AR | Sensing | Smartphone

Technology Reports

Special Articles on Mobile AR Technology

Information Search and Presentation Methods for AR Services Using Location Data

Recently, with the spread of smartphones, mobile terminals with GPS, wireless LAN, camera and other capabilities have become common, and AR and other new services are spreading. With AR services, various issues have come to light, such as, when information is overlaid on a camera image, visibility and operability can be impaired by overlapping information. New ways to simplify information search are also needed. Accordingly, we have developed a way to improve visibility and operability by eliminating overlapping information, as well as a new search method that makes use of GPS, geomagnetic sensors and accelerometers.

Service & Solution Development Department **Keiichi Ochiai**
Shin Hasegawa

1. Introduction

Recently, mobile terminals have begun to incorporate various sensors, including GPS, geomagnetic sensors[*1], accelerometers[*2] and proximity sensors[*3]. This trend is particularly strong with smartphones such as Android™[*4] terminals and the iPhone®[*5], and as smartphones have spread, many new services making use of these sensors are becoming available. Augmented Reality (AR) services are typical of these types of services.

AR is a technology which presents digital information to the user, overlaid on an image of the real world, as though the information was in the image. As the smartphone market expands, it is expected that applications of AR services will expand into various fields; not only search and navigation but also others such as advertising and simulation (**Figure 1**). At NTT DOCOMO, we have focused on areas for which mobile terminals are used frequently, including search, navigation and communications, and have developed an AR service that enables more intuitive and simple operation.

In this article, we give an overview and describe how various issues were resolved with our "Chokkan Navi (Intuitive navigation) for Golf" service, which displays the locations of greens and hazards[*6] on a golf course, and our "Chokkan Navi" service, which provides search for restaurants and other facilities in streets, towns and other urban areas. We also describe how these services were built.

*1 **Geomagnetic sensor**: An electronic compass which can detect the geomagnetic field to determine orientation. Able to detect the orientation of a mobile terminal.

*2 **Accelerometer**: A sensor that measures changes in speed. Equipping a mobile terminal with an accelerometer allows it to sense orientation and movements.

*3 **Proximity sensor**: A sensor which detects whether objects are approaching.

2. AR Overview

2.1 AR Implementations

AR implementations can be categorized broadly into two types (**Figure 2**):

(a) Location-based methods

For location-based methods, GPS, wireless LAN and various other sensors are used to obtain absolute or relative positions, and geomagnetic and other sensors are used to obtain the orientation of the user (or camera). Then, display positions for digital information (hereinafter referred to as "content") is decided from a combination of this sensor data and content location information.

Figure 1 Examples of AR application areas

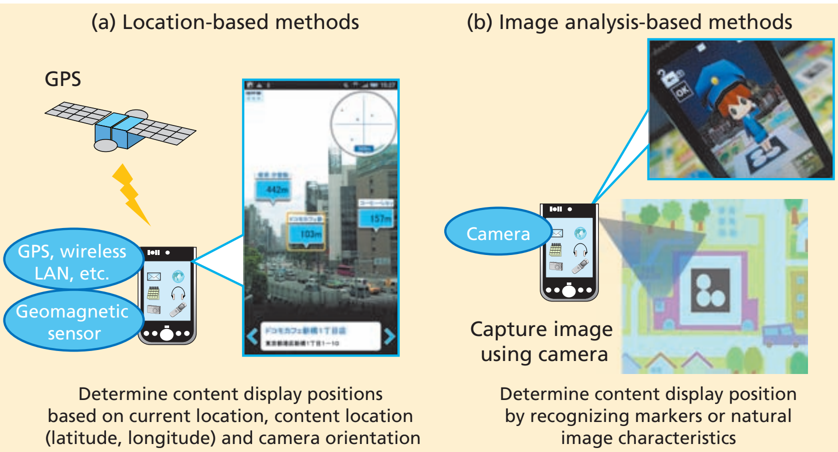

Figure 2 AR implementations

(b) Image analysis-based methods

There are two main types of method using image-analysis to determine where to position content; those that recognize markers[1], which are black-and-white rectangular images similar to 2D barcodes, and those that recognize natural characteristics of the image, such as corners and straight lines, instead of markers[2].

Of the AR services available for mobile terminals (hereinafter referred to as "mobile AR"), all but a few use location information. Examples of AR services using location information include "Chokkan Navi for Golf" and "Chokkan Navi," which are described in this article. Sekai Camera and Layar*7 are two more examples.

2.2 Mobile AR Service Issues

The main two issues with current mobile AR services are as follows.

Issue (1): Decrease in visibility of information and operability due to overlapping of displayed content

With mobile AR, visibility and operability tends to decrease if there are many content items to be displayed due to overlapping of content items. A way to display information is needed which allows users to select their desired information

*4 **Android™**: An open-source platform targeted mainly at mobile terminals and advocated by Google Inc. Android™ is a trademark or registered trademark of Google Inc. in the United States.

*5 **iPhone®**: A registered trademark of Apple Inc. in the United States.

*6 **Hazard**: Obstacles such as bunkers or ponds placed within a golf course.

*7 **Layar**: A trademark of Layar B.V. in the Netherlands and other countries.

easily and takes into consideration use with a touch panel, which is common on many smartphones.

Issue (2): Achieving simplicity in information search

Many mobile AR services using location information use it to display search results overlaid on a camera image. For this reason, both a way to present this information, and an easy way to initiate searches are needed.

3. Service Overview

With the Chokkan Navi for Golf and Chokkan Navi services that we have developed, we combined AR technology with search and navigation functions using maps of golf courses and towns, so that users can intuitively find out the direction, distance and how to get to their destinations, by simply holding up their mobile terminal camera.

With Chokkan Navi for Golf, users can find out the distance and direction to the green accurately, even if it is not visible due to rough terrain, trees or other obstructions. With Chokkan Navi, even those that are not confident with city scenarios or maps in unfamiliar areas can navigate intuitively, with simple searches in their destination area and with route markings overlaid on the camera image.

3.1 Chokkan Navi for Golf

Chokkan Navi for Golf has the following three main features (**Figure 3**).

(a) AR golf navigation

Intuitively discover distances and directions to the greens and hazards, by simply holding up the mobile terminal. Find out information about greens and hazards by displaying a layout of the golf course.

(b) Check play history

Shot distances and the scores are entered automatically by registering locations for each shot.

(c) Network link

Send messages and share scores with other parties or party members.

For Chokkan Navi for Golf, we have developed a method for avoiding overlap of green and hazard information, when it is overlaid on the camera image. This solves issue (1) as described above. The method detects when elements will overlap and repositions them.

3.2 Chokkan Navi

Chokkan Navi has the following three main features (**Figure 4**).

Figure 3 Overview of Chokkan Navi for Golf

Figure 4 Chokkan Navi service overview

(a) Chokkan Navi

The application searches for stores and other facilities in the direction of view and displays them over the camera image by simply holding up the mobile terminal. It can also provide navigation to a selected facility.

(b) Throwing search

Simple searches for local information can be done by waving the mobile terminal, and the scope of the search is set according to the direction and strength with which the mobile terminal is waved.

(c) Twitter[*8] link

Have fun with communication, sharing "weak presence" information by posting search, navigation and bookmark history on Twitter.

With Chokkan Navi, we have attempted to solve issue (2), as described above, by developing a simple search function called "Throwing search." For issue (1) above, Chokkan Navi produced a large amount of information to display, so in addition to the techniques used for Chokkan Navi for Golf, we added an ability to filter the content displayed with factors such as distance and item type.

3.3 System Architecture

The system architecture is shown in **Figure 5**. The Chokkan Navi for Golf and Chokkan Navi systems have almost the same architecture. The systems consist of a client application, which runs on Android terminals, and an AR server, which retain the content that the client application will overlay on the camera image.

The client application obtains the current terminal location and notificates it to the AR server (Fig. 5 (1)). The AR server then notificates content surrounding the current location (facilities, golf course data, etc.) to the client application (Fig. 5 (2)). The client application then obtains the orientation of the terminal using the geomagnetic sensor, and based on it, determines which content is in the direction the user is pointing the mobile terminal, positions it relative to the camera image, and displays it on the screen (Fig. 5 (3)).

4. New Information Presentation Method

For Chokkan Navi for Golf, we resolve issue (1) above by developing a method to avoid content overlap when it is displayed over the camera image. This process is shown in **Figure 6**.

*8 **Twitter**: A registered trademark of Twitter Inc. in the United States and other countries.

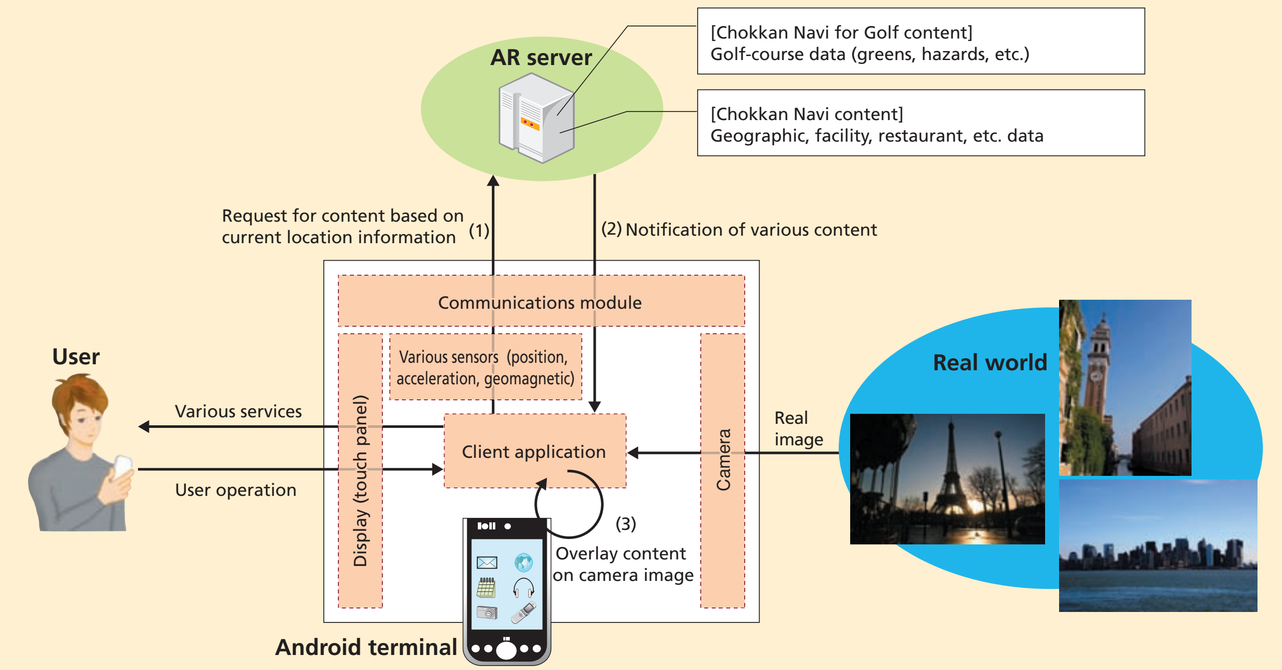

Figure 5 System architecture

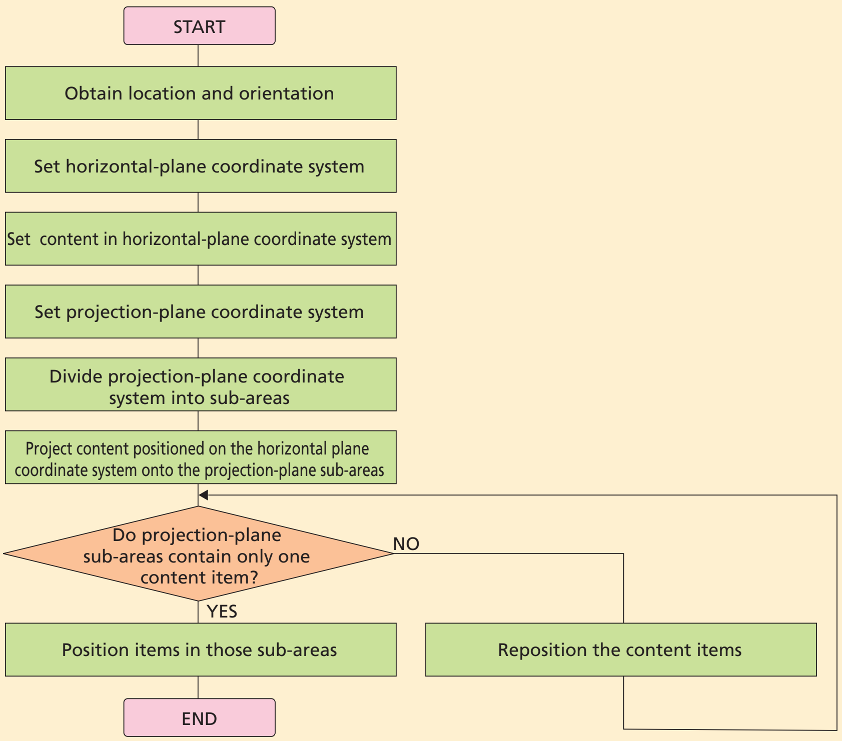

Figure 6 Process for avoiding information overlap

The course data to be overlaid on the camera image is downloaded from the AR server before hand, including type and position data for items such as greens, bunkers and water hazards, as well as data tables for elements that comprise them, and these are maintained by the client application.

The application first obtains the current position, and uses the geomagnetic sensor to determine the camera orientation. It then sets a horizontal plane (XY-plane) coordinate system based on the line directly from the current position to the green (**Figure 7**), places the course data based on its position data within this coordinate system, and then projects the horizontal-plane coordinates onto the projection plane (XZ-plane) as though it is being viewed from the camera. This projection plane coordinate system is then divided into sub-areas, and if multiple course-data items are projected into the same sub-area, the items are repositioned starting with the item of least priority, according to pre-set item priorities. Several possible methods for repositioning items, such as moving to the position vertically or horizontally adjacent to the sub-area where the item was initially projected.

We compared images before and after applying this method (**Figure 8**). Using this method to avoid overlapping content, we were able to improve the visibility of information, and operability. This helps prevent overlooking information about hazards, and should be very useful for scenarios such as golf. This mechanism was used for Chokkan Navi for Golf, but, as mentioned before, could also be used for Chokkan Navi.

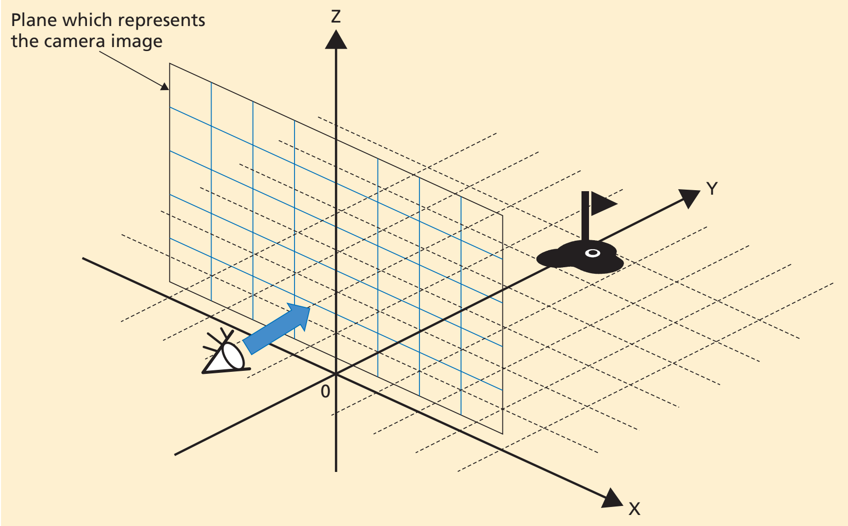

Figure 7 Setting the coordinate systems

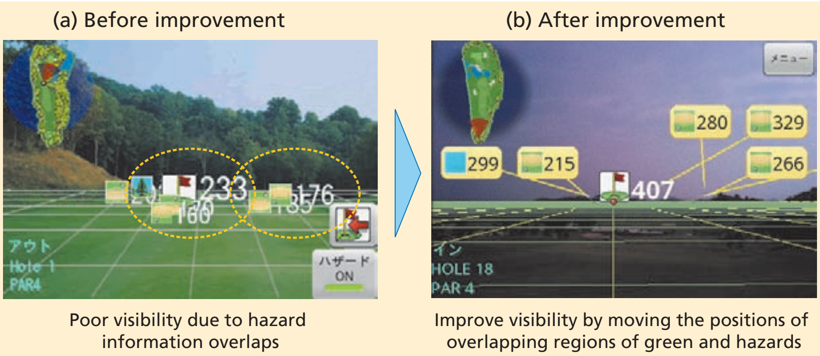

Figure 8 Before and after processing to avoid overlap

5. New Information Search Method

We developed a "Throwing search" method for Chokkan Navi to solve issue (2) as described above.

Services helping to find facilities such as restaurants are becoming increasingly common, and most of them require entering text to search for the facility or area or allow geographic regions to be selected. There are also search methods that first obtain the current location and use it to support search.

However, when a user is headed toward a particular destination and wants to search for a facility in that area, a search in the current area will include in the opposite direction and other unnecessary content that is not of interest (**Figure 9**(a)). In this type of scenario, it is difficult to provide helpful information using only the current location information.

Accordingly, we have proposed a method that allows the search range to be set easily using orientation and acceleration information in addition to location information. Specifically, the direction and distance for the search range can be set by facing and waving the mobile terminal in the desired search direction (Fig. 9 (b)).

A terminal position sensor such as GPS, a geomagnetic sensor, and accelerometers are used to set the search range. The position sensor gives

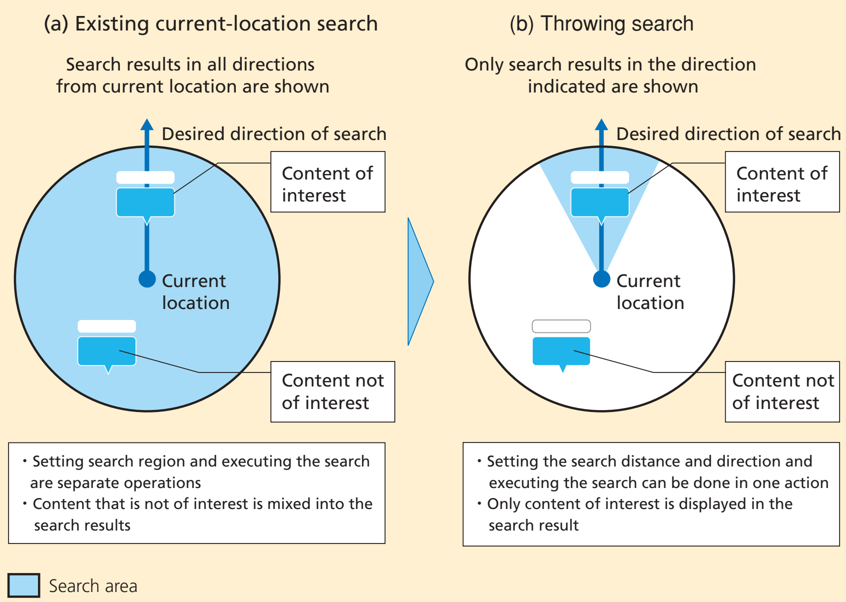

Figure 9 "Throw search" mechanism

the current location, the geomagnetic sensor gives the direction with which the mobile terminal is being waved, and the accelerometers give the speed with which the mobile terminal is being waved. The search is done using the current location as the base point, the direction from the geomagnetic sensor as the search direction, and the magnitude from the accelerometers to determine the search radius.

In this way, with the single action of waving the mobile terminal, we can set the search range and the orientation and execute search. The results are then displayed, eliminating content that is of no interest.

6. Conclusion

In this article, we have given an overview of two new AR services that we have developed: Chokkan Navi for Golf, and Chokkan Navi. We have also described some of the issues encountered and solutions found during the development.

In the future, it will become possible to provide new added value by using this service to summarize usage history and personal data on the cloud[*9] through the mobile terminal as a sensor hub. We also expect services like these, making use of sensors, to expand further as more types and more accurate sensors are incorporated into mobile terminals. As LTE services begin and spread, their high-speed and low latency characteristics will enable heavy processing tasks such as image processing to be moved to servers, distributing this load further.

Taking these trends into consideration, we intend to provide AR services with added value, making use of usage history and personal data, and with further applications of image processing techniques and so forth.

REFERENCES

[1] H. Kato and M. Billinghurst: "Marker Tracking and HMD Calibration for a Video-based Augmented Reality Conferencing System," Proc. of the 2nd International Workshop on Augmented Reality (IWAR 99), pp. 85-94, Oct. 1999.

[2] G. Klein and D. Murray: "Parallel Tracking and Mapping for Small AR Workspaces," Proc. of the International Symposium on Mixed and Augmented Reality (ISMAR '07), pp. 225-234, Nov. 2007.

*9 **Cloud**: A format and structures for providing services over networks. Server resources can be distributed according to usage conditions, so it provides good scalability.