DEVELOPMENT OF TRANSLATION TOOL LETTER AND NUMBER OF INDONESIAN LANGUAGE FOR DEAF AND DUMB USING ARDUINO

Gunali Rezqi Mauludi[1], Angga Setiyadi[2]

[1,2] Informatics Engineering – Universitas Komputer Indonesia
Jl. Dipatiukur 112-114 Bandung
E-mail : hello.gunalirezqi@gmail.com[1], angga.setiyadi@email.unikom.ac.id[2]

ABSTRACT

The purpose of this research is to assist the community in providing learning letter and number cues for the deaf and accurate, by implementing the technology of hand-bending and hand-slope detection. In this study, the translation of letter and number cues was done using the Arduino associated with the flex sensor and the accelerometer sensor. The flex sensors are used to read the value of the finger-bending while the accelerometer sensor is used to read the value of the hand slope. The result of the capture of the hand and slope of the hand will be classification using the K-Nearest Neighbors algorithm where the algorithm will look for the closest distance value between the data test and the training data. From the classification of the gesture will be performed the appropriate cue sound data playback. Based on the test results, the tool can translate letter and number cues to the sound output, but the success rate is only 55.135%. The Error is obtained because there is a gesture attribute value similar to even worth between one gesture to another in the training data so that the K-Nearest Neighbors algorithm provides a classification value that does not correspond to the Expected results.
Kata kunci : Deaf, Dumb, Letter Gestures, Number Gestures, Arduino.

1. INTRODUCTION

A language is a communication tool that is very important for people and life because in language there is a process of exchanging information that can add human understanding. There are various languages used to communicate among a spoken language that many people commonly use, but some use sign language in the form of body movements. This language is usually used by the deaf and dumb.

There are four fundamental rights of the deaf, i.e., sign-language rights, the right to be bilingual education (Indonesian language and gesture), access rights and interpreter service rights. Deaf and dumb using sign language. Sign language is non-verbal communication because it is a language that does not use the voice but uses the shape and direction of the hands, movements of hands, lips, body and facial expressions to convey the intent and thought of a speaker. No international sign Language because the sign language in each country is not necessarily the same. Deaf and dumb in Indonesia communicate using sign language referring to two systems namely SIBI (Gesture System Indonesian Language) and BISINDO (Indonesian Sign Language). SIBI was developed by a normal person, not deaf. SIBI is the same as sign language used in American ASL (American Sign Language) while BISINDO is developed by the deaf person through GERKATIN (Indonesian Deaf Welfare Movement) [1].

Based on the results of the existing literature that more than 5% of the world's population is about 360 million people who have a way to lead and are deaf (328 million adults and 32 million children) [2]. As well as most of those who initially had difficulties in the sign language were as self-esteem. It can be concluded that the deaf and well-being have difficulty in learning letters and numbers that learn these letters and numbers is one of the earliest for the deaf persons and this speech conduct communication.

The methods of collecting data used in this study use the study of the library, which is the method of collecting data through literature, journals and paper and the readings related to the development of the Translator Tool. Sign Language Letters and numbers [3]. The purpose of this research is to help people to provide learning letters and numbers against deaf and dumb.

2. RESEARCH CONTENTS

2.1 Deaf

Deaf is a lack or loss of hearing ability either in part or in full by an individual, the cause is because it does not function in part or all of the hearing device, so that the individual cannot use His hearing device in daily life. The development of children's language is one of the consequences caused by impaired individuals who are deaf [4].

2.2 Dumb

Dumb is a verbal disorder or limitation in a person that has difficulty in communicating through sound. Dumb is often associated with the deaf. Some of the ways are those who suffer from deaf since infants or born, because someone with disabilities can not capture the talks of others, so as not able to develop their skills While not experiencing interference with the sound [5].

2.3 Sign Language

In Dictionary great Bahasa Indonesia (KBBI), sign language is a language that does not use the sound of human speech or writing in the system of symbolism [2]. In Indonesia, the sign language is distinguished into two categories, namely SIBI and BISINDO [6].

2.3.1 BISINDO (Indonesian Sign Language)

BISINDO is a language that is encouraged by the Indonesian Deaf Welfare Movement (GERKATIN) and developed by the deaf community itself, making Bisindo a practical and effective communication system for people with disabilities in Indonesia Because BISINDO was born from the deaf persons themselves [2].

2.4 Arduino Nano

The Arduino Nano is one of the small, fully-equipped microcontroller development boards and supports the use of breadboards. The Arduino Nano was created with an ATmega328 microcontroller base (for Arduino Nano version 3. x) or ATmega 168 (for Arduino version 2. x). Arduino Nano more or less has the same function as the Arduino Duemilanove but in different packages. Arduino Nano designed and manufactured by Gravitech Company [8]. The shape of the Arduino Nano can be seen in Figure 1.

Figure 1. Arduino Nano

2.5 Flex Sensor

Flex Sensor is a sensor that releases resistance changes due to a change in the sensor. Freeze on Flex Sensor is divided into 5 main frozen states, namely 0^o, 45^o, 180^o, 135^o, and 180^o. The working principle of Flex Sensor is the same as the resistor variable. Flex Sensor will provide an Arduino resistance change through the voltage divider circuit depending on the amount of freeze received by the Sensor. The shape of the Flex Sensor can be seen in Figure 2.

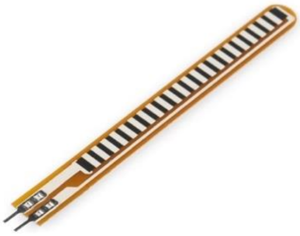


Figure 2. Flex Sensor

2.6 Accelerometer Sensor ADXL335

ADXL335 is a 3 axis accelerometer (x, Y, z) module with small size, low power usage, and provides a divided signal output voltage. It can measure +-3g magnetic field, so it can measure the slope with the application of gravity acceleration. The form of ADXL335 can be seen in Figure 3.

Figure 3. Accelerometer Sensor ADXL335

2.7 Algorithm K-Nearest Neighbors

The K-Nearest Neighbors (KNN) algorithm is a method of classifying the object based on the learning data that is closest to that object [9]. Close or far neighbors are usually calculated based on Euclidean with the formula as in the narrow (1)

$$distance = \sqrt{\sum_{i=1}^{n} (x_{training}^{i} - x_{testing})^2} \quad (1)$$

$x^{i}_{training}$: training data to-i

$x_{testing}$: data testing

i : to-i records from the table

n : amount of training data

2.8 Gloves

Gloves are included in the type of personal protective equipment (PPE). Personal Protective Equipment (APD) is a tool that serves to protect a person in the work where the function isolates the body of labor from danger in the work environment. Personal Protective Equipment is a set of tools that must be used by the workforce to protect the body against the possibility of potential hazards or accidents. Figure 4 can be seen as examples of glove shapes.

Figure 4. Gloves

3. ANALYSIS AND PLANNING

3.1 System Architecture

The system architecture analysis aims to identify the architecture to be built and explain the overall system image to see how the system runs. Here is the architecture to be built in this research that can be seen in Figure 5.

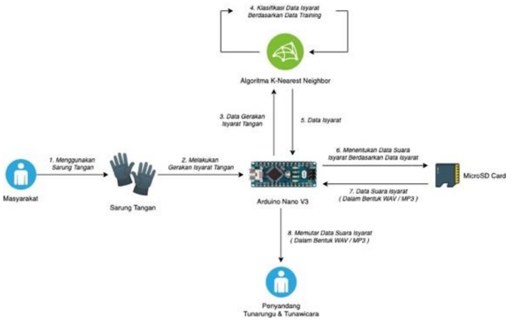


Figure 5. System Architecture

Here is a description related to Figure 4 about the system architecture:

1. Society uses gloves.
2. The community performs a hand gesture to the Arduino Nano V3 device.
3. Arduino Nano V3 sends the hand gesture data performed by the public against the algorithm K-Nearest Neighbors.
4. The K-Nearest Neighbors algorithm classifies the gesture data based on the training data.
5. From the process of classification of algorithm K-Nearest Neighbors, obtained a result in the form of cue data.
6. Arduino Nano V3 determines the cue sound data on the MicroSD Card based on the cue data already obtained from the classification process of the K-Nearest Neighbors algorithm.
7. Once the gesture sound data is determined, the Arduino will call the sound data from the MicroSD Card.
8. Arduino plays the gesture sound data (in the form of WAV or MP3) to have listened to the deaf and the dumb.

3.2 Hands-on Bending Analysis

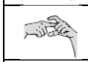
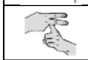
The analysis of the finger is the analysis to know the value of each finger hand done by the user in the community. The value of this hand finger is determined based on the value of the curvature of the Dualflex sensor, where the flex sensor is divided into 5 arches, namely 0°, 45°, 180°, 135° and 180°. Movement of the fingers can be Seen in Table 1.

Table 1. Degrees Freeze Hand finger

No	Image	Description
1		Freeze Fingers 0 °
2		Freeze Fingers 45 °
3		Freeze Fingers 90 °
4		Freeze Fingers 135 °
5		Freeze Fingers 180 °

Based on the angle value of each finger, the hand is obtained by the fingers of the letter and number gesture, the data can be seen in Table 2.

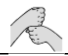
Tabel 2. Finger Freeze Value By Letter And Number Gesture

Image	Finger Freeze Value On The Left Hand					Cue
	1	2	3	4	5	
	0	0	180	180	180	A
	180	0	180	180	180	B
	180	180	180	180	180	C
	180	0	180	180	180	D
	180	0	180	180	180	E
	180	0	180	180	180	F
	180	180	180	180	180	G
	180	0	180	180	180	H
	180	180	180	180	180	I
	180	180	180	180	180	J
	180	0	180	180	180	K

3.3 Hand Slope Analysis

A hand-slope analysis is an analysis to figure out the value of each hand slope performed by a user when performing gesture gestures. The hand slope value is obtained from the accelerometer sensor where the sensor value has 3 values, including the x-axis slope value, the y-axis, and the z-axis. To determine the value of First using the Arduino. Here are hand-slope data obtained from the value reading results of the accelerometer sensor based on letter and number gesture movements, which can be seen in Table 3.

Table 3. Hand Slope Value Based On Letter And Number Cues

Image	Hand Slope Value			Cue
	X Axis	Y Axis	Z Axis	
	0,61	0,10	-0,45	A
	0,09	1,51	0,63	B
	0,61	0,10	-0,45	C
	0,61	0,10	-0,45	D
	0,61	0,10	-0,45	E
	0,09	1,51	0,63	F
	0,09	1,51	0,63	G
	0,09	1,51	0,63	H
	0,61	0,10	-0,45	I
	0,09	1,51	0,63	J
	0,68	0,37	-0,45	K

3.4 Data Analysis Training

Analysis of the training data is analyzed to know the data that will be used by the classification algorithm in predicting a class of each instance. Each instance will have an attribute and a class. the attribute is the caption contained in the data itself, each data can have more than one attribute. Usually, the attribute uses a discrete variable. The attribute that will be used in the training data is the attribute of the results of the analysis of the finger and hand slope analysis. This training Data uses the eight attribute that is obtained in the analysis of the wrist and hand slope analysis, following the attribute that will be used in this study can be seen in Table 4.

Tabel 4. Attribute Data Instance

Attribute	**Description**
X1	Left-handed thumb value
X2	Left-handed index finger
X3	Left of Middle-handed
X4	Left-handed Sweet fingers
X5	Left hand bending value
X6	Right-hand thumb value
X7	Right-handed index finger
X8	Right-handed middle finger
X9	Right-handed sweet fingers
X10	Right-little finger bending value
X11	Value of the hand position on the X-axis
X12	Value of the hand position on the Y-axis
X13	Value of hand position on the Z-axis

Every repeated gesture will result in the possibility of varying values there will be a time of the value of the cue movement that differs from the value that has been obtained in the previous analysis is the analysis of the finger bending , therefore the need to give tolerance value to the value of the correct data training at the value of hand finger, the awarding of this tolerance is done by duplicating the training data from each gesture by 3 times, And the data is rated as both plus and less 5 degrees. The following is the training data of each of the gesture movements obtained can be seen in Table 5.

Table 5. Data Training Letter And Number Gesture Movement

Instances						
Finger Freeze Value On the left hand					Hand Tilt Position	*Classes*
X1	X2	X3	X4	X5		
0	0	180	180	180	0,61	A
180	0	180	180	180	0,09	B
180	180	180	180	180	0,61	C
180	0	180	180	180	0,61	D
180	0	180	180	180	0,61	E
180	0	180	180	180	0,09	F
180	180	180	180	180	0,09	G
180	0	180	180	180	0,09	H
180	180	180	180	180	0,61	I
180	180	180	180	180	0,09	J
180	0	180	180	180	0,68	K

3.5 Training Data Retention Analysis

Analysis of data storage is analysis to know how the training data that has been obtained in the previous analysis is the analysis of the training data is stored. In this research, the training data is stored in an array, where there are two arrays, namely arrays instances and array classes. The arrays instances are used to store hand gesture data values consisting of a hand-bending value and a hand slope position, while array classes are used to store the classification data from an array of instances. The Data array will then be saved in a file and compiled in conjunction with the program syntax.

3.6 Gesture Classification Analysis

The gesture classification analysis is an analysis for classifying new data (data tests) i.e. data from hand gesture movements performed by deaf and/or misguidance with training data set out in data analysis Training. In classifying these gesture movements using the K-Nearest Neighbors (KNN) algorithm. The classifications of the cue movement using the K-Nearest Neighbors (KNN) algorithm can be seen in Figure 6.

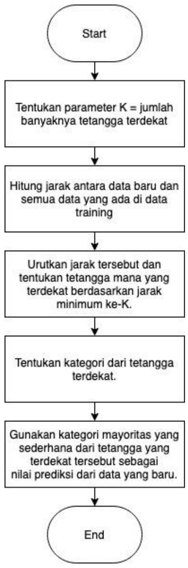


Figure 6. Flowchart Algorithm K-Nearest Neighbors

As for the clarification of the K-Nearest Neighbors algorithm (KNN) to be the following :

1. Specify a parameter K = number of nearby neighbors.
2. Calculate the distance between new data and all data present in the training data.
3. Sort those distances and determine which neighbors are closest based on the K minimum distance.
4. Assign a category from the nearest neighbor.
5. Use a simple majority category of the closest neighbor as a predictive value of the new data

3.7 Alert Voice Data Determination Analysis

The analysis of the cue-sound data determination is an analysis to know how to define cue sound data based on the user's hand gesture movement. Each gesture has its signal sound data, the cue data is a WAV or MP3 file that is stored in a MicroSD Card.

In this research the cue sound data is determined based on the classification result obtained in the previous analysis of the Cue Movement classification analysis, from the classification analysis of the gesture is obtained the cue data in the form of strings, If a gesture classification result is successful and in finding the appropriate data then the cue sound file will be played. Here is the sound data based on the classification of gesture letter and number of cues that can be seen in Table 6.

Table 6. Letter And Number Gesture Sound Data

No	Classification results	File Name	Description
1	"A"	001-HURUF_A.wav	The resulting Output is a sound-letter "A"
2	"B"	002-HURUF_B.wav	The resulting Output is a sound-letter "B"
3	"C"	003-HURUF_C.wav	The resulting Output is a sound-letter "C"
4	"D"	004-HURUF_D.wav	The resulting Output is a sound-letter "D"
5	"E"	005-HURUF_E.wav	The resulting Output is a sound-letter "E"
6	"F"	006-HURUF_F.wav	The resulting Output is a sound-letter "F"
7	"G"	007-HURUF_G.wav	The resulting Output is a sound-letter "G"
8	"H"	008-HURUF_H.wav	The resulting Output is a sound-letter "H"
9	"I"	009-HURUF_I.wav	The resulting Output is a sound-letter "I"
10	"J"	010-HURUF_J.wav	The resulting Output is a sound-letter "J"
11	"K"	011-HURUF_K.wav	The resulting Output is a sound-letter "K"

3.8 None Functional Needs Analysis

The analysis of non-functional needs is done to generate details about the things that the system does when implemented. As for some parts that are included in the analysis of Non-functional needs, namely the analysis of hardware requirements, software needs analysis and user analysis.

3.8.1 Hardware Requirements Analysis

The hardware requirement analysis will be outlined for non-functional hardware-related needs. The following is the hardware along with the proposed specifications based on the need to run the letter and Number Translator tool, viewable in Table 7.

Table 7. Hardware Requirement Analysis

No	Hardware Type	Specifications
1	Microcontroller	Arduino Nano V3
2	Flex Sensor	Sparkfun Flex Sensor 2.2"
3	Accelerometer Sensor	ADXL335 Accelerometer (3-Axis)
4	Bluetooth Module	HC-05 Bluetooth
5	Battery Charging Module	TP5100U (Support 2 Cell Battery)
7	MP3 Player Module	YX5300 UART Control Serial MP3
6	Battery	Lithium 18650 (2 Cell)
8	MicroSD Card	SanDisk MicroSD Card Kapasistas 1 GB
9	Speaker	Speaker 0.5W 8 Ω

3.8.2 Software Requirements Analysis

In the analysis of the needs of this software will be outlined non-functional needs related to software specifications. The following are the software specifications required to run the letter and Number Translator tool, which can be seen in Table 8.

Tabel 8. Software Requirements Analysis

No	Type of software	Specifications
1	Arduino Bootloader	ATmega328P Bootloader

3.8.3 User Needs Analysis

User analysis is intended to know the various users who will be engaged in the use of tools to be built, so hopefully, users who use the tool can fulfill some. The users who will be involved in the use of the tool can be seen in Table 9.

Table 9. User Analysis

No	Users	Skill Level
1	Community	Understand the letter and number of cues BISINDO.

3.9 Functional Needs Analysis

The analysis of functional needs is a representation or arrangement of several separate elements into a unified and functional whole. Tools to illustrate this system using Unified Modelling Language (UML).

3.9.1 Use Case Diagram

Use case diagrams are used to describe the function of a system to describe the needs of the user. The following use case diagram can be seen in Figure 7.

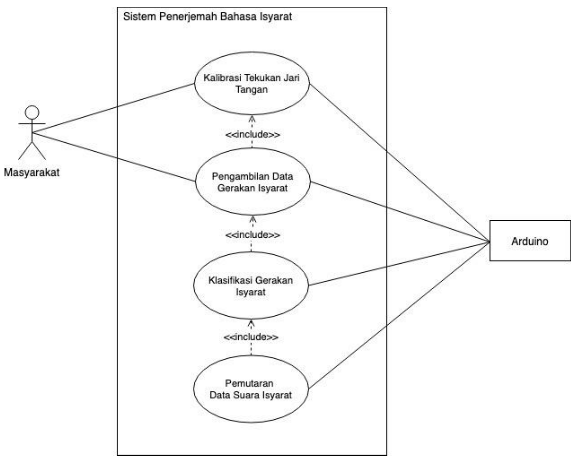


Figure 7. Use Case System Diagram Tool Translator Letters And Numbers

4 IMPLEMENTATION AND TESTING

4.1 Implementations

Implementation is a stage of implementation based on analysis results into a specific programming language and the implementation of the system to be built in the real environment.

4.1.1 Hardware Used

Hardware that is implemented in the development of the letter Translator tool and this number is the hardware that has been determined at the analysis stage. The following hardware that is implemented can be seen in Table 10.

Table 10. Hardware Implementation

No	Hardware Type	Specifications
1	Microcontroller	Arduino Nano V3
2	Flex Sensor	Sparkfun Flex Sensor 2.2”
3	Accelerometer Sensor	ADXL335 Accelerometer (3-Axis)
4	Bluetooth	HC-05 Bluetooth
5	Battery Charging Module	TP5100U (Support 2 Cell Battery)
7	MP3 Player Module	YX5300 UART Control Serial MP3
6	Battery	Lithium 18650 (2 Cell)
8	MicroSD Card	SanDisk MicroSD Card Kapasistas 1 GB
9	Speaker	Speaker 0.5W 8 Ω

4.1.2 Software Used

The software that is implemented in the development of the letter Translator tool and this number is software that has been specified at the analysis stage. The following implemented software can be seen in Table 11.

Table 11. Software Implementation

No	Type of software	Specifications
1	Arduino Bootloader	ATmega328P Bootloader

4.1.3 Implementation Tools

Implementation of the tool is the result of the installation of a device that has been made in the layout planning phase of the device into a glove. The implementation of this tool can be seen in Figure 9.

Figure 9. Implementation Tools

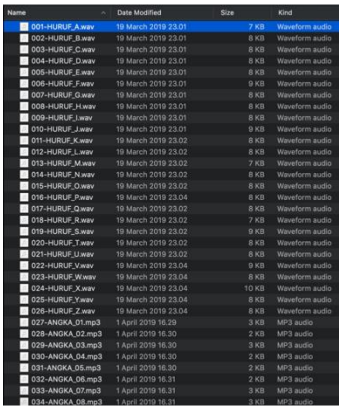
In Figure 9 has been done mounting the device against gloves, among its :

1. Arduino Nano V3 Device
2. Device Accelerometer Sensor ADXL335
3. Flex Sensor Device
4. Serial MP3 Devices YX5300

5. MicroSD Card Device
6. Speaker Devices
7. Device Battery Charging TP5100
8. Lithium Battery Device 18650
9. Bluetooth Device HC-05

4.1.7 Gesture Voice Data implementation

At the stage of the signal sound data analytic has been explained that the signal sound data in the form of MP3 and WAV files are stored in the MicroSD Card. The result of this gesture sound data storage implementation can be seen in Figure 8.



Name	Date Modified	Size	Kind
001-HURUF_A.wav	19 March 2019 23.01	7 KB	Waveform audio
002-HURUF_B.wav	19 March 2019 23.01	8 KB	Waveform audio
003-HURUF_C.wav	19 March 2019 23.01	8 KB	Waveform audio
004-HURUF_D.wav	19 March 2019 23.01	8 KB	Waveform audio
005-HURUF_E.wav	19 March 2019 23.01	8 KB	Waveform audio
006-HURUF_F.wav	19 March 2019 23.01	9 KB	Waveform audio
007-HURUF_G.wav	19 March 2019 23.01	8 KB	Waveform audio
008-HURUF_H.wav	19 March 2019 23.01	8 KB	Waveform audio
009-HURUF_I.wav	19 March 2019 23.01	8 KB	Waveform audio
010-HURUF_J.wav	19 March 2019 23.01	9 KB	Waveform audio
011-HURUF_K.wav	19 March 2019 23.02	8 KB	Waveform audio
012-HURUF_L.wav	19 March 2019 23.02	8 KB	Waveform audio
013-HURUF_M.wav	19 March 2019 23.02	7 KB	Waveform audio
014-HURUF_N.wav	19 March 2019 23.02	8 KB	Waveform audio
015-HURUF_O.wav	19 March 2019 23.02	8 KB	Waveform audio
016-HURUF_P.wav	19 March 2019 23.04	8 KB	Waveform audio
017-HURUF_Q.wav	19 March 2019 23.02	8 KB	Waveform audio
018-HURUF_R.wav	19 March 2019 23.02	7 KB	Waveform audio
019-HURUF_S.wav	19 March 2019 23.02	9 KB	Waveform audio
020-HURUF_T.wav	19 March 2019 23.02	8 KB	Waveform audio
021-HURUF_U.wav	19 March 2019 23.02	8 KB	Waveform audio
022-HURUF_V.wav	19 March 2019 23.04	9 KB	Waveform audio
023-HURUF_W.wav	19 March 2019 23.04	8 KB	Waveform audio
024-HURUF_X.wav	19 March 2019 23.04	10 KB	Waveform audio
025-HURUF_Y.wav	19 March 2019 23.04	8 KB	Waveform audio
026-HURUF_Z.wav	19 March 2019 23.04	8 KB	Waveform audio
027-ANGKA_01.mp3	1 April 2019 16.29	3 KB	MP3 audio
028-ANGKA_02.mp3	1 April 2019 16.30	2 KB	MP3 audio
029-ANGKA_03.mp3	1 April 2019 16.30	3 KB	MP3 audio
030-ANGKA_04.mp3	1 April 2019 16.30	2 KB	MP3 audio
031-ANGKA_05.mp3	1 April 2019 16.30	2 KB	MP3 audio
032-ANGKA_06.mp3	1 April 2019 16.31	2 KB	MP3 audio
033-ANGKA_07.mp3	1 April 2019 16.31	3 KB	MP3 audio
034-ANGKA_08.mp3	1 April 2019 16.31	3 KB	MP3 audio

Figure 8. Gesture Sound Data

In Figure 8 visible set of cue sound data as MP3 and WAV files of each letter and number gesture sound. The cue sound Data will be played by the classification results obtained through the classification stage of gesture movement using the K-Nearest Neighbors algorithm.

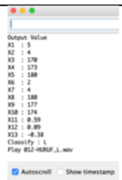
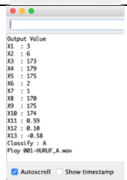
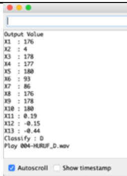
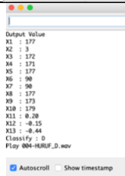
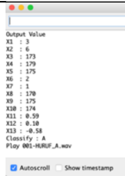
4.2 Testing

Testing is the most important thing that aims to find errors in the tested tools. This test intends to know the tools that are made to meet the criteria that fit the purpose of the design or not.

4.2.7 Test Letter A gesture

Here are the results of the letter A gesture test that tested 5 times the recurrence, the test results can be seen in the following Table 12.

Table 12. A Gesture Test Letter A

No	Image	Result	Description
1			Inappropriate
2			Appropriate
3			Inappropriate
4			Inappropriate
5			Appropriate

Based on the results of the gesture test letter A in Table 12, it can be obtained the percentage of the suitability of the gesture of letter A as follows.

Total success / Number of tests x 100

2 / 5 x 100 = 40 %

4 CONSLUSION AND SUGGESTIONS

4.1 Conclusion

Based on the research and test results that have been done on the translator tool and this number, it can be concluded that the gesture of cue letters and numbers can already be translated into sound using Arduino, Flex Sensor, and Sensor accelerometers, but the success rate is only 55,135%. The Error is obtained because there is a gesture attribute value similar to even worth between one gesture to another in the training data so that the K-Nearest Neighbors algorithm provides a classification value that does not correspond to the Expected results.

4.2 Suggestions

Translation tool letters and numbers Bahasa Indonesia is still a prototype that needs to be developed again, therefore some suggestions can be used as a development guide in the better direction to support tools translator letters and language numbers Indonesian. The suggestions on the development of translator tool letters and numbers are as follows:

1. Signal motion Data is still a gesture of letters and numbers, the need to apply cue words that are commonly used day by the deaf and.
2. The training data is compiled together with the script built so that the training data can be kept limited to the storage capacity of Arduino Nano V3, so it takes an external database to store the training data.
3. K-Nearest Neighbors algorithm will give the results of the classification on each movement even if the movement is not available on the training data Dikarenakan Algortima K-Nearest

Neighbors will find the nearest value with the available value on the training data, Hence, the need for the application of other Algortima in conducting a hand signal movement classification so that the output fits.

BIBLIOGRAPHY

[1] F. S. Nehemia Sugianto, “Analisa Manfaat Dan Penerimaan Terhadap Implementasi Bahasa Isyarat Indonesia Pada Latar Belakang Komplek Menggunakan Kinect Dan Jaringan Syaraf Tiruan (Studi Kasus SLB Karya Mulia 1),” *JUISI*, vol. 01, no. 01, p. 56, 2015.

[2] A. A. S. Gunawan and A. Salim, “Pembelajaran Bahasa Isyarat Dengan Kinect Dan Metode Dynamic Time Warping,” *Math. Stat. Dep. Sch. Comput. Sci. Binus Univ.*, vol. 13, no. 2, pp. 77–84, 2013.

[3] A. SETIYADI and T. Harihayati, “Penerapan SQLite Pada Aplikasi Pengaturan Waktu Ujian dan Presentasi,” *Maj. Ilm. UNIKOM*, vol. 13, no. 2, 2015.

[4] M. Winarsih, *Intervensi Dini Bagi Anak TunaRungu Dalam Pemerolehan Bahasa*. Jakarta: Departemen Pendidikan Nasional Direktorat Jenderal Pendidikan Tinggi Direktorat Ketenagaan, 2007.

[5] Sadjaah, *Pendidikan Bahasa bagi Anak Gangguan Pendengaran dalam Keluaga.* Jakarta: Depdiknas Dirjen Pendidikan Tinggi Direktorat Pembinaan Pendidikan Tenaga Kependidikan dan Ketenagaan Perguruan Tinggi, 2005.

[6] Yuni, “Studi Komparatif Ketrampilkan Komunikasi Interpersonal antara pengguna Bahasa isyarat SIBI Dengan BISINDO,” 2014.

[7] D. I. Setyawan, H. Tolle, and A. P. Kharisma, “Perancangan Aplikasi Communication Board Berbasis Android Tablet Sebagai Media Pembelajaran dan Komunikasi Bagi Anak Tuna Rungu,” *J. Pengemb. Teknol. Inf. dan Ilmu Komput.*, vol. 2, no. 8, pp. 2933–2943, 2018.

[8] Ihsan, “Berkenalan Dengan Arduino Nano,” *2016*. [Online]. Available: http://ecadio.com/mengenal-dan-belajar-arduino-nano.

[9] K. Teknomo, “K-Nearest Neighbours Tutorial, K-Tetangga Terdekat Tutorial,” 2010. .

[10] S. Budiono, *Bunga Rampai HIPERKES & Kesehatan Kerja*. Semarang: Badan Penerbit Universitas Diponegoro., 2006.