TIMES-iCON2019

The 4th Technology Innovation Management and Engineering Science International Conference
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Bangkok, Thailand

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Museum Visitor Activity Tracker using Indoor Positioning System

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Postponement of TIMES-iCON2020

Dear Colleagues,

Due to ongoing concerns surrounding the coronavirus (COVID-19), the Technology Innovation Management and Engineering Science International Conference (TIMES-iCON) committee has decided to postpone the **TIMES-iCON2020**, due to take place in Thailand.

We believe this is the best decision to ensure the health and safety of our wonderful research community of attendees, sponsors, and staff. **In the meantime, all attendees should cancel their hotel reservations at Bangkok.**

Therefore, the conference will be arranged in 2021 which will be announced for details in the website as soon as possible.

Please contact our secretary at **secretary@timesicon.org** for additional information.We appreciate your understanding and support as we manage to navigate through these unusual circumstances.

Thank you,
TIMES-iCON Organizing Committee

- Final Program Update!!! Please see the final program of TIMES-iCON2019 at Conference Program (conf_program.html) page.

- As IEEE copyright policy, an author or authors in each paper must submit the IEEE copyright transfer form (scanned PDF file) signed by pen.

- The registration detail is ready. Please see at registration page (registration.html).

The 4th Technology Innovation Management and Engineering Science International Conference (TIMES-iCON2019) will be held in Bangkok, Thailand, December 11-13, 2019. The TIMES-iCON2019 will be the most comprehensive conference focused on management, innovation technology and information technology covering the research areas of the digital economy, digital society, digital healthcare, digital organization, digital country, digital government and digital transformation. **All accepted papers are expected to be included in IEEE Xplore and indexed by EI.** Also selected papers are encouraged to extend and publish in ITMSOC journal or Journal of Global Business Review.

The TIMES-iCON2019 will be held in Bangkok, Thailand, on December 11-13, 2019. Bangkok is a capital city in Thailand. It is a center for tourists who will go and connect to other city. Bangkok is the city integrated between the part of old and new city which many interested places for the tourisms such as

Wat Phra Kaew, The Grand Palace, Sanam Luang, Chao Phraya River, Khao San Road, Bangkok Chinatown Yaowarat, Chatuchak Market, Train Night Market Ratchada etc. The organizing committee is pleased to invite all researchers to attend the conference. The topics for regular sessions include, but are not limited to, the followings:

- Blockchain Applications
- Information Technology Management
- Data Science and Big Data
- Science and Technology Engineering
- Digital Business Management, Project Management and Organizational Development
- Digital Education, Innovation and Knowledge Management
- Strategic Management, Change Management and Entrepreneurship
- HR Management, Organizational Culture and Leadership in Digital Era
- Behavioral Sciences and Communication Studies
- Other related fields
- Thai Track

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Prospective authors are invited to submit full-length papers, including figures, tables, and references, via our website at http://www.times-icon.org/2018/ (http://www.times-icon.org/2019/). All papers will be peer reviewed and handled electronically. All papers submitted must be previously unpublished and may not be considered for publication elsewhere at any time during the review period. Any accepted paper included in the final program is expected to have at least one author or qualified proxy attend and present the paper at the conference. For additional information and submission guidelines, please visit our website at http://www.times-icon.org/2019/ (http://www.times-icon.org/2019/).

Important Dates

All dates are on GMT+7 time zone.

Regular paper submission deadline	~~*31 August 2019*~~ ~~*15 September 2019*~~ 30 September 2019
Notification of regular paper acceptance	20 October 2019
Camera-ready submission deadline	1 November 2019
Early registration deadline	1 November 2019

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Museum Visitor Activity Tracker using Indoor Positioning System(Conference Paper)(Open Access)

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Abstract

Tourism is one of the sources of state revenue that has enormous potential, especially for developing countries. One of the great tourism potential is the museum. In displaying the artifacts and their information the museum manager has difficulty in recognizing the behavior of museum visitors such as the route chosen in seeing the artifacts presented, how long they have been at a location, what artifacts are of their interest, etc. This is quite difficult to do, especially with the many artifacts that exist in a museum. This research created an activity tracker system for museum visitors using the Indoor Positioning System by utilizing Bluetooth Low Energy (BLE) beacons. Signals from BLE beacons detected by museum visitors' smartphones are used as a reference to estimate the location of visitors using the trilateration method and the Kalman filter. This location data is then stored in a server to be information of the movement of visitors in the museum. Based on this information, museum managers can find out which locations are often / rarely visited by visitors and how long visitors spend at that particular location. According to the distance error testing that compare real location and calculation position, it shows that the average error distance is around 114.35 cm. So, it can be concluded that the information obtained is sufficient to represent the position of the museum visitors.

SciVal Topic Prominence

Topic: Indoor Positioning Systems | Received Signal Strength | Wi-Fi

Prominence percentile: 99.559

Author keywords

Activity Tracker | BLE Beacon | Indoor Positioning System | Museum | Smartphone

Indexed keywords

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Engineering uncontrolled terms: Average errors | BLE Beacon | Bluetooth low energies (BLE) | Error testing | Location data | Museum visitor | Tracker system | Trilateration

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***Abstract*—Tourism is one of the sources of state revenue that has enormous potential, especially for developing countries. One of the great tourism potential is the museum. In displaying the artifacts and their information the museum manager has difficulty in recognizing the behavior of museum visitors such as the route chosen in seeing the artifacts presented, how long they have been at a location, what artifacts are of their interest, etc. This is quite difficult to do, especially with the many artifacts that exist in a museum. This research created an activity tracker system for museum visitors using the Indoor Positioning System by utilizing Bluetooth Low Energy (BLE) beacons. Signals from BLE beacons detected by museum visitors' smartphones are used as a reference to estimate the location of visitors using the trilateration method and the Kalman filter. This location data is then stored in a server to be information of the movement of visitors in the museum. Based on this information, museum managers can find out which locations are often / rarely visited by visitors and how long visitors spend at that particular location. According to the distance error testing that compare real location and calculation position, it shows that the average error distance is around 114.35 cm. So, it can be concluded that the information obtained is sufficient to represent the position of the museum visitors**

Keywords—Museum; Activity Tracker; Indoor Positioning System; BLE Beacon; Smartphone

I. INTRODUCTION

Tourism is one of the major state revenue, especially for developing countries that do not have the technological ability or trading of state revenues. Indonesia as one of the developing countries sees this as a state revenue opportunity. In Indonesia, the tourism is the fourth largest contributor to income (9%) after oil and gas, coal and palm oil [1]. Moreover, the tourism sector is able to absorb 10 million workers. Therefore tourism is crucial to get serious attention. Indonesia is an island nation that is endowed with abundant natural beauty. The natural beauty that there are diverse ranging from mountains, forests, seas, beaches, and so on. In addition, Indonesia also has a diversity of flora and fauna as well as a variety of customs, cultures, and historic relics ranging from ancient relics such as temples and inscriptions, to the legacy of the war against the invaders. This, makes Indonesia one of the countries that has a huge tourism potential.

One of the tourism visits offered is a visit to the museum. Consider that Indonesia has many historical artifacts such as cultural artifacts of the past (temples, monuments), religious artifacts (churches, temples, mosques) as well as artifacts of the colonial period (fortresses, cannons, weapons). These artifacts are stored in museums spread throughout Indonesia. The Indonesian government has made several improvements such as standardization and classification of museums (120 museums out of 400 museums in Indonesia) [2] and museum revitalization efforts (80 museums) [3].

In order to present museum information, museums generally display their artifacts using display media that placed in surrounding museum rooms. The layout of the artifacts becomes very important. Because it can provide important and interesting information for visitors. The number of artifacts in a museum that can be reach thousands of pieces. Such as The National Museum Indonesia which has 141.000 artifacts [4]. The artifacts display and layout must be very challenging in order to build an informative and interesting information for museum visitors.

Another problem that arises is how the museum manager can find out whether the artifacts display layout and information that provided is in suitable with what the museum manager wants. Where the route chosen by visitors when viewing artifacts display in the museum. Whether information about the artifacts provided can attract visitors.

Therefore, this research will track the location of museum visitors while in the museum location (indoor). The location of museum visitors when they see the display of artifacts in this

museum will be taken periodically and stored on a server. The location data will then be mapped into the route chosen by visitors during the museum visit. This route mapping aims to help the process of a thorough analysis of the display of artifacts that have been prepared by the museum manager.

This museum visitor tracking route was built using the Indoor Positioning System (IPS) method by utilizing Bluetooth Low Energy (BLE) beacons and Bluetooth equipment that is on smartphones owned by museum visitors. Museum visitors are asked to install the museum information application (via Google Playstore) that has been made in previous research [5]. The application will be equipped with information about artifacts in the museum. So, it can help visitors in obtaining information on the artifacts they want more deeply. The application also features a museum (indoor) map and information on where visitors are currently located in the museum. To find out the location of the visitor, the application uses the Bluetooth facility on the mobile to detect the location of the BLE beacons that have been placed at certain locations in the museum. The location of these visitors will then be stored on a server periodically to create museum visitor route data.

Each BLE beacon will emit a signal that can be received by Bluetooth devices that are on the museum visitor's smartphone. From the received BLE beacon signal strength, the application will calculate the approximate location of the museum visitors. This calculation is done by calculating the distance of the smartphone with the location of the BLE beacon detected by the smartphone by looking at the signal strength of the BLE beacon. The method used to calculate the position of visitors is to use trilateration and kalman filter. Then, information about the location of the visitor is then sent to the server as the location of the museum visitors. The data is then managed to be the route information of visitors when in the museum and the number of visitors who are in a location in the museum.

With this visitor route information, the museum manager can analyze whether the placement of artifact displays is suitable. Like for example if there are certain locations in the museum that are rarely passed by museum visitors, in which areas visitors often pass, which locations are frequented by visitors, when and where visitors pass certain routes, and others. With this information, the museum manager can rearrange the layout of the room and the location of the artifacts so that they are needed or organize the flow of visitors so that the displayed artifacts can be seen by visitors properly.

II. LITERATURE REVIEW

Research to develop tourism and interesting museum visits continue to be developed, such as Botturi et al. [6] who use games on smartphones to study cultural heritage. Chivarov et al. [7] developed interactive presentations with smartphones to create a modern museum. Handojo et al. [8] uses smartphones, GPS technology to trace the history route of the battle for independence in Surabaya. Turan and Kesser [9] created an ancient car museum guide using a smartphone. Handojo [10] created a battle of independence in Surabaya using GPS and smartphone technology.

Research on the Indoor Positioning System (IPS) to determine the location of users in a room in a building (indoor) is also widely developed. Like Thamm et al. [11] and Yeo et al. [12] uses IPS in shopping malls. Narzullaev et al. [13] who used IPS in equipment in hospitals and warehouses. Handojo [5] using IPS for broadcast information to museum visitors.

By considering the enormous growth rate of smartphone usage in Indonesia, this research choose to build a museum visitors activity tracker using smartphone. According to data from the Indonesian Internet Service Users Association - APJII (Penetration and Behavior of Indonesian Internet users) [14], the growth of internet users in Indonesia continues to grow to reach 143.26 million users from a total of 262 million people in Indonesia (Fig. 1). This means that approximately 54.68% of Indonesia's population has used the internet. APJII also reports that the majority of internet access is done through smartphones (85%). With easy network access and the availability of smartphone devices, this museum visitor's tracker will be easy to adopt for any museums.

Fig. 1. Internet users in Indonesia

III. IMPLEMENTATION

This research will conduct at Trowulan Museum that's located in Mojokerto, a town on East Java Province in Indonesia. The Museum provide artifacts information from the Majapahit Empire (1293-1500 AD). Majapahit is one of the major ancient empire that controls most of Indonesia, Singapore, and parts of Malaysia. There's so many artifacts such as weapons, sculpture, statue, pottery, temple.

There are 3 main rooms in Trowulan Museum, namely Metal Room (contains metal equipment, metal weapons, etc.), Terracotta Room (contains pottery, roof tile, etc.), and Statue Room (contains statue, sculpture, etc.). The Metal Room and Terracotta rooms are both surrounded by walls, but the Statue Room is an open space room with roof.

In order to build IPS, this research place some BLE Beacons (WEMOS LOLIN32 Lite) at certain location in the museum (Fig. 2). Besides the low price, this BLE beacon has the advantage that relatively small in size (13 x 5 cm) so that they can easily be placed in various places in the museum room without disturbing the artifacts on display. in addition, this BLE beacon also has a very low energy consumption level so that it can operate using small batteries that only need to be replaced once a year. This BLE beacons are also easy to install.

Based on this consideration, this BLE beacon the right choice to be implemented in museums in Indonesia which have various levels of diversity such as in terms of financial budget, use of technology, and the number of daily visitors.

Fig. 2. WEMOS LOLIN32 Lite Bluetooth Low Energy Beacon

Each BLE beacon will emit a signal that will be obtained by a museum visitor's smartphone (Fig 3.). The application on the smartphone will then send the beacon id to the server to find out the location of the BLE beacon. The application will then calculate the user's current approximate location based on the strength of the BLE beacon signal that was successfully obtained. The approximate location is then sent to the server and stored by the server. Based on the collection of user locations, a mapping of visitor tracker information was built. This information will be useful for analyzing the behavior of museum visitors.

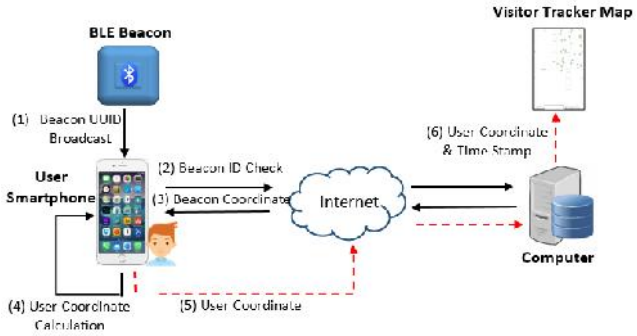

Fig. 3. Museum Visitors Activity Tracker System Design

This study maps the location of museum visitors to the website-based museum tracker application as shown in Fig. 4. Museum manager can see visually the movements of museum visitors based on a certain time according to the input. For example museum manager want to know visitors movement on Terracotta Room start from 10:00 AM. The application will plot the visitor location that recorded by server on the map. The museum manager then can input the tracking duration that he/she want to view (for example for every three minutes). The museum manager then can click next/previous duration button to see visitor location. This application will show the location of museum visitors for the next period of time (on the next three minutes / 10:03 AM).

(a) (b)

(c) (d)

Fig. 4. Museum Visitors Tracker Testing on Terracota Room Report

By this application museum manager could see the visitors' movement in the museum room. From this information museum manager could analyze the effectiveness of the existing room layout and artifacts. Museum manager could also see how long each visitors stay on each museum room and in which locations museum visitors spend their time. From this information museum manager could analyze which exhibitions are of appealing to visitors.

This research tests the accuracy of the estimated location of visitors obtained data. Testing is done by comparing the estimated location of visitors (calculation results) with the actual location, as can be seen in Fig. 5. From these tests the calculation of the resulting error rate is calculated, as shown in Table 1. From the position accuracy testing conducted, the results show that the accuracy level is strongly influenced by the Received Signal Strength Indicators (RSSI) BLE beacons received by Bluetooth devices on smartphone visitors to the museum visitors. Where testing numbers 6, 9, 4, and 5 (Table 1) has the best RSSI level. So that it has an error rate of distance around 47.12 to 97.28 cm.

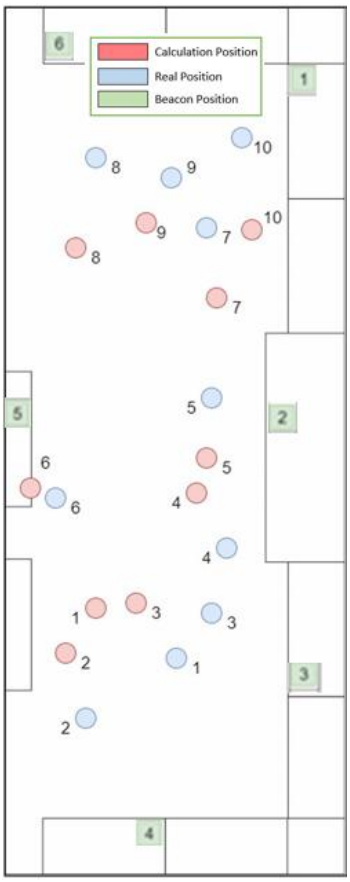

Fig. 5. Position Accuration Testing

So, it can be concluded that the location of each BLE beacon is very important in terms of increasing the accuracy of approximate location. Therefore, the location of each beacon must consider the range of each beacon and the need to cover each room. Overall error rate from comparing real locations with estimated locations based on calculations obtained an error of 114.35 cm so that it can be concluded that the system created can be a reference for visitor movement information.

IV. CONCLUSION

This research tries to determine the behavior of museum visitors when visiting the museum. Visitor behavior is recognized by tracking the movement of visitors in the museum. Information on the location of visitors during the museum is obtained by using the Indoor Positioning System with BLE beacons. Signals from BLE beacons placed in various positions in the museum will be detected by Bluetooth on the user's smartphone as a reference for calculating the visitor's location estimation by trilateration and the Kalman filter method. The visitor's location is then mapped on the website-based museum map application. Through this visitor movement information the museum manager can find out the route chosen by visitors while in the museum, which locations in the museum are frequently visited, which artifacts are of interest to visitors, etc. Based on this information the museum manager can analyze and evaluate the layout and laying of artifacts and displays in the museum.

Based on error testing by comparing the distance of real locations and estimation locations based on the calculations. The level of error that obtained is 47 to 174 cm with an average of 114.35 cm. So, it can be concluded that the location information obtained by visitors is sufficient to be able to present the position of the museum visitors in order to obtain information on the behavior of museum visitors.

TABLE I. TESTING OF POSITION ACCURACY

No	Real Position		RSSI Beacon (Strongest Detected)			Calculation Position		Distance Error (cm)
	X	*Y*	*1*	*2*	*3*	*X*	*Y*	
1	232.47	197.67	-165.87	-170.00	-160.48	116.00	220.57	174.12
2	106.67	97.88	-104.23	-105.53	-107.59	103.27	198.65	110.94
3	256.56	219.33	-114.00	-120.07	-119.09	158.43	222.67	125.14
4	264.38	236.27	-90.07	-92.23	-97.00	253.67	251.00	95.40
5	254.97	275.70	-98.31	-93.88	-99.40	254.33	256.10	97.28
6	100.90	250.27	-60.84	-59.52	-58.53	87.67	253.33	47.16
7	254.21	462.32	-115.89	-125.00	-113.39	255.17	455.10	129.24
8	117.33	580.00	-142.48	-143.51	-158.24	109.67	459.44	165.26
9	228.00	575.33	-79.35	-82.55	-88.33	162.63	468.90	68.41
10	297.33	628.39	-117.67	-128.47	-112.09	307.93	463.67	130.59
Average								114.35

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