An Effective User Positioning Scheme based on AR Interface for Ubiquitous Computing

Chung-Pyo Hong and Cheong-Ghil Kim

Abstract—**The emergence of Smartphone with built-in GPS has resulted in the launch of a series of location-based AR applications with graphic location contents. This allows an easy way of searching and consuming location-based information. Here, location information is the fundamental factor to select any proper services available in a certain place. So, the accuracy of the location of a user must be guaranteed, otherwise, the information placement of POIs on the display can be uncorrelated with reality. This paper proposes a novel method to recognize the exact location of a user with AR interface using 3D object of POI.**

Index Terms—**Augmented Reality, Ubiquitous Computing, Location Based Service, Mobile Computing, Point of Interest**

I. Introduction

As the recent advances in network and wireless communications and semiconductor design and process technologies, our computing platform is rapidly shifting from desktop PCs to mobile devices such as tables, Smartphone, UMPC (Ultra Mobile PC). Market research and analysis firm IDC has expected that smart connected devices which IDC defines as Smartphone, computers, and media tablets are expected to go from 494 million units in 2011, to 660 million in 2012 (33 percent growth), and nearly triple to 1.16 billion units in 2016 [1].

Thanks to these recent advances and the availability of massive geographic referenced archives of data (e.g., remote sensing, geo-referenced social photo websites and geoscience data) an effective and meaningful integration of AR and geodata is becoming feasible [2]. Consequently, Smartphone has emerged as the platform of LBS (Location-Based Services) combining with a new type of user interface called AR (Augmented Reality), the act of overlaying information on an image taken through Smartphone's camera and motion sensors. The latest developments in AR technology on software and hardware allow many applications to work on mobile devices in real time [3]. For example, some of them already have been becoming a recent focus, Layar [4] and Wikitude [5].

Smartphones equip with many sensors, such as GPS, accelerometer, compass, and gyroscope and most of outdoor Mobile AR applications rely on GPS antennas, digital compasses and accelerometers. Due to imprecise readings, the 2D placement of points of interest (POI) on the display can be uncorrelated with reality. Hence, aligning sensor information with vision will become even more difficult, requiring us to formulate and solve a "mismatch minimization" problem.

In this paper, we introduce a differentiated approach to utilize AR technique with the smart devices. Location information is the most important element to provide services which is available in a specific place. We propose an effective method to measure user's location with the AR interface.

The rest of this paper is organized as follows: Section 2 introduces related researches. Section 3 describes the proposed scheme. Finally, Section 4 summarizes this work.

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II. Background

The term, AR was described by many authors with minor variations in the definition. The concept of AR is associated with virtual reality (VR) that creates an interactive artificial world, but AR also augments the real world with an artificial environment [6]. AR is a technology used to superimpose the physical objects on virtual imagery in real time [7]. According to Pang et al. [8], AR is a real environment augmented with virtual objects. Milgram [9] describes that AR is the subfield of the broader concept mixed reality (MR). We can define an AR system based on the most commonly accepted definition by Azuma [10], it combines real and virtual imagery, it is interactive in real time, and registered in 3D.

Smartphones today are fully featured high-end mobile phones featuring PDA capabilities, so that applications for data-processing and connectivity can be installed on them. They become more powerful than the desktops of the 1990 with a lot of functions – IrDa, Wi-Fi, Bluetooth, camera, internet, fax, email, text messages, music, video, GPS, calendar – available on finger tips [11]. As the processing capability of Smartphones is improving, their application use has been increasing. For examples, Jonietza [12] use their Smartphone to calculate the location of just about any object its camera is aimed at. As the Smartphone changes location, it retrieves the names and geographical coordinates of nearby landmarks from an external database. The user can then download additional information about a chosen location from the Web. Rashid et al [13], Wagner et al [14], Henrysson et al [15], Olwal et al [16] utilize them as final mobile AR displays. They are also often used in conjunction with a stationary server, as in the case of Rauhala et al [17], where a

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notebook PC was also used as an intermediate central data processing unit. This work presents an overview of handheld Augmented Reality focusing on applications with introducing the basic issues of them. For this purpose, an example system is cited, which introduces the most significant problems and various methods of solving them through the experience of converting existing PC-based AR system into handheld AR.

These researches show the possibility of utilizing AR as an emerging technology which can be used as the primary interface of smart devices. But the differentiated approach to utilize the AR interface is required. In this paper, we propose a novel method to measure user's exact location.

III. Proposed Scheme

For the ubiquitous computing, the context information is the most important feature to provide adequate services. And location information is the fundamental factor to select any proper services available in a certain place. So, the accuracy of the location of a user must be guaranteed. Recently, the AR technique is used as a basic interface of the ubiquitous computing. In this section, we propose a novel method to recognize the exact location of a user with AR interface.

A. Motivating idea

Recent mobile augmented reality researches have reached the maturity in which mobile phones can service AR without the cumbersome structured environment of fiducial markers and fast enough to service in real-time. State-of-the-art works on natural features such as SIFT and Fern have been successively ported to the mobile phone [18]. However, recent AR applications do not provide a method to display information with these latest techniques. Many AR applications provide services based on the location information from the GPS module and direction information. With the location and direction information, an application finds the proper Point of Interest (POI). And applications display any certain information on the screen as scaling the content based on the distance between a user and POI. But there are errors on acquiring location and direction information, the information appeared on the screen is located not on exact position of the rendered POI.

And also, tracking any object is mentioned in several works such as [19], they showed a framework to track multiple objects and it combines a scalable recognition module and a detection/tracking module. But they are not providing any method to track user's location exactly based on the corresponding POI. However, it is not only required to track the exact location of POI but also required to track the exact location of any user. The exact location information of any certain user is necessary to provide AR applications effectively. With the exact location, the AR service can propose the proper services or information more exactly.

Therefore, we propose a new mobile AR framework that utilizes 3D object of POI for the exact information display. And also, new scheme to acquire the exact location information of users is introduced. With the 3D POI object, we can display information exactly on the rendered 3D image on the screen. The location of user can be calculated based on the viewing angle and the direction between a user and corresponding object. The viewing angle is also measured by matching the 3D POI object and acquired image of the real object. A specially designed equation is used when calculating the distance between a user and a real object. The basic concept of calculating the distance is shown in Fig. 1.

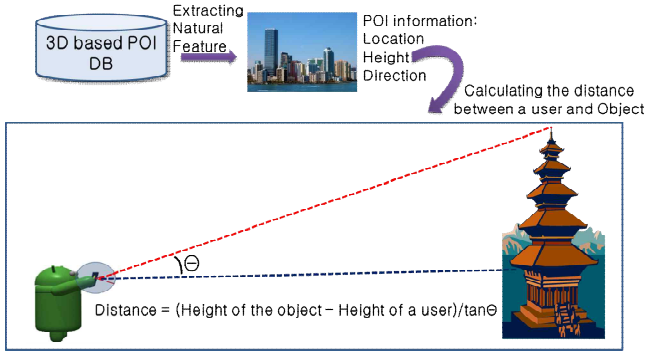
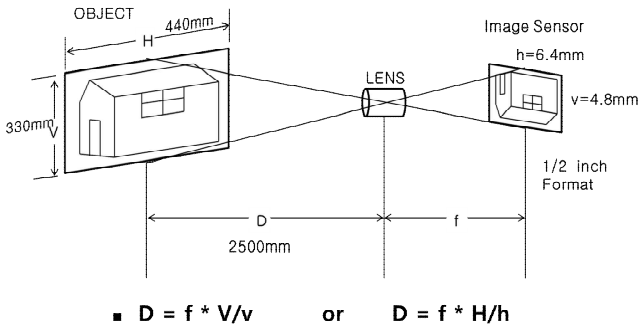


Fig. 1. Conceptual framework of calculating the actual distance.

B. Measuring user location

Usually, the AR interface is utilized to display information on the corresponding real object in the display device. But, if we can find the proper information and the displaying position of it on the screen, then we can conclude that we know the exact information regarding the real object. The information includes the coordination of the object. Based on this assumption, we can invent a novel method to find user location by calculating some equation related to the vision process.



※ Where D = Distance from lens to object, f = focal length of lens, V = vertical size of object, v = vertical size of image, H = horizontal size of object, h = horizontal size of image

Fig. 2. Distance measurement between user and real object.

In this case, the distance of the user and real object targeted can be calculated with the optical equation. The method is appeared in Fig. 2.

With the calculated distance, we can find the exact location of any given user. By applying triangular equation to the fixed coordination of targeted real object, we can find the relative angle of user location. In this case, we assume that the view angle from user to real object is given by the vision information. The calculation of the exact user location is shown in Fig. 3.

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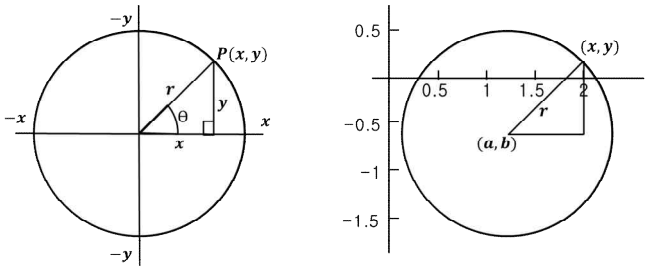

$$x^2 + y^2 = r^2$$
$$(x = r\cos\theta) \qquad (y = r\sin\theta)$$

$$(x-a)^2 + (y-b)^2 = r^2$$
$$(x = a + r\cos\theta) \qquad (y = b + r\sin\theta)$$

Fig. 3. The calculation of the exact user location.

IV. Conclusion

In this paper, we propose a new mobile AR framework that utilizes 3D object of POI for the exact information display. And also, new scheme to acquire the exact location information of users is introduced. Location information is the fundamental factor to select any proper services available in a certain place. So, the accuracy of the location of a user must be guaranteed, otherwise, the information placement of POIs on the display can be uncorrelated with reality. As a result, it can be expected that with the 3D POI object, we can display information exactly on the rendered 3D image on the screen.

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