PROTOTYPE APPLICATION OF CROWD DETECTION SYSTEM FOR TRADITIONAL MARKET VISITOR BASED ON IOT USING RFID MFRC522

Wirmanto Suteddy[1)], Dastin Aryo Atmanto[2)], Rizki Nuriman[3)] and Afila Ansori[4)]
[1,2,3)]Jurusan Teknik Komputer, Universitas Pendidikan Indonesia
[4)]Jurusan Rekayasa Perangkat Lunak, Universitas Pendidikan Indonesia
Jl. Raya Cileunyi-Cibiru KM 15 Bandung
e-mail: wirmanto.suteddy@upi.edu[1)], dastinaryo5@upi.edu[2)], rizkinuriman@upi.edu[3)], afilaansori@upi.edu[4)]

ABSTRACT

Crowds of people are the government's concern in dealing with the COVID-19 pandemic because the virus transfers unwittingly from one person to another and transmits it to the closest environment. One of the locations where crowds are difficult to avoid is a traditional market and is thought to be one of the places that have the potential to become the center of the spread of COVID-19. Various efforts made by the government in suppressing crowds have yielded results, but not a few violations that occur are carried out intentionally or unintentionally, one of the efforts to prevent crowd violations is the traditional market visitor detection monitoring system by market management so that market visitors do not violate health protocols and crowds that occur in an area can be avoided. In this study, an IoT-based crowd detection system application prototype uses an RFID sensor MFRC522 as a crowd indicator based on data on the number of visitors entering a kiosk that is recorded in the database and then displayed on the application, this data becomes an indicator of which kiosk other visitors want to go to so that the crowd can be avoided. System functionality testing was carried out with 4 scenarios and system reliability testing through data transmission was carried out 10 times with test data in the form of kiosk id and visitor id sent via a single Transmission Control Protocol (TCP) with a full-duplex communication channel. The test results show that crowd indications can be detected in the application with data transmission speeds reaching 875 KB/s with an average delay of 231.4 ms and a standard deviation of 215 ± 313 ms.

***Keywords**: Crowd Detection System, RFID, IoT, Traditional Market.*

I. INTRODUCTION

The traditional market is the heart of the economy for small communities to pit the value of their commodity goods and has a very vital role in the economy in Indonesia. However, the traditional market is suspected to be one of the centres for the spread of the virus, causing many new cases to emerge and potentially opening up opportunities for the emergence of new clusters of Covid-19 [1][2]. This is because the crowds that occur in the market area are difficult to avoid so unwittingly the transfer of the virus will be faster and undetected. In addition, the low application of health protocols in traditional markets is also a very difficult problem to overcome [3]. The government has also appealed to the public to comply with health rules when carrying out activities with several policies, such as wearing masks, avoiding crowds and keeping each other at a distance. However, in its application, there are still many individuals and community groups who do not comply with health protocols, such as crowding and exceeding the maximum capacity in the market area so restrictions on activities during the pandemic remain in place.

The new policy on activity restrictions during the pandemic makes it difficult for traders to cause stalls in traditional markets to be quieter, the reduced purchasing power of the community and the distribution of materials hampered [4]. Thus, the supervision of the market area to prevent the virus from spreading needs to be implemented carefully, not only does every individual who has to adapt but market management also needs to be vigilant in maintaining their environment.

Based on these problems this study will be designed a prototype application of a traditional market visitor detection system based on *the Internet of Things* (IoT) to supervise traditional market areas by limiting the number of market visitors at each kiosk. This traditional market visitor detection system is an intelligent device using *MFRC522 RFID* sensors designed to identify crowds by monitoring the number of visitors at each kiosk. The device will be integrated with android-based applications as *User Interface* (UI) made using *Android Studio*. This application serves to display information about the area of harmony on the kiosk by calculating the number of visitors in the area so that it is hoped that the crowd in the area can be avoided. In addition, in the future, this application will also be developed as a *platform* or *marketplace* so that visitors who come directly or from home can make buying and selling transactions at the seller's store easily.

Visitors who want to shop at a traditional market store must have a shopping cart in the form of *an RFID tag* that is used to record the number of visitors when making transactions at the store. Monitoring of the market area in each store can be done through an integrated application. If the store is detected to exceed normal capacity, a notification status will appear on the application which is also displayed on the *seller's LCD* that the store exceeds capacity so that visitors who want to come are advised to shop at other stores. The prototype of the traditional market visitor crowd detection system application is expected to help market management to monitor the state of the market area so that visitors do not violate health protocols and crowds that occur in an area can be avoided.

II. Literature Review

Crowd detection systems have been widely researched by researchers around the world, the technology used by the majority of camera-based as done by Qiming et al. [5]. It uses the camera in facial recognition as its detection object and features such as *Haar* and *the Adaboost* algorithm, but the human subjects in it are still in a class. Choudary et al. [6] also uses *camera surveillance* and *SIFT* extraction feature techniques and *genetic algorithms* in detecting human crowds in a video. Fatih et al. [7] use *fully-convolutional network* techniques with *input* in the form of a series of images taken on a drone-based recorded video camera to detect crowds. Kuchhold et al. [8] apply *scale-adaptive* techniques in detecting large numbers of *people* based on drones with outdoor human crowd objects such as at tourist attractions, demonstrations or concerts. Bour et al. [9] Conducted an in-depth *state-of-the-art* analysis of the techniques used to detect crowds using microscopic and *macroscopic* approaches from the point of view of stationary cameras and mobile cameras. On the one hand, the detection of anomalies or behaviour in a crowd based on surveillance cameras or video sources is carried out by [10] *Deep learning*, wherein the crowd detected the behaviour of the crowd such as crowd demonstrations, crowds at traffic jams, normal crowds, crowds at riots. or human emotions in the crowd are detected positively or negatively.

In the case of crowds related to the *COVID-19* pandemic where crowds are detected manually through raids of crowd-indicated locations, then one of the efforts made is to create a smart camera-based community surveillance application as done by Liem et al. [11], where if a crowd is detected through *a pyroelectric* sensor it will be seen on the *GPS* application that the area is indicated by a crowd, but this system requires considerable costs because each area is given a surveillance camera equipped with all support equipment and sensors. The detection system for the use of masks in the human crowd area can also be categorized as a crowd detection system, it's just that the object detected in the mask, if there are many mask objects nearby then the crowd is detected, if a few masks are detected, then the crowd indication is not detected as done by [12][13]. In addition, Juhana [14] in his research made an RFID-based crowd prevention device in an office area, where if a room indicated a crowd based on the calculation of the number of RFID-based employee identity card entries through the door, then the door of the room was locked automatically. Crowd detected in addition to preventing the spread of *COVID-19* is also used as detecting unusual activities in the same area such as shopping malls and airports for security reasons and crime investigations such as those carried out by [15], where the *Support Vector Machine* (SVM) method is used as an image processing technique. *Radio-frequency identification* (RFID) technology through variations in *received Received Strength Signal Indicator* (RSSI) values and adopts entropy and morphological imagery and then combined with *machine learning methods* are used to calculate human objects as done by [16][17], where if more and more human objects pass between *passive tags* and *RFID* readers are emitted periodically and if the RSSI value varies, then a crowd indicates.

In this study, we proposed a prototype application of a traditional market visitor crowd detection system where the location is indicated as one of the locations of the spread of *COVID-19* that is difficult for the crowd to avoid with the method that we propose based on *the Internet of Things* (IoT) using *RFID MFRC522* as its main sensor. connected with *esp32 WROOM DevKit V1 microcontroller. The microcontroller* will be connected to the internet network which will provide notifications on the application as a crowd counting tool in an area of the seller's store with indicators if more than 10 buyers are detected at the store then indicated as a crowd. The reason for choosing *the MFRC522 RFID* sensor is in addition to the fairly affordable price, also as a development that can be integrated with the current payment system and the *RFID* card can be privately owned by visitors to the traditional market or can be purchased at the entrance of the traditional market. The parameters of the system are the speed of transmission of data sent to the *cloud* as a medium between the system and the application and the average delay generated in real-time.

III. RESEARCH METHOD

Research methods are carried out with the following framework.

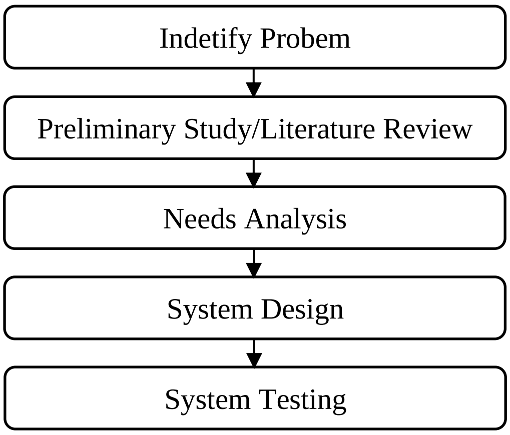


Figure. 1. Research Framework

A. *Problem Identification and Preliminary Studies*

Identify the problem and preliminary studies described above in Title I. Introduction and Title II. Library Review.

B. *Needs Analysis*

Considerations related to the analysis of needs in the application of this crowd detection system are low cost, easy, efficient and reliable, but related to the reliability of this research still requires future development, on our hardware using *ESP32 WROOM DevKit V1* as a microcontroller, *MFRC522 RFID* module and *ID Tag* card as the main sensor, 16 cm *LCD* x16 cm as a display on the seller's store, *buzzer* as a voice notification, *Google Firebase-based* cloud computing media as a data storage location, and Android-based applications as a medium between visitors and sellers.

C. *System Design*

Outline, the prototype of this crowd detection system application is divided into 4 parts, that is (1) Input part, (2) Process part, (3) Storage part, and (4) Output part. The input section where the visitor detection process is based on the main sensor, the part of the process where the data that has been received from the sensor will be passed on to the output and storage section, the storage section will record the data that has been received, the output part will display the data from the storage section as shown in Figure 2 below.

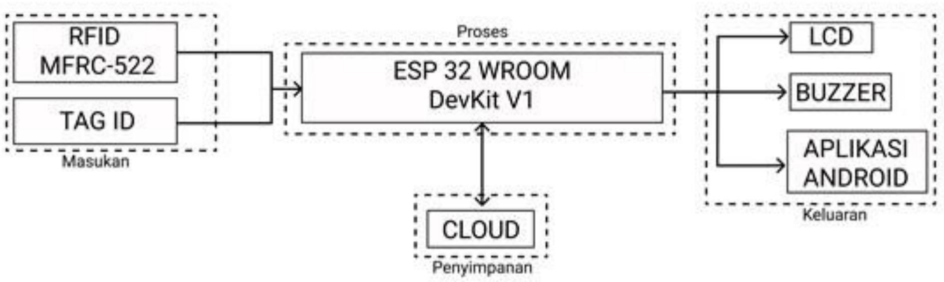


Figure. 2. System Block Diagram

The system block diagram has the following flow, first visitors at the traditional market look first at the application whether the seller's stores detected a crowd or not, then visitors can decide to go to the seller's store that is not indicated by the crowd, then the first time the visitor as a buyer *tapping* as detection of crowd indicators using *the TAG ID* card on the sensor *RFID MFRC522* and bring out *the sound of the beep* on *the buzzer* and information on the *LCD* screen, in this section is the input and output part. Then in the process section using *the ESP32 WROOM DevKit V1* microcontroller that serves as a processor that already has a *WIFI* module will be connected to the *router* and will send market visitor detection data as an indication of the crowd on the *cloud* that will be visible in the application wherein this section is the storage section, after which visitors can make buying and selling transactions at the seller's store, as usual, after the visitor finishes transacting, the visitor will *tap* last as the visitor indicator has been completed and the crowd indicator data is reduced which will be displayed on the

LCD and application so that other market visitors can see crowd indicators and market management can monitor the crowd of store locations on the application. The flowchart of the crowd detection system application is shown as follows in Figure 3.

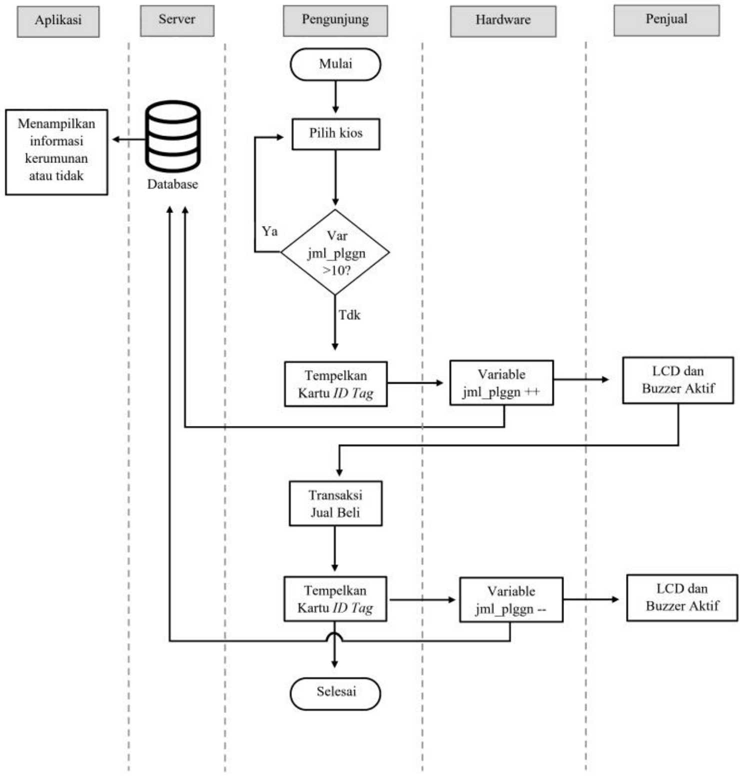


Figure. 3. Crowd detection system flowchart

In the process of transmitting data coming from the device to the server and in the application will use *the WebSocket* communication protocol so that the data sent can be displayed on the application. This protocol is used because in the delivery process it can be faster compared to other protocols such as *Message Queuing Telemetry Transport* (MQTT) and *Hypertext Transfer Protocol* (HTTP). The prototype implementation of the tool from the market visitor crowd detection system is shown in Figure 4.

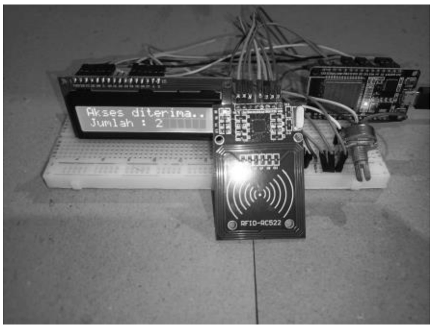


Figure. 4. IoT-based visitor detection tool prototype.

IV. TESTING AND DISCUSSION

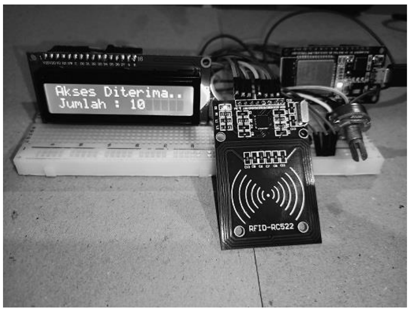
The components of the system are successfully assembled as shown in Figure 3, the compression of this hardware interface is designed to be placed in front of the store so that visitors have no difficulty accessing it. Testing is performed to find out the functionality of the system whether it works as designed by following Figure 2, with the following detection test scenarios:

1) Scenario 1, the first *tapping* test of 10 visitors at a store and shows the results in Figure 5(a), Figure 6(a) and Figure 6(d).
2) Scenario 2, the first *tapping* test of visitors when the store has indicated the crowd is shown in the results in Figure 5(b) and Figure 6(e).
3) Scenario 3, testing the second *tapping* of visitors as an indicator of visitors exiting the store, to show the

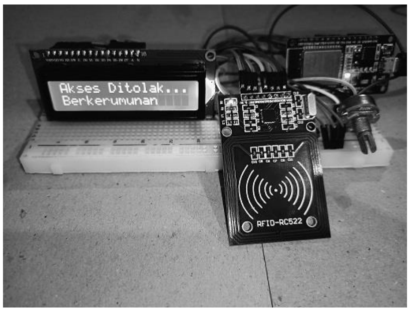
functionality of the device and application that the crowd is reduced shown in Figure 5(c), Figure 6(b) and Figure 6(f).

4) Scenario 4, the first *tapping* test of visitors when the store is not indicated by the crowd is shown in Figure 5(d), Figure 6(c) and Figure 6(g).

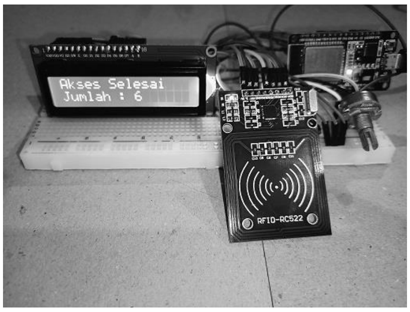
For the entire test scenario, when the incoming visitor is numbered 10 and if it is detected > 10 visitors at the same store, then in addition the application will show the crowd indicated store, the *buzzer* will actively make a sound and *the LCD* will display a notification as shown in Figure 5. b) and the results of the functional testing of the 4 scenarios described above are shown in Table I.



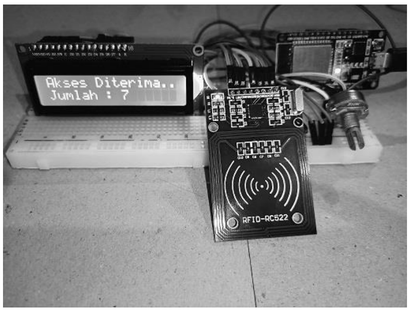
(a)



(b)



(c)



(d)

Figure. 5. (a) Notification of *tapping* scenarios on *LCD displays* for a total of 10 visitors, (b) Notification of tapping scenarios on LCD displays if the crowd is indicated, (c) Notification of second *tapping* scenarios on *LCD displays* indicates a reduced number of visitors, (d) Scenario notifications *first tapping* on the LCD *displays* visitors increase

TABLE I
SYSTEM TEST RESULTS

Test scenarios	*Tapping* in visitors	Status *Tapping*	*Tapping* out visitors	Number of Visitors	Crowd Status
1	10	Accepted	-	10	Undetected
2	1	Rejected	-	11	Detected
3	-	Accepted	4	7	Undetected
4	1	Accepted	-	8	Undetected

A. Application Functionality

Results on *the database* and application show that visitor data is successfully recorded and displayed on the application as shown in Figures 5(a) to (g). Visitors to traditional markets must first look at the application to see the status of the crowd at a particular store and when it has entered a store that is not indicated by the crowd, visitors must do 2 taps of *the RFID* card, *tapping* first to provide incoming visitor information so that the number of visitors increases which are then sent to the *database* and can be viewed on the application. *The second tapping* provides visitor information out of the store so that the visitor number data is reduced and visible on the application, after the visitor makes *the first tapping*, then the visitor can make transactions as usual. The Android-based application will provide red cross notifications for crowd-indicated stores and green check marks for stores that are not indicated by the crowd and the last status of the crowd or not indicated by the crowd from the store can be a reference for other visitors to visit the store. Implementations in databases and applications are indicated in Figures 6(a) through (g).

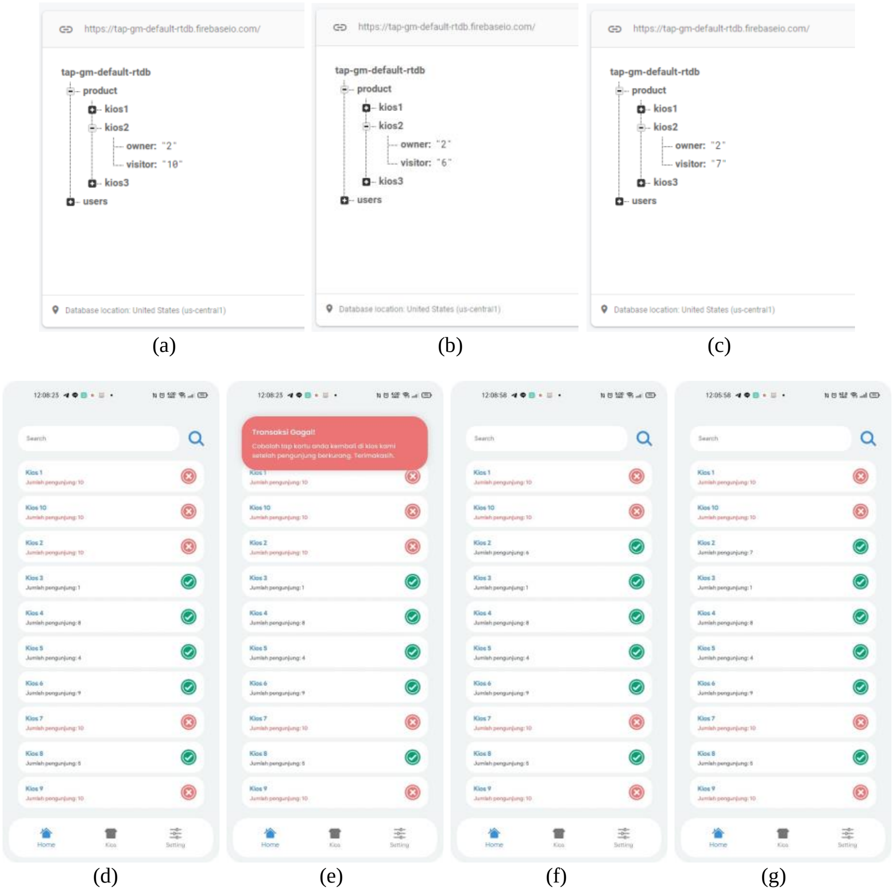


Figure. 6. ((a) Data *tapping* visitors on *a database* of 10 visitors, (b) Visitor data on the *database* when visitors exit the store, (c) Data on the *database* when the visitor taping first with the status of the store has not been detected crowd, (d) Crowd notifications on the application are marked with red crosses, (e) Tapping notifications fail on the application because the store has indicated a crowd, (f) Notifications on the application are marked with reduced visitors on store 2, (g) Notifications on the application the number of visitors increases on store 2.

B. System Reliability

In an application system, it is necessary to test the reliability of the system by testing the performance of data transmission received on the hardware and then sent to the *cloud* and displayed on the application, while the parameters of this reliability are the average delay and standard deviation of the data transmission carried out. In this test, we used *a Google Firebase-based* database that already has a performance monitoring feature and calculation of the data transmission speed received and then *parsed* from the database and displayed on the application by looking at the average delay of transmission of store *id*-data on the database and *id* detected visitors as shown in Table II as follows.

TABLE II
DATA TRANSMISSION TEST RESULT

Experiment	Transmission data	*Delay* (ms)
1	*Store* ID and *Visitor ID*	313
2	*Store* ID and *Visitor ID*	227
3	*Store* ID and *Visitor ID*	224
4	*Store* ID and *Visitor ID*	228
5	*Store* ID and *Visitor ID*	215
6	*Store* ID and *Visitor ID*	221
7	*Store* ID and *Visitor ID*	217
8	*Store* ID and *Visitor ID*	217
9	*Store* ID and *Visitor ID*	224
10	*Store* ID and *Visitor ID*	228

Testing the performance of data transmission from the *database* and displayed on the application is done 10 times. Based on Table II, it was found that this system has an average *delay* of 231.4 ms with a standard deviation of 215 ± 313 ms.

V. CONCLUSION

Based on the results of tests and discussions that have been carried out, it can be concluded that the crowd detection system has run as designed, but the testing has not been at the implementation stage in the field because there has not been permitted by the local traditional market manager who is the test site. The following development plan is the addition of infrared sensors to validate the number of market visitors in front of the store both for visitors who make transactions and for visitors who pass by, as well as the integration of payment *platforms* for merchandise buying and selling transactions on existing digital payment systems.

From our observations, the comparison of crowd detection methods based on *RFID* sensors with camera-based methods is a method based on *RFID* sensors is a cheap and reliable system method and can be proven 100% indication of crowd numbers with a specified indicator if the number of visitors e.g. more than 10 or 20 visitors and if follow the flow of the system correctly, but still require validation from visitors through *RFID* cards, while camera-based methods with *machine learning* methods are also very effective but the effectiveness of the level of accuracy detected and tracking moving objects based on problems if the object has obstacles, variations in movement and display, causing loss of detection and Exploration is still a research topic that is still being researched today and has the advantage of not validating the person.

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