A Design of RFID-Based Personnel Navigation Platform

Der-Cherng Liaw, Chien-Chih Kuo, Chiung-Ren Huang

***Abstract*—A simple personnel navigation platform is proposed in this study by using the radio frequency identification (RFID) technology and smart mobile device. In the design, the RFID devices play as locators for providing the location information and a smart mobile device acts as the trip guider for calculating the shortest routing path and giving the direction for the movement of personnel to the set desired destination. Experimental results on a selected campus environment are obtained to demonstrate the success of the proposed design.**

***Index Terms*—RFID, navigation, routing**

I. INTRODUCTION

The study of vehicle navigation system has recently attracted lots of attention, especially for self-driving cars. For instance, Google Company has developed a self-driving car, which is known as Google “driverless car.” Most of vehicle navigation systems are known to use the Global Positioning System (GPS) or GLONASS as locater for telling the current global position of the vehicle. However, the signals of those two types of locators might be influenced by environment. For instance, when the vehicle is driving inside a tunnel, either the signal of GPS or that of GLONASS will be lost. In addition, the high-rise building in city may influence the function of GPS or GLONASS. Thus, such a technique might not be suitable for personnel navigation where the environment might be complicated. Instead of using satellite-based techniques such as GPS or GLONASS, several different schemes have been applied to personnel navigation (e.g., [1]-[4]). Among those designs, a wireless sensor networks (WSN) based design was proposed for speedy emergency navigation [1] and an inertial navigation scheme was employed to determine pedestrian’s location [2]. Besides, a design of combining GPS and sensors was developed for outdoor human navigation [3], and Bluetooth-based as well as RFID-based platform were proposed in [4] and [5], respectively, for either indoor navigation or indoor surveillance.

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Among all known methods, the recent popular way for practical personnel outdoor navigation is to use the web of google map [6] with the help of mobile phone or Wifi-based device. However, the key for such a design is to have the help from both of GPS and internet. In the area of which it isn’t covered by either internet or GPS, the google-map based navigation method will be failed to provide the help. A cost-effective scheme by using RFID technology but not internet was proposed for personnel navigation [7].

Simulation results from a mockup model were also obtained to demonstrate the proposed major functions. In this paper, we will extend our previous study presented in [7] to develop a practical platform for outdoor personnel navigation.

One of the main goals for this study is to construct an effective route searching algorithms for the personnel navigation. There are several well-known shortest path searching algorithms such as Dijkstra’s Algorithm, Bellman-Ford Algorithm and Floyd-Warshall Algorithm (e.g., [8]-[13]). Among those existing related researches, a performance comparison study has been presented in [9], while an application to grocery store was given in [10]. Besides, a computational load analysis of three common algorithms: Dijkstra, A*, and Floyd-Warshall algorithms has been given in [13]. In this paper, we will employ Dijkstra’s scheme to construct an algorithm for finding the shortest path of the personnel navigation.

The paper is organized as follows. First, the Dijkstra’s searching method and the procedure for developing an APP will be recalled in Section II. It is followed by the discussion of main design of the proposed platform. Experimental results are obtained in Section IV to demonstrate the proposed functions. Finally, conclusions are given in Section IV to summarize the main results.

II. PRELIMINARIES

In this section, we briefly recall the Dijkstra’s algorithm from [14]. It will then be used in Section III to develop personnel navigation platform. Details are given below.

The Dijkstra’s algorithm [14] is known to solve for the shortest path problem of a graph with given source and non-negative weight. Denote s a given source vertex in a non-negative weight directed graph G. Let v be a vertex in G and u denote the current intersection node. In addition, array Q is defined as an unvisited set for storing all v which has not been visited and array N is used to store all neighboring nodes of u. The flowchart of Dijkstra’s algorithm can then be constructed as the one given in Fig. 1 below.

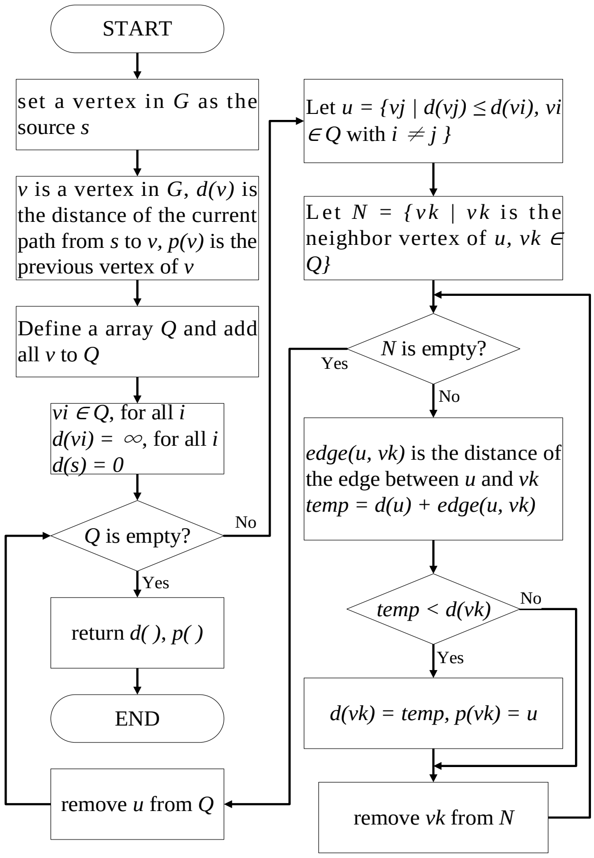


Fig. 1 Flowchart for Dijkstra's algorithm

III. Design of Navigation Platform

In the recent years, a GPS plus Geographic Information System (GIS) platform has been popularly used for practical vehicle guidance. By such a design, the driver of vehicle only needs to enter the destination of the trip. The vehicle guidance system will then direct the route on the map of GIS for the driver to follow. In addition, the GPS will play the role as a locator to tell where the current location of the vehicle by showing the information on the same electronic map of GIS. Unfortunately, no similar design has been developed for personnel yet. Instead, the use of web of google map with the help of mobile phone or Wifi-based device has recently become a popular way for practical personnel outdoor guidance. Generally, people can use laptop or desktop computer to connect to the website of Google map. Then enter the interesting location and the destination for finding the path of navigation. In such a way, there is no locator to tell where the user is. The whole procedure is only for obtaining the trip information of possible routes from interesting point to the destination with corresponding time needed. In the outdoor environment, the same procedure will be followed. The major difference compared with indoor is to use mobile phone or Wifi-based communication module to link with internet. Although people can know where he or she is by the help of GPS, however, the location information has not been connected with google map to give an automatic navigation as the one for vehicle guidance.

In the following, we will develop a simple personnel navigation platform to be used for personnel outdoor touring. Here, we use RFID technology to replace GPS for playing the role of locator. Part of a university campus will be used as an example for carrying out the design and real outdoor demonstration. Details are given as follows.

A. Navigation platform

First, we will propose a RFID-based navigation platform which is consisted of several RFID tags and a mobile phone. An example with RFID tag and SONY XPERIA mobile phone is shown in Fig. 2. Here, the RFID tag will play as passive locator and the mobile phone will provide the function of navigation map as well the best route calculation between the interesting point and the destination.

Fig. 2 RFID tag and mobile device.

It is known that each RFID tag has unique universal identification number (UID). Thus, we can use those UID's to represent different locations and/or buildings for the interesting points where the RFID tag is attached to the corresponding location or building. The mobile device is designed to read the UID of the tag by the built-in RFID reader to tell the corresponding location or building as depicted in Fig. 3. In addition, the mobile device will also need to provide the functions of best route calculation and guidance scenario on its screen.

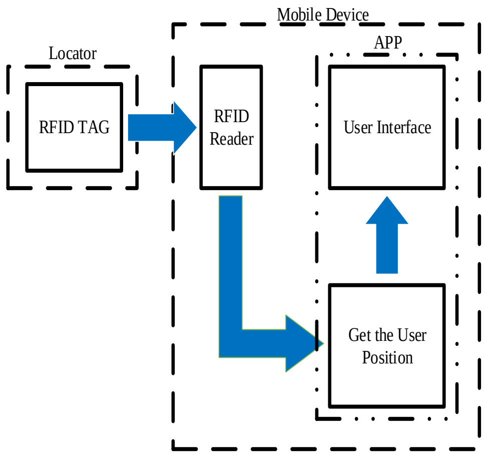


Fig. 3 Structure of the proposed personnel navigation platform.

In this study, we choose the RFID tag complied with the ISO 15693 standard which is designed as a close-range communication with transmission frequency of 13.56MHz. In addition, the ISO 15693 standard tag does not need battery for providing electric power. Instead, the required power of the tag will be simultaneously wireless charged by the reader during read or write cycle of data communication. A specific ISO 15693 standard reader is used in [7] for the design. Here, for general application we use the mobile device which has built-in function of near-field communication (NFC) as a reader. The NFC is a communication protocol, which covers communications protocols and data exchange formats for RFID tag complied with both of ISO 14443 and ISO 15693 standards [15]. So, we can use NFC as reader to get the RFID tag information. The RFID tag contains a set of non-editable UID with 8 bytes and 64 read/write memory blocks. Each memory block can store 4 bytes of data. Here, we mainly use the UID to identify the place where the tag is attached.

B. Outdoor environment

Next, we consider a real outdoor environment for the design. A part of a university campus as depicted in Fig. 4 is used for the design. In the concerned area, we choose 12 buildings as marked with red-dot in Fig. 4 for the demonstration of the proposed personnel navigation platform. In addition, according to the real environment, we have 8 intersection points of the road which are marked with blue-dot in Fig. 4. Besides, the black line in Fig. 4 indicates the path among buildings and those intersection points. In the proposed design, we place RFID tag on each building and each intersection point as locators. The corresponding photos for the holder of two tags are shown in Fig. 5.

The twelve buildings are then marked as Building A to Building L as given in TABLE I, while the distance between two nearest buildings with non-dimensional scale is also shown in TABLE I. Note that, the symbol “X” in TABLE I indicates that there is no direct path between the two buildings. Based on the information given in TABLE I, we can now construct a weight directed graph as depicted in Fig. 6 for the calculation of the best route from one building to the other. Here, each building on the map of Fig. 4 is marked as a vertex and the distances between two buildings are treated as edge. In addition, the number inside the circle of each vertex represents the corresponding weighting value.

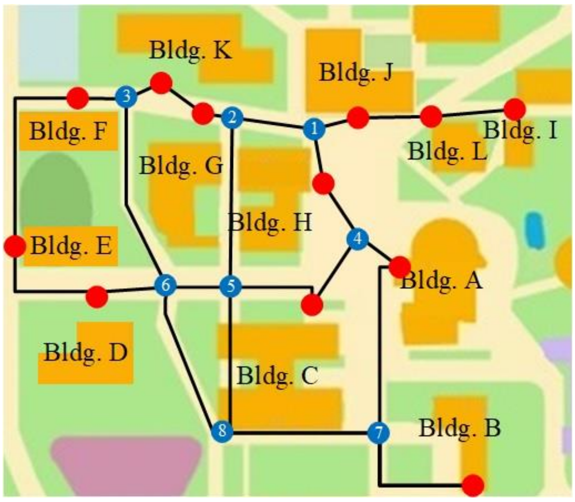


Fig. 4 Map of outdoor environment.

C. Shortest path searching

Now, we will apply Dijkstra’s Algorithm as recalled in Section II to the calculation of the shortest distance between any two buildings of the twelve interesting nodes defined in Table I.

(a) (b)

Fig. 5 RFID Tag: (a) on building, and (b) on intersection point.

TABLE I The distance between two nearest buildings

	A	B	C	D	E	F	G	H	I	J	K	L
A	0											
B	254	0										
C	100	370	0									
D	X	385	175	0								
E	X	X	X	95	0							
F	X	540	312	X	155	0						
G	X	460	195	210	X	100	0					
H	60	X	90	X	X	X	115	0				
I	X	X	X	X	X	X	X	X	0			
J	X	X	243	302	X	X	92	29	X	0		
K	X	X	264	184	X	57	41	X	X	X	0	
L	X	X	X	X	X	X	X	X	45	72	X	0

A : Library and Information Center
B : Management Building 2
C : Engineer Building 5
D : Engineer Building 6
E : CPT Building
F : Tin Ka-Ping Photonic Building
G : Engineer Building 4
H : Engineer Building 3
I : Humanities and Social Sciences Building 1-A
J : Information Tech. Service Center
K : Science Building 1.
L : Humanities and Social Sciences Building 1-B

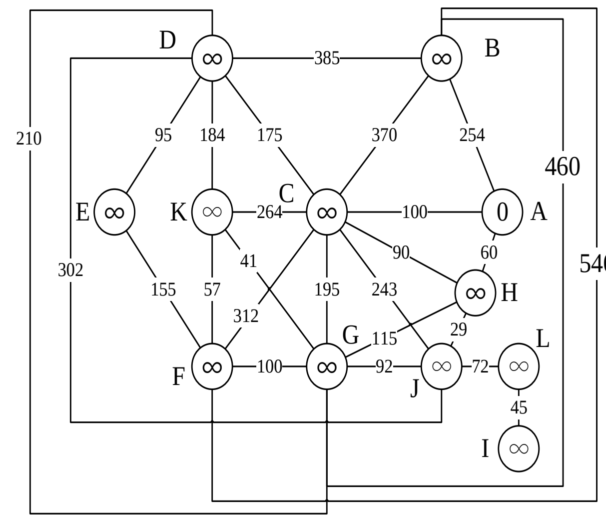


Fig. 6 Weight directed graph

First, we create an unvisited set Q which contains all twelve vertices and choose vertex A as the source node. In the Iteration 1, source A denotes the current intersection node u. We can then calculate the weighting value between the current intersection and the neighbor vertices, which will then make the weighting values of vertex B, vertex C and vertex H be changed from ∞ to 254, 100 and 60, respectively. In addition, the neighbor vertices of u have been calculated which makes the set N to be empty. The source node A will also be marked as a visited node and be deleted from the set Q.

In the Iteration 2, the weighting value of vertex H is the smallest one among all of the unvisited vertices. So, the vertex H becomes the current intersection u. The same procedure as that in Iteration 1 will be repeated. It is found that the calculated weighting value of vertex C in the previous iteration is 100. That value is smaller than the new calculated weighting value 150 in Iteration 2. According to Dijkstra's Algorithm, the vertex C will maintain the original weighting value. In addition, the weighting value of the vertex G and vertex J will be changed from ∞ to 175 and 89, respectively.

In Iteration 3, the vertex C becomes the new intersection node u, and the calculated weighting value of vertex D in the previous iteration is 391. This value is bigger than the new calculated weight value 275. According to Dijkstra's Algorithm, the weighting value of the vertex D will be replaced by the new weighting value. The same procedure will continue until the set Q becomes empty. We can then construct the shortest path from source A to any other vertices as shown in Fig. 7. In addition, the corresponding connected graphs for each shortest path from source A are also depicted with different colors in Iteration 12 of Fig. 7.

Next, we choose any one of the remaining eleven vertices as new source node and repeat the same procedure above until all eleven nodes have played the source node. The shortest distance between any two buildings of the twelve interesting nodes are then calculated as given in TABLE II.

D. APP interface design

In order to provide the function of trip guider, in this study we have developed an APP program to fulfill the required tasks. There are two major functions for the trip guider. One is called "LOCATION" for finding the location of current place on the road map, which is achieved by placing the mobile device near the tag put on the building or the intersection. The mobile device will read the UID of the tag and translate the corresponding name of building or intersection point, and then show the place on the road map. The other is named as "NAVIGATE" for finding the shortest route between the current place and the desired destination. In the execution of such a function, the user can choose the destination from the scrolling list built on the mobile device. Then the APP will calculate the shortest routing path between the current place and the destination by using the results of Section III.C.

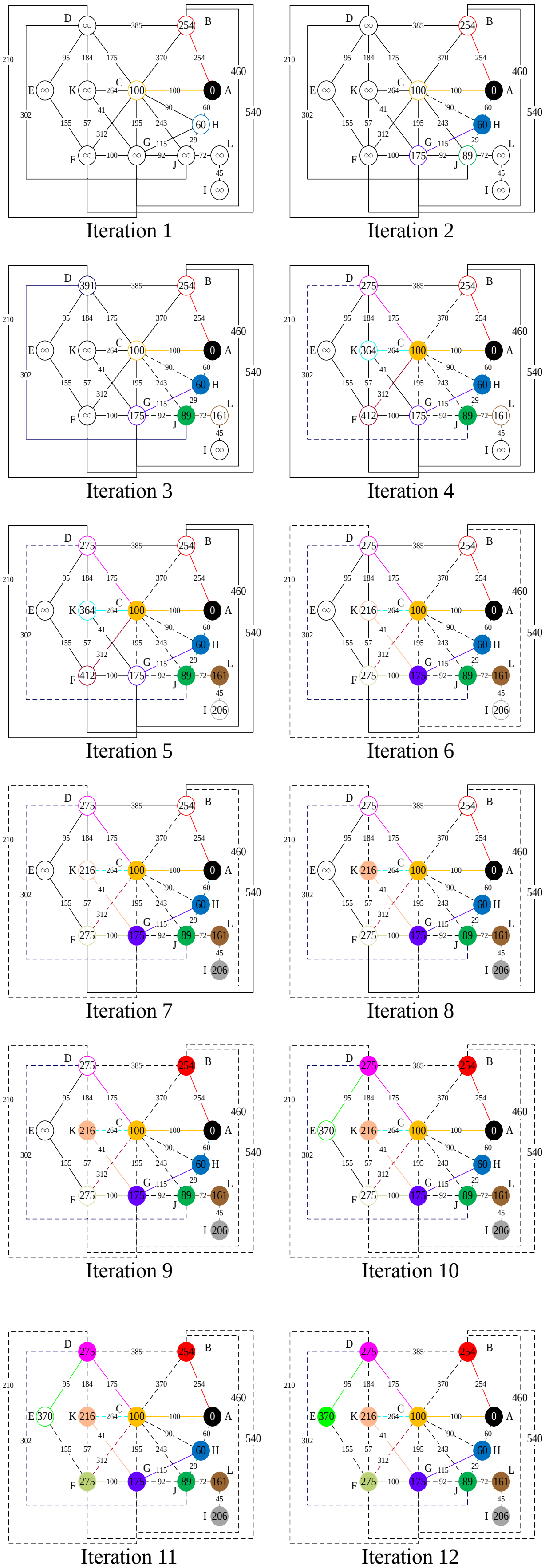


Fig. 7 Calculation procedure for shortest path searching.

An APP interface is developed in this study for the mobile device SONY XPERIA as shown in Fig. 2. There are three parts of APP interface. Among those three parts, the first one is marked by red-square for the execution of the command "LOCATION." In addition, the second part is surrounded by a blue line and is for the execution of the command "NAVIGATE." A scrolling destination list is given on the left side of the second part, while the command button of "NAVIGATE" is on the right side. The last part is surrounded by a green line and is used as display window for road map.

TABLE II The calculated weighting value for the shortest distance

	A	B	C	D	E	F	G	H	I	J	K	L
A	0											
B	254	0										
C	100	354	0									
D	275	385	175	0								
E	370	480	270	95	0							
F	275	540	295	250	155	0						
G	175	429	195	210	255	100	0					
H	60	314	90	265	370	215	115	0				
I	206	460	236	411	464	309	209	146	0			
J	89	343	119	294	347	192	92	29	117	0		
K	216	470	236	184	212	57	41	156	250	133	0	
L	161	415	191	366	419	264	164	101	45	72	205	0

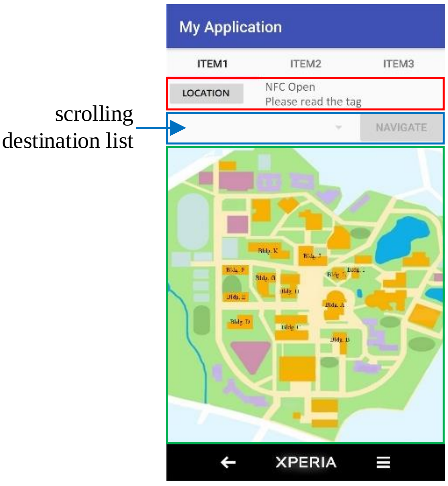


Fig. 8 Self-designed APP interface.

IV. EXPERIMENTAL RESULTS

In the following, we will verify the functions of the navigation platform proposed in Section III for practical usage on outdoor touring. As depicted in Fig. 5, in the proposed design we have developed two types of tag holder for building and intersection point, respectively. Both types of tags can be identified by the command "LOCATION" built-in the mobile device to tell the current place where the user is.

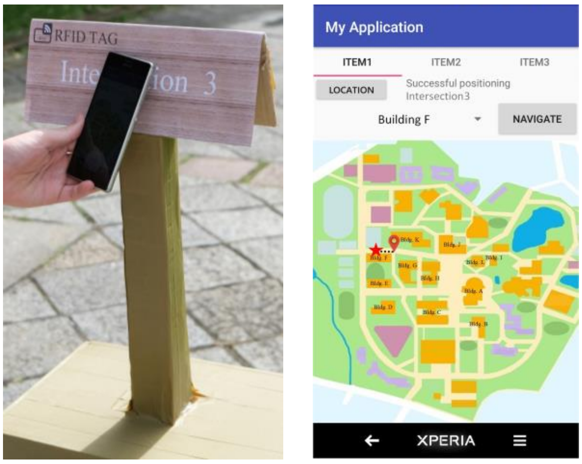
A scenario is set up for experimental demonstration as follows. In the experiment, we choose the Building A as the starting point and the Building F as the destination, respectively. So, a user is first going to the Building A and press the "LOCATION" button on the APP screen of the mobile device as shown in Fig. 9 (a). The third part of the screen will then show the place of the Building A with a mark of red-spot as depicted in Fig. 9 (b). Next, the person uses the scrolling destination list to choose the Building F and press the "NAVIGATE" button on the APP screen for generating the shortest path between the Building A and the Building F as depicted Fig. 9 (c). Here, the Building F as the destination is marked with read-star on the road map and the suggested navigation path is displayed by red-dot line.

When the user arrives at the Intersection 3, he does not know where he is. So, he puts the mobile device close to the tag and presses the "LOCATION" button on the APP screen to locate the position. After the reading is successful, the corresponding name of the current position will be displayed on the screen of the mobile device as depicted in Fig. 10. In addition, as depicted on Fig. 10 (b) the remaining navigation route is also shown on the APP screen.

Now, the user decides to change the destination from the Building F to the Building H. So, he repeats the same procedure to use the scrolling destination list to choose the Building H and press the "NAVIGATE" button. The new navigation path will then be created as shown in Fig. 11. Finally, when the user arrives at the Building H, he can press the "LOCATION" button on the APP screen to make sure the building is the right one for the desired destination as depicted in Fig. 12.

(a) (b) (c)

Fig. 9 Experiment result 1: (a) Actual situation, (b) APP interface in "LOCATION", and (c) APP interface in "NAVIGATE".

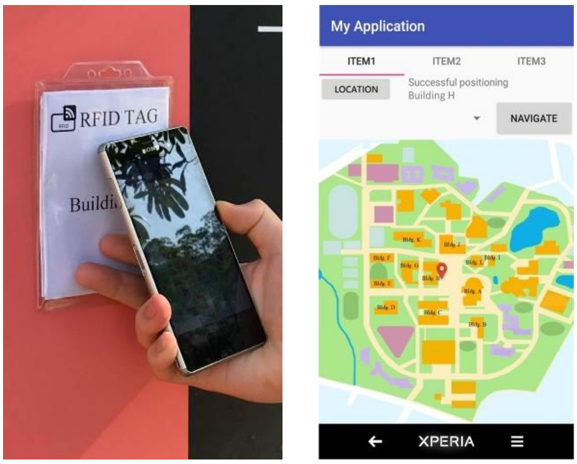


(a) (b)

Fig. 10 Experimental result 2: (a) actual situation, and (b) APP interface.

(a) (b)

Fig. 11 Experimental result 3: (a) actual situation, and (b) APP interface.



(a) (b)

Fig. 12 Experimental result 4: (a) actual situation, and (b) APP interface.

V. Conclusions

In this study, we have constructed an RFID-based personnel navigation platform for outdoor touring. The experimental results have demonstrated the success of the proposed design. Compared with the Google-map based navigation scheme, the proposed platform can provide real time trip guidance. In addition, the proposed design is simple, cheap and easy for practical implementation.

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