Proceedings of the 3rd Faculty of Industrial Technology International Congress
Bandung, Indonesia, October 28-29, 2021
ISSN

Implementation of Human Detection on Robot Prototype Using Admp401 Sensor

Ceppy Ari Sugiharto[1, a)], Decy Nataliana[1], Niken Syafitri[1]

[1] *Institut Teknologi Nasional (Itenas), Bandung – INDONESIA*

[a)] Corresponding author: ceppy.ari21@gmail.com

Abstract. The ability of robots to robustly detect and localize what people see and hear is an important task that will be very useful in many robot interactions. In this study, four ADMP401 microphone sensors arranged with a polar directivity pattern to detect the north, south, east, and west directions of the potential presence of disaster victims through sound media using Arduino IDE and Audacity software. The tests carried out are by doing a hand clapping test as well as the noise produced by the victim and the victim's voice without obstruction with obstruction. As a result, the ability of the ADMP401 microphone sensor in detecting the direction of the sound of the potential presence of the victim has an accuracy of up to 81.85%. In this test, the sound of clapping which reduces the sound of the victim's voice is reduced to 57.71% and the victim's voice is reduced to 43.01% due to obstacles that can disperse and dissipate the intensity of the sound power captured by the ADMP401 microphone sensor.

INTRODUCTION

During the 21st century, more than 522 significant earthquakes occurred, with a death toll of more than 430,000 worldwide. The majority of deaths were caused by collapsed buildings trapped underground. If patients are uninjured, healthy, and without fresh air, they can survive for about 72 hours. Eighty percent of survivors can be saved alive within 48 hours of the collapse, but after 72 hours the survival rate decreases exponentially. This time limit can be much shorter due to lack of air supply, ambient temperature, victim's health condition, and so on. Therefore, to reduce deaths after natural disasters, the rapid detection of victims inside the collapsed structure is of utmost importance. The current search method is based on victim testimony to establish possible victims under the rubble [1].

Humans can find sounds. The system formed by the ear and brain can automatically detect the signal, process it, and determine where the sound is coming from. Thanks to the shape of the ear and the delay caused by sound propagation, the brain can find its source within a certain range of failure. From the XIX century to the present, humans have intended to make devices with these human features. To mimic the human ear a different microphone-array system has been applied [2].

The ability of robots to robustly detect and localize what people see and hear is an important task that will be very useful in many robotic interaction scenarios. There are many approaches to identifying active speakers among a group of people. Typical techniques involve audio and vision as input modalities. Several methods take advantage of audio-visual synchronization to identify active speakers. The main problem of this method is to find the correspondence between the acoustic signals from the microphone. Finding correspondence means identifying the temporal location of the signal associated with the same acoustic event [3].

Micro Electro Mechanical Systems (MEMS) can be useful for very low size situations because of their ability to build very small sensors with precise geometries. Microphones and other low-level differential pressure transducers are often used in aeroacoustic measurements for characterization, flow thermal mapping via acoustic pyrometry, and aircraft flight tests [4].

A disaster victim detection robot with an automatic waypoint system for return trips has been implemented by [5]. In this study, the robot uses the RCWL-0516 microwave sensor to detect the potential presence of living disaster victims based on small movements behind the rubble. Disaster victims tend to have a survival instinct by making small movements to be free from the burden of rubble. In addition, the victim also has the potential to produce sounds so that the rescue team can identify the position of the victim who is still alive. Therefore, this research will design and implement a prototype system for detecting disaster victims through the sound produced by victims using four ADMP401 sensors arranged in such a way that they can localize and recognize the potential direction of sound produced by disaster victims.

MATERIAL AND METHOD

The system design consists of hardware and software. The hardware consists of a series of ADMP401 microphone modules, 28BYJ-48 stepper motors, Arduino Uno R3, project boards, and ISD1820 modules. The software used in this design is using Arduino IDE and Audacity. Figure 1. presents a block diagram of the designed system.

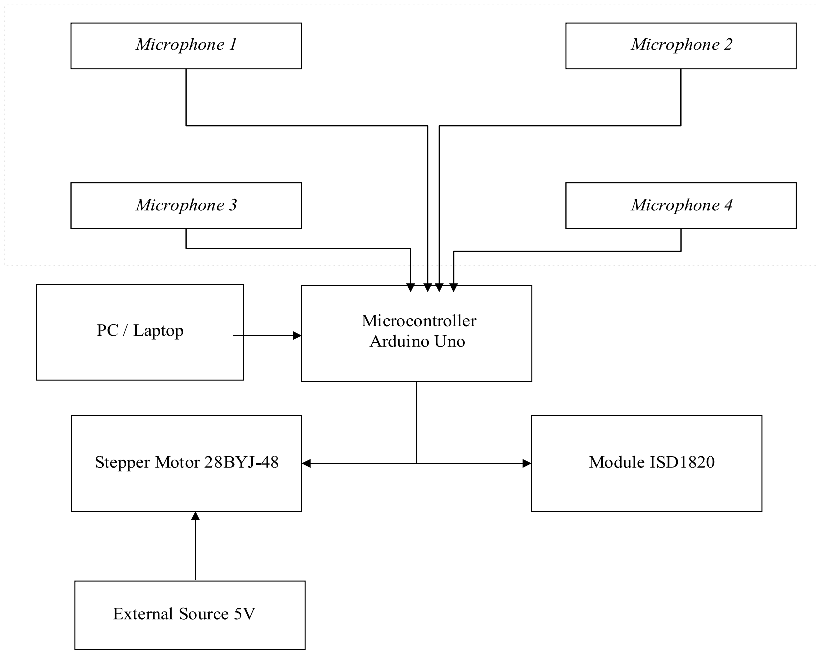

FIGURE 1. System Block Diagram

Based on the system block diagram in Figure 1, the design in this study aims to develop and implement a prototype of a disaster victim detection robot with a detection system using four ADMP401 microphones placed on an acrylic/wooden pattern with a polar directivity pattern. In this study, one personal computer (PC) is used as a source or power supply for Arduino Uno and a power bank as an external source +5V for the 28BYJ-48 stepper motor. An external +5V source is used because when the stepper motor draws a very large current from the Arduino Uno, the Arduino Uno may be damaged. In addition, sourcing the stepper motor via the Arduino Uno gives inconsistent results (step rotation errors such as stuck or won't move). After four ADMP401 microphones detect sound from four possible sound directions with a sound intensity level difference approach, the detection data from the microphone is sent to Arduino Uno to provide a signal to the actuator, namely the 28BYJ-48 stepper motor in the form of moving steps towards the sound source and ISD1820 in the form of a voice line. "victim detected".

System Flowchart

The system flowchart explains how the stages of the system are integrated with each other starting from the detection of victims through sound by the ADMP401 microphone to the actuator, namely the 28BYJ-48 stepper motor by taking steps towards the potential victim's voice and the "victim detected" voiceline from the ISD1820 module. The following Figure 2 show the flow diagram of the designed system.

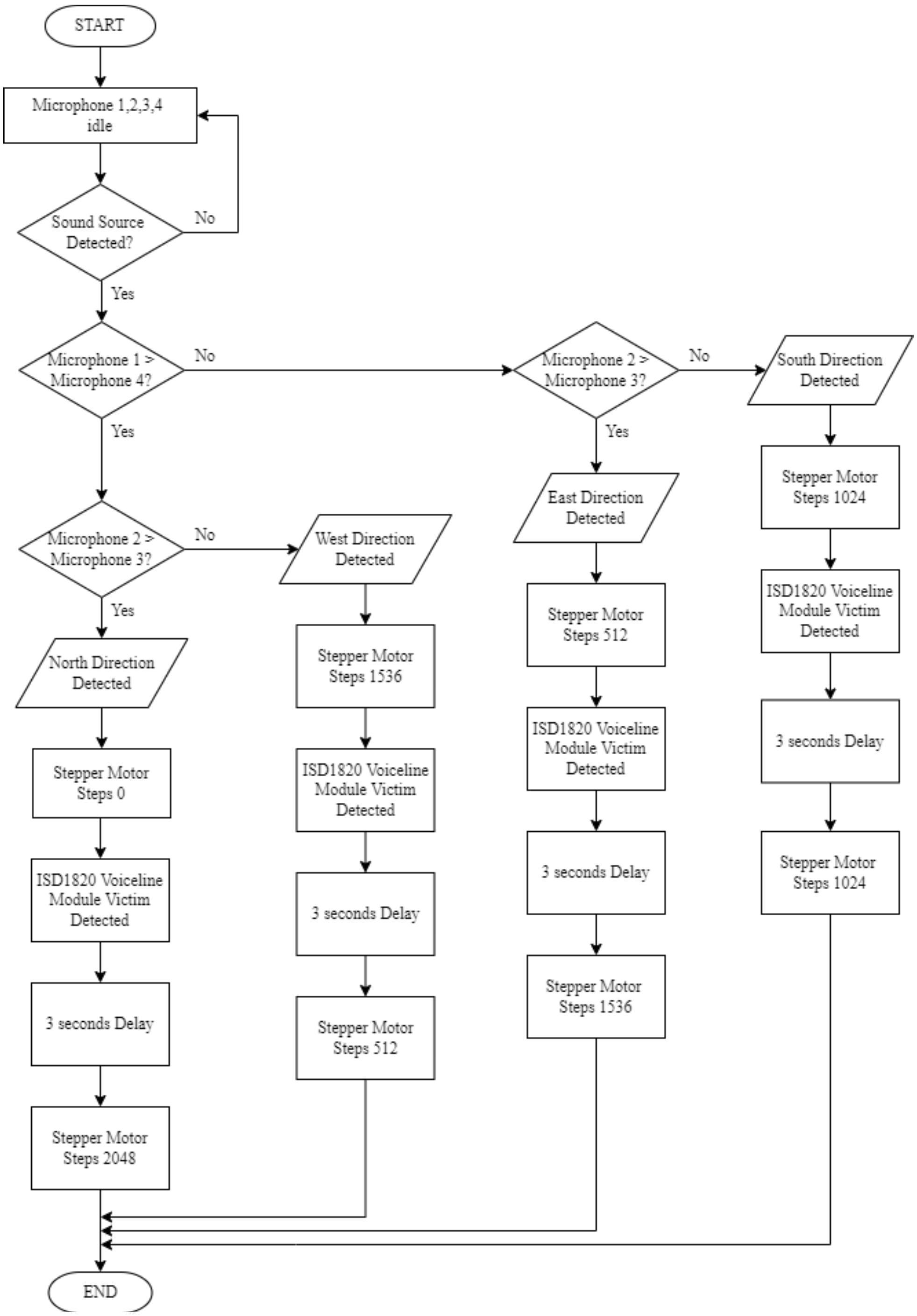

FIGURE 2. System Flowchart

In Figure 2, it can be seen how the flow diagram of the entire system is designed. First, microphones 1, 2, 3, and 4 are in an idle state, which is less than 14. Previously, the system designed for the microphone was to convert the acoustic signal received by the microphone into 10-bits ADC data from 0 to 1023. So, the sound intensity level is characterized by changes in low and high data from 0 to 1023. After microphones 1, 2, 3, and 4 detect a sound signal in the form of an acoustic signal, the idle data that is < 14 will increase according to the intensity of the received sound power. The method used to determine the direction is to compare the intensity of the sound power of the four microphones. The comparison method designed is when microphone 1 > microphone 4 and microphone 2 > microphone 3, then the direction that is read is north. When microphone 1 > microphone 4 and microphone 3 > microphone 2, the direction that is read is west. When microphone 4 > microphone 1 and microphone 2 > microphone 3, the direction that is read is east. When microphone 4 > microphone 1 and microphone 3 > microphone 2, the direction that is read is south. Furthermore, when the direction of the victim's voice has been detected, the stepper motor will take steps according to the direction of the potential sound. Since the stepper motor cannot recognize the starting point or recognize the angle, unlike the servo motor, it is necessary to manually adjust it by performing manual steps until the direction of the pointer is in the north direction. This stepper motor runs in full-step mode, so the number of steps required for one revolution is 2048. The initial position of the stepper motor is in the north direction. When the north direction is detected, the stepper motor will not perform steps or 0 steps, when the east direction is detected, the stepper motor will perform steps of 512 steps, when the south direction is detected, the stepper motor will perform steps of 1024 steps, and when the west direction is detected, the stepper the motor will perform steps of 1536 steps. This system is also given a delay of 3 seconds so that changes can be observed. Steps that occur after the delay function to return the direction pointer to its initial position, namely the north position. This stepper motor can rotate at a maximum speed of 15 revolutions per minute (RPM). If divided by one minute, the stepper motor will make one revolution in 2 seconds at a rotational speed of 15 revolutions per minute (RPM). After adding 3 and 2 seconds of delay time and stepper motor revolution time, it is obtained that 5 seconds is used to adjust the microphone delay in detecting the direction of the victim's voice. In the process of giving a delay of 3 seconds too, the ISD1820 module will provide a "victim detected" voiceline.

RESULT AND DISCUSSION

Victim's Voice Direction Detection Test

This test was carried out using the comparison method of sound intensity on four ADMP401 microphones by testing hand-clapping which was assumed to be the noise produced by the victim and testing the sound with medium intensity sound produced by the victim. In addition, the test is divided into two, namely with obstacles (door barriers) and without obstacles. The detection distance tested ranges from 0.5 meters to 5 meters in increments of 0.5 meters. Table 1 present south direction applause trial without obstacle.

TABLE 1. South Direction Applause Trial Without Obstacle

No	Distance (m)	South Direction Test				Description
		Microphone 1	Microphone 2	Microphone 3	Microphone 4	
1	0.5	229	281	436	487	Detected, right direction
		326	406	617	481	Detected, right direction
		234	238	437	260	Detected, right direction
2	1	370	236	269	402	Detected, right direction
		275	192	416	312	Detected, right direction
		393	361	449	452	Detected, right direction
3	1.5	234	145	192	281	Detected, right direction
		291	267	372	330	Detected, right direction
		274	222	354	292	Detected, right direction
4	2	143	154	192	232	Detected, right direction
		139	176	194	277	Detected, right direction
		146	232	384	272	Detected, right direction
5	2.5	207	198	296	254	Detected, right direction
		312	371	398	410	Detected, right direction
		184	123	284	204	Detected, right direction
6	3	159	147	247	193	Detected, right direction
		101	139	160	155	Detected, right direction
		226	216	273	290	Detected, right direction
7	3.5	303	265	307	325	Detected, right direction
		151	106	187	192	Detected, right direction
		126	97	141	226	Detected, right direction

TABLE 1. South Direction Applause Trial Without Obstacle (continue)

No	Distance (m)	South Direction Test				Description
		Microphone 1	Microphone 2	Microphone 3	Microphone 4	
8	4	135	164	163	170	Detected, wrong direction
		113	98	155	140	Detected, right direction
		100	158	219	166	Detected, right direction
9	4.5	96	101	120	134	Detected, right direction
		120	133	132	142	Detected, wrong direction
		90	92	97	103	Detected, right direction
10	5	88	90	107	111	Detected, right direction
		75	81	89	94	Detected, right direction
		73	79	77	83	Detected, wrong direction

Table 2 present south direction applause trial with obstacle.

TABLE 2. South Direction Applause Trial with Obstacle

No	Distance (m)	South Direction Test				Description
		Microphone 1	Microphone 2	Microphone 3	Microphone 4	
1	0.5	129	120	213	234	Detected, right direction
		154	144	243	228	Detected, right direction
		136	155	176	180	Detected, right direction
2	1	151	164	181	172	Detected, right direction
		138	143	191	184	Detected, right direction
		131	125	167	166	Detected, right direction
3	1.5	98	114	132	140	Detected, right direction
		93	101	125	112	Detected, right direction
		70	67	88	101	Detected, right direction
4	2	51	61	54	53	Detected, wrong direction
		47	48	57	76	Detected, right direction
		61	62	78	82	Detected, right direction
5	2.5	21	22	25	26	Detected, right direction
		40	41	39	40	Detected, wrong direction
		31	32	39	37	Detected, right direction
6	3	31	30	36	29	Detected, wrong direction
		23	24	28	33	Detected, right direction
		24	28	42	44	Detected, right direction
7	3.5	25	25	28	35	Detected, right direction
		18	18	22	24	Detected, right direction
		27	31	38	37	Detected, right direction
8	4	21	21	26	28	Detected, right direction
		24	26	29	32	Detected, right direction
		17	22	24	26	Detected, right direction
9	4.5	22	23	29	28	Detected, right direction
		25	23	27	31	Detected, right direction
		19	21	25	25	Detected, right direction
10	5	19	19	22	24	Detected, right direction
		21	23	31	27	Detected, right direction
		18	23	22	25	Detected, wrong direction

Table 3 present south direction victim's voice trial without obstacle.

TABLE 3. South Direction victim's Voice Trial Without Obstacle

No	Distance (m)	South Direction Test				Description
		Microphone 1	Microphone 2	Microphone 3	Microphone 4	
1	0.5	111	98	138	135	Detected, right direction
		154	103	196	181	Detected, right direction
		123	129	152	157	Detected, right direction
2	1	88	94	114	175	Detected, right direction
		97	85	100	135	Detected, right direction
		101	88	114	125	Detected, right direction
3	1.5	87	81	108	115	Detected, right direction
		67	63	85	90	Detected, right direction
		78	74	81	110	Detected, right direction
4	2	118	128	147	152	Detected, right direction
		81	114	120	124	Detected, right direction
		107	119	133	149	Detected, right direction
5	2.5	89	74	114	122	Detected, right direction
		87	96	110	104	Detected, right direction
		81	86	85	96	Detected, wrong direction
6	3	79	88	122	103	Detected, right direction
		56	54	68	62	Detected, right direction
		74	66	81	82	Detected, right direction
7	3.5	38	40	45	56	Detected, right direction
		33	31	44	47	Detected, right direction
		39	56	69	70	Detected, right direction
8	4	66	69	79	94	Detected, right direction
		32	33	53	60	Detected, right direction
		81	80	90	86	Detected, right direction
9	4.5	79	79	85	88	Detected, right direction
		66	69	68	74	Detected, wrong direction
		62	57	64	59	Detected, wrong direction
10	5	43	39	45	51	Detected, right direction
		35	32	47	49	Detected, right direction
		48	52	50	59	Detected, wrong direction

Table 4 present south direction victim's voice trial with obstacle.

TABLE 4. South Direction Victim's Voice Trial with Obstacle

No	Distance (m)	South Direction Test				Description
		Microphone 1	Microphone 2	Microphone 3	Microphone 4	
1	0.5	79	87	100	96	Detected, right direction
		83	82	92	95	Detected, right direction
		73	77	89	87	Detected, right direction
2	1	61	65	76	73	Detected, right direction
		59	60	72	70	Detected, right direction
		62	51	69	65	Detected, right direction
3	1.5	44	41	56	55	Detected, right direction
		46	38	50	51	Detected, right direction
		39	44	42	47	Detected, wrong direction

TABLE 4. South Direction Victim's Voice Trial with Obstacle (continue)

No	Distance (m)	South Direction Test				Description
		Microphone 1	Microphone 2	Microphone 3	Microphone 4	
4	2	37	38	46	54	Detected, right direction
		22	22	24	29	Detected, right direction
		60	60	77	63	Detected, right direction
5	2.5	22	23	27	28	Detected, right direction
		34	37	35	42	Detected, wrong direction
		35	35	39	39	Detected, right direction
6	3	37	39	41	43	Detected, right direction
		34	35	43	43	Detected, right direction
		47	50	49	53	Detected, wrong direction
7	3.5	18	18	26	22	Detected, right direction
		30	36	45	40	Detected, right direction
		20	23	27	27	Detected, right direction
8	4	17	18	23	26	Detected, right direction
		10	10	14	13	Detected, right direction
		14	18	24	20	Detected, right direction
9	4.5	16	19	18	20	Detected, wrong direction
		19	19	22	21	Detected, right direction
		22	19	24	20	Detected, right direction
10	5	15	15	19	18	Detected, right direction
		14	18	17	22	Detected, wrong direction
		9	9	9	9	Not detected

As seen in Table 1, Table 2, Table 3, and Table 4, the test was carried out three times every 0.5 meters. By the algorithm that has been designed, when microphone 3 > microphone 2 and microphone 4 > 1, the direction shown is south. An example can be taken in Table 1. at 0.5 meters in the first experiment, microphone 3 which is worth 436 is greater than microphone 2 which is worth 281, and microphone 4 which is worth 487 is greater than microphone 1 which is worth 229. If microphone 1 > microphone 4 or microphone 2 > microphone 3 then in the south direction test, the result is that the detected direction is not correct. For detection, if the value of microphone 1, microphone 2, microphone 3, and microphone 4 is more than the idle value of 14, it can be indicated that the sound source is detected. In Table 4. there are test data that are not detected, namely at 5 meters. This indicates that at 5 meters if the intensity of the sound power is not large enough, the ADMP401 microphone sensor cannot detect the sound source of the potential victim. Therefore, this study was only carried out from 0.5 meters to 5 meters because with medium sound intensity, the microphone had difficulty detecting at 5 meters. Medium sound intensity is used to take the midpoint of low sound intensity and high sound intensity.

In the obstacle and unobstructed test, take the example in Table 1. at 0.5 meters the first test of microphone 3 produces 436 data, and Table 2. at 0.5 meters the first test of microphone 3 produces 213 data, without obstruction tends to have a strong intensity the greater sound is due to the obstacle test (door barrier) the intensity of the sound power produced by the potential victim is dispersed or dissipated so that the intensity of the sound power from the victim's sound source decreases in quality due to collision with the obstacle being tested. The total average score obtained in the unhindered clapping test was 234.40. The total average value obtained in the clapping test with obstacles was 75.97. The total average score obtained in the test of the victim's voice without obstruction is 99.13. The total average value obtained in the test of the victim's voice with obstruction is 43.30. If it is seen from the average value data, in the presence of obstacles, the sound of clapping produced by the victim is reduced to 57.71% and the voice of the victim is reduced to 43.01%. Table 5 present microphone testing average.

TABLE 5. Microphone Testing Average

No	Distance (m)	Average Value							
		Hand clapping				Victim's voice			
		Without obstruction		With obstruction		Without obstruction		With obstruction	
		Closer mic	Further mic	Closer mic	Further mic	Closer mic	Further mic	Closer mic	Further mic
1	0.5	522.87	373.45	213.87	167.45	206.70	164.04	103.16	89.125
2	1	378.53	278.5	180.70	154.41	169.08	133.25	72.75	63.75
3	0.6	315.41	252.33	134.70	113.79	130.75	113.41	61.33	52.08
4	2	267.20	205.41	85.125	72.20	117.95	99.41	50.87	44.20
5	0.7	286.16	215.70	51.95	42.16	97.83	78.83	42.20	34.33
6	3	233.75	191	44.79	36.95	76.79	65.91	42.625	36.375
7	0.8	234.5	189.58	37.66	30.66	62.70	51.25	32.41	26.29
8	4	175.29	143.5	32.33	26.875	62.33	49.29	23.66	18.41
9	0.9	132	111.41	28	22.833	58.04	50.04	21.33	17.45
10	5	97.37	84.25	23.79	19.25	44.20	35.58	18.37	15.41

As seen in Table 5., the average value generated by the ADMP401 microphone sensor in detecting the potential presence of victims from 0.5 meters to 5 meters. The closer mic defines the two microphones that are closer to the sound source and the farther mic defines the two microphones that are further away. This average value is calculated to determine whether the intensity of the sound power is higher or lower than the average result. An example can be taken in Table 1. testing at 0.5 meters for the second test, with an average value of a closer mic of 522.87, microphone 3 which produces a value of 617 proves that the intensity of the sound power at the time of testing is slightly greater than the average. average. However, in the third test of microphone 3 which produces a value of 437, it proves that the intensity of the sound power at the time of testing is slightly lower than the average. The total accuracy of the four-way unobstructed clapping test has a value of 85.825%. The total accuracy of the clapping test with a four-way obstacle has a value of 79.125%. The total accuracy of the victim's voice test without four-way obstruction has a value of 84.975%. The total accuracy of the victim's voice test with four-way obstruction has a value of 77.475%. Therefore, testing the ADMP401 microphone sensor in detecting the potential presence of the victim's voice direction has an accuracy of up to 81.85%.

Recording Testing and Signal Analysis

Two ADMP401 microphones to detect the direction and recording media, two micro SD as storage media, a micro SD card adapter module as a liaison between micro SD and Arduino Uno, two Arduino Uno as a microcontroller, project board as a coupling medium, and push buttons which are used for the record and stop button. Microphone A and microphone B are placed at 13.5 cm. The sound source test is closer to microphone A than to microphone B. The recording settings used in this test are recording frequency at 16000 Hz and buffer size 254. Figure 3 shows testing recording on Audacity software

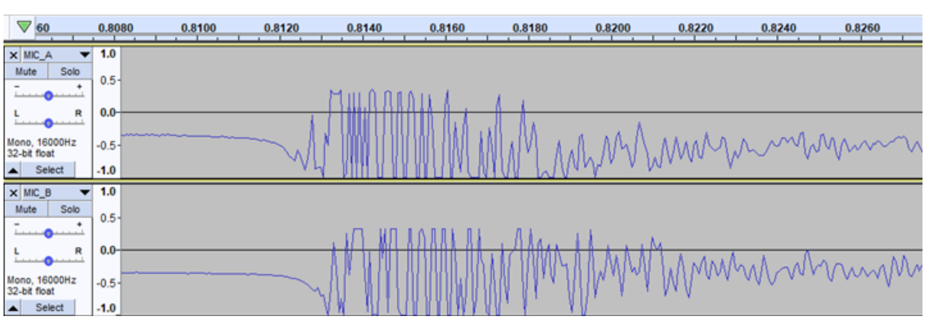

FIGURE 3. Testing Recording on Audacity Software

As seen in Figure 3, microphone A first receives the resulting sound signal, while microphone B gets a delay and then receives the resulting signal. This proves that the closer the sound source is to the microphone, the faster the microphone will receive an acoustic signal from the sound source. Figure 4 present RMS testing on Audacity software.

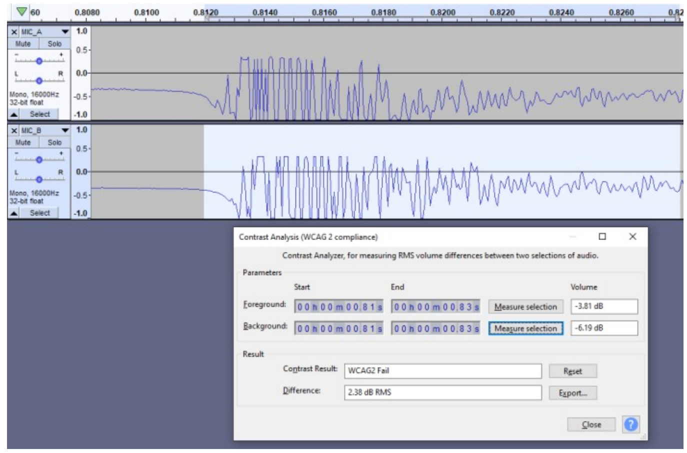

FIGURE 4. RMS Testing on Audacity Software

As seen in Figure 4., microphone A produces a Root Mean Square (RMS) of -3.81 dB while microphone B produces a Root Mean Square (RMS) of -6.19 dB. This proves that the distance from the sound source to the microphone can create different sound strengths. In addition to non-real-time data, this test also carried out real-time experiments on two microphones connected to the Arduino Uno and the signal could be seen on the serial plotter. Figure 5 shows signal form on serial plotter.

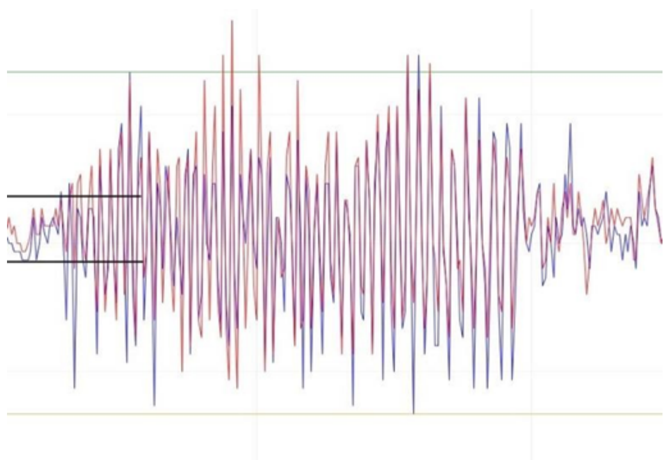

FIGURE 5. Signal Form on Serial Plotter

As seen in Figure 5., the blue microphone A signal responds to the acoustic signal from the sound source first then the red microphone B, this proves that microphone A, which is closer to the sound source, receives an acoustic signal first than the microphone B.

CONCLUSION

Based on the results of research and analysis, several things can be said, namely the ADMP401 microphone sensor can detect the presence of the victim's voice up to a distance of ± 8 meters. Obstacles can reduce the sound of clapping up to 57.71% and the voice of the victim up to 43.01%. The ADMP401 microphone sensor can detect the presence of the victim's voice with a total accuracy of up to 81.85%, with an accuracy of clapping hands without the obstruction of 85.825%, the accuracy of the victim's voice without obstruction 84.975%, the accuracy of clapping with obstruction of 79.125%, and accuracy of the victim's voice with the obstruction by 77.475%. The high and low intensity of the sound received by the microphone depends on the intensity of the sound from the victim and the distance between the victim and the microphone.

ACKNOWLEDGEMENTS

The author would like to thank parents, lecturers, and colleagues who have helped and encouraged the author since the start of this research.

REFERENCES

1. D. Zhang, S. Sessa, R. Kasai, S. and Cosentino, “Evaluation of a Sensor System for Detecting Humans Trapped Under Rubble: A Pilot Study”, *MDPI*, 18, (2018).
2. C.F. Scola and M.D. Orteg, “Direction of Arrival Estimation - A Two Microphones Approach”, *BTH*, 96, (2010).
3. J. Cech, R. Mittal, A. Deleforge, and J.S. Riera, “Active-Speaker Detection and Localization with Microphones and Cameras Embedded Into a Robotic Head”, *HAL,* (2013).
4. L. Swathy and L. Abraham, “Wireless Acoustic Signal Monitoring Using MEMS Sensor and ATmega on LabVIEW Platform”, *IJCSMC*, 3 (8), 257 – 266, (2014).
5. I.F. Ammarprawira, M.S. Fauzi, A.A. Jabbaar, and N. Syafitri N, “Implementation of Automatic Waypoint for Return Trip on Autonomous Robot with Reference Point for Potential Disaster Victims”. *ELKOMIKA*, 8,1. doi: http://dx.doi.org/10.26760/elkomika.v8i1.203, (2020).