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Bluetooth Based Indoor Navigation System

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Abstract — **With the increase in the size of malls, airport and buildings, People find it difficult to navigate inside the large buildings. Hence a guidance system can be introduced that becomes to attract attention. As a position estimation technology for indoor guidance, a Wi-Fi positioning system has been studied.However, Wi-Fi radio waves are not available in the hospitals and airport because that affect operations of medical equipment and the radar in the aircraft. Therefore in this paper, we propose a new real time indoor guidance system using Bluetooth through an Android device application for visitors. Our proposed system utilizes a combination of Received Signal Strength Indication (RSSI) of Personal Handy-phone System (PHS) and Dead Reckoning based on sensors of an Android device like accelerometer, compass etc. in order to estimate a user's indoor position without affecting operation of medical equipment's and radar communication. Through the experimental evaluation from various papers, we have clarified that the proposed system has successfully guided subjects to the destinations with accuracy of more than 93.3[%].**

Index Terms — **Indoor Position Estimation, PHS, RSSI, Dead Reckoning, Android.**

I. INTRODUCTION

In a large buildings consisting of many departments, it is difficult for visitors to reach their destinations smoothly.
In particular, in case of a medical examination and boarding
in the airport, visitors often get lost because they should visit many medical departments or terminal during a round trip and even in cases where departments are apart from each other. This causes a serious problem particularly for elderly people and also for people who are new to the location . To solve this problem, a guidance system that can be used in this location is attracting attention. In the guidance system, indoor position estimation is one of the most important technologies. As the indoor positioning technology, Dead Reckoning has been widely studied [1], [2], [3]. In the Dead Reckoning, a user's movement is estimated by analyzing data obtained from various sensors (e.g., acceleration, gyroscope, etc.). Especially, in recent years, Android phones become the best candidate of the sensing device because they are equipped with a wide variety of sensors. Furthermore, as an indoor position estimation technology, a wireless positioning system using Wi-Fi [4], [5] has been studied. However, Wi-Fi access points are not available in the hospitals and airport because
2.4GHz radio waves affect operations of medical equipment. On the other hand, an indoor Personal Handy-phone System (PHS) is commonly used for constructing inter-office telephone in the hospitals. This is because a PHS device does not use the 2.4GHz Industry-Science-Medical (ISM) radio bands and its maximum transmission power is

much lower than a cell phone [6]. Therefore, this paper proposes new real time guidance system for indoor navigation using the concept of a PHS and Dead Reckoning with the help of an Android device. The Android device estimates user's position based on the Received Signal Strength Indication (RSSI) of Bluetooth waves in addition to Dead Reckoning with acceleration, compass and gyroscopes sensor, and then displays route guidance. A user-friendly interface on the Android is also proposed, which can be easily understood by the people. Furthermore, the effectiveness of the proposed system is evaluated by comparing the results of the route guidance experiments from the reference paper

I. RELATED WORKS AND OBJECTIVES OF THIS STUDY

A. Issue of Guidance in Hospital and Airport

Now a days, patients and diseases are rapidly increasing [7] and their health-care becomes a critical social cost. Medical examination at an early stage is very important to detect a sign
of diseases, hence will decrease medical cost for afterwards
surgical operation, hospitalization, etc. On the other hand,
there are many inspection items more than 10 in the medical
examination or in the master check-up and the inspection items are expected to increase further with advance in medical technology. A typical guidance board in a hospital consists of many medical departments and examinees should visit a lot of examination rooms (e.g., C.T. scan, MRI, endoscopy, etc.) that are apart from each other. For this reason, route of medical examination is complicated and guidance in a hospital is an important issue.

In the case of airports lots of people are travelling across the globe. Form a single airport on an average 500 flights come and goes to more than 1000 cities across the globe. Hence directing the passenger from the boarding point to the terminal gate will be a huge problem as there as many gates stating from A-Z with terminal number ranging from 1 to as many

Figure 1. A lot of destinations listed on guidance board in an Airport.

However, automated guidance which can lead visitors to an
appropriate place at an appropriate time has not been established yet although IT is utilized for various activities
because the automated guidance system cannot compute the circumstances of the exceptional cases.

B. Existing Studies

The position estimation system using a GPS has become
available with a wide spread of mobile devices equipped with GPS. However, the GPS cannot be used in indoor
environment because GPS signals are blocked by walls or
ceilings. As indoor positioning technologies, methods using radio waves transmitted from multiple transmitters have been researched and developed. In these systems, signal strength of radio waves of Wi-Fi [8] or Bluetooth [9] is used. However, these radio waves use the ISM bands, which may interfere with medical equipment, and hence must not be used in hospitals. On the other hand, PHS can be used for inter-office telephone in the hospital because the impact on medical equipment is very small [10]. Furthermore, as shown in Table 1, the output power of PHS is small compared with a cellular phone. An outdoor positioning method using radio waves of PHS has already been studied [11]. However, the practicality of PHS radio waves for indoor guidance system has not been investigated.

TABLE 1. OUTPUT POWER OF EACH TELECOMMUNICATIONS TECHNOLOGIES

Telecommunications Technology	Burst Average Power [mW]
PHS	80
IMT-2000(3G)	200 or 250

Furthermore, a positioning technology using sensors on the
Android device has been studied [12]. Position estimation
using various motion sensors is called Dead Reckoning. The
Dead Reckoning does not generate radio wave, hence the
indoor position estimation method using the Dead Reckoningis a useful tool in the hospital. However, in

the Dead Reckoning, error of the sensor data is accumulated with time [13], hence, correction of the accumulated error is one of the important issues.

C. Objectives of This Study

Considering these situations, we propose a guidance system
for indoor navigation which utilizes a combination of ideas from RSSI of PHS and Dead Reckoning using sensors of Android devices. In this study, acceleration, compass and gyroscope sensors on the Android device have been utilized for estimating the user's position by the Dead Reckoning. The aim of our study is to develop an Indoor guidance system on an Android device with Bluetooth signal based navigation including smart user interface which can be used by peoples of all the ages.

II. PROPOSED SYSTEM

Overview of the Existing system

The User is provided with a hardware called the Personal Handy Phone (PHS) which is used to identify the current location and also helps to track the destination using the Received Signal Strength. Based on the received signal strength identification, user's current location is identified. But using PHS device the communication cost is high.

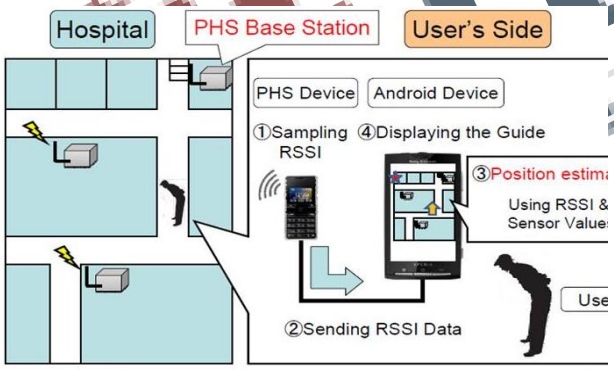

Figure 2. Overview of the guidance system using PHS

Figure 2 shows an overview of the proposed guidance system in the hospital. This system provides a route guidance interface which is easy even for elderly users to understand. The procedures of the system are given as follows.

1. A PHS device samples RSSI of radio waves from PHS
base stations (PBS).
2. The RSSI is transmitted from the PHS device to an Android device through USB.
3. The Android device estimates the user's position based on the RSSI and Dead Reckoning using sensors.
4. The Android device displays a guidance of the user's position to the destination.

In this study, it is assumed that the user holds an Android
device and a small PHS device, which are received at a reception desk of the hospital. Although there's a small and
compact PHS device in the current market, it can be a chip
when this system becomes a commercial product. In addition, a PHS smart phone operated by Android OS has already been available on the market and it can make the proposed system more convenient.

Proposed System

In the proposed system Bluetooth is used to keep track of the user location and path to destination. The user sends a request map to the destination, the system will find out the current location using the nearest Bluetooth signal strength the user is present and using shortest path algorithm and RSSI algorithm the route guidance map is generated and makes a clear path for the user to move from the origin to the destination. These Bluetooth signals lesser than 2.4 GHz that of Wi-Fi. Hence they can be operational in hospitals and in airports without any damage to the machines and radar communication. In the proposed system, the Bluetooth dongle will be placed in the every location of the rooms at the range each and every of 100meters. As the user moves, with the help of these change in signal and its strength the user is guided to the destination.

The efficiency of the system is increased form the values of additional sensor such as acceleration, compass etc. Dead Reckoning is a method of estimating the users position based on the sensor data. In the Dead Reckoning, the position change is estimated by detecting user's movements and changes of the moving direction of the user from the sensor data. The procedure of the Dead Reckoning is composed of the following ways.

1. The number of steps during walking is detected by an acceleration sensor.
2. A moving distance is calculated by multiplying the number of steps and the user's stride length.
3. Direction of movement is detected by compass sensor.
4. Turning direction at a corner is estimated using a

gyroscope sensor values.
5. The estimated position is adjusted to coordinates of the corner when the change of the moving direction is detected in order to correct error.

Hence the working of the application will be like

1. The user sends the request map for the destination.
2. The system finds the nearest user Bluetooth signal range and strength.
3. With this the system now can have the users current location.
4. Then with Dijkstra's algorithm the route map is being generated.
5. As the user moves the Bluetooth signal strength changes and goes to a new range with the help of RSSI of the Bluetooth signal waves and by using the Dead Reckoning the user is guided to the destination.

User Interface

The Route Guidance Screen displays information for guiding a visitor from the estimated position to the destination. User interface of the guidance should be friendly for elderly
people who are main visitors of a hospital. Therefore, we
adopt Turn by Turn method [15] as a UI of the guidance
display. The Turn by Turn method guides the user to a destination by indicating the moving direction at each corner.
Compared with the method displaying the route on a map
image, the Turn by Turn method has merits that the instructions are intuitive and easy to be understood.

Route Search

In the application, Dijkstra's algorithm [16] is
utilized to automatically determine a route between the estimated user's position to the destination. By using the
algorithm, the shortest path can be derived at low cost.

Experiment Result

Evaluation result of the proposed route guidance system is
given in Table 2.

TABLE 2. RESULT OF ROUTE GUIDANCE EXPERIMENT

Route	Subjects	Medical examination point	Guidance success rate[%]		
			DR only	DR & PHS	DR & PHS & Bluetooth
1	5	6	60.0	100	100
2	5	6	60.0	100	100
3	5	6	100	80.0	95.0
Average			73.33	93.33	**98.33**

When the method uses the Dead Reckoning only, the guidance success rate was 73.3[%]. On the other hand, the
position estimation using the Dead Reckoning and the RSSI of PHS achieved a high success rate of 93.3[%]. This is because the Dead Reckoning cannot decide the correct one from multiple nodes on the same corridor, while the estimated position can be corrected by detecting that the subject had passed in front of the PBS from the RSSI values. These results suggest that the position correction by RSSI of PHS is effective. The method using the Dead Reckoning and PHS could not complete the guidance in Route 3. This was caused by the case when the stride length of a subject became longer than the premeasured one. Therefore, we will develop an automatic adjustment method of user's stride in the future study.

CONCLUSIONS

This paper has proposed a real time guidance system in a
hospital using Bluetooth and Android device. Specific feature of this system is a use of the combination of Dead Reckoning based on sensor data and RSSI from the Bluetooth doongle. The Dead Reckoning is basically used to estimate user's indoor location, and accumulated error of the estimated location is corrected by utilizing the PHS radio waves, which have less impact on the medical equipment. Furthermore, a new intuitive user interface based on the turn by turn method has been proposed.

In order to evaluate effectiveness of the proposed guidance application, we have conducted route guidance experiments results as such done in Nagaoka University of Technology campus. Evaluation result of the developed system has shown that the position estimation using the Dead Reckoning and the RSSI of PHS achieves a rate of 93.3[%] and with Bluetooth dongle achieves a high success rate of 98.8[%] . The results indicate that the combination of the RSSI of

Bluetooth signal and the Dead Reckoning realizes accurate route guidance in a large buildings. In the future study, we'll further study to develop a dynamic estimation method of user's stride for improving the guidance success rate.

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