

Omniguider - The Next Generation of GPS Navigation System

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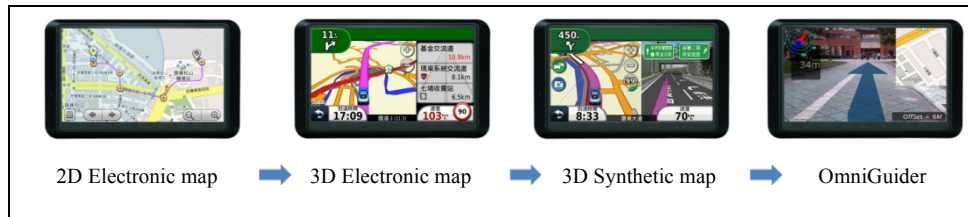
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INTRODUCTION

GPS navigational system belongs to an application of Location Based Service(LBS). However, navigational information provided by the conventional GPS navigation system is not adequately intuitive to a user. Moreover, the environment often affects the accuracy of a hardware sensor in a GPS navigation system, so as to make users to frequently stay in a disorientation status during navigation. The scenario owes that the navigation map provided by the conventional GPS system is not always consistent with a user's cognitive map. The navigation map [1] refers to navigational guidance with its related geographical information derived from conventional paper charts or electronic maps. Developed by Tolman in 1948 [2], the cognitive map refers to the ability of the human subconscious to accumulate and construct spatial and temporal information. This ability implies the type of mental processing through a series of psychological transformations. Consequently, an individual can acquire, code, store, recall and decode information regarding the relative locations and attributes of phenomena in their daily or metaphorical spatial environment. Namely, a cognitive map allows humans to sense and identify the environment where they reside. This map is derived from the accumulation of humans' familiarity and perceptions while wandering in their living spaces. Hence, a navigation system largely depends on consistency of the navigation map and cognitive map in terms of performance.

From the standpoint of navigational user interface, the continuum of the GPS system development can be sketched out as below diagram. This figure can also be viewed as illustrating the history of navigation systems regarding user's mental cognition from the past until now. This continuum has two implications. First, the view of a discrete navigation continuum exhibits the evolvement of GPS navigation, along with technology progress, from the simple 2D electronic map, simulated 3D electronic map with synthetic view, to the live-view navigation. However, the perspective of continuous navigation continuum reveals the efforts of providing sufficient navigational information from the previous simple 2D electronic map to a simulated 3D electronic map accompanied with an emulated landscape image. Although attempting to provide users with more intuitive information by multi-windows of a simulated scene, the latest navigation system fails to solve the mental rotation problem and even further increases the users' mental burden.



Consequently, by extending the results of previous cognitive map studies, OmniGuider system is the next generation of GPS navigation systems that adopt context-aware technology to eliminate hardware sensor signal errors and resolve the inconsistency problem between cognitive and navigation maps. Namely, after retrieving live video via a camera sensor, the proposed system integrates navigation information and live video on the same screen to merge users' navigation map and cognitive map. Hence, among the above continuum, the OmniGuider system is the closest to the user's cognitive awareness.

THE CONCEPT OF OMNIGUIDER

The previous studies on factors impacting navigational performance can be summarized as personal capability and environmental characteristics. Personal capability is related to the user's cognitive map that is dominated by age, gender and environmental familiarity; meanwhile, environmental characteristics refer to the street map of the surrounding environment. A cognitive map is a user's mental space in geographical recognition and has an egocentric orientation. Hence, if the cognitive map can be understood from user's behavior, the personal capability of a user can be enhanced by using augmented reality (AR) technique tag environmental characteristics on the navigation display.

Context-aware technology extracts context data of users to perceive their intention to provide a proper service. As user's surrounding information perceived by hardware sensors, the context data represent all related information of the user's statuses, including identification, spatial information, time, and activities. The greatest challenge of designing such a context-aware system is the complexity of collecting, extracting, and interpreting contextual data. Context-aware technology attempts to make the system "intelligent" and reduce the user burden with respect to mental space.

The Omniguider system adopts context-aware technology to sense a user's mental space and then utilizes the AR approach to provide intuitive navigational information. Hence, the features of the Omniguider system can be summarized as follows.

1. **Perceptive GPS positioning method:** the Omniguider System exploits habitual behavior to further calibrate GPS data. According to context-aware scheme, the system extracts feature data from received GPS data first. User's motion status is then perceived from feature data based on Newton's Law of Motion. The drifted GPS data can then be amended based on the perceived motion status.
2. **Egocentric navigation approach:** With the assistance of the perceived motion status from received GPS data, the system further adopts the context-aware scheme to predict

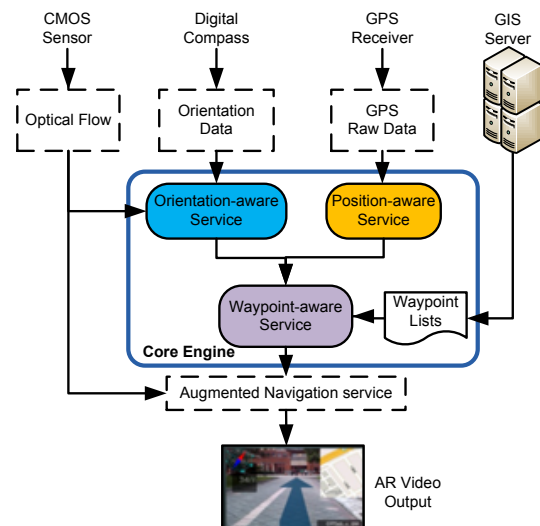
users' mental status when they are not following a planned route. In other words, when users deviate from a planned route, the system can determine if they are lost or simply do not want to follow the planned route.

3. **Intuitive user interface:** The interface design of the conventional GPS navigation system is still trapped within the concept of an electronic map. Although commercially available GPS navigation systems adopt a bird's eye view to render a map and provide a simulated interchange or important junction snapshot image, they cannot match the user's intuition on the directional guidance. Conversely, the Omniguider system uses the AR scheme to integrate a directional arrow with live video in order to provide intuitive navigational information. In this manner, a user's cognitive map can tightly couple with navigational information.

In contrast with current AR navigation research, the Omniguider system attempts to detect a user's cognitive map from the received GPS data and provide proper navigation information. Namely, the Omniguider system adopts context-aware and AR approaches to provide a navigational approach to ensure that the users' cognitive maps are consistent with their navigation map. Therefore, the Omniguider system is a means of providing a personalized and intuitive GPS navigational experience.

THE ARCHITECTURE

The architecture of the Omniguider system is illustrated on the right. Its core engine comprises a position-aware service to amend GPS drift data according to the habitual behavior of users, an orientation-aware service to eliminate digital compass accumulated errors by a simple image process and a waypoint-aware service to detect the users' mental status from their perceived motion status. Finally, results of the waypoint-aware service are input into an AR render module to produce an appropriate arrow sign on live video from a video camera. The following respective subsection discusses each service in detail.



● Position-aware Service

Position-aware service mainly focuses on computing a user's actual position based on the received GPS data. The process begins with acquiring the user's moving status from the received GPS data. Understanding the user's movements allows this service to further detect whether an environmental phenomena error, multi-path error, or even a receiver error influences the position data received from a GPS receiver. While most works on calibrating

received GPS data focus on integrating auxiliary hardware, information available around users and their practical requirements are always carelessly neglected. Context-aware technology stresses on how to comprehend a user's actual requirements and provide the appropriate services based on data retrieved from sensors. The position-aware service infers a user's reasonable moving status by interpreting GPS data promptly. Moreover, the user's accurate position can be obtained by amending the GPS position error based on the perceived moving states.

● **Orientation-aware Service**

Orientation-aware service focuses on inferring the orientation of the mobile device embedded with various orientation sensors, including digital compass, GPS receiver and CMOS sensor. A digital compass utilizes the Hall Effect via the Lorentz Force to estimate the change in magnetic force and subsequently infer orientation data. However, iron materials or any magnetic fields near the digital compass interfere with its local magnetic field, subsequently incurring errors of estimated orientation. Based on the psychology of human motion, humans concentrate on their heading directions when their moving speed is above a certain number. Hence, under this circumstance, the course of ground (COG) data from GPS receiver can be used to cross reference with the orientation data of the digital compass in order to detect magnetic interference and subsequently calculate the precise orientation information.

● **Waypoint-aware Service**

Whenever the Omniguider system detecting the user is not on the planned route, the waypoint-aware service is then activated to analyze users' moving intentions. When not following the planned route, users maybe get lost or they are quite familiar with the region and have their own preferred path. Unaware of the user intentions, some conventional GPS navigation systems provide U-turn guidance as the prime solution when the users are not following a planned route. A human-centric GPS navigation system should be able to tell if the users actually get lost or not and reschedule the navigation path as soon as possible based on the user intentions. The waypoint-aware service is such technique that uses the current state (CS) and perceived state (PS) from the position-aware service to predict if the users get lost or deviate on purpose.

THE INTERFACE

● **Initialization Interface**

After logging in the system, as shown on the right, the startup interface contains only four icons. They are, from upper-left to lower right respectively, Live-view Navigation, My Favorites, Surrounding Attractions and Daily Life Collection.



- “Live-view Navigation” Interface

This interface uses AR technique to tag surrounding attractions around the user. (The screen snapshot is on the left). Due to the accuracy of position-aware service and orientation-aware service, OmniGudier system can accurately locate the attraction and draw an arrow to the attraction that the user is facing. The advertisement of that pointed attraction will then display on the top of the screen along with distance to that attraction shown below. One friendly design of OniGuider is, when the user puts flat the smartphone, the screen will be automatically switched from the AR mode to the map mode (The screen snapshot is on the right) and vice versa.



- “My Favorites” Interface

This interface allows the user to design personal navigation service. User can previously plan his trip by building his own favorite attractions from the website of OmniGuider. (www.omniguider.com) These favorite attractions will then be automatically downloaded to the smartphone upon login. This interface is further divided into three sub-interfaces as below. The left one will show all of the user’s favorite attractions on the map while the middle one will list them. The right sub-interface, another user’s friendly design, allows the user to build new favorite attractions during the trip when he spots something interesting.



- “Surrounding Attractions” Interface

This interface will display all of attractions around the user’s current position. These attractions can be listed as shown on the left image and display on the map as shown on the right.



- “Daily Life Collection” Interface

This interface provides hyper link to websites of daily life information such as movie, weather, stock, railway, ... etc.



CONCLUSION

Current GPS navigation systems are not intuitive enough to the user. Furthermore, the accuracy of hardware sensor on GPS navigation system is often affected by the environment. The used maps are usually taken in the past (static data) while the environment is dynamic. Roads would change according to constructions or events render such static data irrelevant to the user. The ability to provide real-time live view will certainly enhance users’ experiences. The Navigation Map provided by the current GPS systems is not always consistent with user’s Cognitive Map. Cognitive Map enables human to sense and identify the environment where he resides through accumulation of humans’ familiarity and perception while wandering in their existing space. Hence, the consistency of Navigation Map and Cognitive Map is the performance key of this navigation system. The Omniguider system could advance human's intuition in usage which further enhances users’ experiences.

ACKNOWLEDGEMENT

The paper, that describes the detailed design principle of OmniGuider, was already accepted by Communication of ACM dated on June 10, 2011.

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