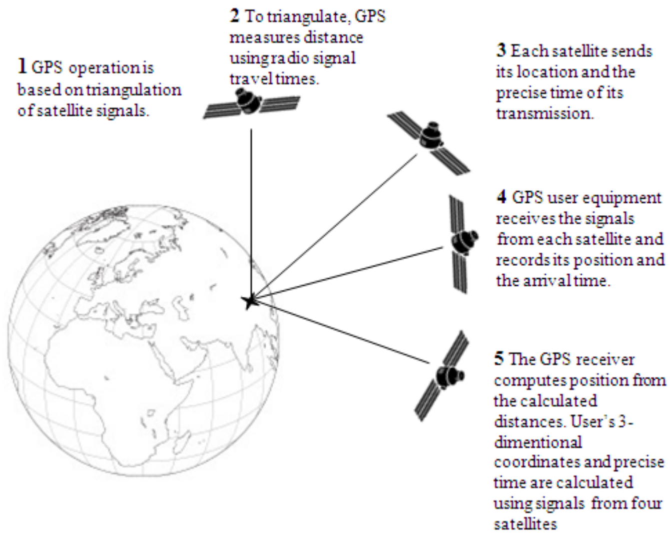

Figure 1: General Works of GPS. (Modified from [2])

It is not possible for each receiver to have its own cesium clock because it would make the technology expensive and non-portable. Therefore, a cheaper clock (similar digital watches) is used with an additional satellite for time precision in the GPS receiver. Time calculation is shifted back and forth so that the imaginary spheres intercepts. Four satellites are needed for a three-dimensional navigation – one for each dimension and an extra for the time. However, when the altitude is known, the GPS can center of the earth can replace one of the satellite.

3. The Proposed Technique

3.1 Framework

Mosque location is an equivalent Point of Interest (POI) with additional tracked object to alternate the tracking position. The presented system framework in our GPS system will initialize all the supported and required contents from a database such as maps, the mosque spatial data (POIs), Tracks, languages, Coordinated Universal Time (UTC) will set each defined prayer time and all data collections which are required. After initialization is done, 15 minutes before prayer time, user will be alerted. The system will generate a small window with a warning text and offers the user to be directed to the nearest mosque in the surrounding area. If the user decided to be directed, the maps will geo-referenced using the points obtained from the GPS receiver and the shortest path will be determined, calculated and displayed. The system framework is depicted in Figure 2.

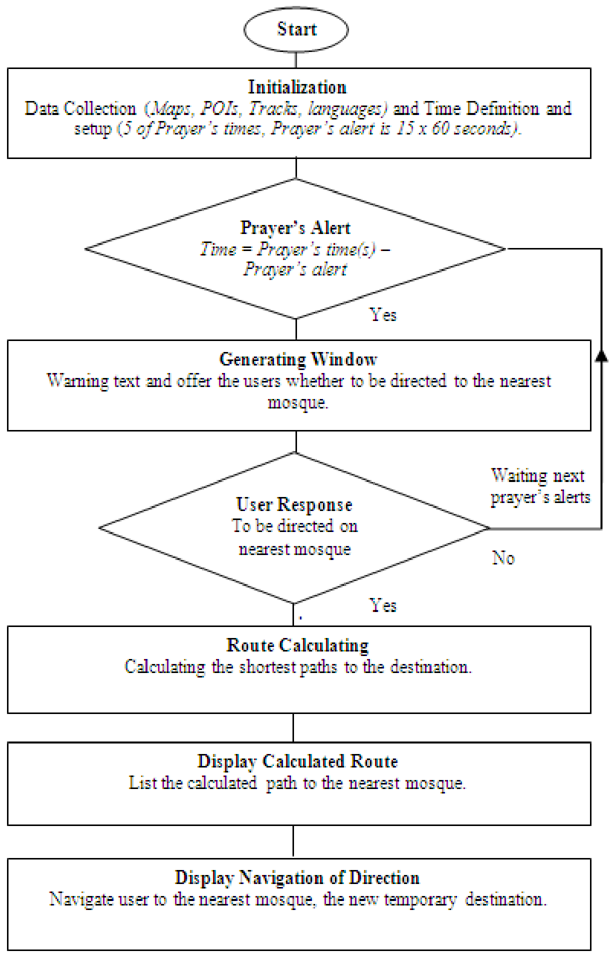

Figure 2: Flow Chart Diagram of Proposed System Framework

The proposed tracking algorithm belongs to the distance-based algorithms [5], but the threshold value for the distance after a new point is entered is obtained adaptively, taking into account the travelling speed and traveler's position. Figure 3 shows how new track point is generated.

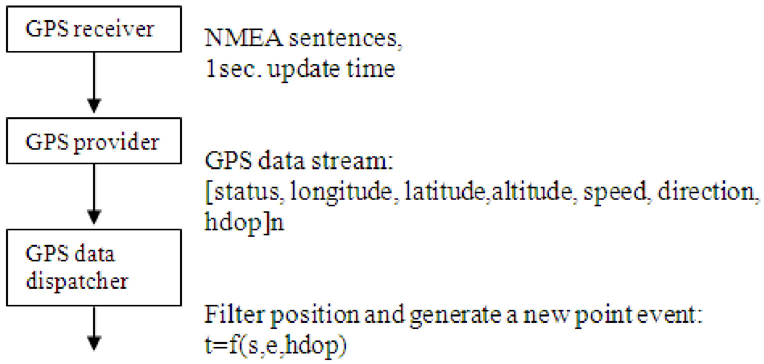

Figure 3: Sequence to Obtain the Moment to Enter a New Track Point

From the GPS receiver, data is passed to "GPS Provider" and then passed to the necessary GPS data dispatcher. The last module will adaptively define the time when the new track point is generated. The accuracy of a traveler's position depends on the first module (GPS receiver) and also the current latitude and longitude. It has to do with the number of visible satellites used and reflected signals. Horizontal Delusion of Precision (HDOP) is the parameter used for current accuracy.

3.2 Real-Time Satellite Mosque Tracking System with Diluted

In the tracking part, we had adopted a track optimization algorithm for describing a GPS route or GIS path [6] and it is adaptive to the accuracy of the GPS receiver [7], current method to determine the position and speed of movements. Also we presented how the geometric dilution assists for solution of position tracking.

Knowing the location of satellites is important when determining how precise readings are and how stable a GPS fix is. Since GPS precision will be covered in detail in part two of this series, so this section will focus on interpreting satellite location and signal strength.

There are twenty-four operational satellites in orbit. Satellites are spaced in orbit so that at any time a minimum of six satellites will be in view to users anywhere in the world. Satellites are constantly in motion, which is good because it prevents the existence of "blind spots" in the world with little or no satellite visibility. Just like finding stars in the sky, satellite locations are described as the combination of an azimuth and an elevation. As mentioned above, azimuth measures a direction around the horizon. Elevation measures a degree value up from the horizon between 0° and 90°, where 0° represents the horizon and 90° represents "zenith," directly overhead. So, if the device says a satellite's azimuth is 45° and its elevation is 45°, the satellite is located halfway up from the horizon towards the northeast. In addition to location, devices report each satellite's "Pseudo-Random Code" (or PRC) which is a number used to uniquely identify one satellite from another. Currently the "$GPRMC"sentence has been fully interpreted, the interpreter can be expanded to support a second sentence: "$GPGSV." This sentence describes the configuration of satellites overhead, in real-time. Another sample code that had developed is written as below.

```
$GPGSV,3,1,10,24,82,023,40,05,62,285,32,01,62,123,00,17,59,229,28*70
```

Each sentence contains up to four blocks of satellite information, comprised of four words. For example, the first block is "24,82,023,40" and the second block is "05,62,285, 32" and so on. The first word of each block gives the satellite's PRC. The second word gives each satellite's elevation, followed by azimuth and signal strength. If this satellite information were to be shown graphically, it would look like Figure 4.

Figure 4: Graphical Representation of a $GPGSV Sentence, Where the Center of the Circle Marks the Current Position and the Edge of the Circle Marks the Horizon.

Perhaps the most important number in this sentence is the "signal-to-noise ratio" (or SNR for short). This number indicates how strongly a satellite's radio signal is being received. Remember, satellites transmit signals at the same strength, but things such as trees and walls can obscure a signal beyond recognition. Typical SNR values are between zero and fifty, where fifty means an excellent signal. (SNR can be as high as ninety-nine, but I've never seen readings above fifty even in wide open sky.) In Figure 4, the green satellites indicate a strong signal, whereas the yellow satellite signifies a moderate signal.

3.2.1 Geometric's Dilution of Precision

GPS devices calculate traveler position using a technique called "3-D multilateration", which is the process of figuring out where several spheres intersect. In the case of GPS, each sphere has a satellite at its center; the radius of the sphere is the calculated distance from the satellite to the GPS device. Ideally, these spheres would intersect at exactly one point, causing there to be only one possible solution to the current location of traveler, but in reality, the intersection forms more of an oddly-shaped area. The device could be located within any point in the area, forcing devices to choose from many possibilities. Figure 5 shows such an area created from three satellites (using part one's $GPGSV sentence). The current location could be any point within the gray-colored area. Precision is said to be "diluted" when the area grows larger, which leads to this article's focus: dilution of precision. The monitoring and control of dilution of precision (or DOP for short) is the key of high-precision applications.

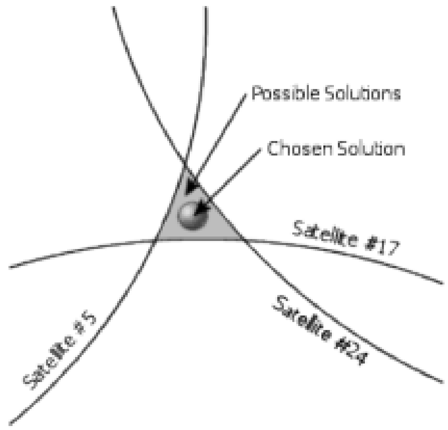

Figure 5: GPS Devices must Choose One of Several Possible Solutions to the Current Location of Traveler

DOP values are reported in three types of measurements: horizontal, vertical, and mean. Horizontal DOP (or HDOP) measures DOP as it relates to latitude and longitude. The vertical DOP (or VDOP) measures precision as it relates to the altitude, Mean DOP also known as Position DOP (PDOP), gives an overall rating of precision for latitude, longitude and altitude. Each DOP value is reported as a number between one and fifty where fifty represents very poor precision and one represents ideal accuracy.

Looking again at figure 5, three satellites created a large area of possible solutions. This situation could be improved by two factors: adding more satellites to the fix, and using satellites evenly distributed throughout the sky. Figure 6 shows figure 5 after three more evenly-distributed satellites have been added.

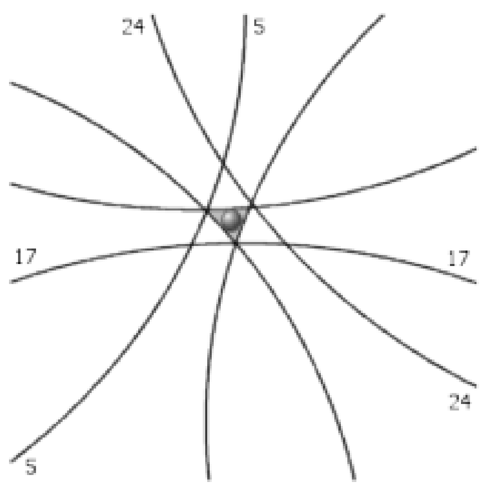

Figure 6: Three more Evenly-Distributed Satellites are Added to Figure 2-4, Creating a High-Precision Environment where Dilution of Precision is Low.

The significance of this method to the tracking mosque system to detect the existence of traveler and most probably of user difficulties on tracking system is bearing of the existence.

Also most of GPS mobile applications utilized 3-D multilateration [8] to figuring the user existence.

3.4 The Algorithm for Optimization of GPS Tracking on a Mobile Platform

It is significant to note that one of the significant attribute in this GPS system is the optimization capability in its tracking system which is applied for outdoor environments [8]. This optimization algorithm which is based on mobile platform has been presented by Ivanov [9]. However, due to the smaller receiver size, mobile platform tends to dilute faster compared to special GPS devices such as Garmin and TomTom. For mass production of Java-based GPS navigation systems (using mobile terminals for middle price segment) it is necessary to optimize the usage of operative memory. On-line optimization of the number of the track points is offered on the basis of the last three points (locations) entered. An additional check is made between point p_2 and p1. In order not to miss important track points [10] in long and smooth curves an additional check is made for the distance (d) between point p_2 and the segment formed by points p_1 and p_3 (nearest path to route). If $d>d_{Th}$, point p_2 belongs to the route notwithstanding that the condition $\gamma \geq \gamma_{Th}$ is not fulfilled. The value of the threshold d_{Th} is obtained adaptively, depending on the current value of HDOP [11]. The module "GPS Data Dispatcher" is intended to inform through messages the other program modules for new events from the GPS receiver. Figure 7 shows the main program loop through which the moment for generation a new point is determined.

1. Initialization:
   E=10, lastLon=0, lastLat=0, distancTh=0, v_{n-1}–n =0
   (Whereby speed value symbolized as (v))
2. Get new GPS data:
   {lat, lon, speed, alt, hdop, direction, status}n
3. AddNewPoint(GPS data)
4. Back to step 2

Figure 7: GPS Data Dispatcher Main Loop

The method AddNewPoint realizes: position filtering, speed filtering, travel mode definition (using car or on walk), generation of a new point, if there are necessary conditions – HDOP, the path and speed passed within the needed ranges (Please refers to Figure 8). The program module which realizes the tracking algorithm must listen its mailbox for "newpoint" message. After receipt of message the GPS data are read by the GetNewPoint method and the optimization of the points is realized with the OptimizeTrack method. (Refer to Figure 9).

```
Algorithm AddNewPoint (GPS data)
v =speed_n
 _n = FilterSpeed(□_n-1, v_n)
if (□_n > v_Th )
    HDOP_max=4.6
else
    HDOP_max=3.6
endif
if (hdopn < HDOP_max)
    e = E.hdop_n
if ( nv >100)
    dist_Th = S_max
else
    distanc_Th = e_n + [(S_max - e_n) / 100]_n((s) = distance and within the range [e, S], where
e = current position)
endif
    [filtLon_n, filtLat_n] = filtPosition(lon_n,lat_n)
    distanc = GPSDist(filtLon,filtLat,lastLon,lastLat)
if (distanc ≥ distanc_Th)
        lastLon = lon_n and lastLat = lat_n
        POBox.add("newpoint")
    endif
endif
```

Figure 8: AddPointTo Track Algorithm (Modified from [9])

```
OptimizeTrack(lon_n, lat_n)
xPath[i] = lon_n , yPath[i] = lat_n
i = i + 1
if (i = 1)
    AddPoint(xpath[0], ypath[0])
    numberOfPoints ++
    return
endif
if (i = 3)
  if (CheckPoints(xpath,ypath,hdop_n) = true)
    xpath[0] = xPath[1], yPath[0] = yPath[1]
    AddPoint(xPath[0], yPath[0])
    numberOfPoints ++
    return
  endif
    Xpath[1] = xPath[2], yPath[1] = yPath[2]
    i = 2
endif
```

Figure 9: OptimizeTrack Algorithm (Modified from [9])

3.3 Prayer Times Synchronization

In Islam, prayers are performed 5 times a day. There are 5 specific prayer times daily according to the position of the sun and these praying times are embedded in the system. In order to pray in congregation, travelers need to reach the mosque in time. Therefore, the system prototype will alert the user 15 minutes before the praying time to enable user to pray in congregation or at least, praying on time. It will synchronize with the real-time satellite in GPS application using atomic clock. Time is the cornerstone of the GPS technology because distances are measured at the speed of light. Each GPS satellite contains four atomic clocks which are used to time its radio transmissions within a few nanoseconds. One fascinating feature is that with just a few lines of code, these atomic clocks can be used to synchronize a computer's clock with millisecond accuracy [12]. The second word of the $GPRMC sentence, "040302.663," contains satellite-derived time in a compressed format. The first two characters represent hours, the next two represent minutes, the next two represent seconds, and everything after the decimal place is milliseconds. Thus, the time is 4:03:02.663 AM. However, satellites report time is in universal time (GMT+0), so the time must be adjusted to the local time zone. Afterwards, prayer times will adjust local time will.

4. Results

The experiment was carried out on Symbian 3rd Generation platform using JAVA Micro Edition (ME) Software Development Kit (SDK) as common Mobile GPS development [13][14] and the POI database on PostgreSQL database platform. In the experimental result, a virtual walkthrough of the system with prayer time alerted until the system navigation directs the users to the destination. The developed GPS software application had been tested using Nokia C6-00 and was built-in an assisted-GPS.

4.1 Five Prayer Times Alert

Fifteen minutes to each prayer time, the system will generate a small window or pop-up which informs the users that prayer is due. The system will then offer the user to be directed to the nearest mosque in the vicinity (please refer to Figure 10).

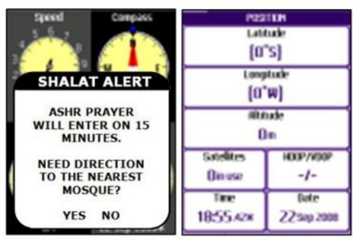

Figure 10: User is Alerted 15min Prior to the Praying Time.

4.2 Calculated Routes and Navigation

After the system reminded the user of the prayer time, the system recalculates and displays calculated routes of the nearest mosque in the vicinity. The display will wait for the user's response to the navigation of chosen destination – whether the user wishes to be redirected. Once agreed, the user will be directed to the new location (the nearest mosque). For navigating, users are allowed to set their maps to be used either in 3D or 2D graphical view (Figure 11).

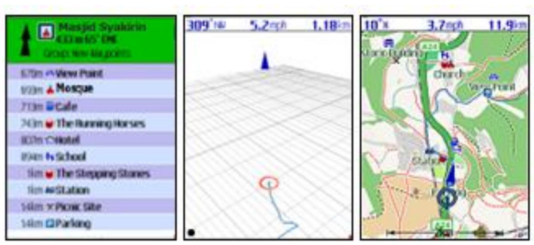

Figure 11: User Interface of the Calculated Routes and Navigation System

5. Conclusion

Praying is important for people of faith. For Muslims, they pray when they are at home or away from home, and for men, praying is preferably at the mosque. This includes the time when they travel. Of course, being in foreign lands, they require richer and well-organized information in order to know where to go to pray. Therefore, to perform the five daily prayers without failing, we help Muslim travelers to find the nearest mosque. Having the five specific times for prayers, we design a tracking application system based on Mobile GPS that can be synchronized with the praying time and also tracking the nearest mosque. The basic idea in this work is assigning mosque as a new POI. To do this, new optimization algorithm for tracking is used. The system will alert and offer users to be directed to the nearest mosque. The current system only has mosques or other worshiping place as POI. Here, we designed the system for Muslims. In the future, we plan to improve the algorithm and the navigation system and at the same time, handle any arising issues related to it.

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