Information with the Blink of an Eye: Making Smart Cars more Intelligent and User Friendly

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Abstract

The advancement in vehicular networks using global positioning system, wireless sensor networks and image processing technologies play an important role in developing attractive applications for the betterment and ease of every individual. More specifically, to get the information of any surrounding object or place while driving is the main objective of this paper. To achieve the desired objective, we use the integration of global positioning system, inertial tracking, eye gaze technology, computer vision and augmented reality. We have practically implemented the proposed system to check its accuracy by comparing the obtained results of an object or place with its actual position and information.

Keywords
Global Positioning System, Navigation, Eye Gaze, Augmented Reality, Computer Vision.

1. Introduction

It is an interesting observation that a person driving in an unexplored area is very much curious in getting real time information about new places in the visiting area, especially when driver is alone. There are some technological solutions available to provide real time information to the user like magic wand which is basically a 3 D input tool through which a user can input hand writing gestures (Simon, R., and Fröhlich, P, 2007) and smart lens which can be used as replacement to eye also known as bionic eye provides seamless information that appears right before the eye (Schmalstieg, D., and Wagner, D, 2007 and Babak A. Parviz., 2009). Virtual peephole offers users an interactive visualization of the environment. Users can retrieve media clips and text-based content related to locations in their vicinity by selecting them in the 3D view (Simon, R., 2006).But in these technologies, one must need to do some physical moments, for example, use their hands to access physical equipment and give input as location or place coordinates to get the information about the interested location.
For instance, a person might come across a place while driving that attracts him and might want to get some information about it such as its name, historical background, working hours etc. More specifically, a

person come across a cinema and wants to know about the scheduled movies for the next few days, or to buy a ticket for a specific movie. But due to traffic laws and conditions, he is not allowed to use mobile or other devices for booking while driving. In this scenario magic wand, smart lens or virtual peephole would not give any benefits to the driver from their technologies as they need some input information to produce an output. In this paper, we present a solution to this scenario. In the proposed solution, the drivers have to drive normally while they will be updated about the desire location by the proposed architecture for the smart cars.

The paper is organized as follow: Section 2 describes the related work while in Section 3 the principle of operation of the proposed system is discussed. Section 4 is dedicated to the results of the proposed system. Finally, Section 4 concludes the paper.

2. Related Work

To provide drivers the location information using human eye orientation technologies is the most recent and interesting research area and for the researchers and scientists the challenge is to find out the deficiencies in the existing navigation, information processing, the detection and decisions based on the human eye orientation. Computers make use of augmented reality (AR) and computer vision (CV) to distinguish between objects. To implement these technologies, first we have to device a system that is capable of pin pointing user location with extreme accuracy (W. T. Fong et al., 2009). With the launch of Global Positioning System (GPS) in 1973, several methods have been devised to make navigation and positioning more accurate and user friendly (Counselman et al. 1981, Pelc, Christopher E., 1987). GPS is a US owned utility that provide user with positioning, navigation and timing services. Since its first launch in 19735, the system is constantly improved by adding more and latest satellites with the last addition to it on May 15, 2013 (US Air Force, 2013). However, its accuracy varies with an average error factor of 13 meters or better in horizontal plane for Standard Positioning Service (SPS, the civilian version of GPS) due to the changes in climate, line of sight (LOS) and user's equipment (Kaplan, E. and Hegarty, C., 2006). To overcome the accuracy problem of GPS and its low coverage in urban environments several other technologies are also in use and one of the most accurate available tracking systems is inertial tracking. Use of inertial tracking in urban and dense environment is becoming very much popular as these systems have overcome the GPS inherit problems (Davidson, P. et al., 2009). Unlike other sensor technologies, there is no inherent latency associated with inertial sensing. All delays are due to data transmission and processing (Eric Robert Bachmann, 2000). Thus, an orientation that is calculated using inertial sensor data is likely to be extremely accurate and have very low latency. The only disadvantage in using inertial tracking is the price of its sensor, the most accurate sensor is the most expensive as well (Eric Robert Bachmann, 2000, Syed, Z.F. et al., 2008).The robustness and accuracy of Computer Vision (CV) is much higher but its algorithm suffers from high computational load (W. T. Fong et al., 2009), which are not desirable for mobile data dependant stations.

Recent research is focused on the Google glasses project. Again even Google glasses are designed to be worn by human being and they cannot be installed in a vehicle. The use of these glasses is limited to walking only as the law prevents the use of such objects while driving.

Researchers Zhiwei Zhu and Qiang Ji, 2007, Ruian Liu et al, 2010, Ebisawa, Y et al, 1997 and Roberts, D. et al, 2009, have proposed models for the human eye orientation. As proposed by Ruian Liu et al. 2010, a simple processor cannot efficiently detect the direction of the eye-gaze hence we need some specialized kind of image processing processor for efficient detection of gaze direction. This creates problem for implementation of eye-gaze technology in general purpose hardware like In-Vehicle Information Systems (IVIS). Solution to this problem is addressed by Ruian Liu et al. 2010. The 3-D gaze estimation technique estimates the 3-D direction of the eyeball's visual axis directly, and determines the gaze by intersecting the visual axis with the object in the scene while for 2-D estimation it estimates the gaze point on the object from a gaze-mapping function directly by inputting a set of features extracted from the eye image.

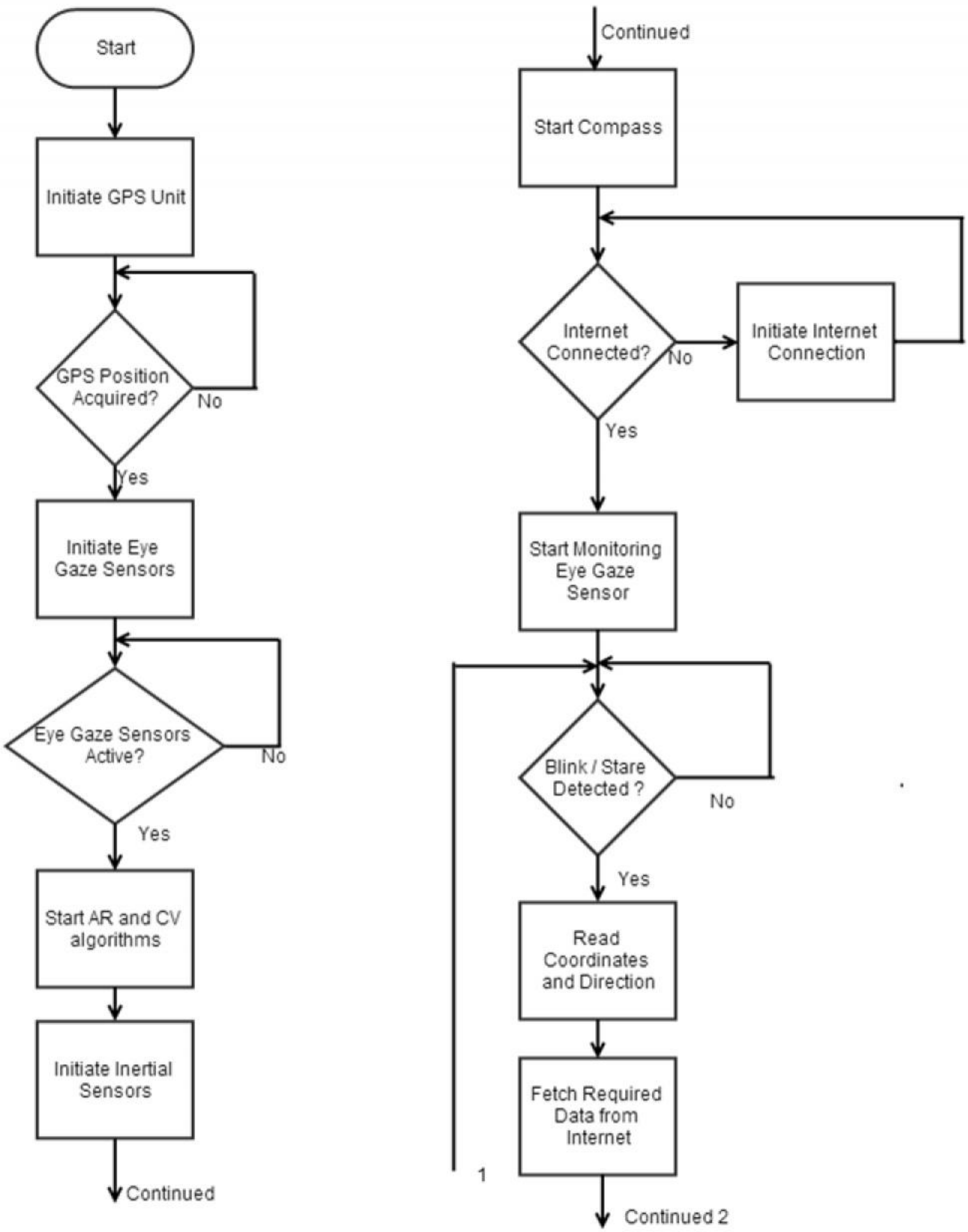

Figure 1. Flow Chart of the proposed system…

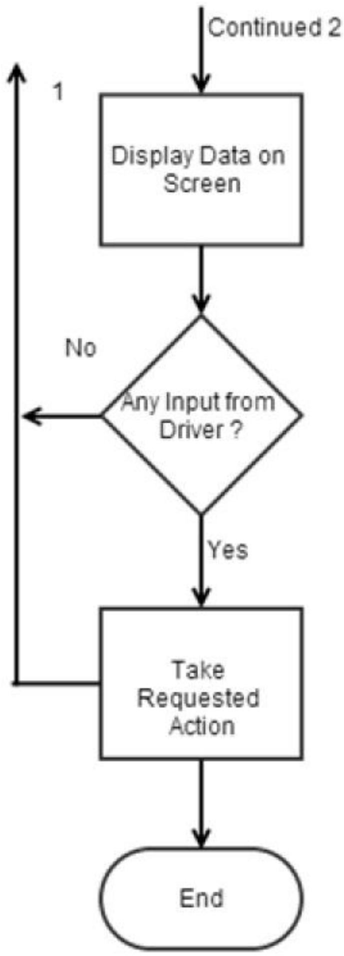

Figure 1. Flow Chart of the proposed system

3. Proposed Architecture

The proposed architecture consists of a GPS module, a GSM chip used to connect to data network and eye gaze detection equipment used in a conference paper by M. Baldauf et al., 2010. In our system we have used Garmin GPS automotive unit "nüvi® 3597LMTHD"25 that has built in GPS receiver, and a sharp 5-inch capacitive TFT screen. For taking advantage of AR and CV we have used iPhone's built-in camera and Application Programming Interface (API) of Google Goggles , Geo Goggles and Family by Sygic. The Jail-broken Apple's Operating System for iPhone (iOS) is used to develop an app for this purpose also iPhone's built-in LTE data transceiver is used to connect to the internet. The results were calculated using Matlab.

4. Principle of Operation

The proposed system consist of a numerous subsystems all working together make the positioning, augmented reality, the computer vision and the network access as precise as possible.

4.1. Positioning

To accurately locate a user or POIs, GPS, as suggested by Simon, R., 2006, Pelc, Christopher E., 1987, Davidson, P. et al., 2009 and inertial sensing suggested by Eric Robert Bachmann 2000, Pinchin, J. et al. 2012, You, S. et al. 1999, Syed, Z.F. et al. 2008, Davidson, P. et al. 2009, and Zhang Tao et al. 2010, works in collaboration with each other. Once the user is located all the POIs and list of buildings is downloaded to the on-board device clearly visible to the user in all directions.

4.2. Identification

Eye gaze technology is used to do multiple tasks, M. Baldauf et al. 2010, Zhiwei Zhu and Qiang Ji 2007, Roberts, D. et al. 2009. It is used to first determine the direction in which the user is looking at, W. T. Fong et al. 2003, and also if it was a random gaze or if a user is interested in something. Once detected that a user is interested in something, e.g. a user stares at a specific place or object for more than usual or blinks repeatedly, the area in the user's visible region is split into four quadrants and a specific quadrant is chosen. Doing so minimizes the volume of data to be downloaded and also helps in displaying and selecting only those places which interests the user.
Once established Computer Vision, W. T. Fong et al. 2003, and Augmented Reality, You, S. et al. 1999, is used to determine the specific POI or building that user is interested in. The whole operation is shown in Figure 1.

5. Results and Evaluation

To test the effectiveness of existing and the proposed system, data is being collected from physical devices. First of all, in different urban areas data of GPS Lock Time, GPS satellites acquired and also the number of buildings and their types is collected. The GPS satellite lock time and the number of satellites signal acquired also the error in the GPS positioning is obtained using Garmin GPS automotive unit "nüvi® 3597LMTHD".

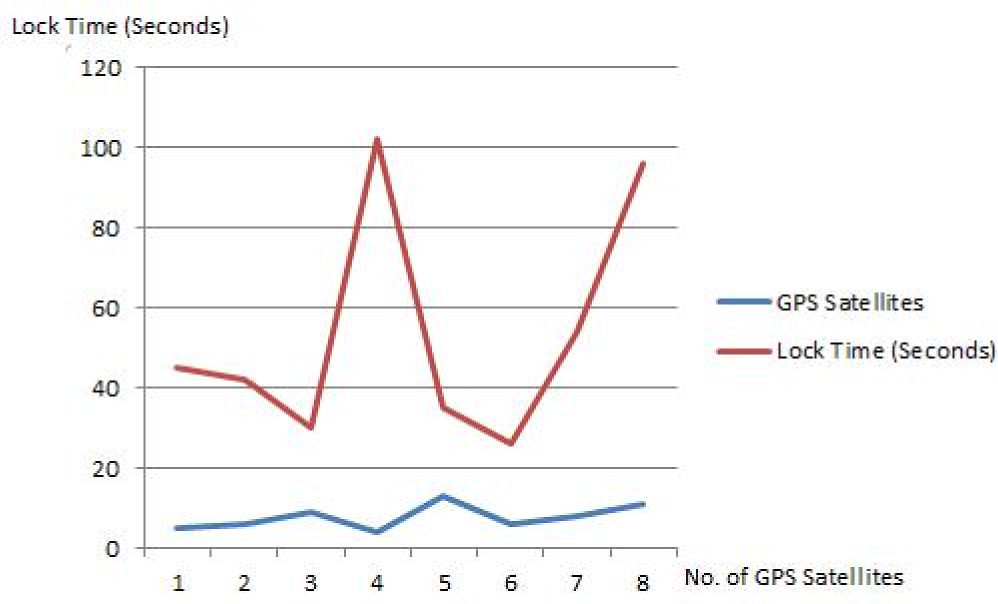

Figure 2. GPS Satellite Lock Time vs. Number of GPS Satellites

Figure 2 shows the amount of time required for first lock versus the number of satellites locked to define the position while in Figure 3 the number of satellites acquired and the error in position (in meters) is shown.

Figure 3. GPS Accuracy Error vs. Number of GPS Satellites

When CV, AR and Inertial Tracking are combined with the GPS positioning; the error in position the lock time and the effect of tall and dense surrounding buildings is minimized considerably as it is evident in Table I and Figure 4.

Table I. GPS Accuracy Table

S. No	Number of Buildings	GPS Accuracy Error (+/-)in Meters	Description
1	9	10	Open Market
2	7	8	Open Market
3	12	3	Open Street
4	6	12	Office Plazas
5	12	3	Residential Street
6	10	2	Residential Street
7	5	6	Offices
8	1	4	Toll Plaza

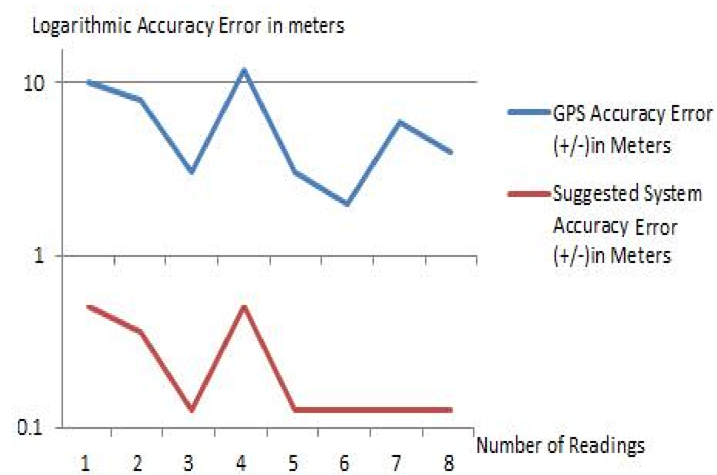

Figure 4. Accuracy Errors comparison

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