DESIGN AND IMPLEMENTATION MOSQUE SMART DIGITAL SIGNAGE, CONNECTED WITH IP CAMERA FOR SERMON

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Abstract

The use of external displays such as monitors or TV that can display khotib when delivering khutbah can help the congregation be more solemn when the khutbah is recited. To accommodate this, a system displayed khotib when greeting the khutbah using a tool that can detect whether khotib has climbed to the pulpit and delivered the khutbah. Wemos D1 R2 was chosen to be the central processing of the text of whether khotib was on the stand and delivered the khutbah and send the detection data to the local server to set the view to be visualized to the worshippers. The test results of this tool had an average accuracy performance of the sensor reached 99% at a test distance of 1 meter and the data was sent in real-time with the trigger of a change in the status of khotib there and did not exist with an average delay of 43.76ms and an average through "put sensor" of 76.8 kbps from hardware to the server using the HTTP POST protocol.

Keyword : Smart Building, Arduino, RTSP, Sensor Ultrasonik, HTTP Method.

1. Introduction

In the history of Islam, Rasulullah built a mosque at Madinah as a praying place and also as a facility to held dakwah, education, social, and political activities. As time passes, these activities also can be supported by using technology.

On the other side, the development of smart building these days is not only for commercial building and residencies but also can be applied in praying place. Mosque equipped with CCTV, AC, and smart door lock can be found in some places. Digital signage to show the pray schedule, khutbah, and the information of mosque activities is also not a new thing.

Digital signage use website-based that will be uploaded in hosting. IP camera CCTV will be connected to the website using RTSP. To change the display on the website when khutbah is held, it will be done automatically by program, which is using ultrasonic sensor.

2. Basic Concepts

2.1 Smart Building

Smart Building system or also known as The Intelligent Building system is the technology integration with components or devices inside the building therefore can be programmed according to the needs through automatic central control. Almost all parts or components in the building can be controlled automatically.

2.2 IP Camera

Internet Protocol Camera is a digital video camera based on the IP network to send video data. The technology that was used is different from analogue CCTV even though both of them can be functioned as a security camera.

2.3 RTSP

IP Camera is equipped with a protocol to run the audio or streaming video in real-time or can be shortened RTSP. RTSP works as an application protocol that controls data delivery, just like HTTP.

On the other side, the web browser that was used to show information does not support this protocol directly. It needs something to change the RTSP protocol to HTTP. To do this change, there are a lot of choices, such as using VLC [1].

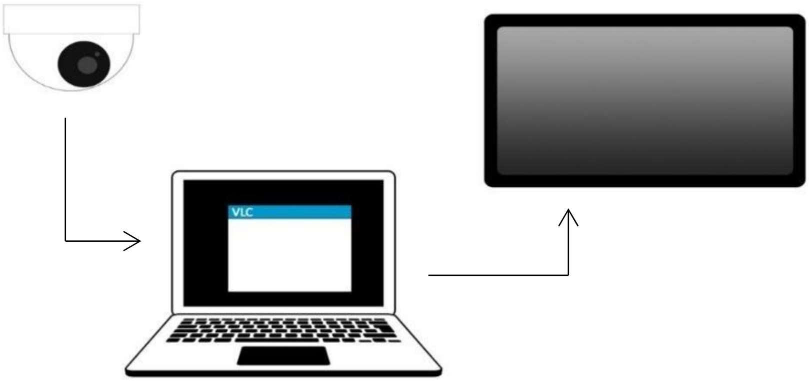


Figure 1. Show the capture of IP Camera streaming in the VLC.

2.4 Website and Digital Signage

A website-based application is a software application using browser technology and can be accessed through the internet network or intranet. The programming language that was used to support the website-based software, such as HTML, Javascript, CSS, PHP, and other programming languages. To ease the designing process of a website, it uses the framework or CMS (Content Management System).

Digital signage is a monitor or television either as plasma, LED or LED which can display website-based information as an interactive application using an existing browser [2]. Also known as digital information boards that can be found in several places such as airports, terminals, offices, hotels, hospitals, schools, and many other places. The advantages of website-based digital signage are that the content is more dynamic and interactive, can be changed, added more easily**.**

2.5 Microcontroller

A microcontroller is a single-chip microcomputer that is used specifically for controller type applications. This microcontroller can perform a variety of different functions and control several processes simultaneously. A single-chip microcomputer comprises at least a CPU, RAM and ROM. Programming uses built-in memory or via an external memory chip.

In this case will be using WeMos D1 R2 which is integrated with the ESP8266 module. A Wi-Fi module as an additional microcontroller like the Arduino to connect to Wi-Fi and make a TCP/ IP connection. This multipurpose Wi-Fi module is an SoC (System on Chip), so programming can be done directly to the ESP8266 without requiring an additional microcontroller.

2.6 Ultrasonic Sensor

This ultrasonic sensor functions to convert sound quantities into electrical quantities and vice versa. The way this sensor works is based on the principle of the reflection of a sound wave so that it can interpret the existence (distance) of an object with a certain frequency. The formula for knowing the distance used by ultrasonic sensors is:

$$Distance = \frac{Speed\ of\ sound\ x\ time}{2} \quad (1)$$

3. Methodology

3.1 Series of System

The following is a series of system performance to be implemented

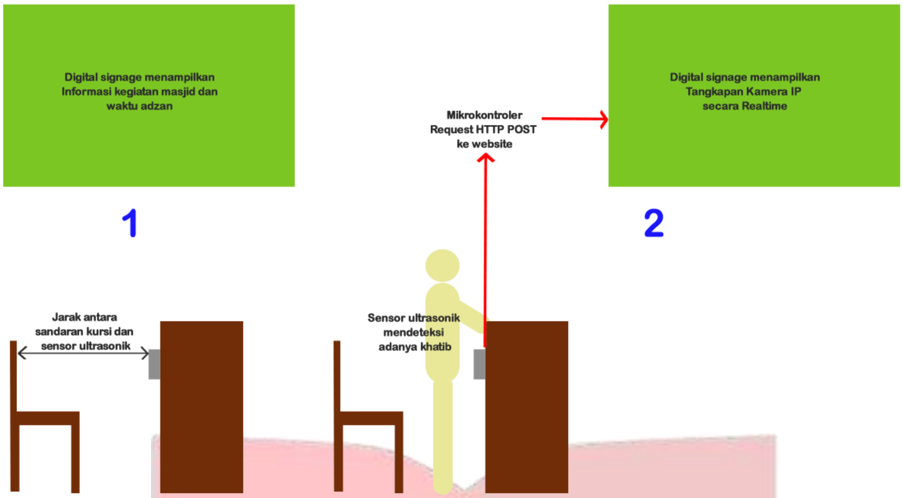


Figure 2. The System Performance Circuit.

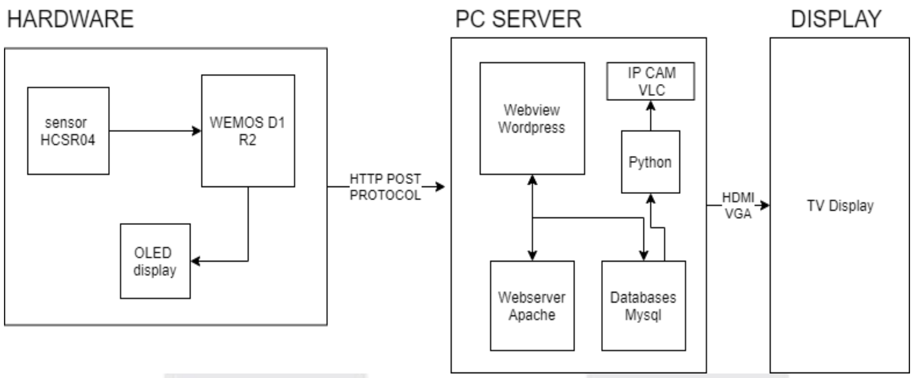


Figure 3. System Block Diagrams.

3.2 Hardware Design

Distance measurement through ultrasonic sensors was analyzed through several stages, namely input, process, output (resulting). The diagram block image can be seen below.

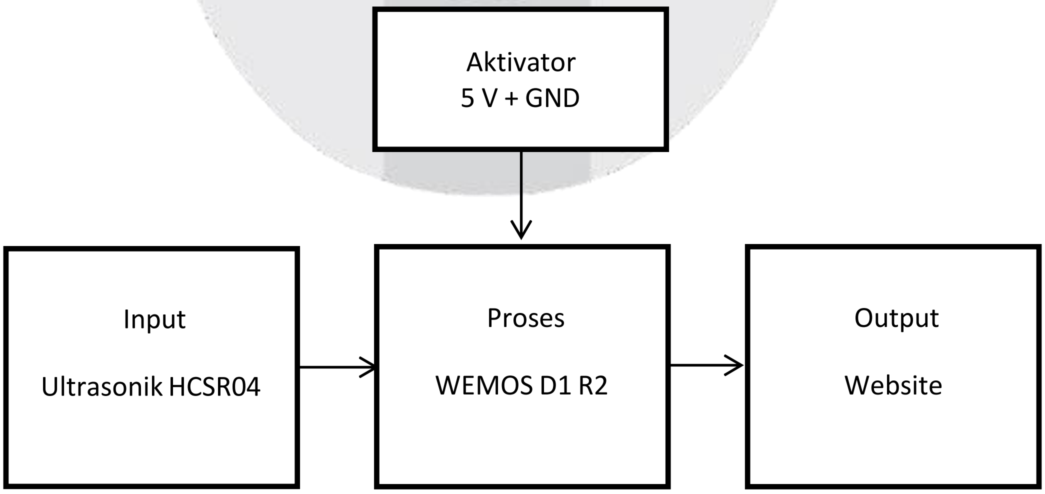


Figure 4. Blocks of Distance Detection Sensor Diagrams.

The first analysis was done on the activator block. This activator block was the DC voltage into the appliance. The voltage used was 5 Volts. Furthermore, the input block section used the ultrasonic sensor HCSR04. The sensor was then processed by WeMos D1 R2, and communication consisted of a program that functions to control the output produced. The output in the above process was the signal that was forwarded to the website. Then the website gave instructions to change the LED or monitor display from information display to IP camera display.

3.3 Flow Chart

The treatment of this tool can be explained through the flow chart as shown below.

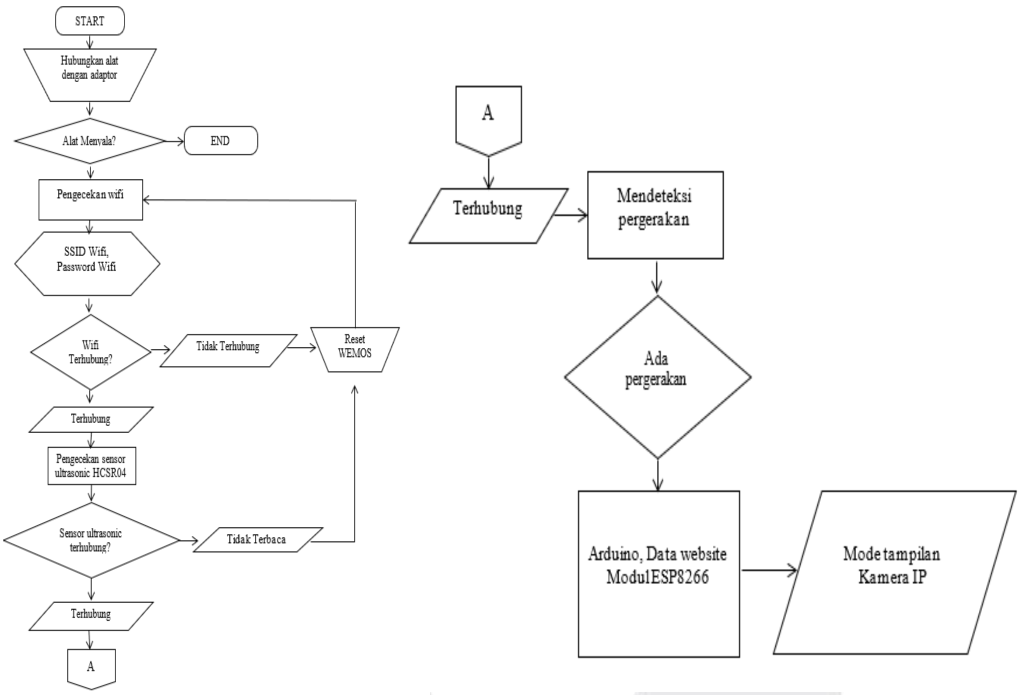


Figure 5. Flow Chart.

3.4 Motion Sensor Test

Motion sensor tests were performed to see if the motion sensor is working to provide the desired output. Motion sensor tests were conducted by:

Put the sensor in the right position and area. Move the object in front of the sensor at a distance of fewer than 1.5 meters. The table below shows the results of PIR sensor tests conducted in the above way:

Tabel 1. Movement Observation Data

Ultrasonic Sensor	Sinyal Website	Display Signage
Distance = 1,5 meter	No commands	Information display mode
Distance < 1,5 meter	Presence of commands signals	IP CAMERA display mode
Distance = 1,5 meter	Presence of commands signals	Blank display mode for 20 minuts

When there was a movement of objects that was the presence of humans in the khatib's podium captured and detected by the sensor then automatically the sensor signalled on the website. Next, the website would give a command to change the display on the LED.

4. Analysis and Discussion

4.1 System Implementation

This was the prototype of the design that created by using an esp8266-based microcontroller embedded in the WEMOS D1 R2 development board.

Figure 6. The Prototype of Smart Signage.

Figure 6 is a prototype that was used for the SMART SIGNAGE application by using a plastic box in size 12,5 x 8,5 x 5 cm as the casing and using an OLED display in size 128 x 64 px to display the menu and the product condition while it worked. HCSR04 ultrasonic sensor was placed in front of the casing so the censor will work optimally.

While the used platform to create the digital signage display is WordPress. WordPress was chosen because of the community support and the good flexibility to use and also can be developed to fit as desired. Following the product design that was discussed in the previous chapter, figure 4.4. is the realization of the used interface.

Figure 7. The Preview of WordPress Interface.

The next part was the VLC software that was used to display the video that was sent by ipcam through RSTP protocol that was connected in one computer server network using open network system menu that available in VLC software.

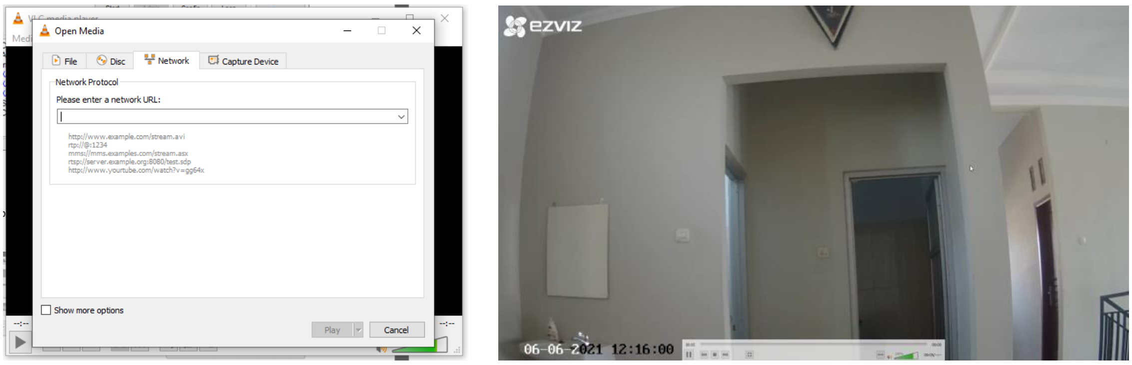


Figure 8. The Preview of VLC Software and Video Stream.

To control the ipcam and webview preview from the shown display was using phyton and to display the newest data from the database.

4.2 The Result of System Testing

After the implementation process had has done, the next step was system testing. System testing is the checking or correcting step toward the researched system, whether it still appropriate with the research goal. The test included the hardware, then the server by following the passed data route to the server and then to the output. The testing process would be done following the process diagram below.

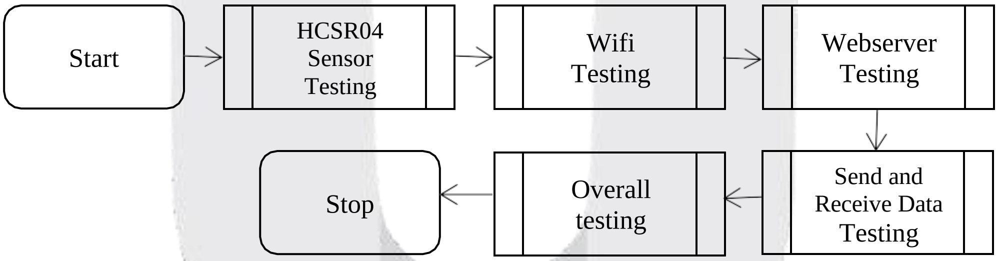


Figure 9. The Diagram of System Testing Process.

4.3 HCSR04 Sensor Testing

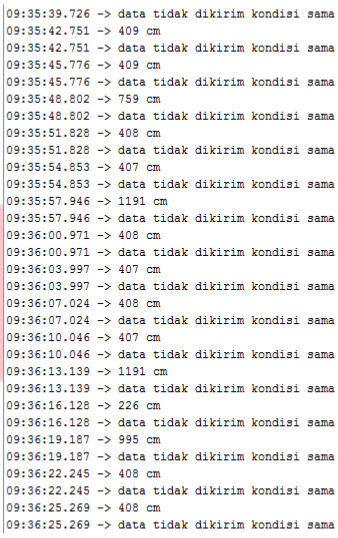
The ultrasonic sensor testing as the distance sensor was done by using a tape measure as the distance comparator. The sensor testing was done 5 times with the results as below.

Table 2. The Sensor Testing Table.

NO	Distance (cm)		Error (%)
	Test	Measurement	
1	48	50	2
2	40	40	0
3	30	30	0
4	79	80	1
5	98	100	2
Average Error			1

From the data above, there was an error value because of the temperature changing in the location testing that affected the wind velocity so the ToF calculation from the sensor was changing. But, the data from the sensor still could be used since the error value was small enough and did not affect the product performance significantly.

According to specification of ultrasonic sensor HC-SR04, it is known that the optimal range of distances that can be measured is 2cm – 400cm. This test only measure at maximum distance which is 400 cm. Below is the result.



```
09:35:39.726 -> data tidak dikirim kondisi sama
09:35:42.751 -> 409 cm
09:35:42.751 -> data tidak dikirim kondisi sama
09:35:45.776 -> 409 cm
09:35:45.776 -> data tidak dikirim kondisi sama
09:35:48.802 -> 759 cm
09:35:48.802 -> data tidak dikirim kondisi sama
09:35:51.828 -> 408 cm
09:35:51.828 -> data tidak dikirim kondisi sama
09:35:54.853 -> 407 cm
09:35:54.853 -> data tidak dikirim kondisi sama
09:35:57.946 -> 1191 cm
09:35:57.946 -> data tidak dikirim kondisi sama
09:36:00.971 -> 408 cm
09:36:00.971 -> data tidak dikirim kondisi sama
09:36:03.997 -> 407 cm
09:36:03.997 -> data tidak dikirim kondisi sama
09:36:07.024 -> 408 cm
09:36:07.024 -> data tidak dikirim kondisi sama
09:36:10.046 -> 407 cm
09:36:10.046 -> data tidak dikirim kondisi sama
09:36:13.139 -> 1191 cm
09:36:13.139 -> data tidak dikirim kondisi sama
09:36:16.128 -> 226 cm
09:36:16.128 -> data tidak dikirim kondisi sama
09:36:19.187 -> 995 cm
09:36:19.187 -> data tidak dikirim kondisi sama
09:36:22.245 -> 408 cm
09:36:22.245 -> data tidak dikirim kondisi sama
09:36:25.269 -> 408 cm
09:36:25.269 -> data tidak dikirim kondisi sama
```

Figure 10. Maximum distance which can be detected by sensor.

4.4 Overall Testing

After testing wifi, webserver, send and receive data testing, the overall test referred to the results of the previous test results so that this test only showed how the tool behaved when implemented. That was by placing objects detected by HCSR04 sensors in a distance of less than 150 cm as a sign of the presence of khotib that would fill Friday's sermon. After the sensor detected objects at that distance it would signal the server then after the data reached the python program server that had has been prepared would process the data with the display output would change from the web to the camera or vice versa. For the overall test results could be observed in the picture below.

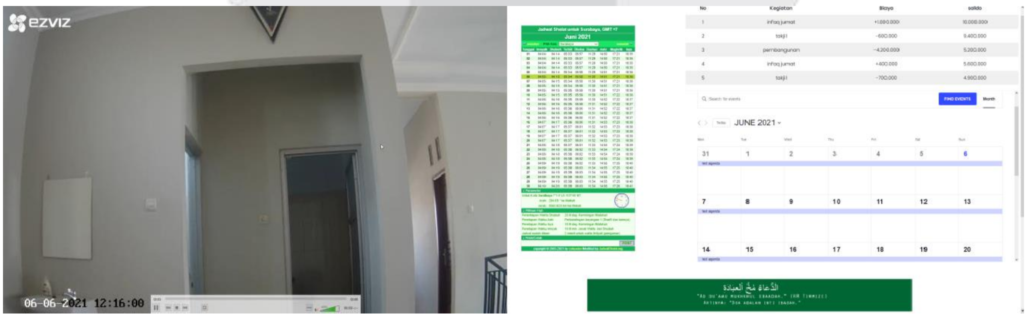


Figure 11. (left) contained object, (right) had no object.

4.5 System Response Time Test

Whereas the system response time is under 0,3ms, it start when the device sent data to server until device received the response. Test result when the sensor covered by object the response time is shown 0,251s as on the figure 12 left side, and the response time is 0,142s when the object is moved from the front of sensor as on figure 12 right side.

Measurement	Captured	Displayed
Packets	59	11 (18.6%)
Time span, s	10.524	0.251
Average pps	5.6	43.9
Average packet size, B	207	108
Bytes	12192	1187 (9.7%)
Average bytes/s	1158	4734
Average bits/s	9267	37k

Measurement	Captured	Displayed
Packets	50	11 (22.0%)
Time span, s	16.579	0.142
Average pps	3.0	77.3
Average packet size, B	205	108
Bytes	10228	1187 (11.6%)
Average bytes/s	616	8342
Average bits/s	4935	66k

Figure 12. System response time.

The System response time test is using wireshark software and filtered by ip source and ip destination. As on the both Figure above, the system response time is taken from time span on **Displayed** column.

4.6 Sensor Sensitivity Measurement

Sensor sensitivity to quantity of measurment object, which mean quantity of change ratio of device output and input or the device response to the input or measured variable. Sensitivity test can be done by using simple linear regression to show two mathematics relation in two variable equation. In this case the dependent variable is measured distance, whereas independent variable is needed time of sensor to measure the distance.

Table 3. The distance and time for sensor sensitivity measurement.

No	X_i (cm)	Y_i (µs)	X_i^2 (cm^2)	Y_i^2 ($µs^2$)	X_iY_i (cm µs)
1	32	1896	1024	3594816	60672
2	43	2564	1849	6574096	110252
3	57	3399	3249	11553201	193743
4	71	4182	5041	17489124	296922
5	91	5378	8281	28922884	489398
6	96	5697	9216	32455809	546912
7	106	6258	11236	39162564	663348
8	113	6689	12769	44742721	755857
9	126	7430	15876	55204900	936180
10	136	8004	18496	64064016	1088544
11	161	9489	25921	90041121	1527729
∑	1032	60986	112958	393805252	6669557

$$\text{Sensitivitas} = \frac{n\sum X_iY_i - \sum X_i \sum Y_i}{n\sum X_i^2 - (\sum X_i)^2} \quad (3)$$

$$= \frac{11\,x\,6669557 - 1032\,x\,60986}{11\,x\,112958^2 - 1032^2}$$

= 58,74 µs/cm

By using simple linear regression equation and the above table, the result of sensor sensitivity measurement is 58,74 µs/cm. Which mean every 1 cm distance increased, will get output time 58,74 µs.

4.7 Analysis

This Analysis section is based on the results of tests that have been conducted.

1. Sensor Accuracy Analysis of Objectives

The accuracy of the sensor used was 99 percent of the average error calculation results that had have been tested before. Thus the result of the reading was very good and the resulting error did not affect significantly from the behavior system which was only 1%.

2. **Analysis of Throughput Testing on system performance**
   The performance of the throughput parameter had has been tested in the previous section. The data showed the performance of data transfer speed from the device to the server had an average of 76.8 this was due to the limited delivery configuration of the device and caused a bottleneck from the device side while the server side had a higher receiving speed capability. But with the transfer speed suffices to meet the needs of data transfer in the form of a string to the server
3. **Analysis of Delaytime Testing on system performance**
   The average delay time system created was 43.76ms. The amount of delay was normal to run the smart signage system was based on because in this smart signage system did not demand a direct response below with a faster response but only with nikai delay time as much as it was very good when compared to the performance expectations and hardware used.

5 Closing

5.1 Conclusion

After implementation, testing, and analysis had been done in the previous chapter. Smart signage system that uses WEMOS D1 R2 microcontroller can help Jemaah see khotib during sermon so that Jemaah easier to digest Friday's sermon. After the analysis, testing, and implementation process can be concluded:

1. Hardware testing by connecting hardware to a local network can be done by inserting a code to connect WEMOS D1 R2 and get the IP address and displayed on the OLED display.
2. By using WEMOS D1 R2 and ultrasonic sensor HCSR04 prototype successfully made with satisfactory hardware performance.
3. Performance of HCSR04 sensor to be successfully used to achieve research objectives with an average accuracy of 99%.
4. Smart signage system made can be used, implemented, and can be scaled quickly and easily for large capacity mosques by adding video splitters
5. With an average delay of 43.76ms does not affect the performance of the system significantly and cannot be observed by the Congregation while the system is working.
6. The use of ultrasonic sensor in this study is based on a cheaper price when compared to laser sensors. When compared to infrared-type sensors, ultrasonic sensors are quieter and do not display light.

5.2 Suggestions

After passing the thorough testing and analysis phase, in this final task there are still shortcomings that can be considered for development in the next research:

1. The design of the tool is still not optimal because there is still a lot of free space left from the casing used.
2. The protocol used is still hitchhiking on the local network is expected to be connected to cloud processing and local pc servers can be replaced with smaller controllers.
3. The device still uses a development board so that wiring and components that are not too needed are still consuming power is expected in the future prototype can use independent design as needed.

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