Consumer Propensity and Location Analysis based Real-time Location Tracing Advertisement Service Design and Implementation

Real-time Location based Advertisement System

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Abstract: While distributing Android free of charge, Google intended to expose its advertisements on the platforms to seize users' eyes and make profits. However, smart phones are kept in bags or pockets during most of the time instead of showing screens in front of users' eyes. If the time during which users' eyes cannot be seized becomes longer advertisement effects will decrease as much. In this study, in order to solve these problems, consumers' movement paths are grasped using continuous screens based on the results of analyses of consumer propensity to replay advertisement images. Advertisement image replay lists are composed of related advertisements based on the key words set by consumers. The relevant project was named as shADow meaning Advertisements that follow like shadows.

1 INTRODUCTION

In the revolution of smart phones headed by iPhone, Location Based services (LBS) are in a trend of being expanded from existing technologies that use the GPS (Global Positioning System) or Cellular Networks to the WPS (Wi-Fi Positioning System), a positioning technology that uses wireless Aps (Access Point) (Robert, 2009) and diverse location based services utilizing the WPS are being provided. (Kubber, 2005); (KAIT, 2010)

From the beginning of mobile phone supply, location based services have been receiving attention as one of areas of high growth potential since this is an area that is closest to mobility which is one of the advantages of mobile phones. However, Feature Phones failed to bring about the activation of location based services due to problems such as high data communication costs, lack of contents and the issue of the openness of platforms.

The popularization of smart phones brought about great changes in location based services and thus location based services are rapidly rising to become core services of mobile communications. It has become possible to develop diverse location based applications through smart phone platforms such as Android and iPhone. To this end, not only the existing positioning technologies through GPS but also indoor/outdoor wireless positioning methods and technologies through diverse data are necessary.

The WPS which is one of the aforementioned technologies is a positioning method using Wi-Fi, that is, wireless APs of WLAN networks. In general, terminals find positions by measuring the intensities of signals (RSSI) from wireless APs and calculating signal transmitting distances based on signal attenuation. The WPS method is frequently used because it can provide high-speed Internet services to many users in regions where there are many indoor movements and it can be conveniently installed and managed. Positioning methods utilizing Wi-Fi can be largely divided into three types; Fingerprinting, Cell-ID and triangular surveying (Kim, 2006).

Figure 1: Conceptual diagram of shadow.

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Initial applications using smart phones' location based services were mainly concentrated on services such as Navigation, positioning, security, etc. Currently, those applications are provided with diverse forms of services such as user searches, place searches, augmented reality and SNS. As revealed in the recent mobile advertisement business M&A between Google and Apple, mobile advertisements count as one of areas of the highest possibility of growth in the market. In this study, services were implemented that would always exist in front of consumers' eyes through real time positioning using smart phones to enhance advertisement effects. These services are called shadow (Shadow + Advertisement) in this paper.

2 RELATED STUDIES

2.1 Indoor Positioning Technology

2.1.1 Fingerprint based Positioning Technique

The fingerprint based indoor positioning technology is one of most frequently studied techniques since it was applied to Wi-Fi in the early 2000s. (Bahl, 2000) When entering into an environment where an AP has been installed, this is used to measure the intensity of signals from the AP and compare the result with the signal intensities of the RPs (Reference point) stored in the DB in advance to assume that the RP that has the most similar characteristics as the location of the terminal.

This technique is divided into a training stage to grasp the characteristics of signals in preset areas and store the characteristics in the DB and a positioning stage to determine the location with the characteristics. Although this technique has disadvantages in that it requires preceding work to set areas in advance before positioning, grasp the characteristics of signals by area and store the results in the DB and that these processes should be repeated every time the environments in positioning areas are changed, it has advantages in that it is not restricted very much by surrounding environments since it reflects the information on noises and environments in surroundings on positioning and that the accuracy of positions determined through it is excellent (Cho, 2007).

2.1.2 Cell-ID

The Cell-ID based positioning technology known as Cell-tower based mobile phone positioning technology refers to a technology to estimate the present position based on the identification numbers of Wi-Fi APs in the surroundings.

If a position where an APs has been installed in a certain building is stored in the DB, the identification number of the AP accessed (or searched) by the terminal will be searched from the DB to assume it as the present position of the terminal. Unlike cell-towers of which the transmission distances reach several hundred meters to several kilo meters, each Wi-Fi AP has short transmission distances of around several ten meters to 200m at the maximum depending on environments. Since short transmission distances mean high accuracy as much, this method is meaningful in that it has relatively high accuracy while being simple. This technique is mainly utilized to judge whether terminals exist in the relevant area and its accuracy is enhanced in proportion to the density of installation of Wi-Fi APs at certain intervals.

2.1.3 Triangular Surveying

The triangular surveying is a technique frequently used during positioning using not only wireless APs but also satellites or base stations. The RSSIs measured from at least three points of which the coordinates are known are converted into distances. The measured distances are used as radiuses to draw circles at individual points and the area where these three circles overlap each other is estimated to be the present position.

RSSIs are converted into distances using the following Friis formula.

$$d = \frac{c}{4\pi f} \times 10^{\frac{L}{20}} \quad (1)$$

where, c indicates the propagation velocity, f indicates the frequency and L indicates signal transmission loss. By substituting the distance d obtained from each point into the formula for circles as shown under (2), the position to be measured can be obtained in the method as shown in Figure2.

$$\begin{aligned} d_1^2 &= (x - x_1)^2 + (y - y_1)^2 \\ d_2^2 &= (x - x_2)^2 + (y - y_2)^2 \\ d_3^2 &= (x - x_3)^2 + (y - y_3)^2 \end{aligned} \quad (2)$$

However, this method is quite vulnerable to noise that frequently occur in radio waves since resultant distance values exponentially increase as RSSIs become lower. Therefore, this method requires studies to predict and respond to noises.

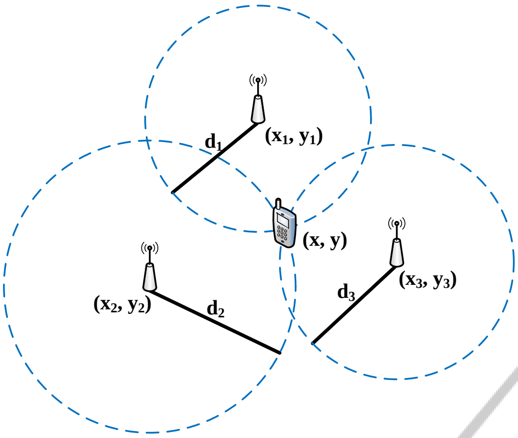

Figure 2: Triangular surveying using the Friis formula.

2.2 Examples of Indoor Positioning

2.2.1 RADAR (Bahl, 2000)

The RADAR introduced by Microsoft Research Group in 2000 is the first Wi-Fi signal intensity based indoor positioning system in the world. Before positioning, the strength of signals (SS) transmitted from the base station by reference point and the signal to noise ratios (SNR) are measured and stored in the DB through an off-line phase. Then, this information is used to analyze the signals actually received by the user in the Real-Time phase to estimate the position. Despite that the RADAR is an outcome of the Wi-Fi based indoor positioning technology studied in the early stage, it uses the Wi-Fi AP infrastructures installed in buildings as they are and combines the DB measured in advance and the characteristics of the signals received by the user in real time to provide high accuracy.

2.2.2 Ekahau (Paul, 2009) (Ekahau)

The Ekahau has been developed to estimate the positions of tags installed with Wi-Fi in hospitals, marts, distribution facilities, factories, public facilities, etc. and it uses already installed APs for positioning using the Fingerprint method. This solution is composed of Positioning Engines, Managers, Applications (Finder, Tracker, Logger), and Tags and the Tags are provided in diverse forms depending on the purposes of utilization. Since the Fingerprint method is used, a stage of collecting fingerprints in the relevant area should be gone through and the accuracy of positions is proportional to the density of the collected fingerprints.

2.2.3 Playmap (Playmap)

The Playmap is an LBS+SNS form service published by Hyundai MN Soft in 2009 and is an LBS application that received a prize in the Mobile Technology Grand Prize hosted by Korea Communications Commission in 2009.

With wire/wireless interlocking place sharing services consisting of the Playmap website and applications, this has functions to search position, explore routes and share information and provides diverse functions combined with maps.

This enables sharing restaurants that provide delicious foods encountered by users in their life, places good for taking images and enjoyable travel destinations and in particular, the post function and the function to recommend popular places in real time based on the degree of interest of users present the direction of evolution of LBS to analyze users' use behavior by combining SNS elements with LBS along with the business model of Foursquare.

2.2.4 Foursquare (Foursquare)

This is an LBS based SNS to enable users to inform their locations and what they are doing and leave memos through smart phones in order to share information with friends.

If a Foursquare user press the 'check in' button when he has come to a certain place, he will validate that he came to the place. As this check in value increases, the user's position will be enhanced and the user can finally receive a badge.

As of April 2011, the number of Foursquare users in the world exceeded 8 million. Using this Foursquare, sales promotions of off-line shops are conducted utilizing location based SNS and new revenue models of LBS are being presented such as the provision of gifts or discount services based on the frequency of off-line visits.

3 REAL TIME POSITIONING USING WIRELESS APS AND ACCELERATION SENSORS

3.1 Removal of Noises in RSSI Values

RSSI measurement in smart phones that use Android has an update period of 1500ms and a range of around -20dBm ~ -100dBm. When pure RSSIs are measured, noises may increase rapidly depending on the performance of wireless APs and surrounding environments. If these noises increase, RSSI values will decrease rapidly. To respond to this, the weighted averages (Pomalaza, 1984) as shown under (3) are used.

$$N_x = RSSI \times 0.35 + N_{x-1} \times 0.25 + N_{x-2} \times 0.15 + N_{x-3} \times 0.13 + N_{x-4} \times 0.12 \quad (3)$$

In expression (3), the RSSI is the RSSI measured presently and $N_x$is the results of compensation for noises. Expression (3) shows values that will make RSSIs strongest against noises while being able to immediately reflect measurement results determined based on the results of many experiments. The largest weighted values are given to RSSIs that have been collected the most recently and adapted in real time to the intensity of signals exchanged with wireless APs to measure the RSSIs. The results of experiments conducted using expression (3) are as shown in Figure3.

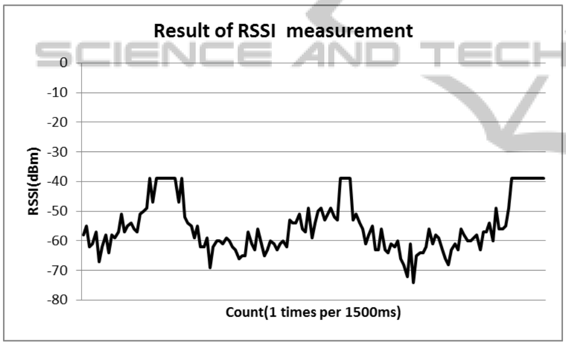

Figure 3: RSSI measurement result.

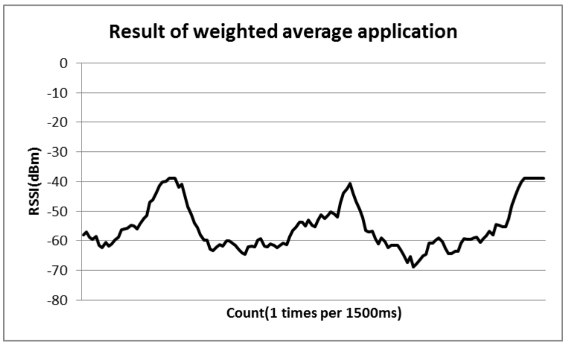

Figure 4: Results of weighted average application.

Figure 2 shows the results of measurement of RSSIs performed while changing the distance between the wireless AP and the smart phone after installing an N2emodel of ipTime at an end of 3m wide 20m long corridor. It can be seen that the RSSI became smaller as the distance between the wireless AP and the smart phone increased while becoming larger as the distance between the wireless AP and the smart phone decreased. Figure2 shows the results of measurement and there are many difficulties as many noises are mixed into signals. On the other hand, Figure 3 shows the results of RSSI measurement corrected using expression (3). It can be seen that noises decreased remarkably compared to pure results of RSSI measurement.

3.2 Measurement of RSSI and Acceleration Sensor Values

Wireless APs were installed at both ends of an actual corridor and the values of RSSIs and acceleration sensors applied with expression (3) were measured for three cases; a case where the experimental subject moved carrying a smart phone in his hand, a case where the experimental subject moved carrying a smart phone in his trouser pocket and a case where the experimental subject moved carrying a smart phone in his bag pocket. In all these cases, the values were measured four times while the subject was moving between the wireless APs and the two ends of the corridors back and forth. The first two measurements were done while the subject was walking and the last two measurements was done while the subject was running.

The upper parts of Figure 5~7 show the largest values among measured values of the acceleration sensors at the X, Y, and Z axes in lines and the lower parts show the RSSIs of the two wireless APs as bent line graphs of solid lines and dotted lines respectively.

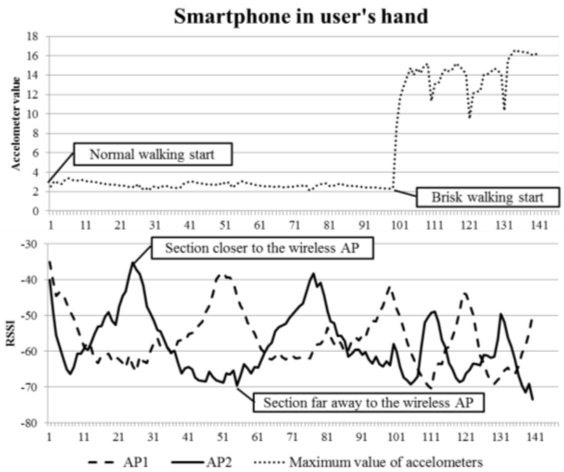

Figure 5: The values of the RSSIs of the two wireless APs and acceleration sensors when the subject was walking and then running carrying a smart phone in his hand.

Although the RSSI values were compensated for noises using weighted averages, it is difficult to determine locations with only RSSI values. However, it is possible to judge whether the user switched the direction using the RSSI values. This paper proposes this in 3.3 Direction switching using RSSIs.

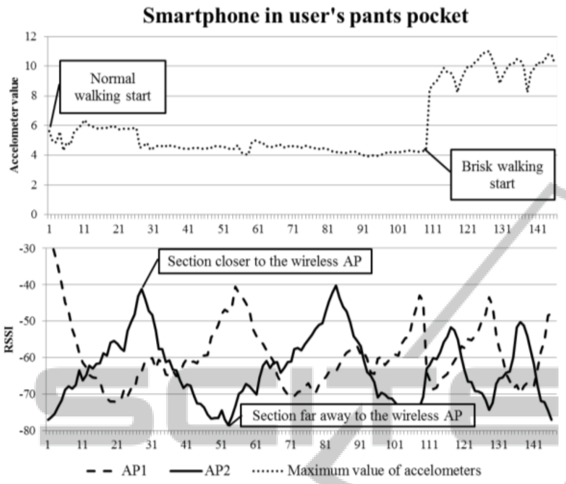

Figure 6: The values of the RSSIs of the two wireless APs and acceleration sensors when the subject was walking and then running carrying a smart phone in his trouser pocket.

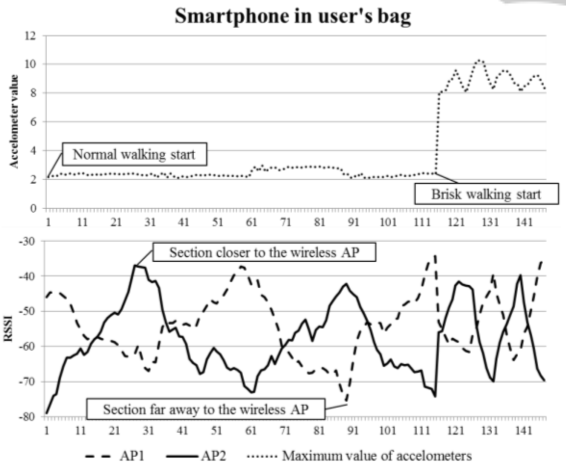

Figure 7: The values of the RSSIs of the two wireless APs and acceleration sensors when the subject was walking and then running carrying a smart phone in his bag.

Although acceleration sensor values showed differences among locations where the smart phone was kept, these values showed a tendency that measured values increased at once when the subject started running after walking. Based on this, cases of walking or cases of running can be judged on the basis of a certain value. (Huang, 2010) This paper proposes this in 3.4 Measurement of moving speeds using weighted averages.

3.3 Direction Changes using RSSIs

With the results of removing noises from the RSSIs measured from two wireless APs, a numerical formula to predict direction changes can be made like expression (4) using expression (3).

$$M_x = \frac{B_x}{A_x} \times 50 + \frac{B_{x-1}}{A_{x-1}} \times 35 + \frac{B_{x-2}}{A_{x-2}} \times 15 \qquad (4)$$

In expression (4), M_x indicates values to check whether the direction has been changed and A_x and B_x are the results of noise removal from signals received from individual wireless APs using expression (3). The weighted values here were determined among values that could immediately reflect measurement results while being the strongest against noises based on the results of many experiments. The largest weighted value is given to the RSSI that has been the most recently corrected to adapt to the intensity of signals exchanged with the wireless AP in real time to measure the RSSI.

Whether the direction has been changed can be determined through changes in the values of M_x in expression (4). If M_x values decrease after showing an increasing trend or increase after showing a decreasing trend, it can be seen that the direction has been changed. An algorithm of this is as shown in Figure 8.

$\text{InputValue}_\text{x}, \text{InputValue}_{\text{x}-1};$
$\text{StateOfRSSI};$
$\text{if}(\text{StateOfRSSI} \equiv \text{DownState})$
$\text{if}(\text{InputValue}_x > \text{InputValue}_{x-1})$
$\text{StateOfRSSI} = \text{UpState};$
$\text{else if}(\text{StateOfRSSI} \equiv \text{UpState})$
$\text{if}(\text{InputValue}_x < \text{InputValue}_{x-1})$
$\text{StateOfRSSI} = \text{DownState}$

Figure 8: Algorithm of direction changes by RSSIs.

In Figure 8, $\text{InputValue}_\text{x}$ is the result of expression (4) and StateOfRSSI is the present state of changes in RSSIs. The moment of a change in StateOfRSSI can be determined as the moment where the direction changes. The results of experiments of this are as shown in Figure 9.

In Figure 9, the bent line graph in a dotted line shows the results of expression (4) and the bar graphs in solid lines show time points at which the direction was actually changed. It can be seen that an infection point appears when around 2~3 RSSIs have been measured and calculated after an actual direction change. An Android smart phone has RSSI renewal periods of 1500ms and perceives the direction change within around 3000~4500ms after an actual direction change.

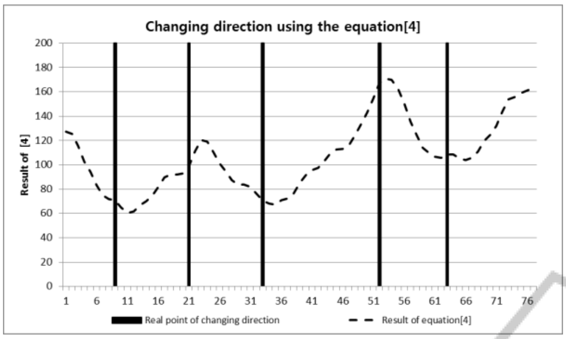

Figure 9: Results of judgment whether the direction has been changed using expression (4).

3.4 Moving Speed Prediction using Acceleration Sensors

Though Figure 5~7 and paper (Huang, 2010), it can be seen that acceleration sensor values suddenly increase when the user starts brisk walking. Acceleration sensor values are separately measured for X, Y and Z axes and to compared on the basis of the axis that has the largest value at each moment, the largest value in the case of normal walking is 6.361706 obtained when the subject was normal walking carrying the smart phone in his trouser pocket and the smallest value is 2.12406525 obtained when the smart phone was put into the bag. On the other hand, the smallest value in the case of brisk walking is 8.119599 obtained when the smart phone was put into the bag. Error ranges mat be set and cases where the value is 8 or larger may be regarded as cases of brisk walking, cases where the value is 1 or larger but smaller than 8 may be regarded as cases of walking and cases where the value is smaller than is may be regarded as cases of no movement. Numerical formulas for these cases are as shown in Table 1.

Table 1: States of movements based on accelerometer measured values.

Condition	State
$\max\begin{pmatrix}\text{Accelerometer X},\\ \text{Accelerometer Y},\\ \text{Accelerometer Z}\end{pmatrix} \geq 8$	Brisk walking
$\max\begin{pmatrix}\text{Accelerometer X},\\ \text{Accelerometer Y},\\ \text{Accelerometer Z}\end{pmatrix} < 8$	Normal walking
$\max\begin{pmatrix}\text{Accelerometer X},\\ \text{Accelerometer Y},\\ \text{Accelerometer Z}\end{pmatrix} < 1$	Stationary

Therefore, the states of user's movements can be known through the accelerometer. "Table 2. Counted versus measured steps at normal and walking brisk speeds; effects of age" in (Melanson, 2004) shows moving averages of moving speeds by the age of users. It can be seen that whereas general adults walk slower than 3MPH at normal speeds, they move faster than 3.5MPH when they walk at high speeds.

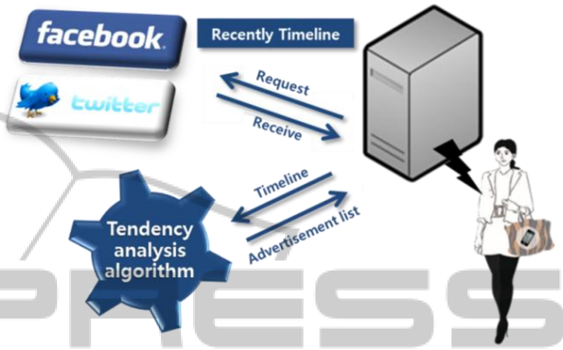

Figure 10: Composition of advertisement lists through consumers' SNS.

4 SELECTION OF ADVERTISEMENTS OF INTEREST USING CONSUMERS' SNS

To expose advertisements that coincide with the matters of consumers' interest instead of non-differential exposure of advertisements, advertisements include key word information in addition to video information. Key words comprise words that are directly related with products under the relevant advertisement. To collect these key words, related key words are collected first using the Open Mind Common Sense (Open Mind Common Sense) which was a project of the MIT media research room.

Thereafter, when the user's smart phone accesses the server and transmits its SNS ID as shown in Figure 8, the server receives the most recent time line from the SNS based on the SNS ID. The propensity analysis algorithm searches the key words in the server from sentences other than negative statements from the most recent time line in sequence. If a time line has the key word, the images of the advertisement having the relevant key words will be added to the list.

When the composition of advertisement lists has been completed, the location of the video player is changed based on the information the location of the

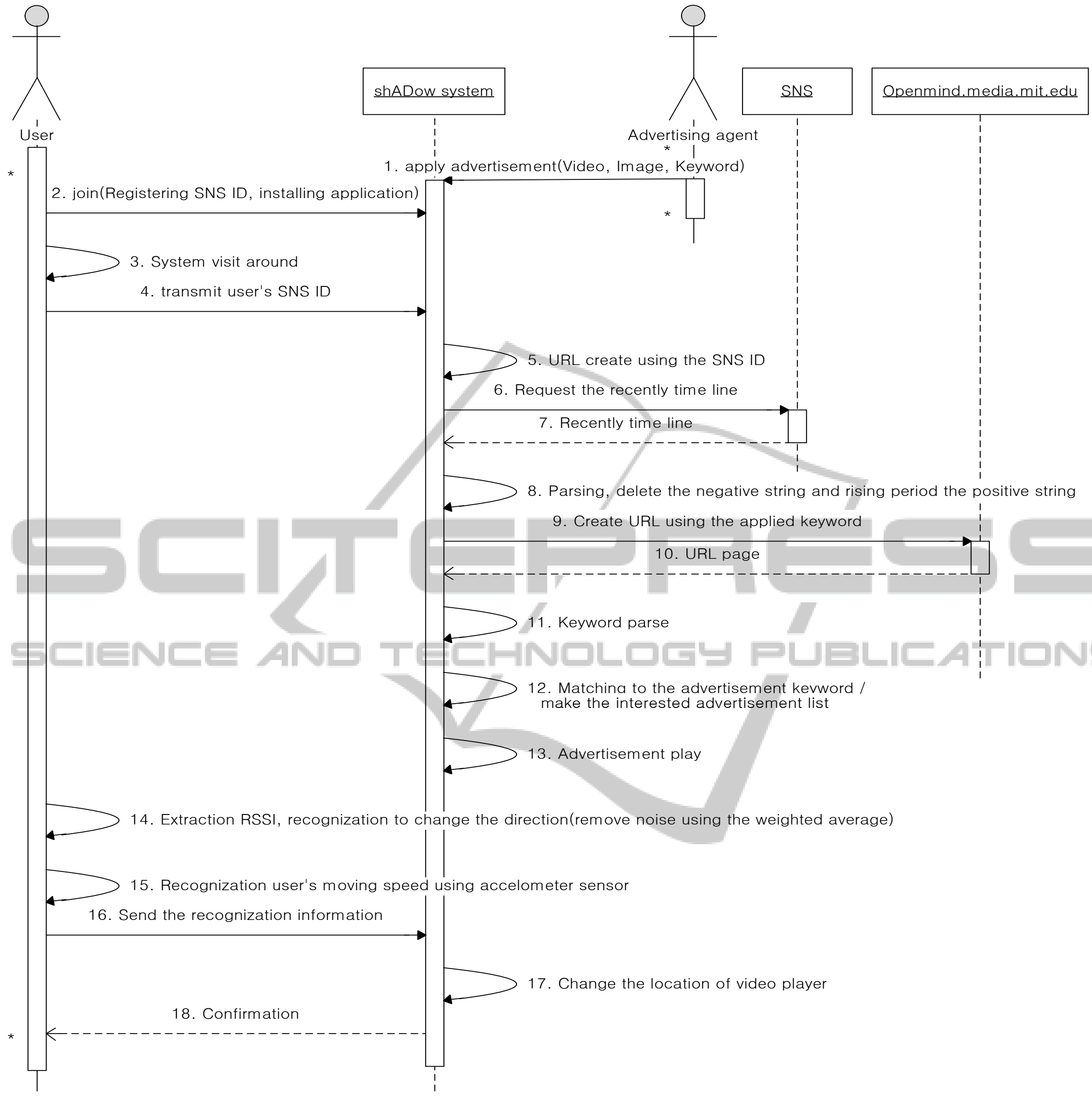

Figure 11: shADow Sequence diagram.

user and the advertisement images in the advertisement lists are replayed in sequence. If information on desired products appears, the user may request the information through his smart phone. At the moment the request has been received, the server sends the price information, location information, discount information, image information, etc. for the product in the advertisement to provide the information to the user.

5 RESULTS OF IMPLEMENTATION AND ANALYSIS

As proposed in chapters 3 and 4, shadow is executed by the operation algorithm shown in Figure 9.

1. When requested by the advertiser, the advertisement is registered in the shADow system. Information such as videos, images and key words is stored in the DB.

2. While installing shADow applications in his smart phone, the user enters his SNS ID.

3. Using the Notification function of Android, the user checks whenever a new wireless AP is found whether registered wireless APs are in the vicinity.

4. The stored SNS ID is sent to the server so that the server can compose advertisement image lists.

5~8. Using the SNS ID received from the user's smart phone, the server prepares URLs for receiving recent writings to receive pages containing recent writings and parse the pages. In individual writings, negative statements are removed and the priorities of positive statements are enhanced.

8~11. Using the registered key words, the server creates URLs that can be used in Open Mind Common Sense (Open Mind Common Sense) and collects related key words.

12. The server checks the statements if they have the key words collected from recent writings in SNS and add the advertisement images of the relevant key words to the list.

13. While replaying the files in the image list, the server changes the position of the player based on the location information received from the user's smart phone. The server was implemented as a multi-server so that information from many clients can be received simultaneously.

14. The Client was made to apply expressions (3) and (4) to measured RSSIs to perceive direction changes through Figure 8 and the measured values of the acceleration sensor trough tables 1 and 2 and send the speeds to the server every 300ms. The screen used is as shown in Figure 11.

Shadow actually operates as shown in Figures 12~16. Figure 10 is a scene where two beam projects were connected to the server to illuminate the experimental subject. The experimental subject carries a smart phone in his hand and moves from the left side to the right side and returns to the left side without any operation of the smart phone. One each wireless AP is installed on the left end and the right end and based on the propensity analysis through the experimental subject's SNS, a ramen advertisement video is being replayed.

Through the direction change algorithm set forth in Figure 8 and expression (2), changes in the direction between the APs could be identified in relation to changes in smart phone locations. Through the experiment, it could be seen that a direction change could be perceived only when data for 3 to 4.5 seconds have been gathered and thus as much delays occurred in direction changes.

Although direction changes were not completely perceived since noises were not completely removed, much more precise positioning was possible than finding locations through triangular surveying.

Figure 12: Smart phone execution screen.

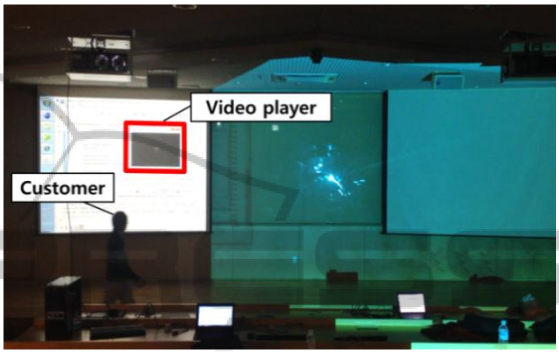

Figure 13: Connection of the shADow with the Client and the start of the video player.

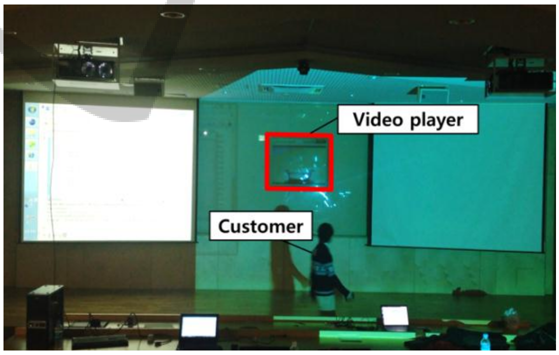

Figure 14: The start of the user's movement.

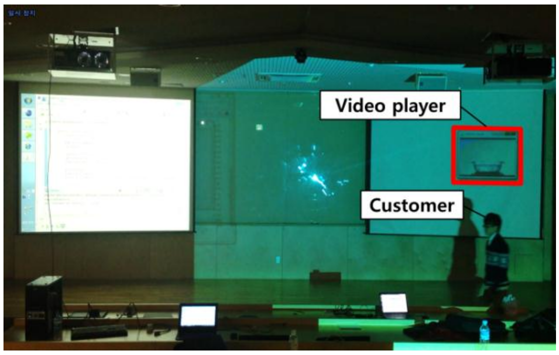

Figure 15: Perception of user direction change.

Movement speed measurement was almost accurate. The algorithm operated normally regardless of locations where the smart phone was kept or movement speeds. In the case of acceleration sensors, no delay occurred because collection periods were very short.

Diverse key words related with those included in advertisements through Open Mind could be compared with the key words of users' interest.

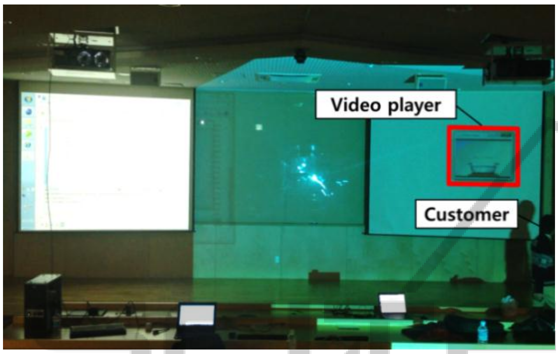

Figure 16: User movement.

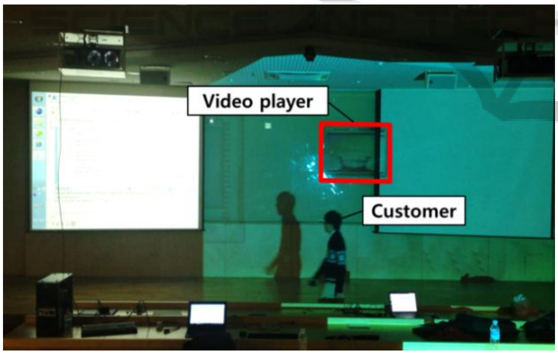

Figure 17: User movement.

6 CONCLUSIONS

Locations that were measured by existing WPS projects had the accuracy at around Room-level. However, shadow can provide more precise services through updates of continuously measured locations and values from acceleration sensors. In addition, it remarkably reduces the number of wireless APs necessary for measurement. The algorithm using the triangular surveying method requires at least three wireless APs and more APs to provide higher accuracy. However, because of the spatial constraint, corridor, shADow can provide services only through two wireless APs.

The shADow system reduces the inconvenience for customers to unavoidably stop to watch advertisements and cases where customers watch advertisements that do not induce interest.

With regard to shADow many studies can be conducted on methods to use probabilities on algorithms to determine direction changes and noise compensation.

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