THE DESIGN OF A NOISE DETECTION AUTOMATISATION TOOL IN LIBRARY – BASED ON INTERNET OF THINGS

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ABSTRACT

The development of the times and technology produces innovations that facilitate human activities, one of which is for librarians to control and maintain library rooms. This study aimed to implement a noise detection automation tool and a sound monitoring system based on the Arduino nano 33 BLE sense microcontroller in a library room. The Arduino processed the data from the sound sensor through the Edge Impulse platform. Suppose a sound with a value exceeds 0.6 and takes more than 10 seconds. In that case, the warning "QUIET, PLEASE!" will be displayed, and a sound warning will also be issued via a buzzer. The sound warning can be monitored to turn on and off the buzzer through the application. When the librarian wants to turn off the buzzer, they can click the button to turn off the speaker; on the other hand, if they want to keep the buzzer on, they can click the button to turn on the speaker.

Keywords: Technology, Arduino nano 33 BLE sense, Edge impulse, buzzer.

1. INTRODUCTION

Libraries are social infrastructure that cannot be separated from society. This makes Library as one of the sources of information services that can unite the reading culture society (Nurhayati, 2018); (Amiruddin, 2022). Library as one of the source of information and learning must have comfortable facilities and avoid noise. Currently, various libraries exist in society. Such as school libraries which is intended for students, in universities for students and public libraries for employees and the general public. Even for some groups who cannot go to public libraries, there are now mobile libraries are available.

Concentration of learning in library can be influenced by several factors, such as the level of indoor noise, humidity, temperature and lighting. Noise is an aspect that needs to be considered in a library that source of sound or noise (Amarta et al., 2019); (Tamrin et al., 2022). One place that is expected to can be avoided from sound noise is the library. Visitors who come to the library certainly need a comfortable and atmosphere so that they can focus and concentrate when reading books or doing activities in the library. However not all visitors understand the rules that apply in the library. There are visitors who only come chatting, and creating noise in the library so that disturbing the concentration of other visitors who are reading. This of course if left unchecked will cause a decrease in interest the public's interest in visiting the library.

According to some library management staff library, the noise in the STIE AMKOP library still often occurs. The noise usually comes from library visitors. STIE AMKOP library staff has made several attempts to keep the library quiet, including by reprimanding library visitors who are caught making noise. Besides time and energy limitations, of course not every time the library staff can control visitor activity. Along with the development of technology the many conveniences to information that can be accessed through the internet, many individuals and organizations have and organizations that use it, including libraries. including libraries. As one of the technologies that has been developed is a noise detector. noise detector.

The problem of noise this needs serious attention because it can affect balance between humans and environment. Because noise is a form of pollution produced by sound. Some noise detection devices sound has indeed been known one of which is the Sound Level Meter (SLM). The tool can only be used to measure the noise level but not yet used to control the comfort of the room automatically. Starting from that, the author wants to make a design of a noise detector in an IoT-based library. This tool will detect sound noise levels with library standards ranging from 45-55 dB (Menteri Negara Lingkungan Hidup, 1996). Where with the tools and noise detection system is expected to be used as a comfort control media in the library room.

Based on the above background, the formulation of this research problem is "how to design an automation tool for noise detection in an Internet of Things-based library with a case study in the STIE AMKOP library". The purpose of this research is to design a noise detector that comes from sound or sound that comes from objects.

2. THEORETICAL FOUNDATION

Nurwati in her research entitled Noise Level Detectors and Warners in Arduino-Based Libraries (2018), in the design of Noise Detectors and Warners in this Library as a whole consists of Arduino Uno Microcontrollers, LED circuits, LM393D sensor circuits, Buzzer circuits, and LCD circuits that are connected as a whole. After the sensor works to detect the presence or absence of sound in the room, the sensor provides voltage input to the Arduino which will be displayed to the LCD and gives a HIGH value to the Buzzer and Led so that the Buzzer and Led can light up (Nurwati, 2018).

Charir Maulana Achsan and Dwi Krisbiantoro in their research entitled Design of Arduino-Based Noise Detection and Warning Tool (Case Study: Amikom Purwokerto University Library) (2021), the tool made in this study is equipped with a sound sensor based on the MAX4466 chip. The selection of the MAX4466 chip-based sound sensor compared to other sound sensors such as LM393 has a reason, namely because MAX4466 is an op-amp chip, has an amplifier and this MAX4466 op-amp chip is a chip that is optimized for use in microphone amplifiers, while LM393 is a dual differential comparator chip, does not have an amplifier and the LM393 chip in theory can only be used to detect loud sounds such as claps and knocks.

This tool is also equipped with a subwoofer buzzer as a noise warner in the form of a warning sound. The use of this type of buzzer has a reason so that the warning sound can be heard in a large enough room and an OLED screen measuring 128x64 pixels as a decibel value viewer as well as a warning text. The OLED screen was chosen because it uses less resources and brighter brightness than the LCD screen. This tool will be powered using an adapter, this was chosen because the adapter has the advantage of being practical to use because AC voltage sources can be found in various places and there is no need to replace and charge batteries. This tool will work by detecting noise levels in decibel units and will provide warnings in the form of warning text and voice warnings if the decibel value is above the 55dB value (Achsan & Krisbiantoro, 2021).

Sena Amarta, Aji Gautama Putrada, S.T., M.T., Novian Anggis Suwastika, S.T., M.T., in his research entitled Noise Assessment. In his research entitled Noise Assessment at Telkom University Open Library Using IoT-Based Sound Monitoring System (2019). The making of the Noise Assessment design at the Telkom University Open Library using an IoT-Based Sound Monitoring System uses tools including the sound sensor used is the Analog Sound Sensor V2, then the NodeMCU ESP8266 CP2102 Wifi IoT Lua as a microcontroller and also as a data storage device to thingspeak, then the data will be displayed to the 16x2 + I2C LCD (Amarta et al., 2019).

Antonio Leandro Martins Candido; Sandro Cesar Silveira Jucá, Renata Imaculada Soares Pereira, Paulo Marvin de Brito Lima, Solonildo Almeida da Silva in his research entitled Low cost Device for Online Monitoring of Noise in Libraries using Internet of Things (2018). This journal describes the development and practical application of an embedded system that performs online monitoring of noise in libraries of educational institutions using the Internet of Things. The main objective of the proposed project is to record sound levels in enclosed areas and to warn users when the permissible limits are exceeded.

Therefore, a set of cost-effective tools is used, such as free software and low-cost technology. Raspberry Pi, PIC microcontroller and sound sensor module are applied in the first stage. In the second phase, only the ESP8266 microcontroller with a sound sensor was used. The results of these two implemented phases are discussed. It is observed that both developed embedded systems, which use the Internet of Things concept, make a satisfactory contribution offering a better space for concentration (Martins Candido et al., 2018).

Based on the explanation above, it can be obtained the difference from previous research with the research that will be made. In the first study, the tools used as in previous studies used buzzers and Ethernet shields to access points while in the research that will be made only use Nodemcu 8266, arduino nano 33 BLE sense, LCD and buzzer. In the second study, from the tools used by previous researchers, namely the LM393D sensor and in the research that will be made using the IoT System while the previous research did not use.

The third research, the tools used such as oled screens, sound sensors equipped with op-amp chips, have amplifiers. Fourth research, this research uses additional modules such as CP2102 and uses Analog Sound Sensor V2. In the fifth study, overall in the second stage there are many similarities found in the tools used but there are few differences such as in the first stage which uses a Raspberry Pi, a PIC microcontroller.

3. RESEARCH METHODS

a. Research stages

Problem Identification

The problem identification stage is the initial stage for researchers to identify problems in the object under study and formulate problems to serve as a background in research.

Data Collection Procedure

In this study, researchers used several methods in data collection, namely:

1) Observation
   Data collection techniques by conducting research and direct observation of the problems and objects of research taken.
2) Interview
   Interview is a data collection technique carried out through face-to-face and direct question and answer between the data collector and the source / data source.
3) Literature study
   Literature study is a method of searching for data from books, browsing the internet or other literature related to the basic theory of the system being created, and documents related to the data needed for research and system design.

Analyze system requirements

After obtaining the necessary data and information, the next step is to analyze system requirements in order to make prototype tools and systems. In this study, all the needs of Arduino will be analyzed, starting from software and hardware. A thorough hardware analysis serves to minimize funds and maximize the work functions of the tools that will be made. Choosing software that is suitable for design needs and writing program code.

Application of Prototype Method

The prototype model can be used to connect the customer's lack of technical understanding and clarify the specifications of the customer's requirements to the software developer. Report Writing The final stage of the research process is then documented in the form of scientific writing. This report contains conclusions and suggestions for further research. (Amarta et al., 2019).

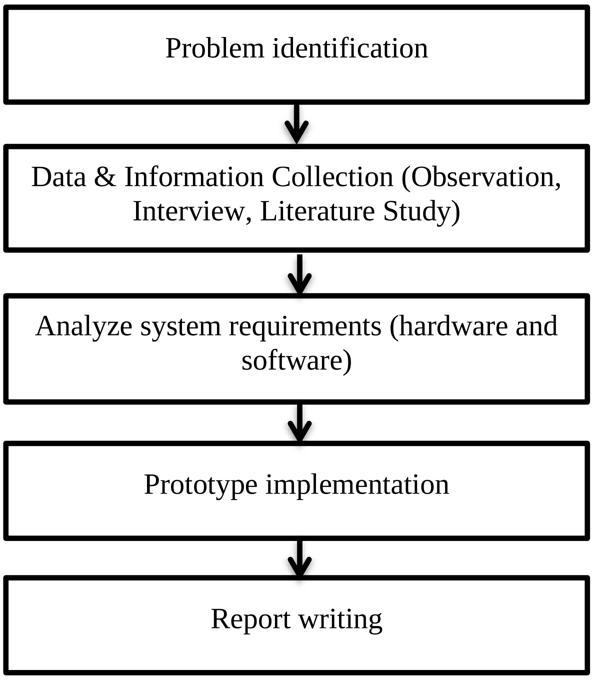

Figure 1. Diagram of research stages

b. Type of Research

Qualitative research is descriptive research using an inductive approach analysis.

c. Research Time

The research time is planned for four months, from March 2022 to June 2022. The research will begin upon approval of this thesis.

d. Place of Research

The research was conducted at the STIE AMKOP library located at jl. Meranti No.1 view, kec. Panakkukang, Makassar city. Below is a plan or layout of the research location.

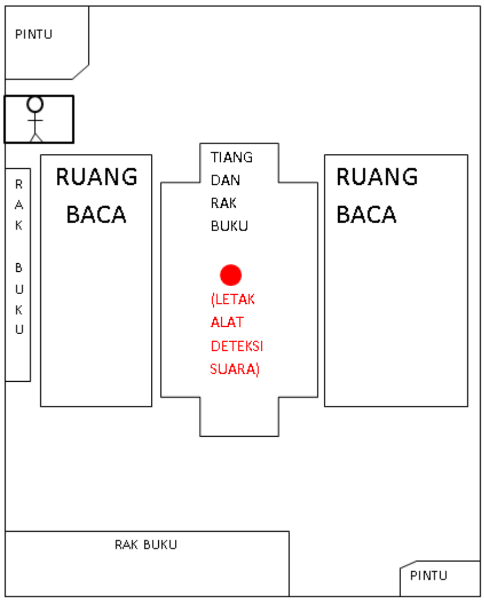

Figure 2. Illustration of STIE AMKOP library room (10X22m)

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e. Research Instruments

The research instruments used in the study are:

Hardware

1) HP AMD RYZEN 5 laptop: 1 piece
2) Arduino Nano BLE *sense* 33 : 1 piece
3) Modul ESP 32
4) I2C
5) LCD Display 16 x 2
6) Power Supply
7) Jumper
8) Buzzer
9) Resistor

The software used in this application is as follows:

1) Arduino IDE
2) Windows 10 Pro 64 bit
3) Vscode
4) Firebase
5) Edge Impulse

f. System Design

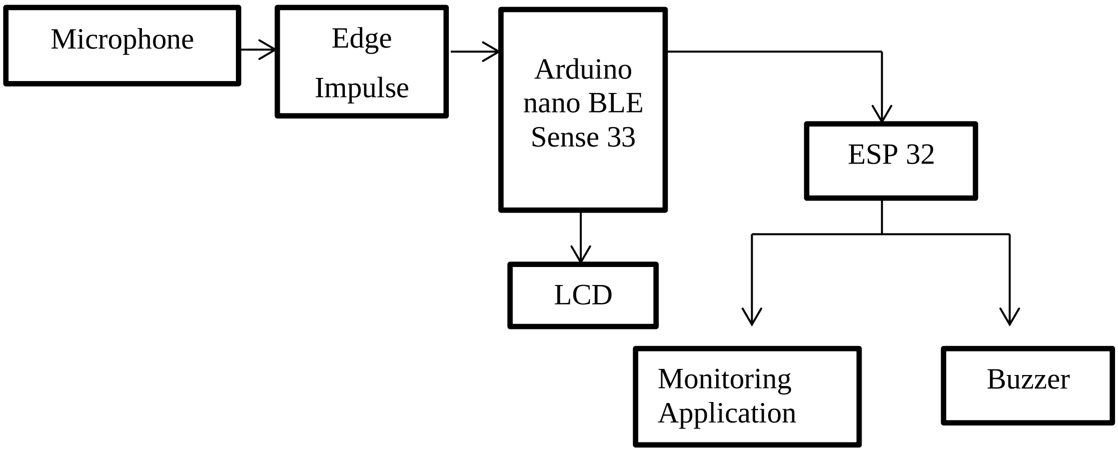

Figure 3. Block Diagrams

Figure 3. above explains the block diagram whose stages start from the microphone that captures the sound then detected by voice recognition and processed in the Arduino which produces a warning output on the LCD, lightening the buzzer and also processed into ESP 32 which will send data via DB to the monitoring application.

4. RESULTS AND DISCUSSION

a. Data Preparation

The identification of noise sources was carried out on the STIE AMKOP campus with data collection four times. In the first week for 2 days on March 21-22 (Monday and Tuesday) and in the second week for 2 days on March 29 and April 1 (Tuesday and Friday). The time used in the collection of sound data starts from 9 to 4 o'clock. Data collection using a microphone from Arduino nano 33 ble sense. The sound recording files are each 1 second to 5 seconds long in .WAV format and have a sound frequency of 16000 Hz. The data can also be added by uploading the file with the provision of renaming according to a predetermined label, for example "talk.01, talk.02, etc.", the file is already in WAV format and has a frequency of 16000Hz so that the recorded voice data and the uploaded file have the same format and are easy to classify on the Edge Impulse Application.

The recorded voice data that has been obtained is then uploaded so that it can be divided into training and testing. Training data is data used for training the model to be used, while testing data is data used to test the accuracy of the model after training. In separating training data and testing data, it is recommended to use a ratio of 70/30 for each label in the dataset.

Tabel 1. Dataset

No.	File Name	Label	Duration
1.	bicara.3465039c.s3	Talk	5s
2.	bicara.3465039c.s2	Talk	4s
3.	bicara.3465039c.s1	Talk	4s
4.	bicara.3464rrlb.s4	Talk	4s
5.	bicara.3464rrlb.s3	Talk	5s
6.	bicara.3464rrlb.s2	Talk	5s
7.	bicara.3464nc52.s4	Talk	5s
8.	bicara.3464nc52.s3	Talk	4s
9.	bicara.3464nc52.s2	Talk	5s
10.	bicara.3464nc52.s1	Talk	5s
11.	diam.33k7bgp8	Silent	5s
12.	bicara.33k6ial3	Talk	5s
13.	hujan.33k797ck	Rain	5s
14.	hujan.33k76vlk	Rain	5s
15.	kursi.33k73pd0.s1	Chair	3s
16.	kursi.33k712pj.s1	Chair	3s
17.	kursi.33k701in	Chair	5s
18.	bicara.33k6l3ii	Talk	5s
19.	bicara.33k6ial3	Talk	5s

b. Classification Model

Make classifications using the Learning Blocks (Classification-2D Convolutional Neural Network) model which is also part of CNN, where in extracting features on processing blocks the method used is MFE. The neural network classification process will take some input data, and will output a probability score that shows how likely it is that the input data belongs to a certain class/label. The workings of the neural network itself, namely the neural network has a number of layers, each of which consists of a number of neurons. Neurons in the first layer are connected to neurons in the second layer, and so on.

The connection weight between two neurons in one layer is determined randomly in the training process. The neural network is then given a set of training data, which is a set of examples that should be predicted. In this stage, the model configuration and training process

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will be used so that later we can get an overview of the performance of our predetermined model. In the Classification learning block, there are two configurations, namely Neural Network Setting and Neural Network Architecture as shown in Figure 4 and Figure 5.

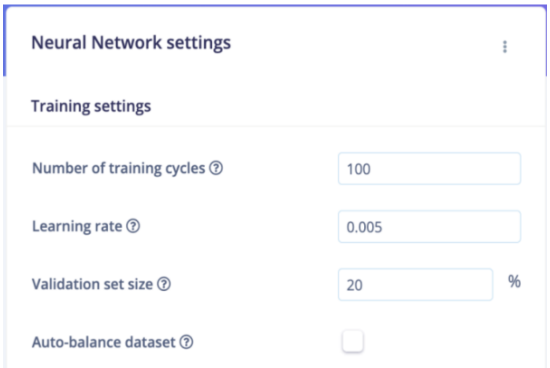


Figure 4. Neural Network Settings

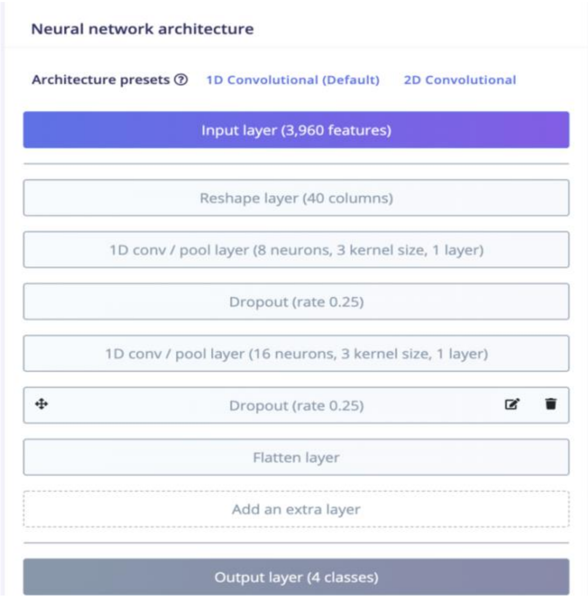


Figure 5. Neural Network Architectures

After conducting the training process, the result that will appear is an overview of the performance of the training model that can help evaluate the training data, so that it can help determine whether the model is able to meet the needs and whether it is necessary to test the data again or need to improve the dataset again. From this process, we can see the performance of the training model and show the accuracy and loss values of the validation set. Confusion Matrix is one of the most useful tools for evaluating models. The labels on the side correspond to the actual labels in each sample, and the labels on the top correspond to the predicted labels from the training model. Here is the image for the result of the confusion matrix.


Last training performance (validation set)

ACCURACY 100.0%

LOSS 0.00

Confusion matrix (validation set)

	BICARA	HUJAN	KURSI	SENYAP
BICARA	100%	0%	0%	0%
HUJAN	0%	100%	0%	0%
KURSI	0%	0%	100%	0%
SENYAP	0%	0%	0%	100%
F1 SCORE	1.00	1.00	1.00	1.00

Figure 6. Confusion Matrix training data

From Figure 6. above, it is obtained that the training data contains 4 classes, namely speech, silence, rain and chairs, each of which has an accuracy of sound, including speech whose accuracy reaches 100%, silence 100%, and rain 100% while the accuracy of the chair is around 100%. Feature Explorer, displays the spatial distribution of the inputted features. Figure 7. visualizes which ones have been classified correctly and which ones have not.

Figure 7. Data Explorer from training data

System testing is carried out to find out whether the sound detection tool runs well according to design. The input data is in the form of sound files of speech, rain, chairs, and silent conditions. Which will be detected based on the size of the sound. From the test results of the tool shown in Figure 1.7, it can be seen that at the time of recording or detecting the sound seen in the graph indicates that the speech sound is detected in a spread or evenly distributed manner while the sound of chairs, rain etc. is detected by the tool in an area that does not spread.

c. Testing Model

At the time of data collection, we divide the dataset into training and testing sets. The model is trained only with the training set, and the testing set is used to validate how well the model will perform on unseen data. This is useful to ensure that the model has not learned to adapt the training data. At this stage the model will classify all the testing set samples and give an overall accuracy of the training model's performance.

SAMPLE NA...	EXPECTED OU...	LEN...	ACCURACY	RESULT
hujan.33...	hujan	5s	100%	9 hujan
kursi.33k...	kursi	5s	77%	7 kursi, 1 bicara, ...
diam.33k...	diam	5s	100%	9 diam
bicara.33...	bicara	5s	100%	9 bicara

Figure 8. Test Data

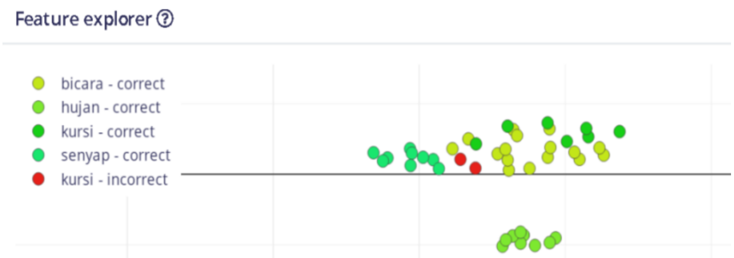
This stage also includes the Confusion Matrix and Feature Explorer to show how the training model performs for each class.

ACCURACY
95.35%

	BICARA	HUJAN	KURSI	SENYAP	UNCERTAIN
BICARA	100%	0%	0%	0%	0%
HUJAN	0%	100%	0%	0%	0%
KURSI	11.1%	0%	77.8%	11.1%	0%
SENYAP	0%	0%	0%	100%	0%
F1 SCORE	0.97	1.00	0.88	0.95	

Figure 9. Confusion Matrix Model testing

From Figure 9 above, it is obtained that the testing data containing 4 classes, namely speech, silence, rain and chairs, each has an accuracy of sound, including speech whose accuracy reaches 100%, silence 100%, and rain 100%, while in the chair the accuracy is around 77.8% which may occur because in the chair sound dataset, 11.1% silent conditions are also detected and what sounds like the sound of people talking, therefore in the speech column 11.1% appears so that the accuracy of the data from the chair is reduced.



Gambar 10. Feature explorer testing

In the final process of sound detection that displays the results of the final output in the form of library visitor conversation sounds, chair sounds, rain sounds, and silent conditions. The diagram shows that of the four types of sounds detected, only the chair sound produces an error.

d. Deployment

After training and validating the model, it can now be applied to any device by performing deployment. Deployment is an activity that aims to implement applications that have been worked on by programmers. In this research, the model will be applied to the Arduino Nano

33 Ble Sense. We will do deployment with the Arduino custom library. In the custom library, there will be signal processing blocks, configuration, and learning blocks into one package. After deployment, we will insert the library that has been built into Arduino which will be connected to other devices, such as ESP32 Module, LCD, Buzzer for testing / classification directly on Arduino. We will also connect to Android Aplication to make it easier for the library keeper to control the process of the device.

e. Implementation of Tools

After the deployment will produce a library that will be run on arduino nano 33 ble sense, then arduino nano will perform voice classification from the architecture model that has been done on edge impulse which is a cloud service as a machine learning model development. In the picture below there is a library visitor sound detection device whose tools include: board, jumper, arduino nano ble sense 33, esp 32, resistor, LM393 sound sensor, LCD, and data cable. The following are the results that appear on the LCD when no sound is heard as shown in Figure 11 below.

Figure 11. Tools when no sound is heard

In Figure 11. is shown when the detector that appears on the LCD screen is the label of the sound and the duration of the sound with units per second. In the picture above, it can be seen that what appears is a silent sound with a duration of 2 seconds, so the sound that is heard is silent or no sound.

Figure 12. Tool when speech sounds are heard for more than 10 seconds

In Figure 12. there is an image that has a speech caption with a duration of 12 seconds, then when the detected speech sound is more than 10 seconds it will perform a command with the text "Please Be Quiet" on the LCD screen.

Figure 13. Tools when a chair sounds

In Figure 13, it can be seen that what appears is the sound of a chair with a time duration of 3 seconds, so the sound heard is the sound of a chair.

Figure 14. Tools when the sound of rain is heard

In Figure 14. there is an image that has a description of rain with a duration of 13 seconds, then what is heard by the tool is the sound of rain.

PCB board point assignment

Table 2. Arduino nano 33 ble sense point

VIN	+ (LCD)
GND	GND (ESP32, LCD, LM393)
SCL	SCL (LCD)
SDA	SDA (LCD)
A0	OUT (LM393)
+3v3	VCC (LM393)
TX	RX2 (ESP 32)
RX	TX2 (ESP 32)

There are several pins used on arduino nano, namely VIN as an external power source for other devices such as LCD, then for GND connected to GND ESP32, LCD, and LM393. The SDA and SCL pins on the arduino nano are connected to the LCD SDA and SCL pins as I2C communication to save pin usage on the arduino nano. Pin A0 is connected to the LM393 OUT pin, to convert the analog value/signal from LM393 into a digital signal and pin 3v3 is connected to the LM393 VCC as a voltage or power source. Then the TX pin of arduino nano is connected to the RX2 pin of ESP32 as a transmitter for serial communication so that it can send data to ESP32 and the RX pin of arduino nano is connected to the TX2 pin of ESP32 as a receiver for serial communication so that it can receive data sent by ESP32.

Table 3. ESP point

TX2	RX (Nano BLE *Sense* 33)
RX2	TX (Nano BLE *Sense* 33)
GND	GND (Nano BLE *Sense* 33) and - (buzzer)
D23	R220 Ω (Resistor) and + (buzzer)

While on the ESP32 pin, the TX2 pin is connected to the RX arduino nano as a transmitter to send data and the RX2 pin is connected to the TX arduino nano as a receiver so that it can receive data from arduino nano. The ESP32 GND pin is connected to the nano GND and the buzzer GND pin. Pin D23 ESP32 as a digital pin is connected to a 220 Ω Resistor which is then connected to the positive pole of the buzzer.

f. Monitoring Aplication

The monitoring application was created to assist library guards in handling and monitoring the library room. In this monitoring application, library guards can see the decibel level of the sound produced in the room, can see what sounds are detected, the duration of the sound, to turn on and off the sound alert. The sound data is obtained from arduino nano ble sense which holds sound data and then sent to esp32 which is connected to wifi internet and the data that has been received by esp32 is sent to the database (firebase), the data that has been sent will appear in the monitoring application.

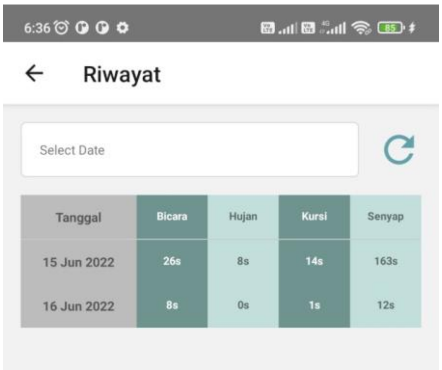


Figure 15. Monitoring application

Figure 15. above is a history display of the duration of sound per day, for example when the first detected speech sound on this day is 3s then detected again 5s, the duration will be summed up then the updated results and will appear in the history is speech with a duration of 8s. Figure 16 below is an image of the display of the library visitor monitoring application.

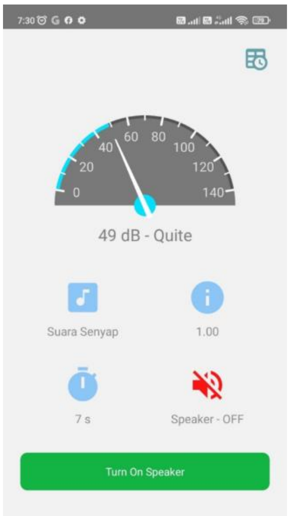


Figure 16. View of the monitoring application

The picture above is the Home view of the application which shows the sound intensity value of the library room, the sound detected by the Arduino nano, the accuracy value of the detected sound, the time duration of the detected sound, and the display whether the speaker is ON/OFF. The application can also disable/enable the speaker. The noise will be detected when the highest speaking voice whose value exceeds 0.6 and the duration of the speaking voice is more than 10 seconds will display a "Please Be Quiet" warning, also issuing a voice warning through a buzzer. The sound alert can be monitored for the on and off of the buzzer in the application. So that when the library guard wants to turn off the buzzer sound, he can click the turn off speaker button, on the other hand, if the buzzer wants to remain turned on, then click the turn on speaker button.

When the tool reads sounds whose training data is obtained from other sources, for example from a mobile phone from a laptop, the results are not very accurate, by changing the sound file type to .WAV, and changing the sound file frequency to 16,000 Hz. The results obtained when the sound of the chair is sounded the sound of rain will be heard, as well as when the condition is silent the sound heard by the tool is the sound of the chair. Meanwhile, when the tool reads the sound whose training data is directly obtained from the arduino nano ble sense 33 recording, the results are quite accurate, because the recorded sound file type will be automatically stored as a .WAV file, so all that needs to be done is to set the sound frequency before the sound recording is done.

5. CONCLUSIONS AND SUGGESTIONS

a. Conclusions

The results obtained from testing with testing data containing 4 classes are that each has an accuracy of sound including speech whose accuracy reaches 100%, silence 100%, and rain 100% while in the chair the accuracy is around 55.6% which may occur because in the chair sound dataset there is also a sound like the sound of people talking (noise), therefore in the speech column appears 44.4% so that the accuracy of the data from the chair is reduced. The way the detection tool works is when the highest speech sound whose value exceeds 0.6 and the duration of the speech sound is more than 10 seconds, it will display a "Please Be Quiet" warning, also issuing a voice warning through a buzzer. The sound alert can be monitored for the on and off of the buzzer in the application. So that when the library guard wants to turn off the buzzer sound, he can click the turn off speaker button, on the other hand, if the buzzer wants to remain turned on, then click the turn on speaker button.

b. Suggestions

In this research, the method used is CNN, the classification is done using a developer platform that already exists on the website. We recommend that future researchers can use manual classification, for example by using python. Further research development is expected to be able to use human voices as a warning sound output without being detected as noisy or noisy by the tool.

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