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Indoor navigation application using augmented reality technology

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ABSTRACT

Modelling indoor and outdoor areas and designing navigation applications based on the created models has been one of the most preferred working areas of geomatics engineers in the last 20 years. Navigation applications that answer the question of how to get there have now become an indispensable part of human life. While the Global Navigation Satellite System (GNSS) provides sufficient solutions for tracking the location of users in outdoor navigation applications, it is not a suitable solution due to signal interruptions in indoor areas. For this reason, researchers have developed different alternative methods to obtain and track the location information of users indoors. However, these methods have limitations such as the need for additional hardware and high cost. This study aims to develop an indoor navigation application for Android-based smartphones using Augmented Reality technology without the need for any additional equipment for user location tracking.

1. INTRODUCTION

In recent years, people spend most of their time in indoor areas such as university buildings, shopping malls and hospitals. The complexity of these areas causes people who have to reach their destination to prefer using navigation tools (Wang 2009). Maps and map-based navigation applications that can be understood by most people regardless of language and culture are tools that help navigate users in an unfamiliar area (Mistry 2008). Most navigation applications use the global navigation satellite system (GNSS) to determine both user and target locations. While GNSS can provide a good solution in outdoor areas, it is not suitable for indoor positioning and navigation applications due to the weakening of GNSS signals in indoor areas and no signal in some areas (Farid 2013; Kim 2004; Rehman 2016; Dardari 2015). Many indoor applications to obtain device positions utilize wi-fi fingerprinting, wireless local area network (WLAN), bluetooth low energy (BLE), radio frequency identification (RFID), ultra-wideband (UWB), inertial sensors, computer vision, hybrid technologies and techniques (Dardari 2015; DiVerdi 2008; Liu 2007; Werner 2001; Chen 2017).

Also, navigation applications use a background map to guide users. This background provides users to match real-world objects with the map symbols. The matching process sometimes can be a challenging task for the map users. Today augmented reality (AR) technology is used to overcome this challenge and increase the interaction between the user and the map interface (Tatzgern 2011). AR systems expand users' visual and auditory perceptions of their environment by enriching the real environment with information generated in the computer environment (Patron 2005; Huey 2011). The users do not need to establish a connection between maps and the real environment as in conventional navigation applications, and thus they can use navigation more interactively and immersively (Vogl 2009; Guzmán 2014). This study focuses on the use of AR technology in indoor navigation. In this context, an indoor navigation application using AR technology was developed with a mobile device with basic equipment suitable for today's technology and accuracy analysis was performed for location tracking accuracy.

2. METHOD

2.1. Study Area

This study was developed for the entrance floor of the Faculty of Architecture located in the South Campus

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of the Karlsruhe Institute of Technology. The floor plan of the study area is shown in Fig 1.

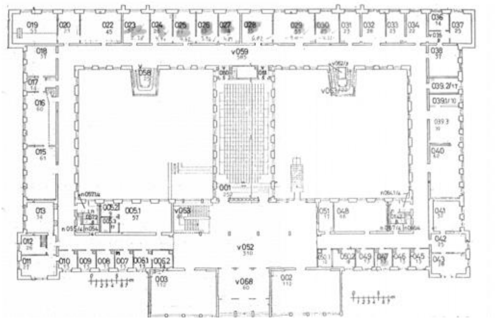

Figure 1. The study area

2.1. Hardware

In this study, the Samsung Galaxy Note 9 device with Google ARCore support was used as a test device and the technical features of the device were given in Table 1.

Table 1. Technical features of the Samsung Galaxy Note 9

Processor	Samsung Exynos 9810
Memory	6 GB RAM
Camera	12 MP, f/1.5-2.4, 26mm
Sensors	Accelerometer, Gyro, Compass, Barometer
Screen Size and Resolution	6.4 inches – 1440x2960
Operating System	Android 8.1

The technical features of the device such as processor, RAM, camera, sensors, and version of the operating system are convenient and efficient both in tracking user's positions and directions, as well as the processing and viewing auxiliary guidance arrows. The most important hardware of a mobile device is the processor that provides the connection between other hardware. A mobile phone camera is used to detect the real environment. A user's location and orientation can be tracked by combining visual information detected from the real environment and sensor data. The screens allow the user to communicate with the application. The device must be running Android 7.0 or newer for using Google ARCore.

2.1. Software

The mobile application, which uses augmented reality technology to help users navigate indoors, was developed on the Unity 3D platform, using the ARCore software development tool and the C# programming language. Google's ARCore is a software development tool that use to track the location of the mobile device. It detects visually different perceptible points called point of interest in the environment with the camera image of the mobile device, and can combine this visual information with the data from the mobile device's sensors to track users. With the mobile device's camera and sensors, ARCore uses a hybrid-based tracking technique, using a combination of computer vision and sensor-based tracking systems.

The interface design of the application was carried out using the Unity 3D development engine and the C# programming language supported by this platform. Unity 3D development engine has wide ease of use and provides library support and a hybrid-based development platform to programmers. The user interface of the application developed is shown in Fig. 2.

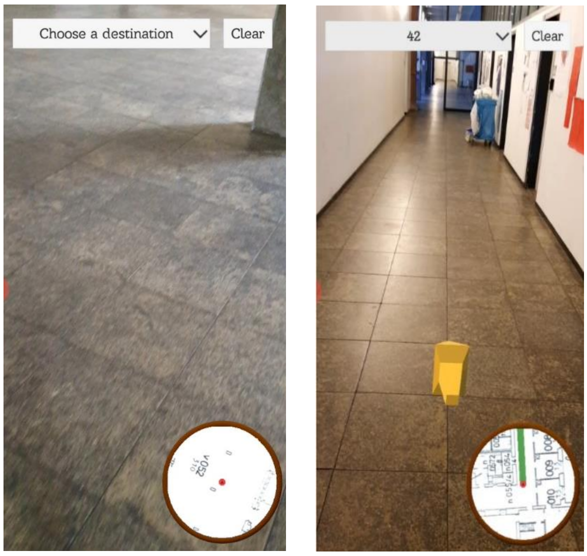

Figure 2. Left: The user interface. Right: Display of the auxiliary arrow used in guiding the user in real environment

While designing the interface, it has been prioritized that the users can use it in the most comfortable and easy way. Therefore, there are only 2 buttons in the application where users can select the location they want to go and delete this selection. In addition to these 2 buttons, there is a mini map where the users can follow their position on the floor plan. As seen in the image on the right of Figure 1, after the user determines the target point, the shortest path is calculated and the path the user will go on the floor plan is shown. In addition to this display, guiding arrows created as the main element in directing the users are displayed on the camera images of the users by using AR technology. Thus, the user does not have to establish a connection between the real world and the application as in classical navigation applications.

3. RESULTS

In order to evaluate the developed system, five test routes with different navigation distances starting from a certain fixed point and ending with the return to that fixed point were determined and a total of six separate walks were performed in these test routes and local position information was recorded on the mobile device. Then, at the end of the walks, the position of the starting point calculated by the application and the actual position value was compared, and the position accuracy was calculated. The position accuracy of the system for different navigation distances are shown in Table 2.

Table 2. Relationship between distance and position accuracy

Navigation Distance (m)	Position Accuracy (m)
34	0.1092
36	0.0397
66	0.5459
80	0.7307
220	4.3877
220	3.4066

According to Table 2, the application has sufficient accuracy at short navigation distances without the need for additional equipment. However, as a result of the 220-meter navigation distance, it was observed that an average error of 3.86 m occurred. The tracking accuracy curve created using the navigation distance and position accuracy shown in Table 2 is shown in Fig. 3.

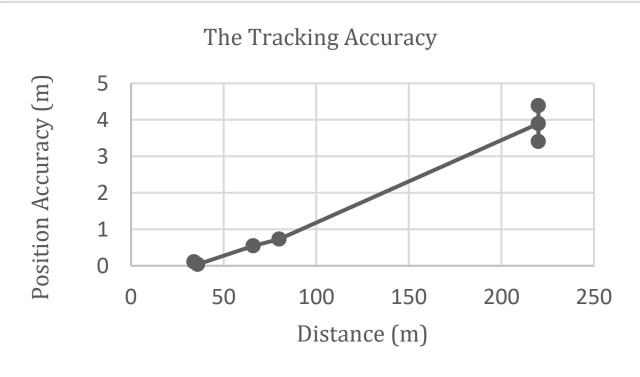

Figure 3. The tracking accuracy

The graph shows that the location accuracy of the system is within one meter until the navigation distance is approximately 100 m.

4. DISCUSSION

In this study, a hybrid-based tracking method using phone sensors and computer vision-based tracking methods together was used. With this system, low-cost user tracking was performed without the need for additional equipment. Accuracy analysis of the system was made according to different walking distances, and as a result of this analysis, it was seen that the system did not give good results after 100 meters and gave good results up to 100 meters. It can be said that one reason for this result is that in some parts of the corridors inside the building, the patterns on the floor continue the same and there are long white walls. Because it has been observed that the location tracking was stopping from time to time since sufficient points of interest for location calculation could not be detected in these areas. Another reason can be said to be the drift effects that may occur in the long-distance tracking of the phone sensors.

In order to improve system performance, location can be updated using a marker at 100m, where position accuracy is rapidly increasing. In addition, more realistic results should be obtained by using more data sets to determine the location accuracy.

5. CONCLUSION

In this study, we examined the effectiveness of indoor navigation application with AR technology. In order to determine the accuracy of the system, the position accuracy resulting from different navigation distances was calculated. According to the position accuracy, it was concluded that users can be tracked without the need for additional equipment. However, it is possible for the accuracy analysis results to change with the change of the test area and the change in the perceptible point of interest in the environment. Therefore, in our future research, it is planned to evaluate the performance of the system by using more data sets and for a different Indoor area. Besides the accuracy analysis of the system, the contribution of augmented reality technology to navigation applications will be researched further, considering the evaluation of user-application performance measurements, including navigation time, ease of use, and user satisfaction.

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REFERENCES

Chen A T Y, Fan J, Biglari-Abhari M, Kevin I, & Wang K (2017). A computationally efficient pipeline for camera-based indoor person tracking. International Conference on Image and Vision Computing New Zealand (IVCNZ), 1-6, Christchurch, New Zealand.

Dardari D, Closas P, & Djurić P M (2015). Indoor tracking: Theory, methods, and technologies. IEEE Transactions on Vehicular Technology, 64(4), 1263-1278.

DiVerdi S, & Höllerer T (2008). Heads up and camera down: A vision-based tracking modality for mobile mixed reality. IEEE Transactions on visualization and computer graphics, 14(3), 500-512.

Farid Z, Nordin R, & Ismail M (2013). Recent advances in wireless indoor localization techniques and system Journal of Computer Networks and Communications, 1-12, https://doi.org/10.1155/2013/185138.

Guzmán Guzmán, J D (2014) Augmented Reality user interface analysis in mobile devices. MS Thesis, Polytechnic University of Catalonia, Barcelona.

Huey L C, Sebasian P, & Drieberg M (2011). Augmented Reality based indoor positioning navigation tool. In IEEE Conference on Open Systems, 256-260, Langkawi, Malaysia.

Kim J W, Jang H J, Hwang D H, & Park C (2004). A step, stride and heading determination for the pedestrian navigation system. Journal of Global Positioning Systems, 3(1-2), 273-279.

Liu H, Darabi H, Banerjee P, & Liu J (2007). Survey of wireless indoor positioning techniques and systems. IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews), 37(6), 1067-1080.

Mistry P, Kuroki T, & Chang C (2008). TaPuMa: tangible public map for information acquirement through the things we carry. In Proceedings of the 1st international conference on Ambient media and systems,1-5, Brussels, Belgium.

Patron C (2005) The concept for the use of augmented reality in assembly planning. PhD Thesis, Technical University of Munich, Munich (in German).

Rehman U, & Cao S (2016). Augmented-reality-based indoor navigation: A comparative analysis of handheld devices versus google glass. IEEE Transactions on Human-Machine Systems, 47(1), 140-151.

Tatzgern M, Kalkofen D, Grasset R, & Schmalstieg D (2011). Embedded virtual views for augmented reality navigation. In Proc. Int. Symp. Mixed Augmented Reality-Workshop Vis. Mixed Reality Environ., 115-123, Basel, Switzerland.

Vogl W (2009) Eine interaktive räumliche Benutzerschnittstelle für die Programmierung Von Industrierobotern. Herbert Utz Verlag. ISBN:3-83160-869-5

Wang P P, Wang T, Ding D, Zhang Y, Bi W, & Bao Y (2009). Mirror world navigation for mobile users based on augmented reality. In Proceedings of the 17th ACM international conference on Multimedia,1025-1026, Beijing, China.

Werner M, Kessel M, & Marouane C (2011). Indoor positioning using smartphone camera. International Conference on Indoor Positioning and Indoor Navigation, 1-6, Guimarães, Portugal.