Tracking with Global Positioning System (GPS) Based on Mobile Devices - A Review

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DOI : https://doi.org/10.51584/IJRIAS.2024.907001

Received: 18 July 2024; Accepted: 22 July 2024; Published: 25 July 2024

ABSTRACT

Persistent incidences of lack of maximum effectiveness in mobile GPS tracking systems are an increasing concern. Methods used to optimize performance were found to be plagued with less implementation and a concern in the industry. This study definitively answers the question regarding correlation between lack of optimal methods for mobile GPS tracking and the problems encountered in mobile GPS tracking systems. The purpose of this study is to investigate the connection between optimizing mobile GPS tracking and the incidences leading to the problem. Review was carried out on the existing methods for fulfilling mobile GPS tracking from the literatures in order to justify their strengths and gaps for relevant improvement. Further studies are needed to establish a model that works optimally and would prevent poor performance in mobile GPS tracking.

Keywords: mobile GPS tracking, smartphone, surveillance, tracking of things of interest, mobile phone tracking

INTRODUCTION

As surmised (Erol et al., 2020), Global Positioning System(GPS) is a radio navigation system that allows land, sea and airborne users to determine their current exact location, velocity and time 24 hours a day (Moloo & Digumber, 2011), in all weather conditions and anywhere in the world, supporting a broad range of military, commercial and consumer applications. With advances in technology, GPS sensors were incorporated in smartphones hence the advent of mobile GPS tracking systems. These systems allow us to track mobile devices directly without using stand-alone GPS trackers as done in the past and allow us to track people and things of interest. As smartphones become ubiquitous in various ranges, sizes and costs, with the right application and setup, mobile GPS tracking system is available. After installing the right application to facilitate tracking and with the right configuration, these systems access the GPS module of tracked device and collect data like via time intervals or motion, then might do some processing and send the data to a server or data center for viewing or further processing. Depending on the system, users can activate various forms of notifications (Moloo & Digumber, 2011;Erol et al., 2020) such as geofence to get alerts if tracked object leaves a certain area which could be time dependent. Quite a number of systems try to support the GPS sensors with collecting data via cell towers, Wi-Fi amongst other sensors (Gadziński, 2018)and they are often referred to as Assisted GPS (A-GPS) systems (Assemi et al., 2020; Michael & Clarke, 2013).

Most of these mobile GPS tracking systems, as good as they might be, still come encumbered with problems (Syed et al., 2022). Some of which include quick battery drainage(Zhang et al., 2013), privacy issues(Michael & Clarke, 2013), redundant data collection, poor data collection(Moloo & Digumber, 2011)and high costs(Alhafnawi et al., 2023;.Paiva & Abreu, 2012) in finance and resources. Using beneficial methods and algorithms to manage the use of sensors (Oliveira et al., 2023; del Rosario et al., 2015) and how data is collected and sent to server (Moloo & Digumber, 2011), can reduce quick battery drainage. Privacy issues should be addressed by enacting robust laws and enforcing them (Michael & Clarke, 2013). Redundant data collection and poor data collection is mitigated by optimization techniques such as collecting new useful information(Moloo & Digumber, 2011) and embracing A-GPS(Michael & Clarke, 2013) approaches to support the use of GPS sensors. Lowering costs is achieved by embracing novel technologies(Elsanhoury et al, 2022; .Lu et al., 2010), open source solutions(Moloo & Digumber, 2011)and the use of optimization methods, algorithms, computational methods and intelligence (Alzantot & Youssef, 2012; Asim & Abd El-Latif, 2023). Based on existing research, a system should be developed that incorporates the advantages, approaches and algorithms that would help us build a robust mobile GPS tracking system that is also desirable.

The purpose of this study is to do a review of the literature and contribute in creating reliable and desirable mobile GPS tracking systems by mitigating costs and challenges due to fast battery drainage, addressing privacy issues and optimizing on how geolocation data is collected and processed.

LITERATURE REVIEW

Low-cost mobile GPS tracking solution was implemented which used cheap Bluetooth GPS receiver connected to a simple Bluetooth-enabled mobile phone or a mobile phone with integrated GPS receiver. It was found that the use of Google Maps APIs, HTTP protocol, intelligent logging, and an intelligent positioning calculation further reduced cost, providing most services provided by existing systems. The intelligent positioning calculation implemented reduced the amount of GPS data sent to the server. If a device's position is static, the application in the device checks whether there is need to send GPS data to the server or not. A distance calculation was performed by the application prior to the last GPS data received(Moloo & Digumber, 2011). In the event that there is a small change in the GPS position, no data is sent to the server, thus reducing costs. By using the free Google Maps API for tract visualization, there was no need to develop a map solution and this contributed in the cost reduction of developing the system. Also for SMS alerts, the existing option of Email SMS was exploited. It was reported that a mobile phone having WAP can receive the SMS alerts and implementing this type of alert is totally free(Moloo & Digumber, 2011). Orange and Emtel, the two major mobile network operators in the study allowed their subscribers to receive text messages sent as an email in the appropriate format. Thus there was no need to have a paid SMS gateway for Geofence alerts.

The proposed system, though cost-effective, had some limitations. The Java application (Midlet) that needed to be installed on mobile phones was compatible only with phones having MIDP 2.0. Also the short span of the battery life of the mobile phone was reported to be put in consideration. Being connected via Bluetooth and to Internet consumed a lot of battery life. It was recommended that it is best to use the mobile phone while it is connected to the battery of a vehicle or in an alternative way(Moloo & Digumber, 2011). Also, it was noted that the SMS alert could be sent only if the mobile phones of the recipients have WAP on their mobile phone, though it does not cost them to get the message. The system was noted to give false GPS position if confined in a building or under a bridge where there was no possibility to capture a GPS position. Another limitation might be the memory of the mobile phone. Actually one hundred records were allowed to be stored on the mobile phone when automatic logging is running. Absence of enough memory space blocked the application. Again concerning memory, the application could not be installed on the mobile phone if it does not have sufficient memory.

About location and tracking of mobile devices, Michael & Clarke, (2013) reported that mobile device location technologies and their applications are enabling surveillance, and producing an enormous leap in intrusions into data privacy and into privacy of the person, privacy of personal communications, and privacy of personal behaviour. Existing privacy laws were incapable of protecting consumers and citizens against the onslaught. Even where consent is claimed, it generally failed the test of being in formed, freely given and granular. There was an urgent need for outcries from oversight agencies, and responses from legislatures. Individual countries could provide some degree of protection, but the extraterritorial nature of so much of the private sector, and the use of corporate havens, in particular the USA, meant that multilateral action is essential in order to overcome the excesses arising from the US laissez faire traditions. The chimeras of self-regulation, and the unenforceability of guidelines, were not safeguards. Sensitive data like location information must be subjected to actual, enforced protections, with guidelines and codes no longer used as a substitute, but merely playing a supporting role. Unless substantial protections for personal location information are enacted and enforced, it was noted that there will be an epidemic of unjustified, disproportionate and covert surveillance, conducted by government and business, and even by citizens (Owens, 2023; .Gillespie, 2009; Abbas et al., 2011).

In a study, it was(Michael & Clarke, 2013) suggested that one approach to the privacy problem would be location privacy protection legislation, although it would need to embody the complete suite of protections rather than the mere notification that the technology breaches privacy. An alternative approach is amendment of the current privacy legislation and other anti-terrorism legislation in order to create appropriate regulatory provisions, and close the gaps that LBS providers are exploiting (Rabling, 2023; Koppel, 2010).

UPTIME (Alzantot & Youssef, 2012)was presented as a mobile phone-based system for ubiquitous pedestrian tracking that works in both outdoor and indoor environments. The system combined a novel FSM approach for step boundary estimation with a SVM classifier for estimating the variable step size based on the user gait. Presented were the details of the FSM and the orientation independent features that allowed their system to provide high accuracy of tracking. To evaluate the system, implementation was carried out on Android-based phones and compared to the state-of-the-art systems(Alzantot & Youssef, 2012). Results showed that the FSM-based step detection algorithm could achieve an accurate estimation with less than 5.72% error for arbitrary phone orientations. In addition, the SVM classifier achieved 97.74% accuracy with most of the error to adjacent classes. Combining both modules together, UPTIME provided a high tracking accuracy with less than 6.9% error in distance estimation for both indoor and outdoor environments.

Currently(Alzantot & Youssef, 2012) reported that they are expanding their system in different directions, including enhancing accuracy by error resetting by synchronizing with the environment and other users, estimating accurate user direction, performing map matching, among others.

In tracking the evolution of smartphone sensing for monitoring human movement, del Rosario et al., (2015) reported that the smartphone has demonstrated a tremendous amount of capability as a non-invasive monitor of physical movement. Studies referenced in the work showed that when the smartphone's vast array of sensing components was utilized, the device could estimate a variety of physical movements with potentially far reaching applications in healthcare.

Further research(del Rosario et al., 2015)gave a report on the need to resolve the issues generated by the multifunctional nature of the device as well as the maturation of smartphone technology to mitigate the limitations imposed by battery capacity. The advent of "smartwatches" which contain MEMSsensors, as well as other items of clothing which may become "smart" (i.e., embedded with electrical components that could transduce movement and communicate with other electronic devices wirelessly)have the potential to dramatically impact future methods for identifying movements. Instead, the smartphone could become the hub to which all data is relayed and processed, rather than solely relying on the sensors within the smartphone to identify physical movement.

The use of data obtained with smartphones (Gadziński, 2018)as reported, might broaden the analytical possibilities in transport studies. The work revealed that they could find several examples of surveys in which interesting results have been provided. Also findings from the researchers pilot study showed that even with the use of simple statistical programs, standard computers and modest budget some promising data could be collected. The great advantage of data obtained from smartphones is the fact that they could eliminate many problems that traditional self-reported surveys face. Zhao et al.,(2015) listed among them such issues as under-reporting of short trips, reporting inaccurate locations and times, and reporting on a "typical" day rather than the actual day. Attempts should also be made to underline the great flexibility in designing the survey what could be very useful for researchers.

However, based on literature review and their pilot study,Gadziński, (2018) were able to indicate some remarks on the utility of surveys with smartphones in travel behaviour studies. First of all, the collection of A-GPS data could be much more problematic than in the case of cell-tower-based data (usually obtained directly from mobile operators) or data obtained with GPS devices. Usually, this process requires a dedicated IT system and an application gathering location data that could significantly increase the cost of research. In addition, the need for a great financial investment seems to be the main barrier in the popularization of surveys with the use of smartphones. Some rewards for participants should be considered when planning a survey budget (especially to compensate for the inconvenience of faster battery drain). Furthermore, the authors could meet sampling problems – due to the uneven distribution of mobile phones in the society. Therefore, some groups of survey participants have to be equipped with smartphones for the research period. Finally, we should also notice that the data processing is usually very complicated. Some analyses require advanced and sophisticated algorithms necessary e.g. for travel mode detection. Raw data have also many disruptions, so they should be cleaned before processing.

Due to these problems, the perspectives of a broader use of data obtained with smartphones in transport policies seem rather unclear. Generally, they could find two main opinions in this matter. Some authors admit that such surveys may never entirely replace surveys that require active interaction with study participants (Chung et al., 2023.; Vij and Shankari, 2015). Geurs et al.,(2015) treated the use of smart-phones also rather as the supplement to traditional research. In turn, (Gong et al.,2014) claimed that surveys with smartphones could become the main method used in travel behaviour studies. Lane et al.,(2010) also believed that in the nearest future “mobile phone sensing systems will ultimately provide both micro- and macroscopic views of cities, communities, and individuals, and help improve how society functions as a whole”. From their perspective, this could become a reality but rather in a distant perspective (Lane et al.,2010; D'Alberto & Giudici, 2023).

Before this happens, all mentioned barriers should be overcome. However, regardless of these doubts, we must undoubtedly agree with (He et al.,2017) that “we are fortunate to be working in exciting times, with great opportunities being provided by our new datasets”.

DISCUSSION

From the review so far, we can see that there is a need to create a mobile GPS tracking system that could cover the challenges met so far. For example, the application to be used is compatible only with phones having MIDP 2.0. and because of this it could be expanded to cover a larger range such as MIDP 3.0 or MEEP or even better options; the challenge of battery drainage could be covered by introducing algorithm that would optimize how sensors are used to receive data by reducing redundancies. Optimize usage of sensors could decrease constant request for coordinates and lead to a longer battery life. When the battery is less than 15%, the request time could be increased. This still gives user tracking data though with larger interval whilst minimizing battery drainage. Reducing redundancies in data collection could optimize how data is also saved in such a way that only necessary information gets saved. Other effective means apart from WAP could be introduced to broaden options of sending SMS alert. A system that uses A-GPS (Assisted Global Positioning System) which combines both GPS and other sensors such as cell-tower location and Wi-Fi can be used to counter the challenge that affects GPS accuracy like when in a canyon, in a building and under a bridge. Having this in place, it could help in checkmating flawed data received when in buildings or environments that provided poor GPS information. Considering advances in technology and creation of cost-effective storage/memory devices, more than a hundred records should be able to be stored on the mobile phone when carrying out automatic logging, enough memory would allow the application to successfully run and allow the application generally to be installed. Necessary algorithm could be developed to further optimize the usage of memory.

A means to tackle the menace of the bridge of privacy has to be addressed. Robust privacy laws ought to be enacted to aid in protecting consumers and citizens against onslaught. Consent should pass the tests of being informed, freely given and granular. The extraterritorial nature of so much of the private sector, and the use of corporate havens, in particular the USA, mean that multilateral action is essential in order to overcome the excesses arising from the US laissez faire traditions. The chimeras of self-regulation, and the unenforceability of guidelines, are to be optimized, so they could stand as safeguards.

Currently,Alzantot & Youssef, (2012), reported that they are expanding their system for ubiquitous pedestrian tracking using mobile phones in different direction including enhancing accuracy by error resetting by synchronizing with the environment and other users, estimating accurate user direction, performing map matching, among others. And this accuracy might also be enhanced by considering using other reliable computational models and computational intelligence approaches; this could be implemented for even the task of step boundary estimation that is dependent on estimating the variable step size based on the user gait (Asim & Abd El-Latif, 2023).

A method could be used as a hybrid, primarily relying on "smart sensors" to collect data for processing by the phone, then as need be, sensory data could still be collected by the phone, secondarily(del Rosario et al., 2015). This could aid in mitigating the limitations imposed by battery capacity.

The collection of A-GPS data could be figured out with fewer problems by implementing a low cost approach such as working with open source systems. Ideas to encourage user participation ought to be embraced especially when considering fast battery drain. Wise approaches should be implemented to mitigate sampling problems. Good algorithms should be developed to assist in processing. Clever approaches should be implemented to clean data before processing.

Surveys could be structured in such a way that mobile phones could capture data and active interaction with study participants too could be embraced as need be. With the right approaches, mobile phone sensing systems could be used to provide micro- and macroscopic views of cities, communities, and individuals, and help improve how society functions as a whole. Barriers ought to be overcome to bring to fruition the grander vision. New datasets could pave the way to remarkable accomplishments.

CONCLUSION

From discussion and analysis, we can see that a lot can still be done to improve on the quality of mobile GPS tracking system. The findings reported on some of these possibilities. First by implementing novel technologies available to us , we can have applications that embrace a broader range than just MIDP 2.0. The challenge of battery drainage could be mitigated by embracing algorithms that optimize how sensors are used while still successfully carrying out tracking operations; this can also aid in reducing redundant data collection and optimizing usage of memory/storage on phone and server. Other effective means can be used to send data apart from WAP. A-GPS system could assist in tracking supporting GPS and covering its weaknesses. Advances in memory and storage technology could allow us to implement more space for automatic logging, allow us run the application easily and install the application. Necessary algorithm could be developed to help further optimize the usage of memory. Robust privacy laws ought to be enacted to aid in protecting consumers and citizens against bridge of privacy. Consent should pass the test of being informed, freely given and granular. Estimating accurate step boundary dependent on estimating the variable step size based on the user gait, estimating user direction, performing map matching, could be addressed by varied reliable computational models and computational intelligence approaches. A method could be used as a hybrid to optimize battery usage, primarily relying on "smart sensors" to collect data for processing by the phone, then as need be, sensory data could still be collected by the phone secondarily.

Low cost approaches could be implemented in collecting A-GPS data by embracing open source solutions. Wise idea should be implemented to encourage user participation considering fast battery drain and sampling problems. Good algorithms should be used to process data and clean data.

Surveys could be structured in such a way that mobile phones could capture information. Active interaction with study participants too could be embraced as need be. When barriers are overcome and with the use of new datasets, mobile phone sensing systems could be used to provide micro- and macroscopic views of cities, communities, and individuals, and help improve how society functions as a whole.

Conducting empirical tests or prototyping the proposed solutions would validate their feasibility and effectiveness in real-world scenarios. Collaborating with hardware and software developers could address the limitations of current mobile devices and facilitate broader compatibility and smart sensor integration. Developing a detailed cost-benefit analysis would provide a clearer understanding of the practical implications of these solutions. Additionally, engaging with policymakers and privacy experts to formulate actionable steps for robust privacy laws would make the recommendations more concrete. Finally, incorporating user feedback through pilot studies could refine the optimization algorithms and hybrid data collection methods, ensuring they effectively meet user needs and expectations.

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ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue VII July 2024

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