The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 2023

Volume 22, Pages 59-73

ICBASET 2023: International Conference on Basic Sciences, Engineering and Technology

Safetree: An Integrated Wearable Device and Mobile Application Solution for Pandemic Mitigation and Post-Pandemic Preparedness, Incorporating Contact Tracing, Social Distancing Emergency Alert Notification, and Socialization Features

Jille Anne R. VERANO
Mapúa University

Doreen Marie S. SORONGON
Mapúa University

Febus Reidj G. CRUZ
Mapúa University

Abstract: The COVID-19 pandemic has highlighted the need for effective mitigation strategies to reduce infectious disease spread. Safetree is an innovative wearable device and mobile application that integrates social distancing, contact tracing, emergency alert notification, and socialization features. The social distancing feature enabled the devices to successfully detect all nearby wearables within a 1-meter range within their line of sight using Bluetooth Low Energy (BLE) as a transceiver. Unfortunately, due to environmental conditions that were present in several of the experimental settings, some of the devices operated outside of the 1-meter range. The success rate in generating the appropriate tree diagram for each situation in the experimentation set-up resulted in 100%. The average response time between the wearable device and the mobile application varied from 9 seconds up to almost 11 seconds. In the fields of contract tracing and social network analysis, the tree algorithm has been shown to be effective for examining user interactions. This algorithm was also implemented on the emergency notification feature and, the socialization feature which enabled the users to interact with one another while maintaining social distancing guidelines, promoting mental health and social well-being amidst and after the pandemic.

Keywords: Social distancing, Contact tracing, Tree algorithm, Internet of things, Bluetooth low energy

Introduction

COVID-19 is an infectious disease transmitted through discharges either in the form of small aerosols or large droplets. In other words, the disease spreads between two people through respiratory discharges. Since the transmission medium is available anywhere, several concerns arose about possible transmissions within large-scale environments, forcing several countries, including the Philippines, to declare a public health emergency. Several monitoring techniques have already been explored, automated, and implemented, such as COVID-19 proximity-based contact tracing system and digital tracing. Proximity-based contact tracing systems utilize technologies to generate proximity data integrated into a contact tracing system to identify possible people with prolonged exposure to a COVID-19-infected person (Lubis & Basari, 2020). Utilization of beacon technology in Bluetooth Low Energy (BLE) enabled proximity detection through the usage of contextual information resulting from the beacons (Lubis & Basari, 2020; Jeom et al., 2018). In the context of proximity detection, the Received Signal Strength Indicator, also known as the RSSI, data is utilized in identifying others who are within the configured proximity range. Existing local implementations of this, such as within an enclosed environment,

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

require further improvements in: (1) proximity detection, (2) signal detection, and (3) battery consumption (Lubis & Basari, 2020). In addition, beacon technology is only able to employ one as a transmitter, while the other device as the receiver, regardless of if there's a or no connection (Lubis & Basari, 2020). The BLE technology is employed chiefly for observance of social distancing. However, current BLE technology supports a dual role on a single device and can be further studied for device communication that does not need a connection. Most of the implemented systems for contact tracing and social distancing can only achieve one purpose: a wearable only designated for social distancing or a developed system for contact tracing. Moreover, the experimental setup of existing social distancing wearables is only one-to-one. The experimentation setup, one-is-to-many, is more effective in minimizing and reducing the spread of the COVID-19 disease within crowded environments as this type of setup limits close face-to-face contact with not only one person but between two or more people (Alhmiedat & Aborkbah, 2021). The research aims to develop a wearable device and mobile application for pandemic mitigation protocols such as social distancing and contact tracing, respectively, along with integrating an emergency alert notification system and socialization feature for post-pandemic preparedness. Specifically, the study aims: (1) to design the electronics of the wearable prototypes, (2) to develop a mobile application with a graphical user interface (GUI) and database server, and (3) to incorporate the tree algorithm in both pandemic mitigation and post-pandemic preparedness features. With this, the research mainly focuses on creating microcontroller-based wearable devices and developing a system through a mobile application and database that will aid in pandemic mitigation. With this, it will mainly identify upcoming human presence via the response of proximity sensing using the RSSI of the Bluetooth Low Energy (BLE) technology. Furthermore, the data for the contact tracing aspect of the wearable can only be stored through device-to-device powered by Bluetooth and Wi-Fi. The developed mobile application will only work on Android cellular devices. The wearable device would be tested using one-to-one type and one-to-many type of experimental trials. In addition, the location included in the emergency notification feature will only be based on the mobile device's location.

Review of Related Literature and Studies

Chain of COVID-19 Infection

A person is categorized as a close contact once he/she falls under the following: (1) had a face-to-face interaction with a confirmed case, a person who tested positive for COVID-19 within one meter for at least 15 minutes, (2) had physical contact with either a probable case or confirmed case and (3) encountered a confirmed case without wearing personal protective equipment/PPE ("Who western pacific | covid-19 information for the public", 2021). In the Philippines, the close contact is mandated to inform his/her respective Barangay Health Emergency Response Team, which will eventually lead to testing for COVID-19 diseases and referral to his/her barangay's TTMF or hospital, whichever applies (Department of Health, 2021). Regardless of the COVID-19 test result of the close contact, he/she must still undergo the whole 14-day quarantine. The second and third generations of close contacts are also encouraged to be traced and monitored in the country (Department of Health, 2021).

Figure 1. Multisys' comprehensive contact tracing (Multisys Technologies Corporation, n.d)

Figure 1 shows the comprehensive contact tracing process which monitors and interprets user health reports included in StaySafe PH, a contact tracing software implemented in the Philippines. This comprehensive feature allows effective tracking and reduces the risk of COVID-19 transmissions spreading (Multisys Technologies Corporation, n.d). This feature is similar to using the tree diagram to visualize COVID-19 confirmed cases along with their close contacts. One of the main objectives of the tree diagram is classification, as it can represent extensive configurations implemented within enclosed virtual spaces, which are interspersed by the following: (1) information, (2) nodes, and (3) connecting lines (Multisys Technologies Corporation, n.d). The study, entitled CovidSIMVL, utilized transmission trees which a; allowed the identification of all people who might have been infected by the Index Case or the confirmed case (Chang et al., 2020). Moreover, this study introduced the forward-facing approach and backward-facing approach. The forward-facing approach can trace the people needing monitoring and treatment in the future. In contrast, the backward-facing approach can depict the big picture of the distributions of COVID-19's chains of infection as the means of contact tracing (Chang et al., 2020). Another research used a tree diagram, as shown in figure 2, as a method for data visualization to showcase the harmful outcomes once people do not comply with social distancing policies. This study uses system dynamics methodology to build a COVID-19-confirmed case model. This model predicts the number of confirmed cases and deaths (Newman, 2021). The model can also predict when the COVID-19 positive cases curve will be flattened (Newman, 2021).

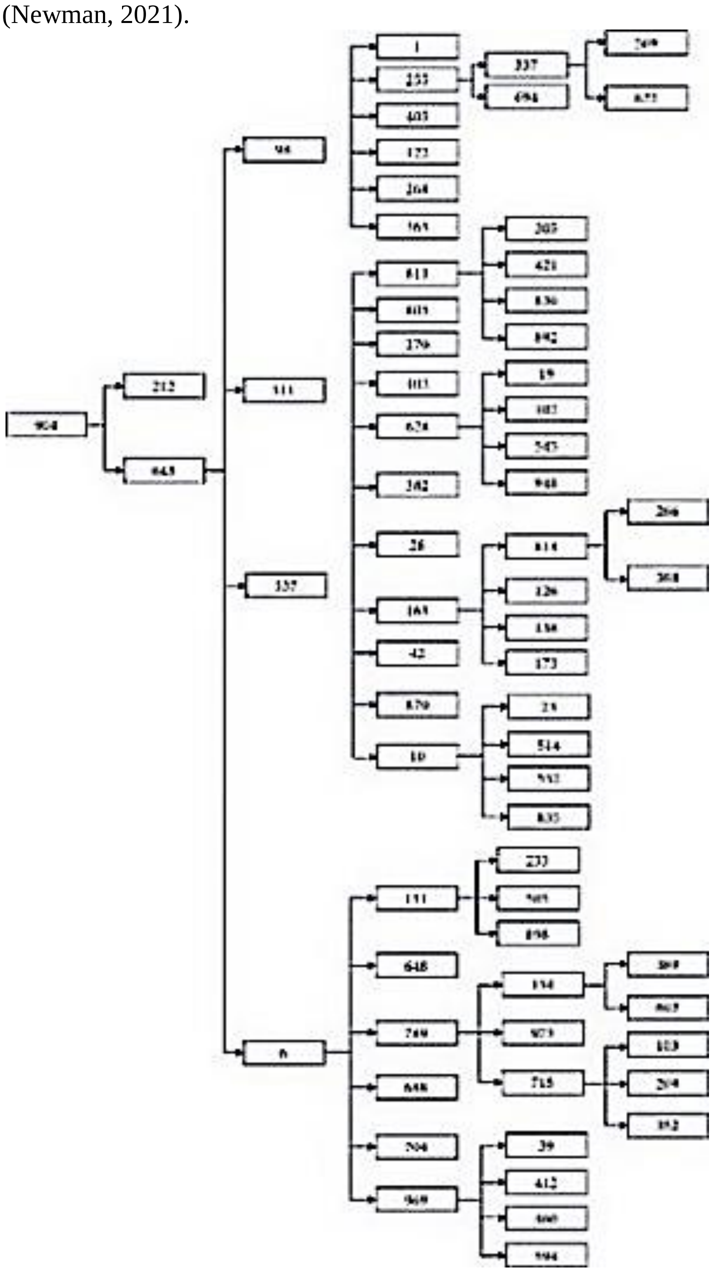

Figure 2. Tree diagram showing the “level” of Covid-19 infections (Newman, 2021)

BLE Technology

New wireless low-power technologies open the door to dynamic device-to-device communication (Jeom et al., 2018). The Internet of Things (IoT), which has several applications in the sectors of automation, health applications, tracking, etc., has been developed as a result of technological advances like BLE .(Lubis & Basari, 2020; Jeom et al., 2) BLE technology is primarily used in low-power applications such as location-based services, wearable technology, and brief communications between devices (Lubis & Basari, 2020). The physical location affects how well BLE's location-based service works (Lubis & Basari, 2020; Jeom et al., 2). With the use of beacon technology, BLE provides an accurate location estimate for the user and can be applied in unmanned proximity-based applications (Lubis & Basari, 2020; Jeom et al., 2; Su et al., 2021).

The usage of advertising and scanning states as beacons are prevalent in proximity-based applications (Lubis & Basari, 2020; Jones et al., 2020). BLE, unlike beacon technology, is constantly growing and only supports one application. Sending protocol is needed for broadcasting data. After then, the Received Signal Strength Indicator (RSSI) or Received Signal Strength plays a significant role in the proximity calculation (RSS). When neighboring devices find an advertising packet broadcast regularly, they can obtain data like the RSS or RSSI (Jones et al., 2020). Low energy consumption requirements are another aspect that can be considered when designing systems. Several modes of operation are used by a few modules purely for power savings (Song et al., 2019; Amft et al., 2020). ESP 32 WROOM 32 modules can switch between active and modem-sleep, light sleep, deep sleep, or hibernation. If there is an external wake-up source to bring it back to its active state, these modes can be programmed to be used in a different order.

Methodology

Conceptual Framework

The intended study's conceptual framework is shown in Figure 3. The input variables are acquired when one user is one meter away from another. When this requirement is satisfied, the device will record the device name, RSSI, date, time, and exposure length into an SD card and send them to the mobile application via serial connection afterward. There are six separate steps in the procedure. The result is projected to be a wearable and mobile application that will improve the monitoring and enforcement of individuals' adherence to established norms for social distancing, contact tracing, and post-pandemic preparedness.

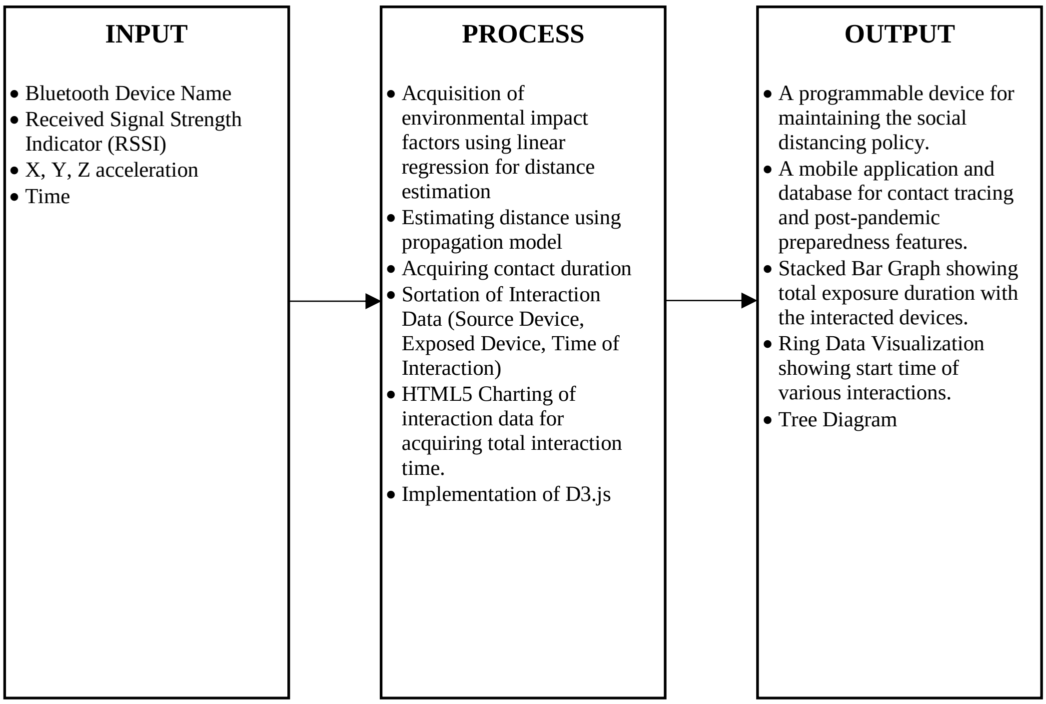

Figure 3. Conceptual framework

Design of the Electronics of the Wearable

Figure 4 shows the overview of the block diagram of the social distancing wearable and contact tracing system.

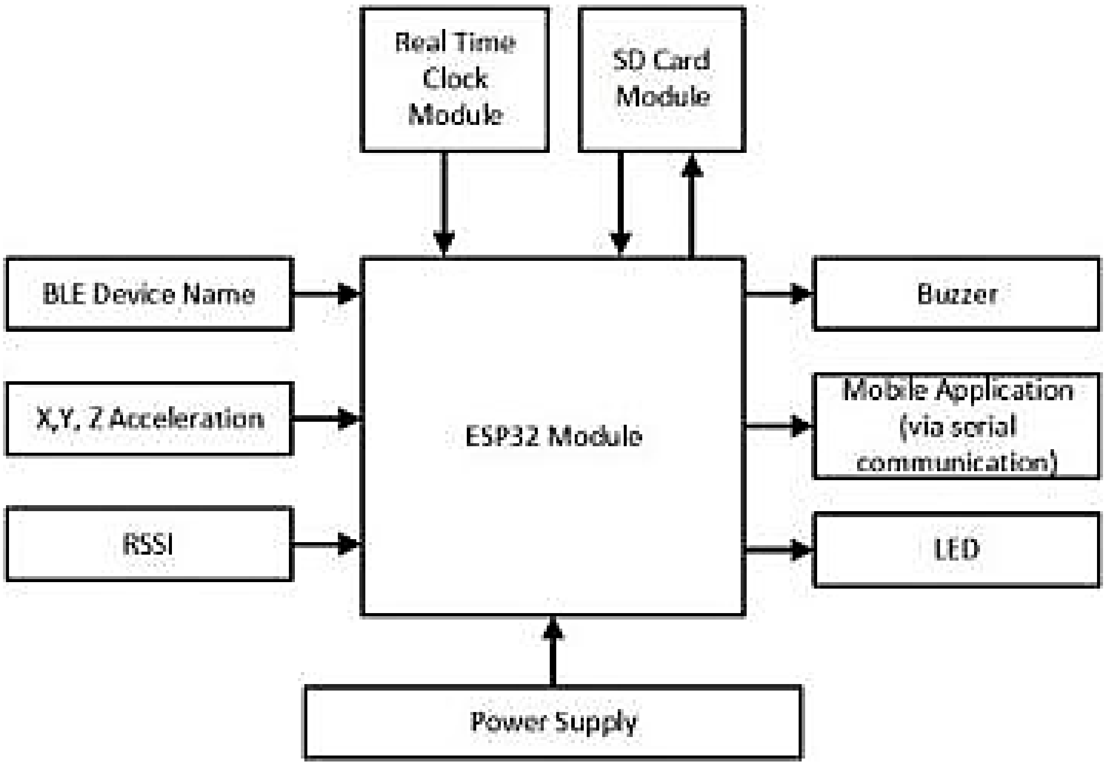

Figure 4. Block diagram of the social distancing wearable

BLE and Security Configuration

Figure 5 provides an overview of proximity detection utilizing the BLE protocol. The proposed system will use the BLE protocol to track social distance. Both devices would be set up as BLE broadcasters and observers for the proposed system. A link need not be established to send information from one configuration to another. The broadcaster's packet in terms of advertising will be set to ADV NONCONN IND, which forbids connection requests and the advertisement of additional data that is not part of the advertising packet. Serial communication using BR/EDR would convey data from the device to the application. The overview of the proximity detection of using the BLE specification is shown above. In the proposed system, the protocol BLE will be used in the monitoring of social distancing. For the proposed system, both devices would be configured as BLE broadcaster and observer. The configuration does not need to establish a connection to relay information from one another. The advertising packet of the broadcaster will be set to ADV_NONCONN_IND which does not allow connection request and does not allow additional data to be advertised that is not included in the advertising packet. For the transfer of data from the device to the application, serial communication through BR/EDR would be used. The ESP32 has the capacity to operate in dual mode, using both BLE and BR/EDR at the same time. The ESP32 uses the SSP by default, which offers secure connections via a shared key. Aside from the SSP, a simple wearable device to mobile application communication was implemented for device authentication as shown in figure 6.

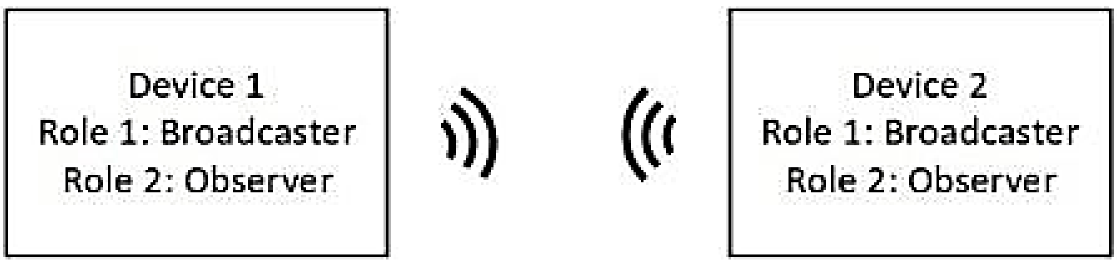

Figure 5. Overview proximity detection using BLE.

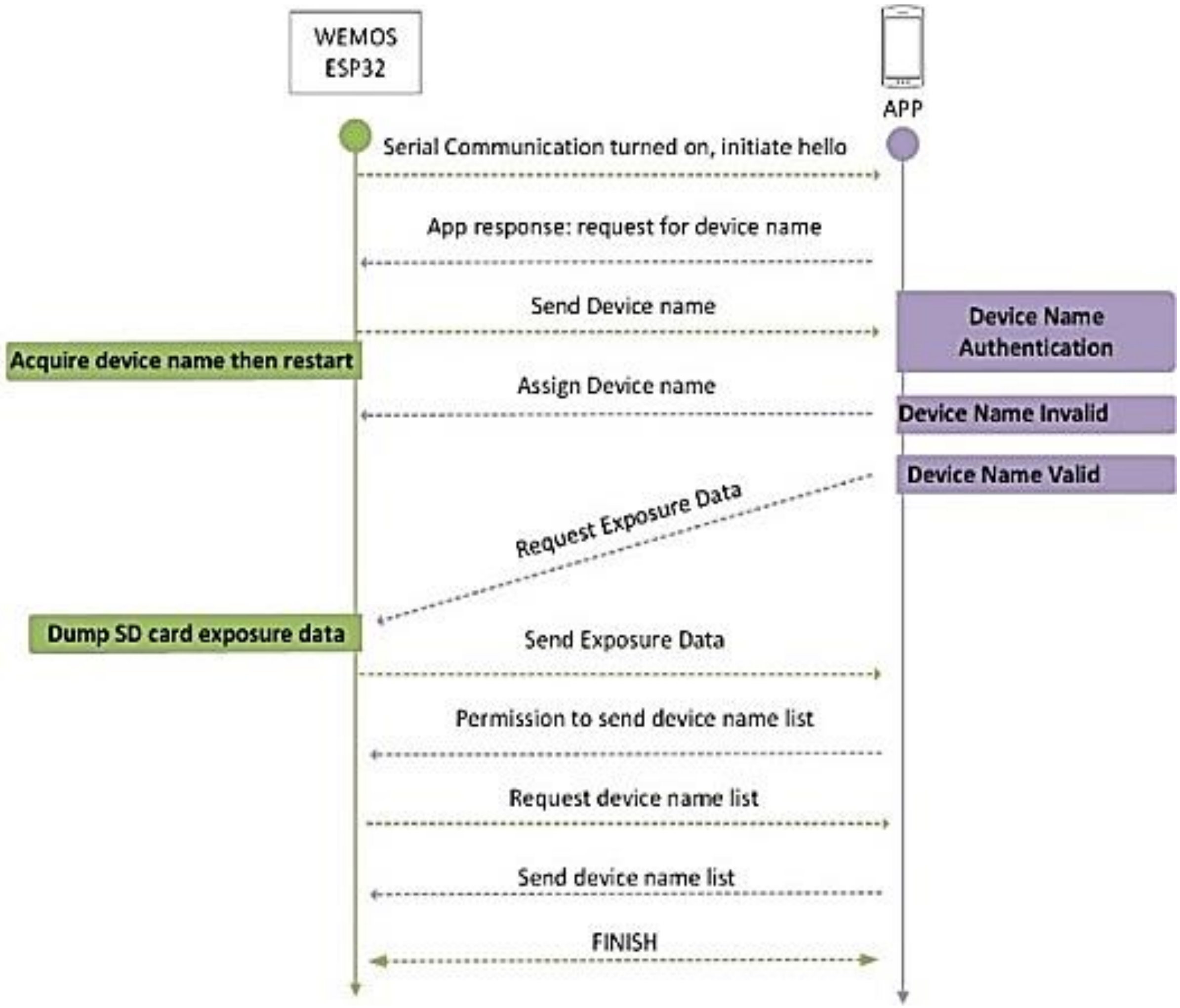

Figure 6. Device authentication with the application

Power Management

The ESP32 module has multiple power management modes that it can enter. The active, modem-sleep, and light sleep modes will all be covered in the study. The device features a chip for wireless connection in active mode, including Wi-Fi, BLE, and Traditional Bluetooth. Wi-Fi and Bluetooth are disabled in the light-sleep mode to decrease power usage. Nonetheless, the light-sleep mode preserves the device's state before light sleep, does not call for module reinitialization, and improves responsiveness to other active devices. The module's least-consumptive mode is deep sleep. The tables below are a summary of the ESP32's specifications and conditions for each of its power modes respectively:

Table 1. Power consumption in different modes

Device Mode	Description
Active	RF working
Light-Sleep	CPU paused, RTC peripherals and RTC memory on
Deep-Sleep	RTC memory an RTC peripherals on

Table 2. Power management mode conditions

Mode	Condition
Active	Devices within 1 meter radius User Standing
Light-Sleep	User Sitting
Deep-Sleep	Device facing downwards

Software Development

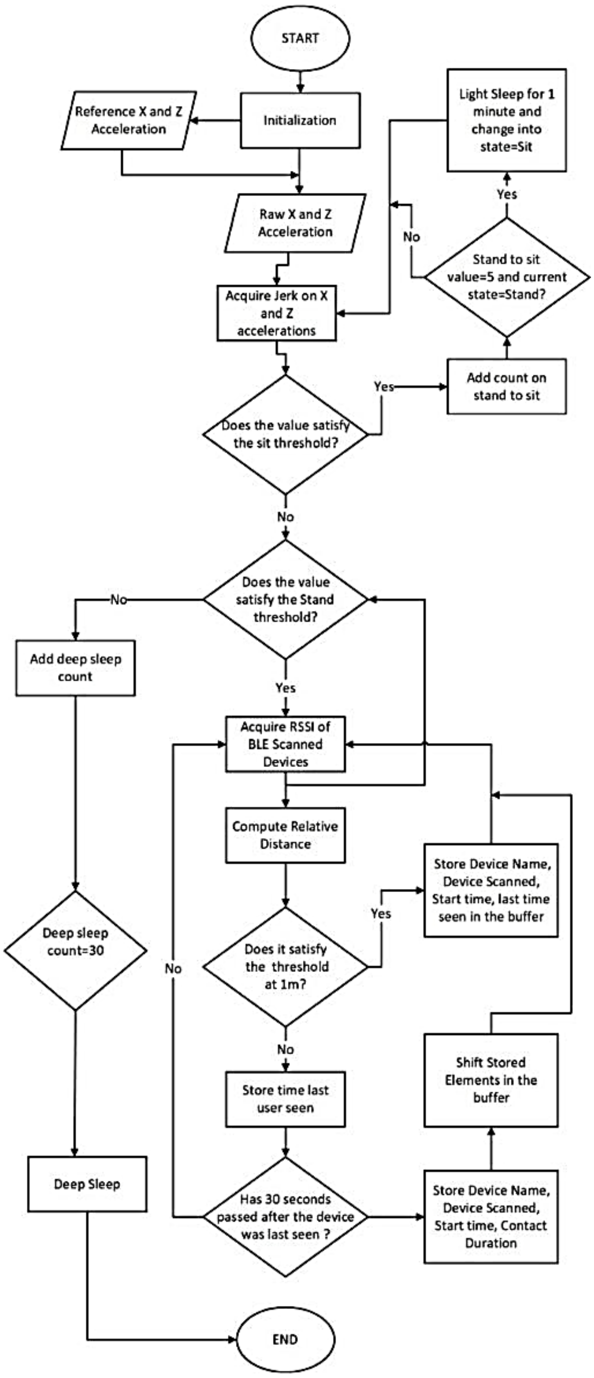

Figure 7. Software development

Figure 7 shows the overview of the software development of the wearable device. The device was programmed using the Arduino IDE. After the device is powered on, it will be initialized and this includes acquiring the reference value for the sit and stand, starting the advertising of BLE and Classic Bluetooth. After the initialization, the device continuously checks the state of the user, whether it is standing or sitting. When the user is in standing position, the device will start to scan for the devices based on a name list defined to be students at the University. If the device assigned to a student is scanned, the device will store the device name, device scanned name, the time it was scanned, and the time it was last seen. The device information would then temporarily store in a buffer. If the device scans a new device, the same thing would be done and it would be added to the buffer. When the scanned device is out of range, the device would store all information about the device in the SD card. The only thing to stop the device from executing its operations is when it is in deep sleep mode or turned off using the power switch. Aside from that, operations on the device are halted for 1 minute when the device is in sleep mode.

Contact Tracing Algorithm

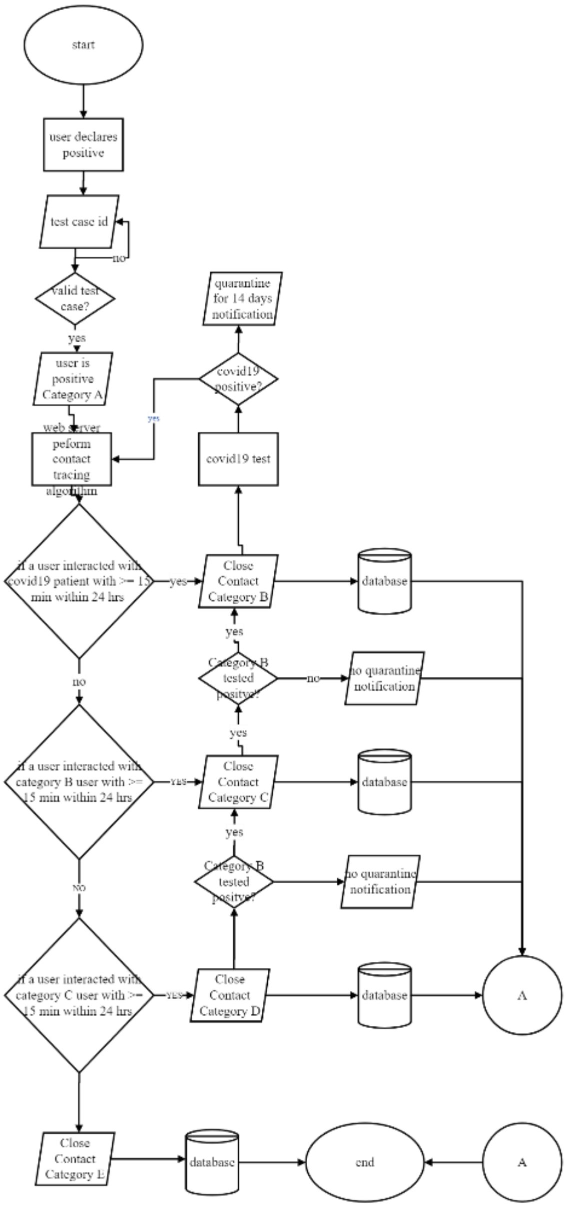

Figure 8. Contact tracing algorithm

An overview of the contact tracing technique used in the mobile application is shown in Figure 8. When a user report having the COVID-19 virus, the mobile application will take them to a screen where they must provide test results that will be verified by the web server. This begins the procedure. The user will be assigned to Category A if the test reference is reliable, and the web server will run the contact tracing method. Users in Category B are those who interacted with Category A for at least 15 minutes. Users who have interacted with a website for at least 15 minutes will be placed in Category B, while those who have interacted with a website for at least 30 minutes will be placed in Category C, and so on. Users in Category B are required to take a COVID-19 test; if they are positive, they will be categorized as Category A instead, and Category B, Category C, and Category D will shift one category as well. Finally, if the users don't have an interaction duration of at least 15 minutes, they will be categorized with any of the Categories stated, and they will be categorized as Category E. Category B users are required to take a COVID-19 test. In contrast, Category B must complete their 14-day quarantine before going back to school if the test was negative. While, if the test result resulted into a negative one, Category B must finish his/her 14-day quarantine before returning to school. While Category C and Category D along with Category E are still allowed to enter the school premises. In contrast, Category B must complete their 14-day quarantine before going back to school if the test was negative. While those belonging in Category E is not permitted on school grounds, those who are considered as Category C and Category D are permitted.

Development of Mobile Application

Systems Architecture

Back-end Development consisting of LAMP Technology Stack and Google Cloud Console Platform. Front-end Development consisting of HTML, CSS, Javascript, MIT App Inventor 2, and Arduino IDE. Tree Algorithm - A depiction of the relationships between users who have engaged with one another is produced by this algorithm after it retrieves interaction data from a database. This is accomplished by looking at interactions that occurred for the input user within 14 days of a specified date and building a list of users who might have encountered that person. After then, the algorithm repeatedly examines each user's interactions to see whether they have any direct ties to other users. Until all connections to the input user have been taken into consideration, this process is repeated. The algorithm then generates a visual representation of this structure on a web page using the PHP programming language and the D3js library.

Calculations

Success Rate

The success rate is the most straightforward usability statistic since it is simple to comprehend and accurately represents a specific dataset (Nielsen & Budiu, 2023). The total number of successes is divided by the total number of trials to determine the success rate. The following mathematical equation demonstrates this:

$$Success\ Rate = \frac{No.\ of\ Successful\ Trials}{Toial\ No. of\ Trials}\ x\ 100 \quad (1)$$

Levels of Success

Table 3. Levels of success

Levels of Success	Interpretation
Complete Success	The expected outcome of the trial was achieved with no error.
Failure	The expected outcome of the trial was not achieved.

This table displays how (Nielsen & Budiu, 2023) interpreted the first two of the four success levels. The first level denotes that the anticipated outcome occurred during the trial, assuming no errors were detected. While the latter level is seen as the opposite of the former.

Battery Life Equation

The battery lifetime can be computed by dividing the battery capacity by the load’s current draw. This is further elaborated by the equation below (“How to Calculate Battery Run Time”, n.d):

$$B_l = \frac{B_c}{I_l} \quad (2)$$

Let:
B_l be the battery lifetime in hours,
B_c be the battery capacity in milliamperes.
I_l be the load device current draw in milliamperes

Engineering Standards

Table 4 shows the engineering standards implemented in this research. The IEEE 802.11ac was the standard for the wireless networking, IEEE 7005 was the standard used for the storage and protection of personal data, BLE for the Bluetooth wireless communication, and IEEE 802.15.1 for the wireless communication.

Table 4. Engineering standards

Engineering Standards	Purpose
IEEE 802.11ac	Wireless Networking Standard
IEEE 7002	Data Privacy Process
IEEE 7005	Storing and Protecting Personal Data
BLE	Bluetooth Wireless Communication
IEEE 802.15.1	Wireless Communication

Results and Discussion

Safetree Wearable Device and Mobile Application

Safetree Wearable Device

Figure 9. Wearable device (Standing and Sitting Position)

Figure 8 shows the wearable device worn by the user in a standing and seating position. The wearable device is a belt accessory, specifically a buckle. The user can adjust the wearable's position on his/her desired waist placement.

Safetree Mobile Application

Figure 10. Mobile application's pandemic mitigation features (Main Features)

Figure 9 shows the main features for pandemic mitigation of the mobile application. This includes the home page of the application which has several functions such as COVID-19 information and another is the covid test verification feature in which users are able to willingly declare if he/she is negative/positive from COVID-19.

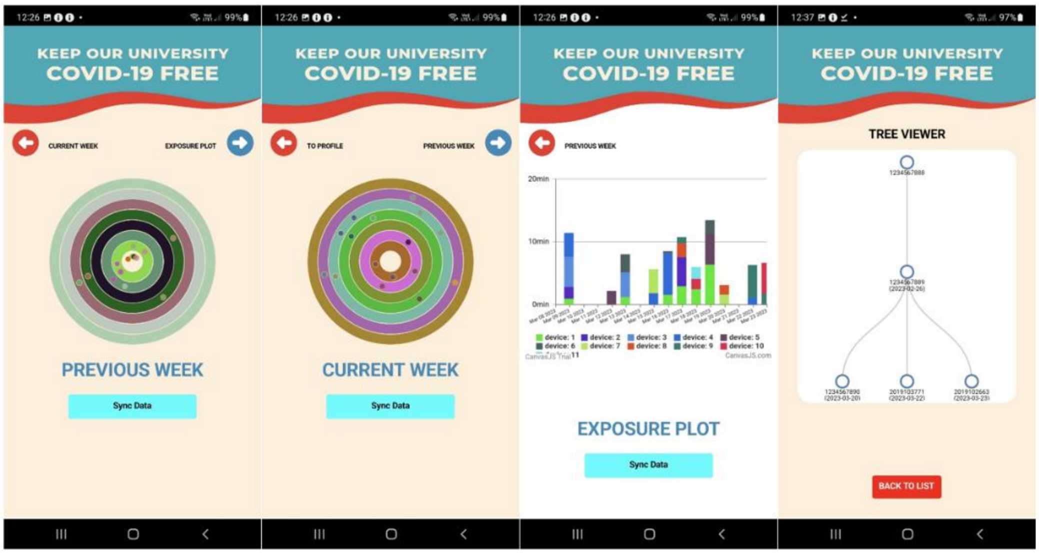

Figure 11. Mobile application's pandemic mitigation features (Data Visualization)

Figure 11 shows the data visualization provided by Safetree. The mobile application offers a ring-like or orbit-like diagram for current and previous weeks of interaction with other users. This diagram can also tell the exact time and day of the week when the interaction occurred. In addition, the size of circles on the orbit-like/ring-like structure vary depending on the duration of the interaction. The most inner ring of the orbit represents the most current day of the week. A stacked bar graph is also used to represent the summary of interaction duration for 14 days. The tree diagram efficiently depicts the extensive interconnectedness of user interactions across the allotted period, giving insightful information into the utilization patterns and relationships. Figure 12 shows the mobile application's post-pandemic preparedness features. This includes the optional enabling of notification exposure to receive messages from other mobile application users the user had previously interacted with. Moreover, an emergency alert notification is also incorporated into the application in which users can alert people who they previously had an interaction with within the day that they are in danger at the specific time and location.

Figure 12. Mobile application's post pandemic preparedness features

Database

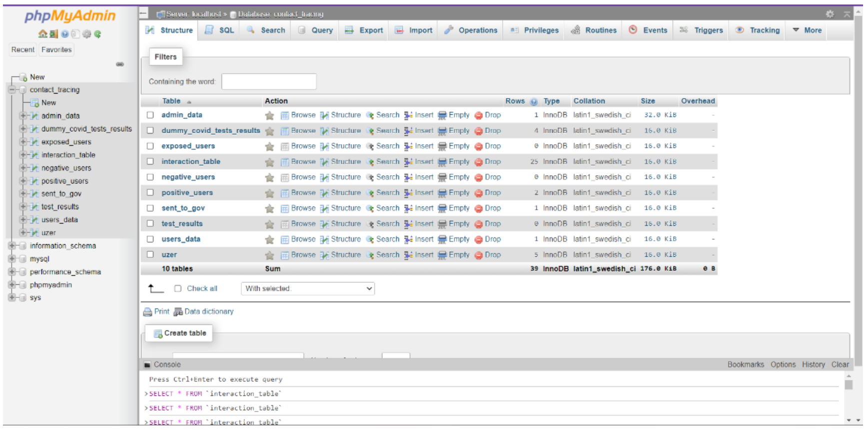

Figure 13. Database

Figure 13 shows the database created which stores the overall interaction data between each user and the COVID-19 test results.

Wearable Device to Mobile Application Communication

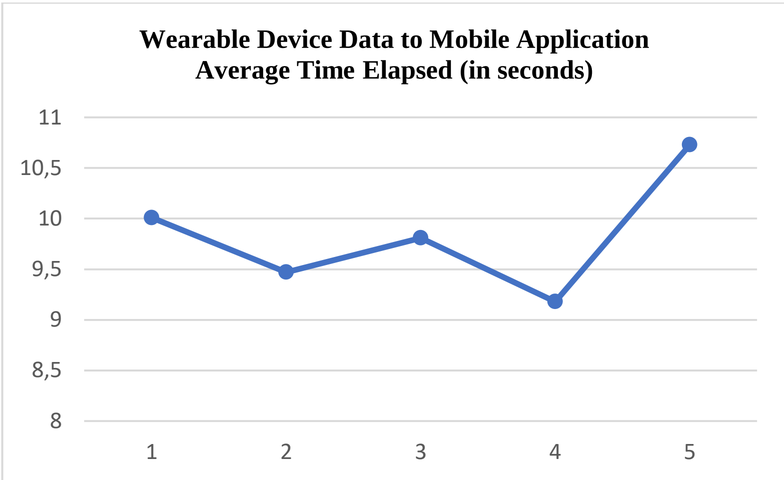

Figure 14. Mobile application's post pandemic preparedness features

Figure 14 shows the graph depicting the average time elapsed for the response between the communication of each wearable device and mobile application. The average response time between the wearable device and the mobile application varied from 9 seconds up to almost 11 seconds.

Power Management

Device Modes' Current Consumption

Table 5. Current consumption of device modes

Device Modes	Current Consumption (in mA)
Active Mode	150
Light Sleep	15
Deep Sleep	6.6

The current consumption of various device modes is displayed in this table. With the device in active mode, which involves active broadcasting and receiving, its current consumption is roughly 150 mA. In light sleep mode, it is roughly measured at 15 mA, while in deep sleep, it is roughly measured at 6.6 mA.

Battery Life

This table displays the wearable device's computed battery life for various device settings based on the measured current consumption. It is possible to stay in active mode for almost 13 hours. Sustained deep sleep mode can persist for around 303 hours, whereas continued light sleep mode can continue for about 133 hours.

Table 6. Battery life

Device Modes	Battery Life (in hours)
Active Mode	13
Light Sleep	133
Deep Sleep	303

Experimentation Set-Ups

Table 7 shows the summary of results for the experimentation set-ups, one-to-one and one-to-many, having broadcaster role-to-receiver role as the situation for both indoor (classroom) and outdoor (hallway) settings. It is expected that both broadcaster and receiver will unsuccessfully function outside the 1-meter range, while functioning completely within the 1-meter range. However, in some of the situations, both roles did not function completely even if they are within the 1-meter range. While in other situations, both roles functioned successfully even if they are outside the 1-meter range. This occurrence is due to the instability behavior of the RSSI and its susceptibility to various factors within an indoor and outdoor environment (Cruz et al., 2018; Cruz, Garcia et al., 2018).

Table 7. Summary of results for the experimentation set-up

Situation (Broadcaster to Receiver)	Location	Success Rate			
		Receiver		Broadcaster	
		Within 1 meter	Outside 1 meter	Within 1 meter	Outside 1 meter
1:1	Classroom	100%	100%	100%	100%
	Hallway	100%	0%	100%	0%
1:2	Classroom	90%	20%	100%	20%
	Hallway	70%	0%	100%	0%
2:1	Classroom	100%	20%	90%	20%
	Hallway	80%	0%	70%	0%
1:3	Classroom	90%	0%	100%	0%
	Hallway	90%	0%	100%	0%
3:1	Classroom	100%	0%	100%	0%
	Hallway	100%	0%	90%	0%
1:4	Classroom	90%	10%	100%	10%
	Hallway	70%	0%	100%	0%
4:1	Classroom	100%	0%	90%	0%
	Hallway	100%	0%	80%	0%

Table 8. Summary of tree algorithm testing (5 trials for each situation)

Situation	Initial Categories					COVID-19 Status					Final Categories					Success Rate
	D1	D2	D3	D4	D5	D1	D2	D3	D4	D5	D1	D2	D3	D4	D5	
1	A	B	C	D	E	+	-	N/A	N/A	N/A	A	B	C	D	E	100%
2	A	B	C	D	E	+	+	-	N/A	N/A	A	A	B	C	E	100%
3	A	B	C	D	E	+	+	+	-	N/A	A	A	A	B	E	100%
4	A	B	C	D	E	+	+	+	+	N/A	A	A	A	A	E	100%

Tree Algorithm Efficiency

Table 8 shows the summary of results for testing the efficiency of the Tree algorithm implemented in the contact tracing aspect of this research in the pre-pandemic and post-pandemic setting with five trials each situation. Category A is the confirmed case, Category B is considered as the close contact of Category A, Category C is the close contact of Category B, Category D is considered as the close contact of Category C, while Category E is neither the close contacts of any categories mentioned. Based on all situations, the tree algorithm resulted in a 100% efficiency or success rate in representing interconnectedness of user interactions across the allotted period. In all the situations, the algorithm provided insightful information into the relationships between confirmed cases and their respective close contacts for each of the devices.

Conclusion

In conclusion, the built wearable device prototypes could detect the presence of other wearable devices within such a 1-meter radius and convey that information to the created mobile application with a database to conduct a contact tracing operation. Users were able to establish contact tracing, ascertain the beginning of the interaction, and gather their exposure duration using all these methods of data visualization. Regardless of how the devices were configured, each wearable in the experiment setup was able to operate correctly within a 1-meter range. Unfortunately, due to environmental conditions that were present in several of the experimental settings, some of the devices operated outside of the 1-meter range. Device power modes can lower the ESP32 module's current usage. Maximum current consumption during active mode is measured up to 150 mA, maximum current consumption during sleep mode is recorded up to 15 mA, and maximum current consumption during deep sleep is measured up to 6.6 mA. The ESP32 module still provides external power to the linked sensors; hence its specification on the datasheet is different. The average response time between the wearable device and the mobile application varied from 9 seconds up to almost 11 seconds. In the fields of contract tracing and social network analysis, the tree method has been shown to be effective for examining user interactions. The extensive network of user interactions was successfully displayed by the tree data visualization within the allotted timeframe, offering important insights into the usage patterns and relationships.

Recommendations

Future researchers are advised to: (1) enhance the data collected by considering that most factors affecting RSSI can be controlled, (2) create a website with only administrative rights, (3) use additional filters to improve RSSI accuracy, (4) integrate real-time data acquisition in wearable device and mobile application communication, and (5) create a cross-platform mobile application that is similar.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Acknowledgements or Notes

* This article was presented as an oral presentation at the International Conference on Basic Sciences, Engineering and Technology (www.icbaset.net) held in Marmaris/Turkey on April 27-30, 2023.

*The researchers wish to convey their profound gratitude to the Lord for giving them faith, understanding, willpower, and direction as they conducted their research. The thesis advisor, Engr. Febus Reid Cruz for his crucial advice and guidance during the entire writing process of this paper. The researchers would also like to express their gratitude to their loved ones for their unwavering encouragement, compassion, and patience in helping them overcome some of the most challenging obstacles they encountered while doing their research.

References

Alhmiedat, T., & Aborokbah, M. (2021). *Social distance monitoring approach using wearable smart tags*. Multidisciplinary Digital Publishing Institute.

Amft, O., Lopera González, L. I., Lukowicz, P., Bian, S., & Burggraf, P. (2020). Wearables to fight COVID-19: from symptom tracking to contact tracing. *IEEE Pervasive Computing*, *19*(4), 53-60.

Chang, E., Moselle, K. A., & Richardson, A. (2020). CovidSIMVL --transmission trees, Superspreaders and contact tracing in agent based models of covid-19 [Preprint]. *medRxiv*. https://doi.org/10.1101/2020.12.21.20248673

Cruz, J. C. D., Cruz, F. R., Sese, J., Borbon, M. D., Cacayuran, A. G., Dela Rea, K., & Gammad, J. R. (2018). Faculty monitoring system with mobile application using received signal strength Indication. In 2018 IEEE 10th *International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management* (HNICEM) (pp. 1-6). Baguio City, Philippines.

Cruz, J. C. D., Garcia, R. G., Garcia, A. J. G., Manalo, K. A. A., Nworgu, V. I., & Payumo, J. B. M. (2018). Proximity tracker using received signal strength, particle filter and extended kalman filter. In 2018 IEEE 10th *International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management* (HNICEM) (pp. 1-6). Baguio City, Philippines.

Department of Health. (2021). *COVID-19 FAQS* [Online]. https://doh.gov.ph/COVID-19/FAQs.

Jeon, K. E., She, J., Soonsawad, P., & Ng, P. C. (2018). BLE beacons for internet of things applications: Survey, challenges, and opportunities. *IEEE Internet of Things Journal*, *5*(2), 811–828.

Jones, N. R., Qureshi, Z. U., Temple, R. J., Larwood, J. P. J., Greenhalgh, T., & Bourouiba, L. (2020). Two metres or one: what is the evidence for physical distancing in covid-19? *BMJ*, 370(September), m3223.

Lithium ion Battery Manufacturer and Supplier in China-DNK Power. (n.d.). *How to calculate battery run time*. https://www.dnkpower.com/how-to-calculate-battery-run-time/

Lubis, A. F., & Basari (2020). Proximity-based COVID-19 contact tracing system devices for locally problems solution. In Proceedings of the 2020 3rd *International Seminar on Research of Information Technology and Intelligent Systems (ISRITI).* (pp. 365-370).

Multisys Technologies Corporation. (2021). *All-in-one eight elaborate features of contact tracing platform staysafe.ph* [Online]. https://www.multisyscorp.com/news/all-in-one-eight-elaborate-features-of-contact-tracing-platform-staysafeph. [Accessed: 12-Oct-2021].

Newman, E. (2021, September). Explaining the decision tree flowchart and its Benefits [Blog post]. https://corp.yonyx.com/customer-service/explaining-the-decision-tree-flowchart-and-its-benefits/

Nielsen, J., & Budiu, R. (2023). Success rate: The simplest usability metric. nielsen norman group. Retrieved from https://www.nngroup.com/articles/success-rate-the-simplest-usability-metric/

Song, S. W., Lee, Y. S., Imdad, F., Niaz, M. T., & Kim, H. S. (2019). Efficient advertiser discovery in Bluetooth low energy devices. *Energies, 12*(9), 1707.

Su, Z., Pahlavan, K., & Agu, E. (2021). Performance evaluation of COVID-19 proximity detection using bluetooth le signal. *IEEE, 9,* 38891–38906.

World Health Organization. (2021). *Who western pacific | Covid-19 information for the public* [Online]. https://www.who.int/philippines/emergencies/covid-19-response-in-the-philippines/information. [Accessed: 12-Oct-2021].

Author Information

Jille Anne R. Verano
Mapúa University
Muralla, St., Intramuros, Manila 1002, Philippines
jarverano@mymail.mapua.edu.ph

Doreen Marie S. Sorongon
Mapúa University
Muralla, St., Intramuros, Manila 1002 Philippines

Febus Reidj G. Cruz
Mapúa University
Muralla, St., Intramuros, Manila 1002, Philippines

To cite this article:

Verano, J.A.R., Sorongon, D.M.S. & Cruz, F.R.G. (2023). Safetree: An integrated wearable device and mobile application solution for pandemic mitigation and post-pandemic preparedness, incorporating contact tracing, social distancing emergency alert notification, and socialization features. *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 22,* 59-73.