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INTEGRATION OF AUGMENTED REALITY AND GEOGRAPHIC INFORMATION SYSTEM: AN APPROACH FOR ENHANCING CONTEXT AND LOCATION-AWARE LEARNING

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Graphical abstract

Abstract

Traditionally, environment orientations are given via signposts, tour guides, or through the web. However, these methods cannot construct a good personal context-aware knowledge environment. With the advancement of Augmented Reality (AR) and mobile devices, mobile learning or ubiquitous context-aware knowledge, becomes easy and boundary-free. AR technology creates a user-centered, visualized operation, and a real-time-feedback knowledge environment by visualizing virtual objects superimposed with the real world. Meanwhile, context and location aware applications are automatically adapt to the environment of a user, for instance location, time, behavior, or physical condition of a person. This paper focuses on the integration of Augmented Reality and Geographic Information System (GIS) to enhance context and location awarenesslearning in mobile environment. The developed application was able to show significant outcome in a way of which information can be disseminated and presented to the user. For example, nearby features can be easily identified, user can obtained contextual information in real-time, information obtained is more on location-oriented, increases user awareness about events in their locality. Subsequently, it increases the level of self-tour-guide experience and context-aware learning environment.

Keywords: Augmented reality, geographic information system, geovisualization, context awareness, location awarenes

1.0 INTRODUCTION

Today, the recent advances in mobile computing have improved a lot, especially in connectivity, performance, stability and graphic visualization. This includes the latest embedded technology in mobile sensors such as GPS, accelerometer, magnetometer and gyroscope which can improve user experience towards a new dimension of mobile GIS application. The use of GIS in mobile devices has long been applied including the use of GIS in real-time tracking, Location based Service (LBS) and also in outdoor navigation. The emerging technology in GIS, LBS and information technology (IT) nowadays leads to the use of GIS in augmented reality. Augmented reality is a variation of Virtual Reality (VR). While VR technology completely immerses users within a synthetic environment where users cannot see the real world around him, AR allows the user to see the real world, with virtual object superimposed upon or composited with the real world [1].

In this paper, the study focuses on enhancing context and location awareness discovery among mobile users by integrating augmented reality and GIS. Augmented reality mainly focuses in visualizing and dynamically representing of virtual objects and

graphics, which can be used for the purpose of enhancing context and location-awareness. A research by Te-Lien [18] highlighted that AR provides a better solution for personal awareness of surrounding context, which might not be satisfied by traditional approaches such as radios, maps, and handheld displays. The integration of AR and GIS will have an immersive potential to provide rich value added information such as building info, hot spot coverage, route navigation, social network and instant direction. Because of the user interaction is one of the main aspects in AR application development; a good information presentation must be taken into account for better context-aware learning. Thus, AR information presentation provides excellent context-awareness learning.

As far as geovisualization is concerned, AR technology offers locationinformation delivery to users by embedding natural and man-made features (geo-objects) into a seamless view. There had been several of studies on exploring the use of AR for outdoor navigation. Feiner [8] developed a Touring Machine which uses backpack computer and head mounted display (HMD) to overlay AR images on the real world. But recently, researchers have moved away from using backpack AR to handheld systems. Recent research from Ming-Kuan [11] studied the integration of GIS and AR for managing nuclear evacuation within nuclear sites accident. The study tries to alert user for radioactive radiation levels at affected location and its surrounding. It also provides solution for immediate evacuation. The developed system were able to identify user's current position and shows the escape route with additional functions such as filtering geographical layers and rapidly generating a relief reports. Meanwhile, Payam [13] have integrated GIS and AR for realistic landscape visualization in order to model temporal changes using GIS-based modeling to dynamically augment a landscape view. The study focuses on visualizing dynamic spread of weeds (blackberries) and their effect on landscape over a period of fourteen years. Therefore, the use of AR in GIS field has proven to be able to improve experience in geovisualization and analysis.

Therefore the following question arises: How can geovisualization support the ubiquitous environment? Since the focus was on augmented platform, what is the best way to visualize intelligent geo-objects in the ubiquitous environment?

The importance of context and location awareness nowadays have become a concerning factor among people because with contextual and location-oriented information, people will become more aware about their surrounding such as current, on-going or upcoming events, activities and news. The traditional environment orientations nowadays are given via signposts, tour guides, newspapers or through the web. However, these methods cannot construct a well personal context-aware knowledge environment [18].

By integrating AR with GIS, a smart and dynamic application can be developed to overcome the problems, at the same time increasing the effectiveness of context and locationinformation dissemination. Educause [7] stated that, an effective location based system is not only provides environment information, but also allow users to quickly utilizing useful resources and enhance environment awareness. For instance, environment awareness includes the information discovery, daily planning, way finding, advertisement and navigational. Therefore AR is undeniably serves as a direct convenient assistance for mobile users.

The paper is organized in the following order: first, short discussion of the current trend on augmented reality in GIS domain. Section 2 discusses the concept of context and location awareness and highlights on how AR could contribute towards the importance of collaborative information. In section 3 we present the concept and system design of the prototype. The solution involving the method to integrate augmented reality in GIS will be discussed in this section. The experiment and discussions are presented in Section 4 and the research is concluded with some future work remarks in Section 5.

2.0 CONCEPT OF CONTEXT AND LOCATION AWARENESS

A Context Awareness

Context is defined as any type of information that can be used to characterize the situation of an entity [4]. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application; including the user and application themselves [5].Context awareness originated as a term from ubiquitous computing or as so-called pervasive computing which sought to deal with linking changes in the environment with computer systems, which are otherwise static [14]. Context aware devices may also try to make assumptions about the user's current situation. Therefore, context awareness service or application system must able to be aware of user's current context and self-adapt to the context changes. This means that the system is able to continuously provide the information about the user's context by automatically alert the user.

Context aware systems are concerned with the acquisition of context (e.g. using sensors to perceive a situation), the abstraction and understanding of context (e.g. matching a perceived sensory stimulus to a context), and application behavior based on the recognized context (e.g. triggering actions based on context) [16]. As the user's activity and location are crucial for many applications, context awareness has been focused more deeply in the research fields of location awareness and activity recognition.

Context awareness is regarded as an enabling technology for ubiquitous computing systems.

Context awareness is used to design innovative user interfaces, and is often used as a part of ubiquitous and wearable computing. Context related to physical environment is structured into three categories: location (absolute position, relative position, co-location), infrastructure (surrounding resources for computation, communication, task performance), and physical conditions (noise, light, pressure) [15].

In order increase the context awareness among users, a context-aware system must be able to obtain contextual information such as location information, proximity to the device, places and persons, environment factor as weather, temperature, time, traffic, status information of device, behavior of the user (talking, sleeping, walking) or personal fitness/health (heart beat).

The advantage of context-aware system is to increase the awareness among the users, especially for mobile users. Context aware system are able to enhanced information services, emergency services, tracking services, advertising, community applications, telematics services, and many more.

B Location Awareness

Location or location awareness is a part of location based services since it provides location-aware application. According to Koeppel [10], LBS can be defined as "any service or application that extends location information processing, or GIS capabilities, to end users via the Internet and/or wireless network", and another says that LBS are "geographically-oriented data and information services to users across mobile telecommunication networks" [17]. From a GIS perspective, the former definition concentrates on the GIS capabilities that are available in networked environments. The latter definition, on the other hand, narrows down specifically to geographic data and information services that are available in a mobile-networked environment. Both definitions emphasize that LBS are services targeted to a wide range of users.

Location-aware technology is a general term for technology that can determine its own geographical location. Knowledge of the location of users and equipment is a prerequisite for the support of context-aware applications. Locating physical objects is itself a distinct research area which involves the development of location hardware devices, software storage structures, and mechanisms to enable location-based querying. Location enablers may give a location directly, such as in the case of GPS, web geolocation or even using Radio Frequency Identification (RFID) tag, attached to a user or objects which periodically communicate with a fixed receiver infrastructure.

C Enhancing Context and Location Awareness

A core value element in mobile services is that they can be used anytime and anywhere, which enables people to communicate or to access information at any location, any time and in any situation [12].The intention to use mobile services is however found to depend on the situational context [3]. Therefore, mobile services and applications that adapt to the context may provide greater added value [2][9]. Context awareness deals with the ability to utilize information about the user's environment (context) in order to adapt services to the user's current situation and needs [6].

As discussed in previous chapter, the context awareness is more geared to the idea that a computer or device capable of detecting and responding in the circumstances. Devices may have information about the circumstances under which they are able to operate and based on rules, or an intelligent stimulus, react accordingly. While locationawareness is more geared to the idea that the user gets the current location information whether by means of the pull or push service. This means that user can find out information such as the nearest surroundings facilities, hotels, restaurants, shopping complex, latest events or even on going events.

An advantage of context-aware is a computer system dynamics and not intrusively adapts itself to the user situation, in the same time reducing the focus on individual computing devices. This process occurs with the device start to recognize the activity that is being done by the user. Context-aware system operates by using a numbers of sensors available in a mobile device. For example, to produce a system that is more context-aware, information such as device movement, rotation, orientation and direction must be obtained and processed by the system, so that it can react as programmed. Therefore, sensors such as accelerometer, gyroscope and magnetometer are important to track the movement of the device.

From the point of location-aware system, the system will try to identify the current location of the device (user) so that the service/information given is related to the environment conditions and surrounding. For example, notification alert to the user about the latest news, on-going events, or nearest service station. Therefore, positioning is an important element in the location-aware system. There are several types of methods used in positioning such as GPS, triangulation of GSM Cell ID, wireless access point positioning system (for indoor positioning), web geolocation, RFID, Bluetooth or ZigBee.

The collaborative of context and locationaware can produce a system that more intelligent and dynamic thus increasing the level of self-tour-guide experience and context-aware learning environment. For example a system that runs a pull service may provide location information and distance of the nearest gas station within 1km while the user is moving. The provided information may be in the form of text and graphic that enable user to identify the physical nature of the location or

building. At the same time the user can change the current view (from text and graphic) to map view which shows and navigate the user through the path to be taken by simply changing the device rotation from portrait to landscape without pressing any buttons. The system automatically detects the changes in user activity and then responds by stimulate command to change the view.

D How AR Contributes in Context and Location Awareness

The use of AR in GIS has significant gives an impact in the field of GIS, especially in the mobile applications. This was evident when some researches were conducted to study the effectiveness of AR in GIS to solve problems and to improve the quality of service in delivering location information [11][13]. AR are capable on context and locationaware computing that allows user to link digital data to actual physical locations, thereby augmenting the real world with a layer of virtual information. The purpose of AR mainly focuses in geovisualization of ground objects, which can be used for enhancing context and locationawareness.

With the integration of GIS and AR, a comprehensive architecture system could be realized by developing a system that able to deliver information about GIS services (data, layers, geographic features) for decision making based on current location and surrounding (as locationaware); or based on rules, user behavior, environment factors and linking data resources (as context aware).

3.0 THE PROTOTYPE AND SYSTEM ARCHITECTURE

A Data Source

The data source used for the prototyping is consisting of local GIS database and external sourced database. Primary data stores the POI that is located within the University main campus. The data is in location format and stored in as point form in the MySQL database. The category of data is divided into 3 categories, which are Faculty, Café and Activity as shown in Table 1. Information of faculty describes about the existing faculty building in the campus. Meanwhile, the data Café and Activity respectively describes about café location and current/upcoming organized activity.

Table 1 The primary database with its table structure

Table	Field
Faculty	FID (int)
	Name (text)
	Lat (float 10,6)
	Lng (float 10,6)
Café	FID (int)
	Name (text)
	Menu (text)
	BusinessHr (text)
	TodaySpecial (text)
	Lat (float 10,6)
	Lng (float 10,6)
Activity	FID (int)
	Name (text)
	Date (date)
	Time (time)
	Lat (float 10,6)
	Lng (float 10,6)

The secondary data is obtained from the external data sources such as Wikipedia, Twitter and Yahoo! Weather. These data is used in order to provide extra information to the user, in other word is to increase the context and locationawareness. Wikipedia data provides information about the main landmark around a location, while Twitter data provides information about the people who has tweet around a location. The use of Yahoo! Weather data is to provide weather information at current user location. This information can be implemented in GIS in order to enhance the context and locationawareness learning. Figure 1 describes the concept of the context and locationawareness developed for the prototype

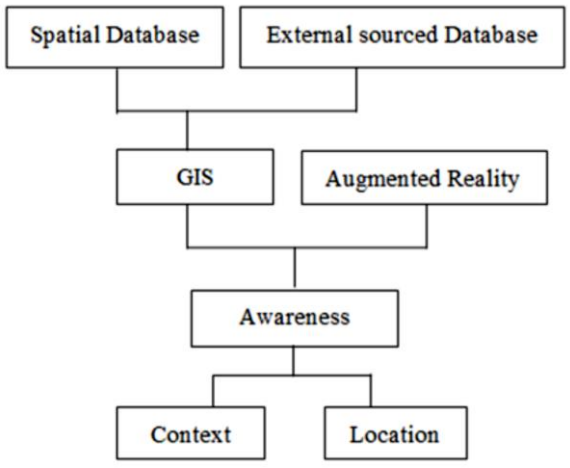


Figure 1 Concept of multiple data sources for context and locationawareness

Format of data return from primary server, Wikipedia and Twitter is in the form of JavaScript Object Notation (JSON). JSON is a text-based open standard design for human-readable data interchange. It is derived from the JavaScript scripting language for representing simple data structures and associative arrays, called objects. While data format return from Yahoo! Weather is in the form of Extensible Markup Language (XML)

B SQL and Web Server

MySQL engine was used to store the primary database while PHP was used to do the server side task and queries and outputted as JSON. The concept of how the request being handled within the application is shown in the Figure 2. The user will send a request (latitude, longitude, and radius) to the server via the developed application in Android environment. At the server side, each request will be processed to perform GIS analysis using independent SQL buffer function. The function runs independently using MySQL's location engine. The returned result is known as the location content which determines the number of POIs that located within the radius area.

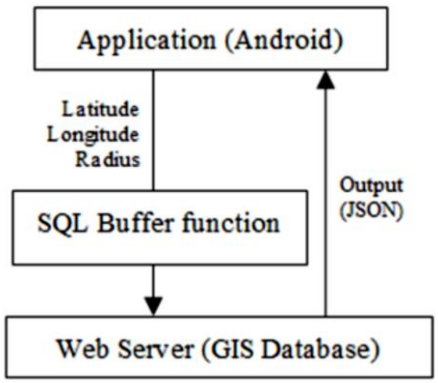


Figure 2 The concept of system application request

A PHP is used to perform to server side task. When a user send a request to the server, the SQL buffer function will be executed and outputted as JSON data format. Figure 3 shows the SQL buffer function code written in PHP.

```
$query = sprintf ("SELECT FID, name,
lat, lng, date, time, ( 6371 * acos(
cos( radians('%s') ) * cos( radians(
lat ) ) * cos( radians( lng ) -
radians('%s') ) + sin( radians('%s') )
* sin( radians( lat ) ) ) ) AS
distance FROM activity HAVING distance
< '%s' ORDER BY distance LIMIT 0 ,
30",     $center_lat,     $center_lng,
$center_lat, $radius);
```

Figure 3 The PHP syntax used to perform SQL buffer (location query) to the database

C The Implementation

The prototype was developed in Android platform using Eclipse and Android Development Tools (ADT).

1) *Application Workflow*

The flow of the developed prototype is shown in Figure 4.

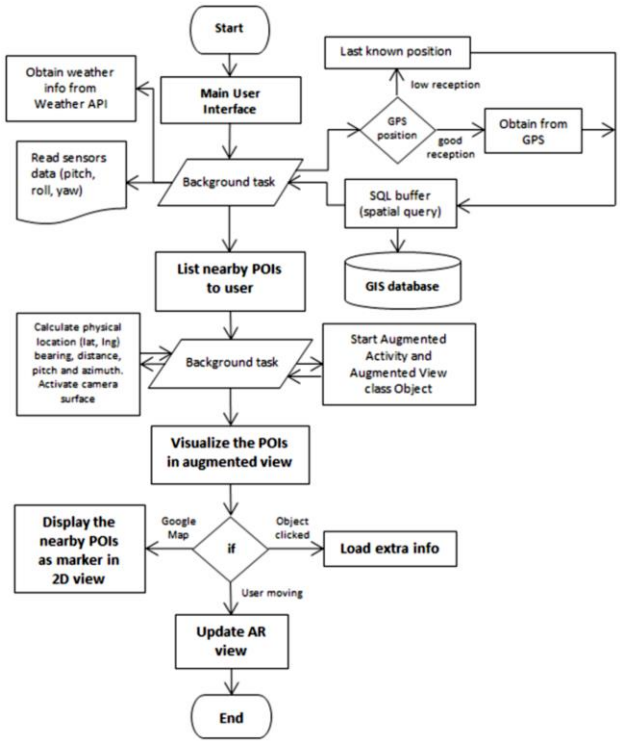


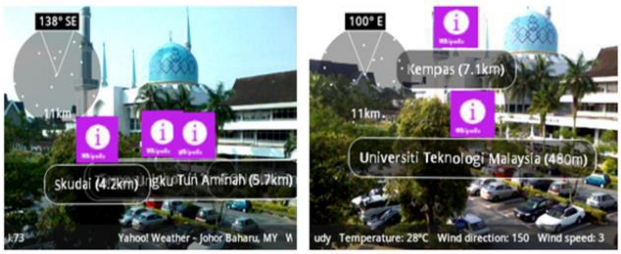
Figure 4 The prototype application workflow

2) *Visualizing Augmented Object*

Visualization of multiple objects or graphics dynamically in AR view has several concerns that need to be addressed. One example is; how will multiple virtual objects be displayed on the screen in order to provide information to the end user. In this paper, the distance and angle of an object with the device are used to the augmented object appropriately. If it is not properly addressed, overlapping objects will occurred, hence giving an inaccurate positioning of augmented objects as shown in Figure 5(a). This research tries to find a solution for visualization of every augmented objects which having different distances from the device.

The strategy used to visualized the augmented object that are overlapping each other is by repositioning the object on the screen without moving the real object position on the ground. This can be realized by shifting the overlap object a bit to the top from the original position on the screen based on ground distance and its bearing. Each object which having longer distance (to the device) will be reposition to the nearest object's top as shown

in Figure 5(b). With this method, the objects still maintain the same position on the ground (with same bearing).



(a) (b)

Figure 5 (a) Overlapping augmented objects; (b) Objects are reposition based on distance

On the angle consideration, if the device is parallel to the ground during the augmented view, there will no objects will be visible to the user. The object will only visible to user when the device's angle is 90 degree facing forward. This research also tries to look on the condition where the collision between object is allowed.

4.0 EXPERIMENT AND DISCUSSION

The application menu divided into five categories namely; Faculty, Café, Wikipedia, Twitter and Activity. The faculty menu will shows the list of nearby buildings in the University's campus, while the café menu will shows the nearby café. For Wikipedia menu it will list the nearby main landmark, and Twitter menu will lists people who have tweet recently within the locality. Activity menu will list the current or upcoming organized activities nearby the user.

A Augmented View

1) Context and Location Aware

The idea of the developed prototype is first to obtain the current position of the user. It is very importance because the position information will be used to make a location query and returned nearby POIs (within selected radius). Without knowing the user position, the application cannot list the context surrounding. From the augmented view shown in Figure 6, name of the building with distance of the POI is presented. The application also updates the user for current weather condition (e.g. weather condition, temperature, wind direction, wind speed, humidity and pressure) within the locality. User will be self-aware of the information based on current position to the targeted location.

Note that the radar plays an important role to highlight objects that are within the selected radius distance (see Figure 7(a)). It is also used to limit's the visible augmented objects and labels that are within the radar's viewing angle as illustrated in Figure 7(b).

From the result, it shows that the application return the list of upcoming activities within 1kilometer (km) radius. It also tells the event name, place, time and date, so that the user is aware about upcoming activities in their place.

Figure 6 Augmented view; the building name with distance from user location with real-time weather updates within the locality

(a) (b)

Figure 7 (a) Augmented labels are only visible when camera position is in place even though a lot of POIs available on radar, (b) the position of the buildings (POIs) shown within radar's viewing angle; far and nearest to the radar's center (pointed out by arrow)

In order to enhance the context awareness, the application will return a list of upcoming activities within 1km radius from user's current location automatically as shown in Figure 8. It informs the userabout the event name, place, time and date

Figure 8 The application sends a request (location query) to the server and returned a list of activity within 1km radius

The integration of 2D map view (ortho) is to provide rich full information such as road name, build name and feature surrounding. The purpose of map view is to map the POIs on top Google Map. It is also able to show current user position either while moving (see Figure 9) or in static mode when GPS is activated. User also able to change the view from map view to augmented view and vice versa.

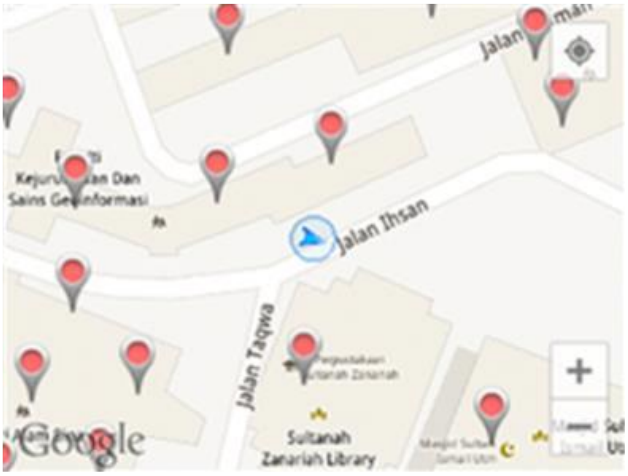


Figure 9 2D map view shows a blue arrow (orientate to current bearing) when user is moving

The result from the map view shows that, the nearby POIs are pointed on the map. User is able to identify the POI by clicking on it. The use of map view is to illustrate the position of POIs around the user.

5.0 CONCLUDING REMARKS

Based on the experiment and discussion, the integration of AR and GIS can enhance the user experience towards context and locationawareness. With AR technology, one can pull the context and location information from various data sources and visualizing it in an interactive form. Nearby features can be easily identified and users can obtained the contextual information in real time. AR also provides advantage for business advertising which is more cost effective. The trend of people now having a smartphone has led to the tremendous mobile application development mainly focuses on social, gaming and networking.

There are some limitations in AR application development; some devices are not fully supported by AR technology. It is because AR required high performance device specification such as large memory and high speed processor. Accuracy of GPS and sensor reading become unreliable when the device become hot, or near to an electromagnetic object. This will lead to the augmented object being position inaccurately, thus affecting the information dissemination process.

In this paper, the GIS data used to integrate with AR is in the form of point. In future recommendation, AR can be integrate with 3D GIS database to visualize the underground or behind concrete walls utilities. It can be conclude that, the use of AR and GIS has proven to be able to improve in terms of GIS application and context-aware learning environment.

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