Human Tracking in Certain Indoor and Outdoor Area by Combining the use of RFID and GPS

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***Abstract*- A similar research experiment on the use of global positioning system (GPS) had successfully been published in 2014 [1]. In this paper, the research was continued by combining radio-frequency identification (RFID) and GPS in order to get better human tracking in both indoor and outdoor area. For indoor tracking, an RFID tag was carried by a user and continually read whenever he/she accessed a room while GPS was used mainly when the user was staying outdoor. GPS would be automatically activated whenever the user leaved the room 3 meters away. The accuracy of this tracking was 100% and the GPS could allocate the user every 3.27 meters. Thus this application is suitable to track the human position for both indoor and outdoor.**

Keywords— GPS, RFID, ADB, raspberry pi, human tracking.

I. INTRODUCTION

In 2014, a human tracking research was carried out to allocate a person in an outdoor area by the use of GPS [1]. The research result was not satisfying since the displacement error was 4 meters far and shorter than it was expected. The main purpose of the previous research was to identify children who sometimes got lost in a theme park or an outdoor sport center. The research was carried in a certain closed area; a building which is mainly used for big sport event, in Jakarta.

In this research, we tried to improve the previous experiment by combining the use of GPS [2] and RFID [3] which were installed in a smartphone. For indoor area, an RFID reader was installed in each room and the user should tap his/her RFID tag in order to be identified. However, GPS would automatically identify the position of the user whenever he/she left the room. Both GPS and RFID would work simultaneously [4] to track the position of the user. The system was developed as a real time system. Further discussion on the performance of the system would be explained in detail later on.

II. SYSTEM DESIGNS

The system design for this experiment can be seen in figure 1 where we used RFID for indoor tracking and GPS for outdoor tracking. A passive RFID tag was used and a user should tap the RFID tag to the reader whenever he/she entered the room. User ID (UID) would be verified online through database server as soon as the user tapped the RFID tag to its reader. Data from GPS input was provided by Google via its application, Google Maps© [5] while transmission and receiver equipment was using smarthphone [6].

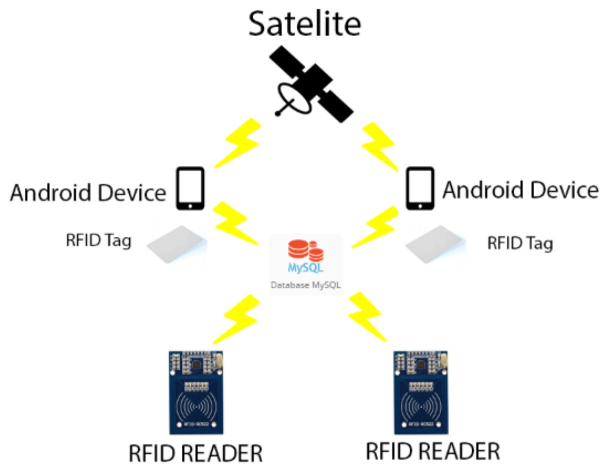


Figure 1: System design.

When the user tapped his/her RFID tag to the reader, UID would be validated by a database server. When it was valid, the RFID would display the position of the user in a smartphone. When the user got out from the room 3 meters away, the RFID would be off and GPS would automatically trace the position of the user.

The smartphone used was Samsung Galaxy Note III and LG Nexus 5 while for microcontroller Raspberry Pi 2 B [7] for RFID controller was used. The selection of smartphone was basically due to its operating system where both smartphones could support Android Debug Bridge (ADB) Integration [8]. The selection of B model due to its availability of 40 pins General Purpose Input Output (GPIO) [9]. This GPIO would do faster transmission from RFID reader to the database server during UID verification. The distance allowed between RFID tag and RFID reader was 50 mm, since we used passive tag in the form of card or key chain. Nevertheless, the distance could be improved if we used an active tag.

Figure 2 shows both flowcharts for RFID and GPS respectively. RFID reader would always be in the standby position until it detected any tapping from an RFID tag. When there was a tapping process, RFID reader would read the UID and sent to a database server for verification. Once the verification was valid, the RFID reader would send the access time and position of the user to the database server. The similar process also happened for GPS. Coordinate of user's location would be sent to a database server when the user approved to track the position.

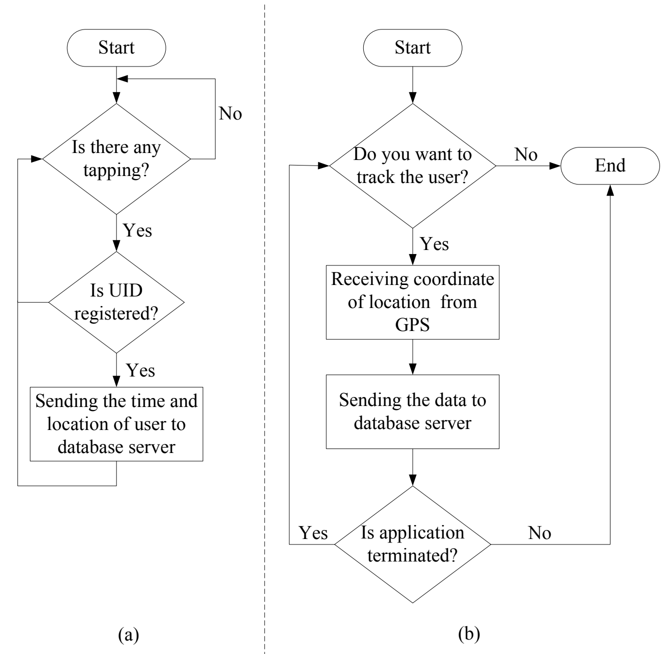


Figure 2: Flowchart for (a) RFID and (b) GPS.

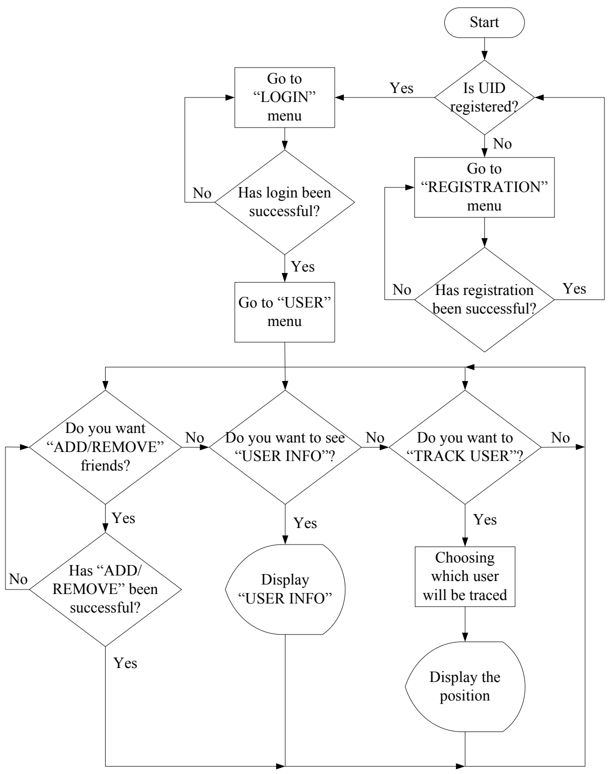


Figure 4: The flowchart of the whole system.

Figure 3 shows the flowchart of the whole system where when both GPS and RFID status were zero, the program would keep on running until either or both of them received signal to be identified or verified. When GPS status was 1 and RFID status was 0, the user would receive a map from a provider used (in this case, Google was used). However, when GPS status was 0 and RFID status was 1, the program would validate the UID before finally it sent the time and position of the user. If both statuses were 1 then the system would choose RFID condition to run.

The whole experiment was done at Bina Nusantara University – Syahdan campus as shown in figure 4 with the scale of 1:720 meters. Base on this scale, we converted the position from Google Maps© into X and Y coordinates where X was latitude and Y was longitude. The indication of each X and Y positions is as follows: position *a* was 6.2, 106.7859; position *b* was 6.2, 106.7849; position *c* was 6.19, 106.7850; and position *d* was 6.19, 106.7858.

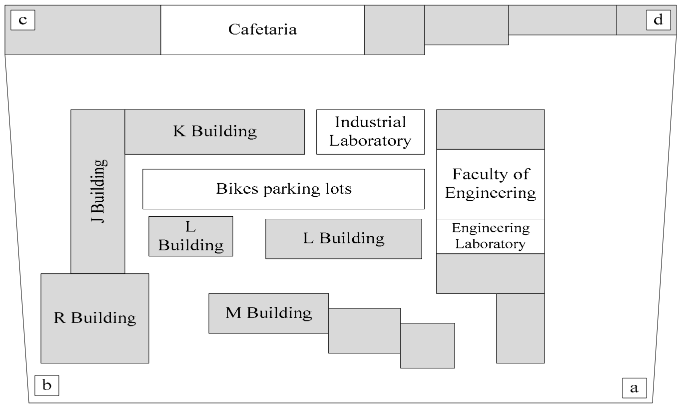


Figure 4: The area where the experiment was carried out.

From this reading, we determined the pixel length of the map for 2144 pixels X 1465 pixels. In order to get the position of the user, we calculated as $(x_a - x_{user}) \times 2144$ for X position and $(y_a - y_{user}) \times 1465$ for Y position. The results was converted into X and Y position in BINUS Application Map which we designed in a smartphone. The screen layouts from smartphone can be seen in figure 5.

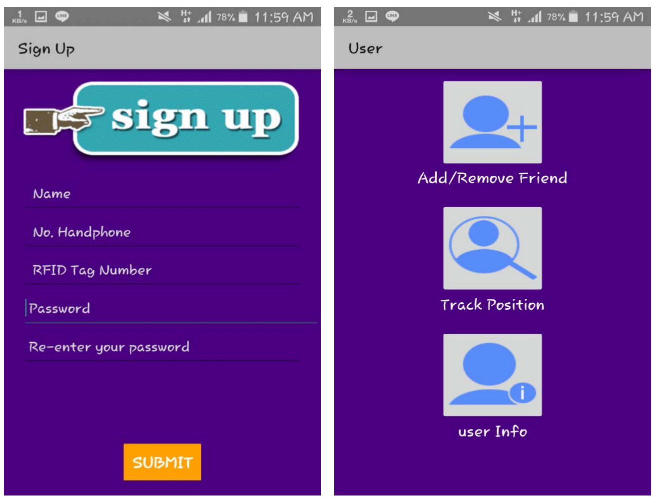
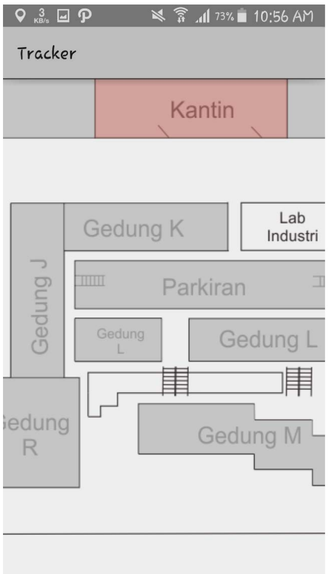


Figure 5: Screen layouts in smartphone.

III. RESULTS AND DISCUSSION

When we developed BINUS Application Map, we used Indonesian language for easiness. Therefore, in several pictures below all words are in Bahasa Indonesia. We tried to allocate one of the users who went to cafeteria and it is successfully shown in figure 6; the screenshot of human tracking. Figure 7 shows when he was in the outdoor area.



in figure 6, User was indicated in the cafeteria. “Kantin” means cafeteria, “Gedung” means building, “Lab Industri” means Industrial Laboratory, and “Parkiran” means bikes parking lots.

In Figure 7, the user was outside the building. “Ruang Fakultas Teknik” means Faculty of Engineering ad “Lab. Fak. Teknik” means Engineering Laboratory.

The blue dot resembled the user who was moving outdoor area and the pink one from indoor area indicated that the user was inside the building in a specific room. Whenever the user left the room, it was suggested the user tap the RFID reader as well as when he entered the room. Nevertheless, if the user forgot to do so, the GPS would automatically activate it as the user was away 3 meters far from the building.

We also tried to calculate the displacement of the user’s exact position. The comparison was between screen display and the real position. We calculated where

$$\frac{pixel\ position\ in\ map}{width\ of\ the\ building\ in\ map} \times the\ real\ width\ of\ the\ building$$

When we measured the R building for 20 m long, we got the movement of each pixels as follows:

$$\frac{1\ pixel}{199\ pixels} \times 20\ meters = 0.168\ meters$$

In order to get the movement of the object was by comparing between the pixels movement and the real movement of the user according to

$$real\ position - (length\ of\ pixel\ movement\ \times 0.168)$$

For this experiment we found that the first movement by the user was 201 pixels or as equal as 35,040 cm, thus

$$35040 - (201 \times 0.168) = 1.258$$

Table 1 shows displacement between the real position and the position which was shown in BINUS Application Map. We found out that the displacement was about 3.26 meters which was almost similar to the previous experiment [1].

Table 1 shows displacement between the real positions and as shown in BINUS Application Map.

Length of the map area in meters	Length of the real area in meters	Displacement in meters
42.33333	48	5.66667
51.66666667	56	4.333333
33.78151122	35.04	1.258489
28.66666724	24	4.666667
19.33333372	21	1.666666
35.83333405	27	3.333334
14.00000003	16	2
6.6666668	8	1.333333
22.1666711	16	6.166671
19.00000038	20	1
6.16666667	8	1.833333
Average		3.257653

Table 1: Displacement between the real positions

More or less, the displacement is likely due to the less precision between the real map and the BINUS application one designed. However, this application is satisfying to show the position trace as it is expected.

IV. CONCLUSION

From two experiments, we found that the displacement from GPS reading with the real position in field was merely similar either for indoor application [1] or outdoor application as in this paper. However, by adding the RFID identification for indoor tracking position, the application became more powerful since it was easier for users to allocate the person whom he/she liked to find. Thus, this application is quite suitable for children tracking position in the theme park or sport center. In the future research, the author suggest adding ip camera in each indoor area. This additional will give visualization to the tracker and add more complexity in integrating the system. More maps are suggested to be added to the application so that the application can be used in several locations.

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