Indoor Navigation Application in Shopping Mall Based on Augmented Reality (AR)

Aekarat Saeliw, Watcharasuda Hualkasin, Supattra Puttinaovarat

Faculty of Science and Industrial Technology, Prince of Songkla University, Surat Thani Campus, Surat Thani, Thailand

Abstract **– The amount and frequency of shopping in department stores reduce due to COVID-19 outbreak all over the world. Thus, consumers have to give precedence to planning to go shopping in department stores in order to reduce social interaction time so as to reduce the risk of COVID-19 infection. This research introduced the development of an application prototype for product location search based on augmented reality (AR) for facilitating customers to search for desirable products with no need to ask salespersons and no need to go for product search on their own. Besides, the introduced application could also present statistical data related to behavior and interest in shopping. Organizations can use the data to make plans for decision making on selling, and to use it as a supportive tool to increase their competitiveness.**

Keywords **–augmented reality, indoor navigation, shopping mall, mobile application.**

1. Introduction

Selling in department stores all over the world requires adaptation, particularly in the world that the technology of the Internet and smartphones plays the key roles for people of all ages [1], [2].

DOI: 10.18421/TEM113-17
https://doi.org/10.18421/TEM113-17

Corresponding author: Supattra Puttinaovarat,
Affiliation Faculty of Science and Industrial Technology, Prince of Songkla University, Surat Thani Campus, Thailand
Email: supattra.p@psu.ac.th

Received: 26 April 2022.
Revised: 31 July 2022.
Accepted: 04 August 2022.
Published: 29 August 2022.

Also, the world currently deals with COVID-19 outbreak [3], [4]. These have changed traditional way of life among consumers from shopping in department stores as a style of travel, to online services instead, along with going shopping in department stores sometimes but with lower frequency. Moreover, consumers also spend less time going shopping because they are aware of social distancing, prevention, and reduce the risk of COVID-19 infection for each individual consumer. One of the problems of shopping in department stores is spending time searching product spots or product location, resulting in more time for consumers, particularly in large department stores or those where consumers have never been to. However, current advanced technology provides several approaches, i.e., augmented reality (AR) [5], [6], global positioning system (GPS) [7], [8], and indoor map navigation [9], to help reducing the limitation in term of durations to search for product locations in department stores. To clarify, mobile applications are developed as a tool to support planning for going shopping. According to the review of related literatures and research, it was found that several applications have been developed to support online and on-site selling [11], [12], [13], [14], [15], [16], [17]. However, those applications still contains some limitations, i.e., they are unable to search for locations or navigate [11], [12], [14], and unable to record the data of searching for each type of products [16].

Thus, this research introduced the development of an application prototype for product location search based on AR, GIS, and GPS so that consumers can use the developed mobile application to search for product information in order to plan and navigate them. This can reduce shopping time in department stores. A web application was also developed to present any statistical data that can be used to plan selling for organizations or department stores in several aspects, e.g., product types under consumer interest in each period, popular departments, and consumer types/groups. The data can be used for further analysis, prediction, and planning their selling efficiently.

2. Related Work

According to the review of literatures and research related to the use of AR, it was found that AR is currently used in several aspects, i.e., navigation application development [18], [19] [20], [21], [22] for tourism [23], [24], education or learning [25], marketing [26], [10], product presentation, and product search [11], [12], [13], [14], [15], [16], [17]. The details of the review of related literatures and research are as follows.

According to the research related to the use of AR for application development to present selling or to search for products that consumers need, it was found that mobile application development was suggested for product presentation in groceries. Safe products were presented based on AR. Consumers could use the application to search for locations of products on shelves. Health parameters could be set, namely, food that did not contain allergens or undesirable ingredients such, e.g., products that did not contain beans, milk, and eggs; low-calorie products; and low-sodium products. According to the study, it was found that the limitations of this application were that users have to search for product shelf only. It did not focus on product location search from remote distance [11]. This conformed to the use of AR for mobile application development to present products online. Consumers could select products in accordance with health conditions as desired with no need to go to select products on their own [12].

AR was used to help selling for retails shops in several platforms, i.e., mobile application development to help selling by GPS analysis in order to study consumer behaviour when going shopping. The results obtained were used as data for product presentation that met the need of each individual user, i.e., product presentation in 3D, product scanning in each shelf, and pop-ups of product details with no need to read descriptions on packages [13]. A mobile application was developed to promote local food in Indonesia based on AR in order to make the recommended menus more attractive. However, this mobile application did not support navigation to restaurants. Thus, the limitation for use still remained [14]. A mobile application development for fashion product development based on AR was also suggested. Users could simulate product visualization based on AR, e.g., simulation of wearing shoes or watches. This made product presentation more attractive [15].

According to the research related to the use of AR for selling in supermarkets, it was found that a mobile application was developed to search for product locations and to present product details. This could navigate consumers to the shelf of each product type. Besides, consumers could read product information with no need to touch products in order to facilitate consumers. However, the limitation of this research was that no statistics of product search were collected for each product type. Thus, the application could not be used for further analysis or used as supporting data for decision making [16]. There was also the study on the use of AR and virtual reality (VR) for application development for product presentation in retail shops. The results revealed that there were approaches for service efficiency improvement of online and on-site selling [17].

According to the research related to the use of AR for navigation, it was found that there was application development for indoor navigation and outdoor navigation [18], [19]. Most outdoor navigation applications were usually developed with GPS, Google Map, and API for navigation to tourist attractions [23], [24] or navigation in government agencies, e.g., university [18], [19]. Most indoor navigation applications mainly focused on operation in buildings, e.g., department stores [16] and university classrooms [10]. According to the study, it was found that the use of AR with GPS and GIS made the presented data more attractive, and could motivate users to use the applications more.

3. Methodology

This research introduced the development of an application prototype for product location search based on AR, GIS, and GPS. The conceptual framework is displayed in Figure 1. According to the figure, it was found that there were 3 groups of users, i.e., customers, managers, and administrators. Customers could use the system through the mobile application. Administrators and managers could use the system through the mobile application and web application. For the development of the application in this research, several types of hardware and software were used, i.e., a microcomputer as a server (Web server and Database server). For AR development, Unity3D and Vuforia were used. As for the details of other types of hardware and software, they are displayed in Table 1.

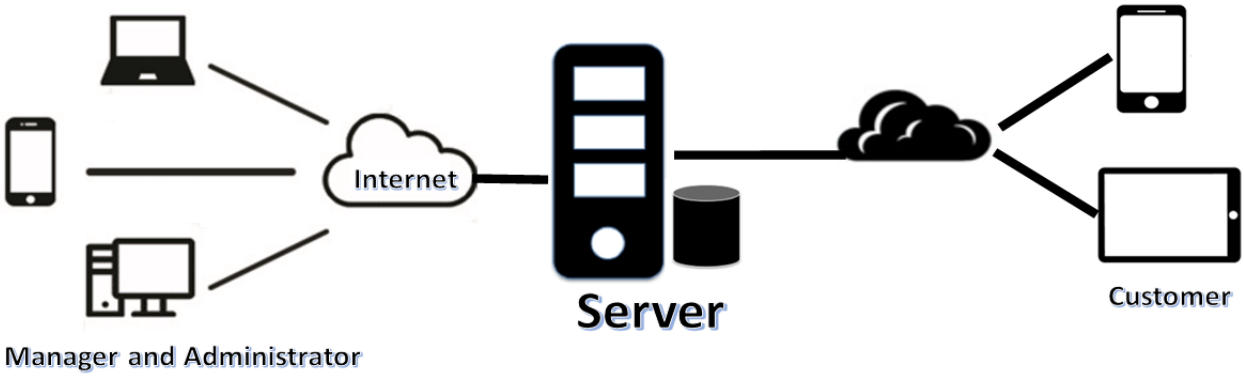

Figure 1. Purpose conceptual framework

Table 1. Hardware and software specification

Topic	Client	Server
Hardware	Microcomputer Mobile devices	Microcomputer
Software	Android Web browser	Windows 10 Android Studio Unity3D Vuforia Apache MySQL
Network	4G/5G/Wi-Fi	Broadband

For system analysis and design in this research, the users were divided into 3 groups, i.e., customers, administrators, and managers. Each group of the users were permitted to access the system differently, as in Figure 2. The use of case diagram from customers could help searching for product locations in the 2 platforms, i.e., product-based and department-based search. This part of application could navigate customers based on AR, GIS, and GPS. Administrators could manipulate different data, i.e., department data, product data, and marker data. Managers could view reports that displayed statistics, e.g., product types that could catch attention from the users and from target departments.

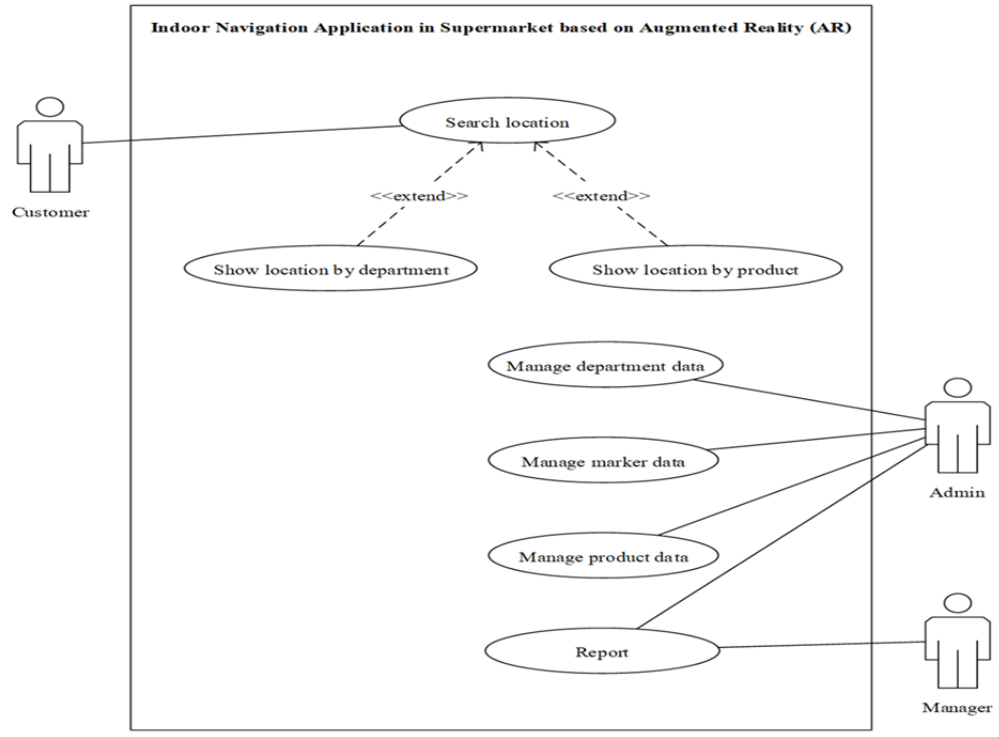

Figure 2. Use case diagram

This research presented class diagrams displaying operation of customers and administrators, along with the relationship with other sub-systems in Figure 3 and 4.

In addition, customers could use the mobile application to search for product locations or departments. The example of the operational process is displayed in Figure 5: Activity diagram. According to the figure, customers could use menus as desired, e.g., department search. Then, the system would bring the names of target departments for their locations and users' locations. Next, the system would display the results of the details of locations and navigation based on AR through the mobile application.

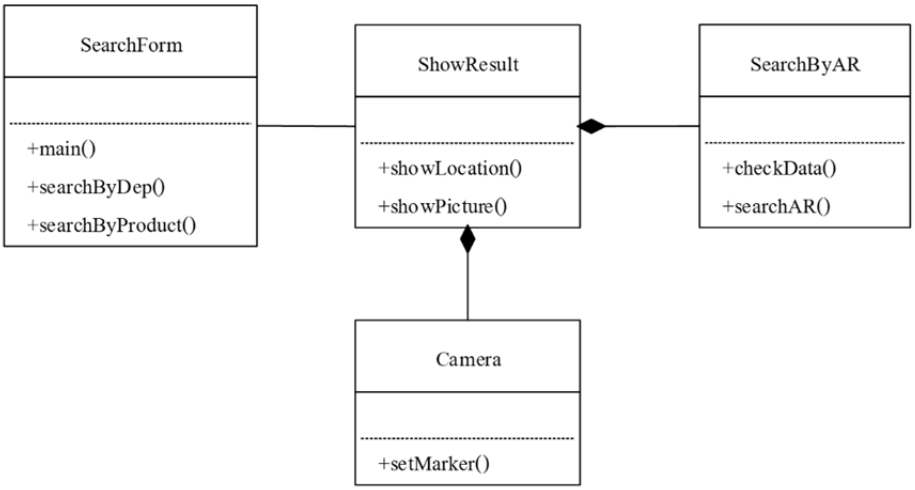

Figure 3. Class diagram for customer

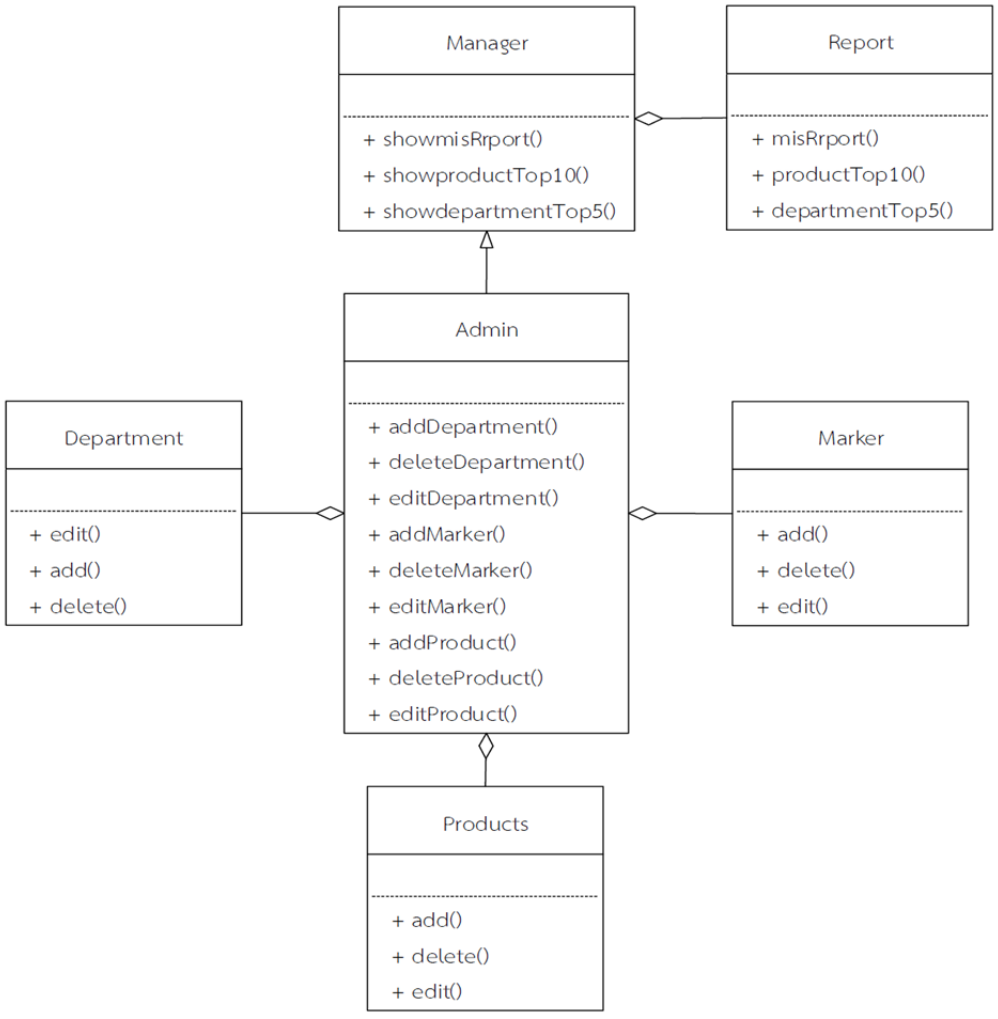

Figure. 4 Class diagram for administrator

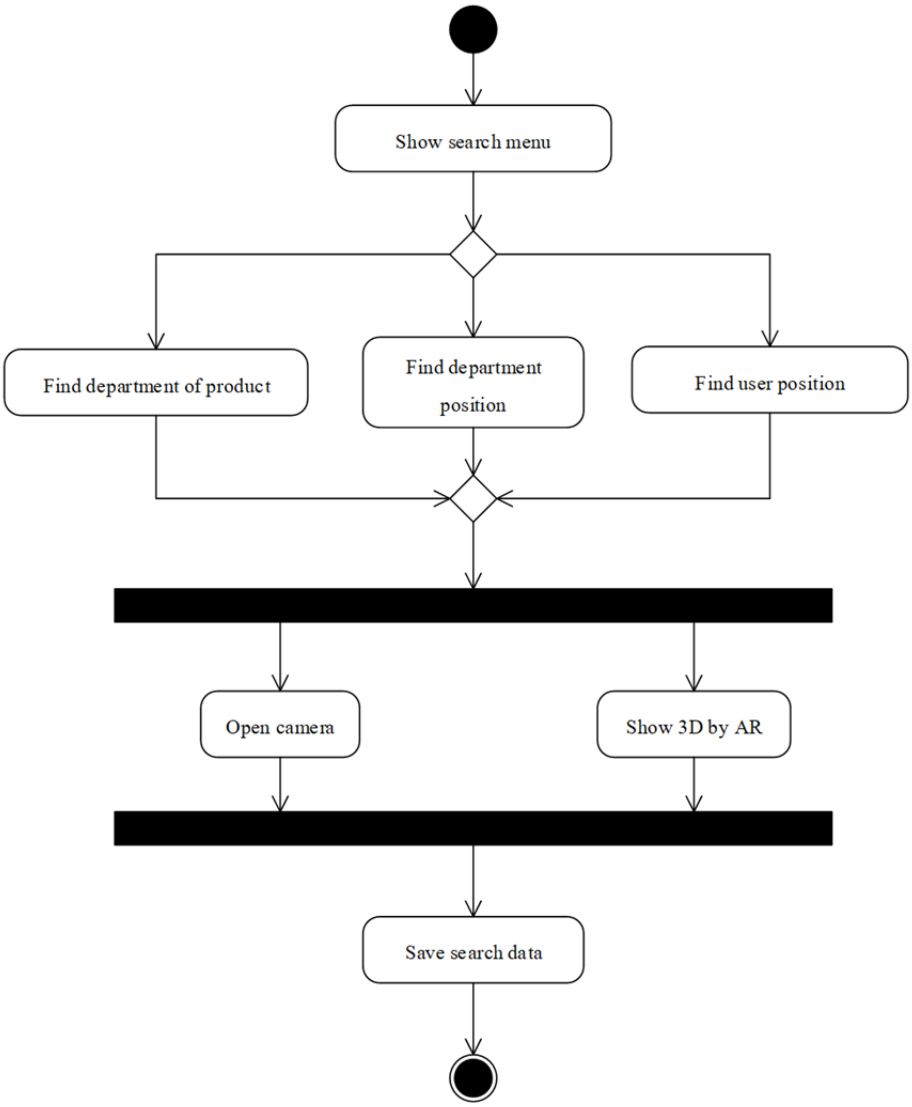

Figure 5. Activity diagram for search

4. Results and Discussion

In this research, the results were divided into 2 parts, i.e., the results of mobile application development and the results of web application development. Customers could use the system through the mobile application. Administrators and managers could use the system through the mobile application and the web application. The example of the mobile application is displayed in Figure 6 and 7. Figure 6 was the example of user interface for displaying the items in the menu of the target department store. The users could select target departments, including product types in order to acknowledge their locations so that the application could navigate. Figure 7 displays the example of AR user interface and the details of navigation based on AR, GIS, and GPS. According to the figure, it implied that the user would like to search for G2000 MAN outfits from his location (G Floor). However, G2000 MAN was actually on 2nd Floor. Thus, the data of the specified location of G2000 MAN was presented. In the meantime, the camera was also used to display the image of the user's location and where he walked past until it could detect the location that the user searched for. The use of AR could facilitate the users to go shopping more conveniently and more quickly with no need to search for products on their own or even to ask salespersons. Thus, the users and the department store would have the tool to facilitate and to increase the opportunity of selling.

The results of web application development are displayed in Figure 8 – 10, i.e., department data and their locations in attribute data, latitude, longitude, product data, location data, and QR code for markets to display the results of AR (Figure 10). Administrators could insert, edit, and delete these data, as per the adding form in Figure 11, and editing as well as deletion forms in Figure 12. The selected data could be edited by clicking on "pencil" icon, and could be deleted by clicking on "cross" icon.

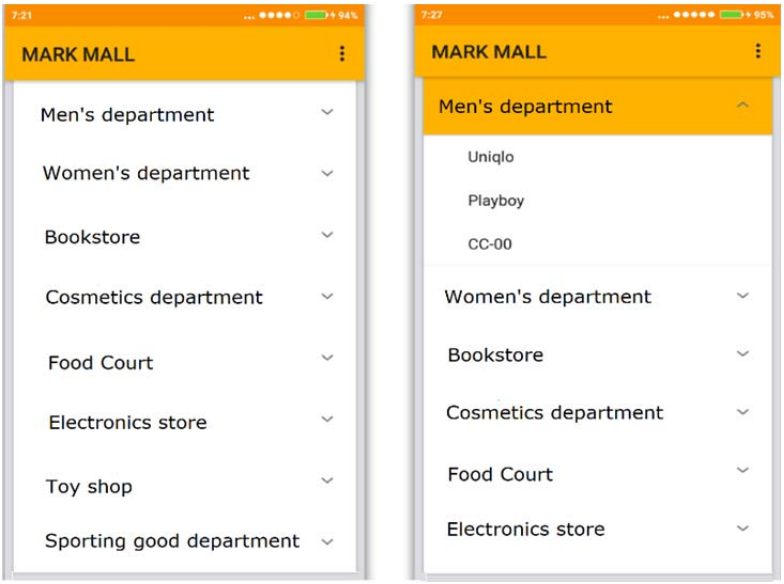

Figure 6. Mobile application

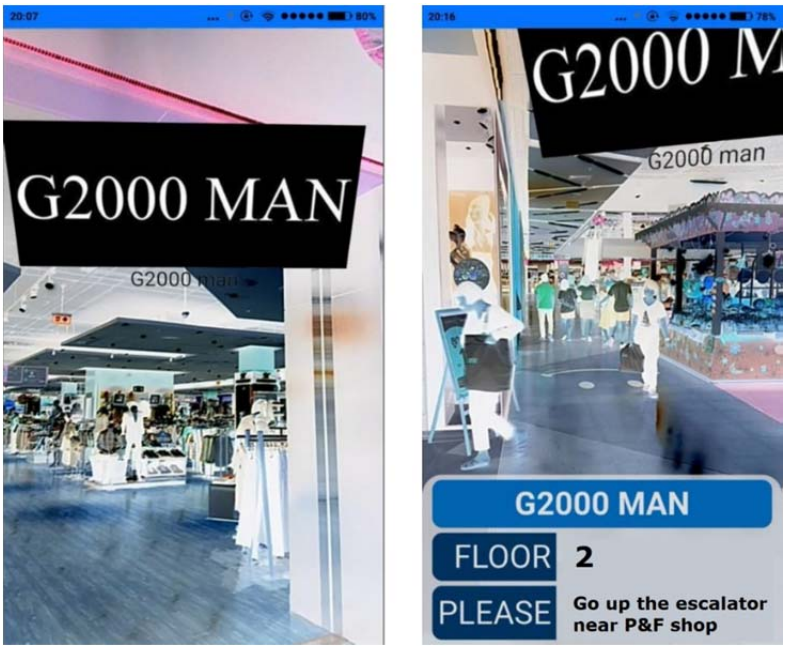

Figure 7. AR navigation mobile application

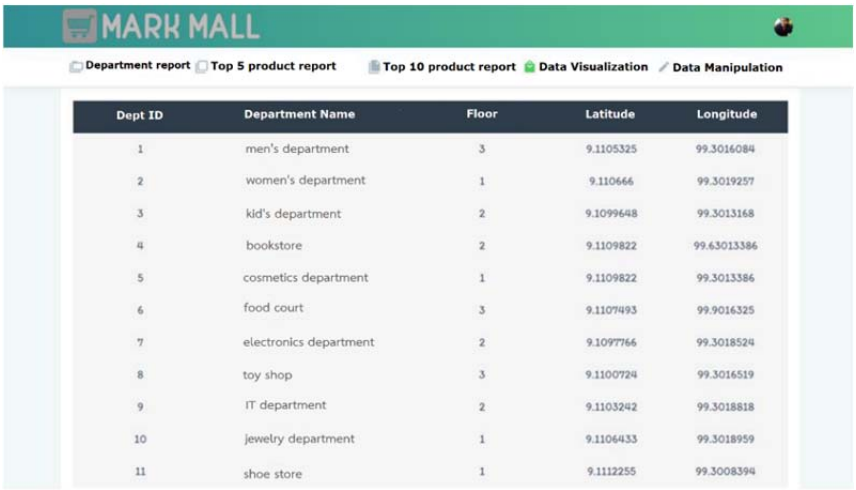

Figure 8. Web application interface of department data

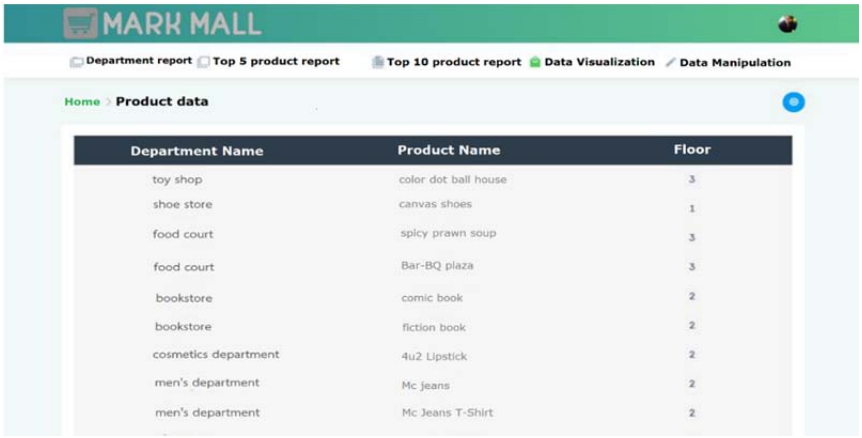

Figure 9. web application interface of product data

Figure 10. web application interface of QR code data

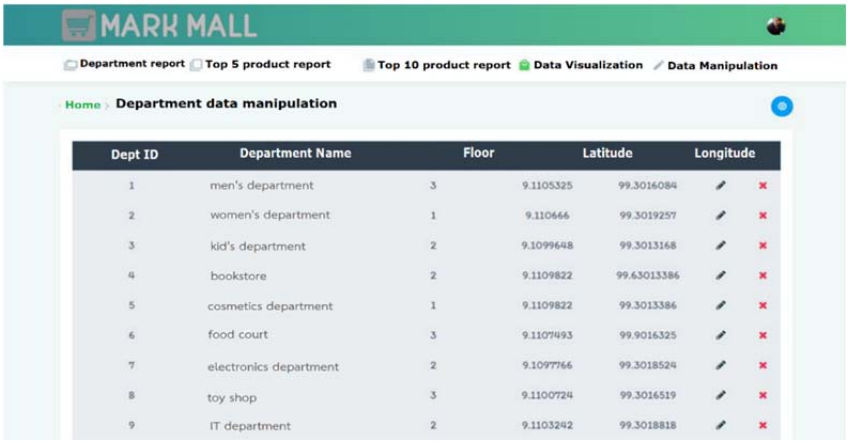

Figure 11. web application interface of data manipulation

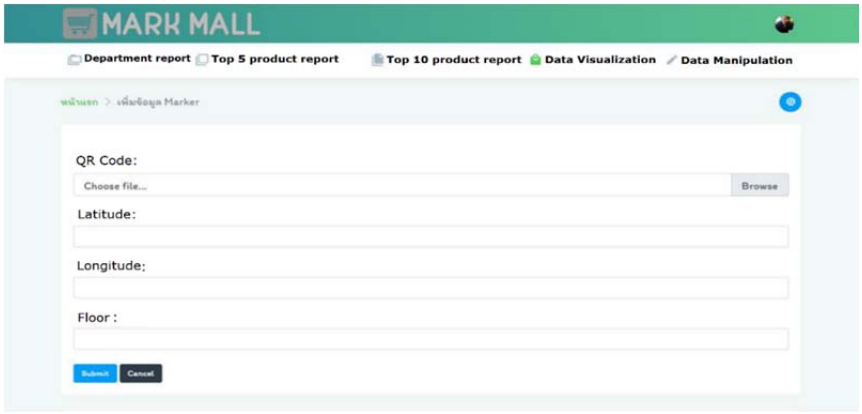

Figure 12. web application interface of input form

Other than these, the developed application could record consumer behavior toward the use of the mobile application in the database. The results were displayed in statistics, as in Figure 13, the examples of bar graphs for top-10 interested products (The top-10 products searched by users). Figure 14 displays the doughnut graphs of top-5 products to reveal the proportion of search in each department so that the difference of user interest in each department was acknowledged.

According to the results of the development of an application prototype for product location search based on AR, GIS, and GPS, customers had the tool for planning and navigating to the department store.

It could reduce time for product search or for asking salespersons. Managers could also use the system for analysis and reports of consumer behavior and interest in several product types. This could be used as supporting data for planning and decision making on product presentation. This research improved the limitations of the related works as per the review of literatures and research in different issues, i.e., location search and navigation [11], [12], [14]. The presented application in this research also includes statistic data collection of product search. Thus, the data can be analyzed further to support decision making, resulting in fewer limitations of the related works [16]; and can be applied to other business types.

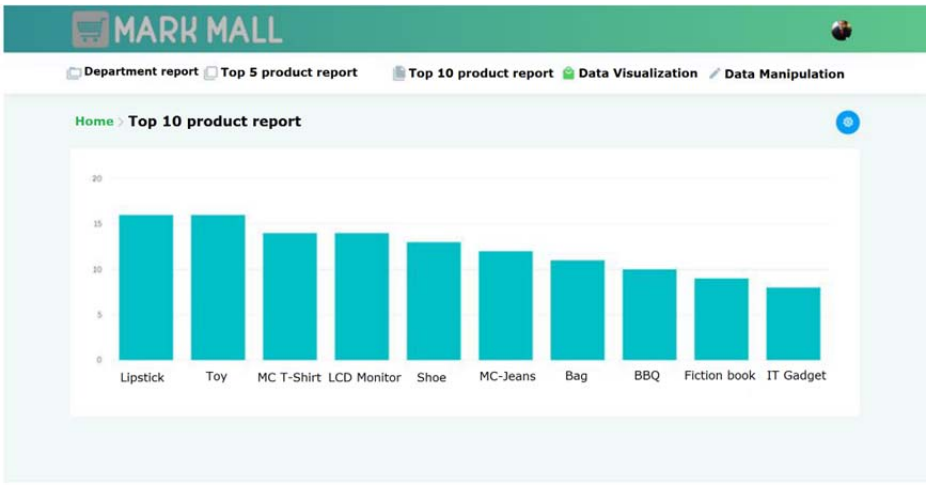

Figure 13. The examples of bar graphs for top-10 interested products

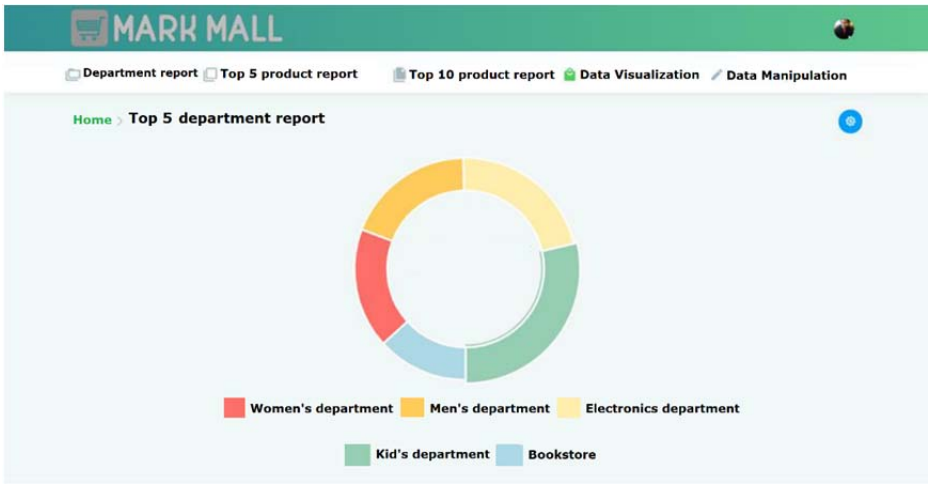

Figure 14. The doughnut graphs of top-5 department

5. Conclusion

According to the results of the development of an application prototype for product location search by the mobile application and the web application based on AR, GIS, and GPS, customers and organizations had the tool to support their planning and decision making. To clarify, customers could use the application to search for product locations in the department stores quickly. It also navigated to those locations accurately. Organizations could use the data for efficient decision making and planning to sell products. For the limitations of this research, the presented mobile application was compatible with Android only. Thus, future research should develop this mobile application to be compatible with iOS, too; or develop it in cross platform to support all users.

References

[1]. Kumar, S., Tiwari, P., & Zymbler, M. (2019). Internet of Things is a revolutionary approach for future technology enhancement: a review. *Journal of Big data*, *6*(1), 1-21.

[2]. Langley, D. J., van Doorn, J., Ng, I. C., Stieglitz, S., Lazovik, A., & Boonstra, A. (2021). The Internet of Everything: Smart things and their impact on business models. *Journal of Business Research*, *122*, 853-863.

[3]. Eriksson, N., & Stenius, M. (2022). Online grocery shoppers due to the Covid-19 pandemic-An analysis of demographic and household characteristics. *Procedia Computer Science*, *196*, 93-100.

[4]. Shen, H., Namdarpour, F., & Lin, J. (2022). Investigation of online grocery shopping and delivery preference before, during, and after COVID-19. *Transportation Research Interdisciplinary Perspectives*, *14*, 100580.

[5]. Riegler, A., Riener, A., & Holzmann, C. (2021). Augmented reality for future mobility: Insights from a literature review and hci workshop. *i-com*, *20*(3), 295-318.

[6]. Chan, H. H., Haerle, S. K., Daly, M. J., Zheng, J., Philp, L., Ferrari, M., ... & Irish, J. C. (2021). An integrated augmented reality surgical navigation platform using multi-modality imaging for guidance. *PloS One*, *16*(4), e0250558.

[7]. Hahm, Y., Yoon, H., & Choi, Y. (2019). The effect of built environments on the walking and shopping behaviors of pedestrians; A study with GPS experiment in Sinchon retail district in Seoul, South Korea. *Cities*, *89*, 1-13.

[8]. Puttinaovarat, S., Horkaew, P., Khaimook, K., & Polnigongit, W. (2015). Adaptive hydrological flow field modeling based on water body extraction and surface information. *Journal of Applied Remote Sensing*, *9*(1), 095041.

[9]. El-Sheimy, N., & Li, Y. (2021). Indoor navigation: State of the art and future trends. *Satellite Navigation*, *2*(1), 1-23.

[10]. Wedel, M., Bigné, E., & Zhang, J. (2020). Virtual and augmented reality: Advancing research in consumer marketing. *International Journal of Research in Marketing*, *37*(3), 443-465.

[11]. Ahn, J., Williamson, J., Gartrell, M., Han, R., Lv, Q., & Mishra, S. (2015). Supporting healthy grocery shopping via mobile augmented reality. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM)*, *12*(1s), 1-24.

[12]. Deshpande, M., Likhita, B., & Bhat, N. (2022). A Personalized Supermarket Product Recommendation System Using Augmented Reality. *ECS Transactions*, *107*(1), 915.

[13]. Kumar, P. A., & Murugavel, R. (2020). Prospects of Augmented Reality in Physical Stores's Using Shopping Assistance App. *Procedia Comput. Sci.*, *172*(1), 406-411.

[14]. Weking, A. N., & Santoso, A. J. (2020). A Development of Augmented Reality Mobile Application to Promote the Traditional Indonesian Food. *International Journal of Interactive Mobile Technologies*, *14*(9).

[15]. Abou El-Seoud, M. S., & Taj-Eddin, I. A. (2019). An Android Augmented Reality Application for Retail Fashion Shopping. *iJIM*, *13*(1), 5.

[16]. Jayananda, P. K. V., Seneviratne, D. H. D., Abeygunawardhana, P., Dodampege, L. N., & Lakshani, A. M. B. (2018, December). Augmented Reality Based Smart Supermarket System with Indoor Navigation using Beacon Technology (Easy Shopping Android Mobile App). In *2018 IEEE International Conference on Information and Automation for Sustainability (ICIAfS)* (pp. 1-6). IEEE.

[17]. Kumar, T. S. (2021). Study of retail applications with virtual and augmented reality technologies. *Journal of Innovative Image Processing (JIIP)*, *3*(02), 144-156.

[18]. Ma, W., Zhang, S., & Huang, J. (2021). Mobile augmented reality based indoor map for improving geo-visualization. *PeerJ Computer Science*, *7*, e704.

[19]. Lu, F., Zhou, H., Guo, L., Chen, J., & Pei, L. (2021). An ARCore-Based Augmented Reality Campus Navigation System. *Applied Sciences*, *11*(16), 7515.

[20]. Arifitama, B., Hanan, G., & Rofiqi, M. H. (2021). Mobile Augmented Reality for Campus Visualization Using Markerless Tracking in an Indonesian Private University. *Int. J. Interact. Mob. Technol*, *15*, 21-33.

[21]. Chidsin, W., Gu, Y., & Goncharenko, I. (2021). AR-based navigation using RGB-D camera and hybrid map. *Sustainability*, *13*(10), 5585.

[22]. Rubio-Sandoval, J. I., Martinez-Rodriguez, J. L., Lopez-Arevalo, I., Rios-Alvarado, A. B., Rodriguez-Rodriguez, A. J., & Vargas-Requena, D. T. (2021). An indoor navigation methodology for mobile devices by integrating augmented reality and semantic web. *Sensors*, *21*(16), 5435.

[23]. Kaźmierczak, R., Szczepańska, A., Kowalczyk, C., Grunwald, G., & Janowski, A. (2021). Using AR technology in tourism based on the example of maritime educational trips—A conceptual model. *Sustainability*, *13*(13), 7172.

[24]. Gharaibeh, M. K., Gharaibeh, N. K., Khan, M. A., Abu-ain, W. A. K., & Alqudah, M. K. (2021). Intention to use mobile augmented reality in the tourism sector. *Computer Systems Science and Engineering*, *37*(2), 187-202.

[25]. Hamzah, M. L., Rizal, F., & Simatupang, W. (2021). Development of Augmented Reality Application for Learning Computer Network Device. *International Journal of Interactive Mobile Technologies*, *15*(12).

[26]. Alcañiz, M., Bigné, E., & Guixeres, J. (2019). Virtual reality in marketing: a framework, review, and research agenda. *Frontiers in psychology*, *10*, 1530.