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The Development of Android for Indonesian Sign Language Using Tensorflow Lite and CNN: An Initial Study

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Abstract. Deaf people in the world have different sign language according to their living place. They tend to use simple sign language to communicate with others. Whereas every country has their own sign language. Usually a country has one national sign language, but there are 2 kinds of sign languages (SIBI and BISINDO) in Indonesia. However, BISINDO (Indonesian Sign Language) had not recognized yet as a formal sign language like as SIBI (Indonesian Sign Language System), it is only a daily sign language among them and with normal people. Thus, researcher propose to promote BISINDO by developing BisAndro (BISINDO using Android) application. At the start, researcher prepare to compare BISINDO systems in cyberspace, develope basic BISINDO website by PHP and MySQL, train some gestures in TensorFlow lite, and make CNN (Convolutional Neural Network) plan before developing BisAndro application. BisAndro application will be built by Python programming, Tensorflow as an image recognition technology, and Android mobile phone as the launcher device. The application is expected can be used by deaf people to communicate with others easily because it facilitates two ways communication through mobile phone. So, the preparation is needed to know about initial requirement of the next BISINDO learning application using Android smartphone in order to be more useful for deaf and normal people directly.

1. Introduction

Deaf is unable to hear, either completely or partly [19], while mute is silent or not speaking or unable to speak [20]. The only thing that separate them and the normal people is communication. Communication between deaf and normal people is not smooth because each of them does not understand the intended conversation of other persons. Deaf-mute people are still getting little attention from the normal people. [1]. There are various categories in the sign language but none of the sign languages are universal or international. A person should know the sign language to understand the language. It becomes complicated when a person who has inability to speak or hear wants to convey something to a person or group of persons, since most of them are not familiar with the sign language [3]. One of the solutions to communicate with the deaf-mute people is by using the services of sign language interpreter. But the usage of sign language interpreter can be expensive. Cheap solution is required so that the deaf-mute and normal people can communicate normally [1]. Sign language is a method that does not


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use voice communication, but the movement of the hands, body, and lips to convey information and express a speaker's thoughts [2]. Some methods had used in sign language learning and recognition based on sign language types in each country.

Researchers who do their researches in various ways starts from the various data acquisition methods because of the cost needed for a good device, but cheap method is needed for the Sign Language Recognition System to be commercialized. Each method has its own strength compare to other methods and researchers are still using different methods in developing their own Sign Language Recognition. Each method also has its own limitations compared to other methods [1]. The most researchers acquire their training data by recording the data from their signer and data set from sign language category, for example alphabets [8]. Samples of sign languages are Indian Sign Language (ISL), American Sign Language (ASL), British Sign Language (BSL), Indonesian Sign Language, Malaysian Sign Language (MSL), Arabic Sign Language, Bangladesh Sign Language (BdSL), and many other sign languages according to each country in the world. Normally, a country has a national sign language, but deaf people in Indonesia has 2 communication methods. Krisnan mentioned that those are *SIBI (Sistem Bahasa Isyarat Indonesia*/Indonesian Sign Language System) and *BISINDO (Bahasa Isyarat Indonesia*/Indonesian Sign Language) [9]. The people with hearing problem also have problem with communication with deaf people. Sign language is one of the solutions to solve the problem. Therefore, in 1994, Ministry of Culture and Education released SIBI as formal Indonesian Sign Language. It consists of various finger positions and hand gesture movements to represent Indonesian vocabulary. However, SIBI is less popular, thus limited people can understand it. Communication among SIBI user who suffer from hearing disability is limited as well [10]. The process of connecting SIBI with Indonesian is not running smoothly because children with hearing impairments do not know Indonesian grammar. Whereas *BISINDO* is a sign language from birth which develop naturally. In fact, the sign language recognized by the government is SIBI. With the enactment of government regulations and in accordance with the second article of Pancasila which reads just and civilized humanity, the Indonesian Deaf Welfare Movement (*GERKATIN/Gerakan untuk Kesejahteraan Tunarungu Indonesia*) then strives for natural sign language and it is consistent with the conscience of the deaf in Indonesia because the sign language *BISINDO* is easier to understand than the SIBI sign language. Deaf people are part of the Indonesian community so they have the rights and attention from the government. In accordance with Law in number 19^{th} of 2011, article 24^{th}, paragraph 3^{rd} of the Convention on the Rights of Persons with Disabilities of the United Nations (*Konvensi Hak Penyandang Disabilitas Perserikatan Bangsa-Bangsa*) that states must take steps which is feasible, including facilitating the learning of sign language and the progress of linguistic identity in terms of deafness [11]. Generally, *BISINDO* is used by deaf people in their daily communication. Deaf people tend to have communication barriers with others. Yet, in the education world, some of them still have high spirit to continue their education until tertiary level. Therefore, they must improve their abilities or competences in communicating with others and try to get information from around the world, for example using sophisticated technology with sign language [12]. In 2018, there are the number of deaf people more than 8.750.000 in Indonesia. Currently, there are about 4 *BISINDO* applications using Android in cyberspace [15, 17, 18] then 2 *BISINDO* websites in Indonesia [19, 20]. All of them provide *BISINDO* learning program like as dictionary in text and video, but there are no performance analysis of application learning and not reciprocal communication directly. There is also an article in Scopus proceeding about the *BISINDO* information system, but no one of *BISINDO* application article in scientific journal, while the SIBI application has already exists in at least 3 journals [10, 21, 22].

Not all the application using Android. While Indonesia is "the sleeping digital technology giant of Asia", due to population of Indonesia which reaches 250 million that offer large market in term of economy scale. Indonesian smart phone users are also growing rapidly. The digital

marketing Emarketer Research Institute estimates that in 2018 there will be more than 100 million active smartphone users in Indonesia. With such a large number, Indonesia will become the country with the fourth largest active smartphone users in the world after China, India and America [13]. The Android is increasingly dominating the smartphone market. After twelve months being launched in October 2015, the Android 6.0 operating system, also known as Marshmallow, is now used by around 18,7 percent of smartphone devices currently owned by users [14].

Based on the above realities, there are many people using Android mobile phone or smartphone as their helping tools in daily life, included deaf people. So, researcher will prepare to build *BisAndro* (*BISINDO* using ANDROid) to help deaf people communication. The main principle of *BisAndro* is to use an Android smartphone to display *BISINDO*'s deep learning application using Tensorflow and it analysis. At the moment, there are some sign language learning using Android application because of it is relative cheaper than using sensors, etc.

2. Method

2.1. The first method

In this research is make comparison among articles related to sign language application to get result of literature taxonomy. The articles published from 2009 to 2018 were adopted in this research and grouped into some categories. Then researcher compare *BISINDO* sign language learning in cyberspace (Android application, website, and Youtube channel). In free application, there are some Indonesian *BISINDO* sign language learning, some of them are 4 Android applications and 2 websites. There are also some Youtube channels that provide online *BISINDO* learning. The *BISINDO* application in cyberspace tends to function like a dictionary for learning sign language using video or picture, the database is incomplete, and it has not showed yet the implementation of algorithm theory of sign language recognition. So *BisAndro* will be built to show deep learning of *BISINDO* with the analysis.

2.2. The second method

for learning *BISINDO* basic is making website about *BISINDO* vocabulary as the main data of *BisAndro* in order to more understand it. Researcher collaborated with truly deaf students to build website in `www.bisindo-surakarta.com`. The website consists of some basic *BISINDO*'s vocabulary especially words in daily communication. The method to design and build website is using laptop with hardware specifications are 2.90 GHz Intel Core i7-7500U 270 GHz processor, 8 GB RAM, and VGA nvidia Geforce 940MX. The software used were XAMPP (PHP and MySQL), Sublime text 3, and browser to display web pages like Google Chrome [12].

Actors in design system as like Figure 1 is divided into 2 main parts according to the user obtained, these are root as admin and user as web visitor. The first stage of the user is open a web browser which has been installed on a computer device, then access the relevant website address. The next step is request data to the server and gets a response from the server in the form of an index page that contains the login page and navigation bar. In the navigation display, there are profile, about us, services, and contact menus. While admin can do anything in website especially to manage and maintain website. Based on Figure 3, it can be seen that there are three actors (visitor, member, and admin). Visitor only can see and read general information, while member also can see and practice sign language then download and doing evaluation after login as member. Admin have authority to edit the contents and manage the data. Mapping system of *Bisindo* sign language information system is shown as in Figure 2 [12].

In Indonesia, sign language types are almost same with BSL and ASL. Sign language often have significant similarities with their respective spoken language, such as *SIBI* and *BISINDO* with Indonesian language. *SIBI* had made by normal people, while *BISINDO* had made by deaf people. *BISINDO* is like mother language of Indonesian deaf people. Thus, *BISINDO* is easier

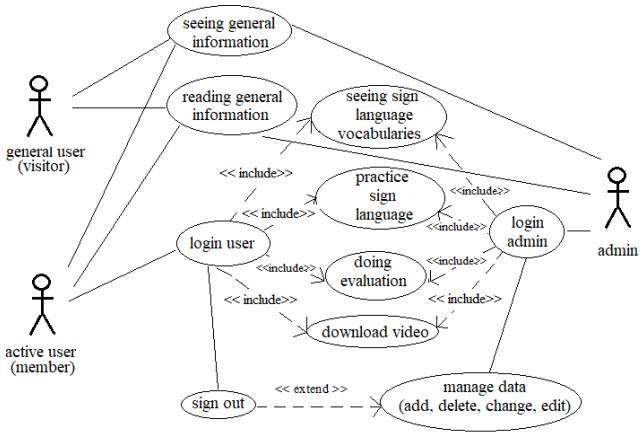


Figure 1: Use case diagram of *BISINDO* information system

to use by deaf people to communicate with others than they use *SIBI*. Based on Figure 2-6, it can be seen that alphabetic *BISINDO* motion method is relative similar to usual alphabetic because it also uses 2 hands to form the alphabetic sketch.

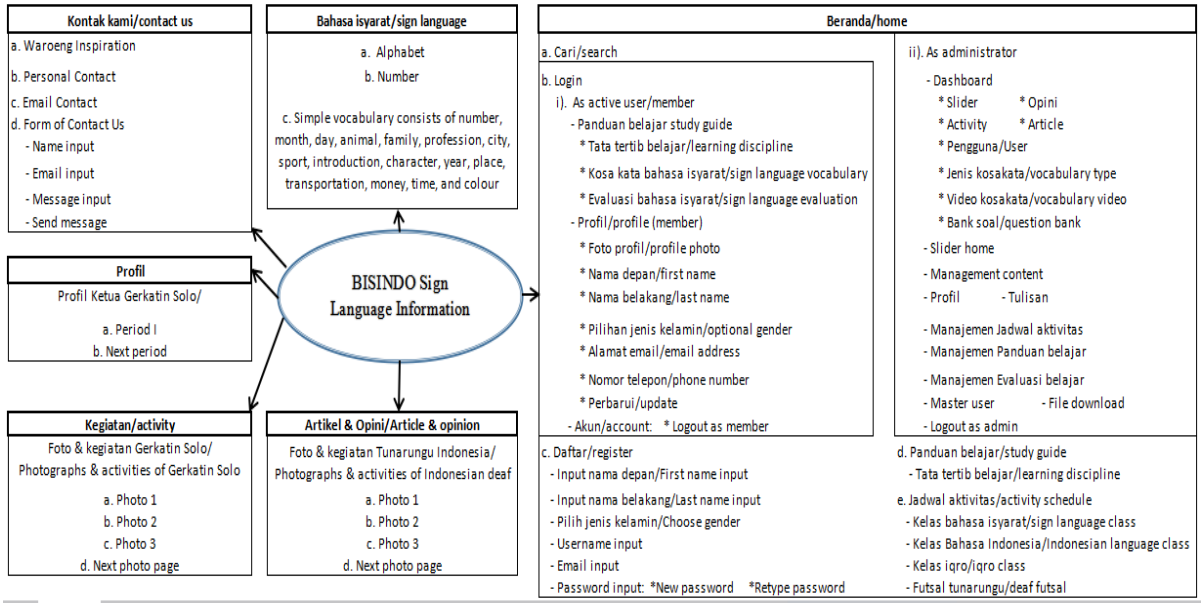


Figure 2: Mapping system of *Bisindo* Information System

BISINDO alphabetic types was adopted from BSL alphabetic types with 42,3% similarities in 11 letters: B, C, D, G, K, M, N, P, Q, X, and Y, like as in Figure 3. The SIBI alphabetic types was adopted from ASL alphabetic types with 84,5% similarities in 22 letters: A, B, C, D, E, F, G, H, I, K, L, M, N, O, P, Q, R, S, U, V, W, and X.

2.3. The third method

Modelling with TensorFlow Lite before sign language launching to users. TensorFlow lite is an open source deep learning framework for on-device inference is used to help modelling. Researcher continue to learn about TensorFlow Lite with the works in Figure 4.

Based on Figure 4, the works of TensorFlow lite are:

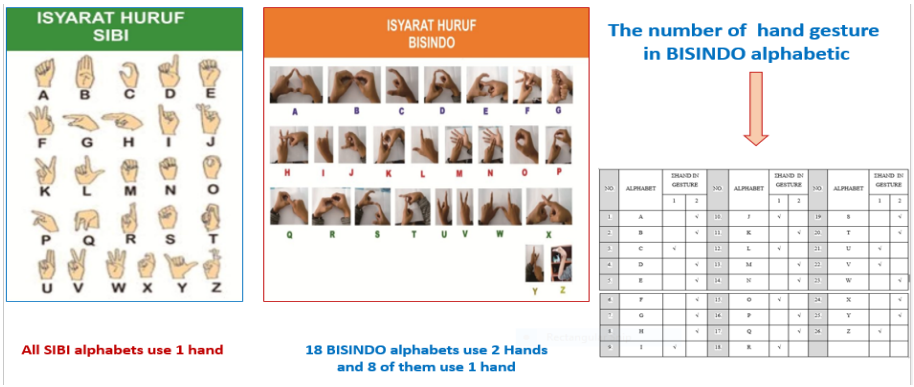


Figure 3: Illustration of Alphabetic SIBI and *BISINDO* method

Figure 4: The works of TensorFlow Lite (modified from `https://www.tensorflow.org/lite`)

(i) Pick a new model or retrain an existing one.
(ii) Convert a TensorFlow model into a compressed flat buffer with the TensorFlow Lite Converter.
(iii) Deploy or take the compressed .tflite file and load it into a mobile or embedded device.
(iv) Optimize or quantize by converting 32-bit floats to more efficient 8-bit integers or run on GPU (Graphics Processing Unit).

2.4. The fourth method

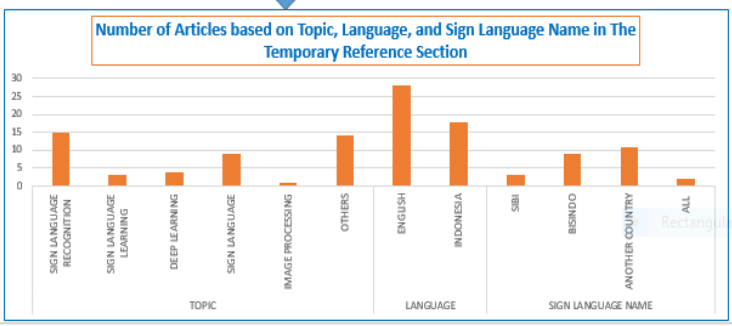
will implement algorithm in CNN (Convolutional Neural Network) which using supervised learning scenario in deep learning, that is one of scenarios in machine learning algorithm. *BISINDO* data will be labelled first before prediction process to translation. In this study also using reinforcement learning scenario to collect active learning information from hand gesture so that the application will interact with the environment and get reply for each action of user.

3. Result and Discussion

Preparation to develop *BisAndro* was began by comparing 46 papers about sign language from 2007 until 2018. Most of them have correlation with sign language recognition technology. In references below, there are 9 articles about *BISINDO* but they are not related to *BISINDO* electronic application.

Based on Figure 5, the most article topic is about sign language recognition (15 papers), only 1 paper about image processing, and 14 of them in review form. Most papers are in English language. *BISINDO* sign language name in second rank after another sign language names in the world. Research about recognizing sign language are conducting in many countries. The sample of research gap in this study can be seen by the screen shoot in Figure 6. There are 3 papers in the past three years about sign language recognition from Bangladesh, India, and Sweden. They used Leap Motion Controller, Matlab programming, and Kinect sensor as the tools to simulate sign language based on each country that they conducted research. The methods are difference each other, these are CNN (Convolutional Neural Network) with HMM

TOPIC						LANGUAGE		SIGN LANGUAGE NAME			
SIGN LANGUAGE RECOGNITION	SIGN LANGUAGE LEARNING	DEEP LEARNING	SIGN LANGUAGE	IMAGE PROCESSING	OTHERS	ENGLISH	INDONESIA	SIBI	BISINDO	ANOTHER COUNTRY	ALL
15	3	4	9	1	14	28	18	3	9	11	2



YEAR	PAPER
2007	1
2009	1
2012	2
2013	1
2014	2
2015	1
2016	4
2017	10
2018	4
TOTAL :	26

Figure 5: Illustration of article number according to the topic, language, and sign language name in table, vertical bar graph, and year data

(Hidden Markov Model), HSV (Hue, Saturation, Value) color model, and educational signing-based games. They have also different strength and weakness.

Figure 6 depicted about 3 papers [4–6] with different languages and sign language recognition methods according to researcher's work and the need for deaf people. They have characteristic themselves. It can complement each other. Interest in automatic action and gesture recognition has grown considerably in the last few years. This is due in part to the large number of application domains for this type of technology.

NO.	TITLE	AUTHOR	METHOD	OBJECTIVES	STRENGTH	WEAKNESS	TOOL
1.	Bangla Sign Language recognition using convolutional neural network	Yasir (2017)	Convolutional neural network (CNN) with Hidden Markov Model (HMM)	Bangla sign language recognition	Without distortion the rate reduced to 2%.	The basic sign expressions in a 3% rate of error	Sensor of Leap motion controller (LMC)
2.	Indian Sign Language Converter System using an Android App	Loke (2017)	Hue, Saturation, Intensity (HSV) color model	Facilitate communication for deaf and mute people.	Recognize single handed as well as double handed gestures accurately	Not recognize gestures in real time and in video format	MATLAB for pattern recognition and Android for display
3.	A Real-time Gesture Recognition System for Isolated Swedish Sign Language Signs	Kalin & Jonas (2016)	Educational signing-based games	Provide an automatic recognition of isolated Swedish Sign Language signs	Signer-dependent recognition rate is 95.3% for the most consistent signer.	Signer-independent recognition rate is on average 57.9% for the experienced signers and 68.9% for the inexperienced	A RGB-D (Kinect) sensor

Figure 6: Sample of Research Gap among Sign Language Systems

As in many other computer vision areas, deep learning based methods have quickly become a reference methodology for obtaining state-of-the-art performance in both tasks [7]. Nowadays, there are many researchers conduct research in field of sign language recognition. They use various ways to implement electronic and computer tools to achieve their goals. Some of them using expensive devices such as electronic sensors. It probably cannot be used commercially because people tend to choose low cost devices to help their activities rather than using higher cost tools. The next comparison are among *BISINDO* in cyberspace like as in Table 1.

Table 1: Comparison among *BISINDO* Learning Systems

TWO BISINDO LEARNING SYSTEM	
A. BISINDO LEARNING VIA ANDROID APPLICATION	
1.	Penabarat (2017) in `https://penabarat.id` Objective: helps heard and deaf people in their daily communication through BISINDO basic. Feature and method: a.Translate Bahasa Indonesia voice to Sign Language (text and hand gesture). b.Translate Sign Language in hand gesture to Bahasa Indonesia (text and accuration value). Note: It providing BISINDO vocabularies (it is around 3 words) and it can be free downloaded [15].
2.	i Sign: Belajar BISINDO (2018) in `https://play.google.com/store/apps/details?id=com.nuryazid.BISINDO\&hl=in` Objective: helps to understand BISINDO sign language through video movement and how to convey it. Feature and method: a. Sign language translation through video movement and how to convey it. a. Quickly find Indonesian sign languages that are searched through the quick search feature i Sign. b. Sign language communities can share information so people know where to learn sign language and find them. Note: It tend to be static and can be free downloaded [16].
3.	JakSL(2018) in `https://play.google.com/store/apps/details?id=com.jaksl.mobile.jaksl\&hl=in` Objective: Respond to a high demand from people – both the deaf and hearing - wanting to learn BISINDO out of interest or to be able to communicate better with the deaf. Feature and method: a. Provide 3 level of difficulties. b. Each level consists of 10 sign language categories. c. Each category has around 30 words in youtube video form. d. Must be online because it needs youtube video access. Note: It can be free downloaded [17].
4.	Kamus BISINDO (2017) in `https://play.google.com/store/apps/details?id=com.hendra.Kamusbisindo\&hl=in` Objective: Make it easier to be ready to learn BISINDO (Indonesian Sign Language). Feature and method: Show sign language video and voice according to optional word in each writing button. Note: This application is still in the stage of developing. If we choose a category, so it consists of same videos in family category. It can be free downloaded [18].
B. BISINDO LEARNING WEBSITE	
1.	chat (2011) in `http://id.i-chat.org/bisindo/` Objective: Help people to know basic BISINDO vocabulary. Feature and method: It consists of 12 BISINDO sign language types (vocabulary groups) and 5 sentence samples.

	Note: The vocabulary is more complete than in `BISINDO-surakarta.com` website. BISINDO in here become one of menu in i-chat website. It can be free online accessed [19].
2.	Web of bisindo-surakarta (2018) in https://bisindo-surakarta.com Objective: Help heard and deaf people to learn BISINDO sign language. Feature and method: a. Learning and evaluation about alphabetic and 16 other vocabulary types of sign language. b. Information about activities of deaf community in Solo (Surakarta). Note: More complete vocabulary. There are only multiple choice and essay questions in evaluation features. It can be free online accessed [20].

Base on Table 1, it can be seen that all applications have the same objective to help deaf people communication with *BISINDO*. There are different features and methods that have almost the same outcomes. By comparing them, so researcher determine the next *BISINDO* Android application (*BisAndro*) that can help deaf and normal people to communicate each other reciprocally. The mapping review of *BISINDO* learning in cyberspace is in Figure 7.

Figure 7: Illustration of *BISINDO* learning in cyberspace

Based on Figure 7, there are *BISINDO* learning in website, Android application, and Youtube media. Each of them is described in their topic and features. The next review is to show about *BisAndro* that will be built in this research, like as in Figure 8. *BisAndro* application will use supervised learning method that consists of training, evaluation, and testing. Actually testing phase is not obligation in supervised learning, but it is better if researcher use it as the last session before this application is launched to the public.

Based on *BisAndro* deep learning plan in Figure 8, the sequential process flows of *BisAndro* that will be reached is like as in Figure 9. It shows about the work process plan of *BisAndro*

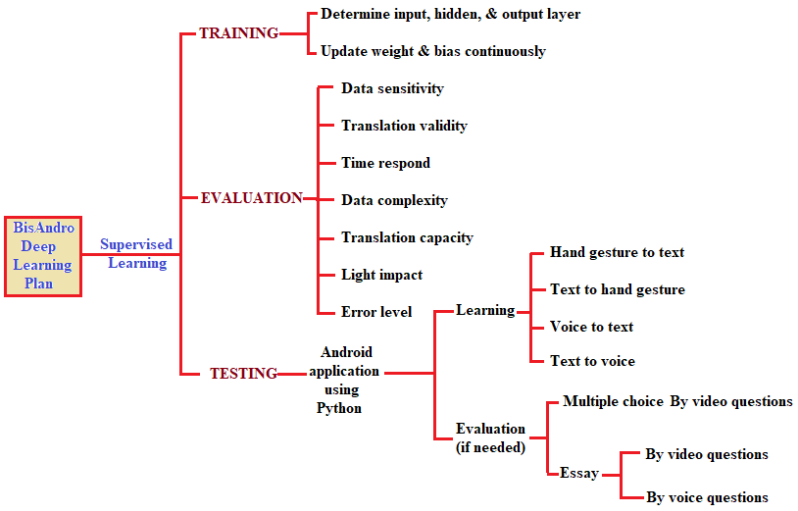


Figure 8: *BisAndro* deep learning plan

application that is reciprocally between deaf and hearing people.

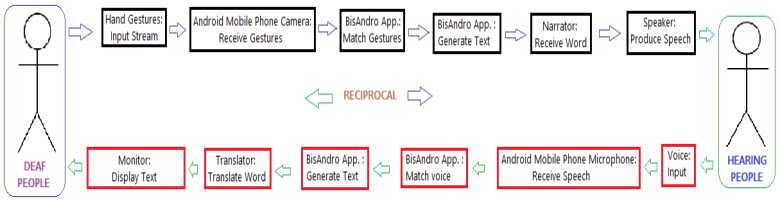


Figure 9: equential process flows of BisAndro application (before it shows performance analysis)

BisAndro need main data source (in this case is *BISINDO*) to be explored. So, for learning *BISINDO* basic, it must be built website about *BISINDO* vocabulary in order to more understand it. Researcher collaborated with truly deaf students to build website in `www.bisindo-surakarta.com`, the content sample is in Figure 10.

Figure 10: Homepage and member page

Based on Figure 10, the main menu of *BISINDO* website consists of *BISINDO* basic learning. There are 3 photos display below the main menu in homepage that flash and change each

other every about 3 seconds. It shows 16 sign language vocabulary types besides alphabet *BISINDO* sign language that can be chosen by member user to be learnt and practiced. Those are number, month, day, animal, family, profession, city, sport, introduction, character, year, place, transportation, money, time, and colour. While in the right side, there are announcement of deaf activity schedule in *Gerkatin Solo* covering sign language class, Indonesian language class, iqro class, and deaf futsal. The tools used in this site are XAMPP (PHP and MySQL), Sublime text 3, and browser to launch web pages like Google Chrome, Mozilla Firefox etc. It provides *BISINDO* learning through basic vocabulary and evaluation of vocabulary understanding by answer multiple choice and essay question. Based on *BISINDO* -surakarta.com website in Figure 10, as a main reference source in this project, there are 16 sign language vocabulary types besides alphabet sign language that can be chosen by member to be learn and practiced. Those are number, month, day, animal, family, profession, city, sport, introduction, character, year, place, transportation, money, time, and colour. The basic *BISINDO* letters and words will be simulated and captured by camera then translated into text by TensorFlow programming.

The next BisAndro preparation in this research is modelling gesture with TensorFlow Lite before sign language launching. TensorFlow lite that have been tried by researcher only in website application. It did not downloaded and transferred to Android smartphone device yet. It is because of there is no complete data that must be trained and tested in the website. So, researcher must prepare for it. For example, researcher had tried until 5 modelling in TensorFlow lite, but it is still high error. It can be seen by Figure 11.

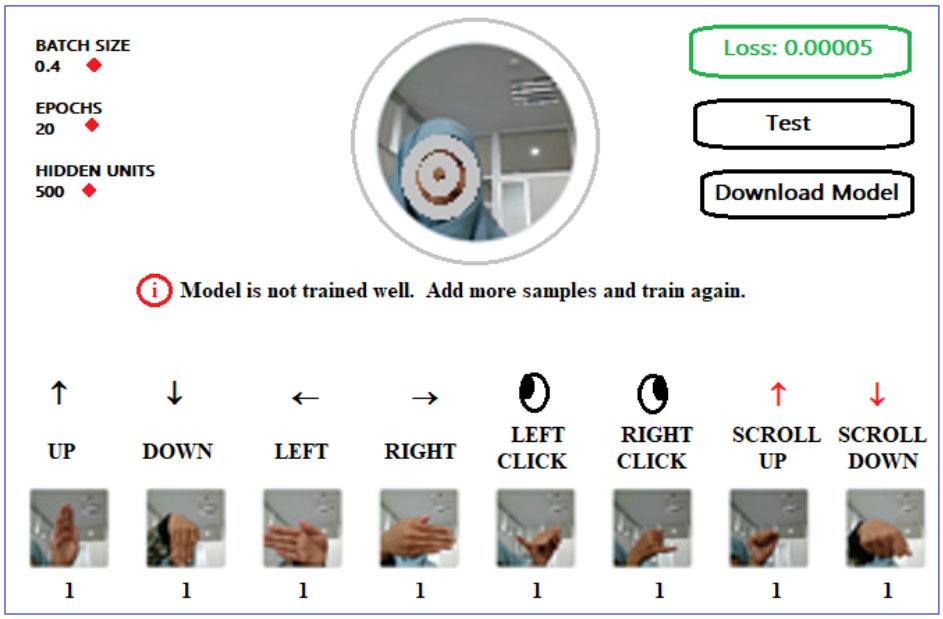


Figure 11: The first train process in TensorFlow lite

Researcher tried to pick models and trained until 5 period of time with difference frequency. The gesture in 8 position of hands from up, down, left, right, left click, right click, scroll up, and scroll down. Each position has the same value of batch size, epochs, and hidden units. The last training is in Figure 12.

Base on Figure 12, it shows that 8 position of hand gestures still follow the default rule of TensorFlow display before training. In the last train, researcher reach loss 0,00009 and two buttons to test and download model are ready to be clicked.

From the fifth experiment, researcher got results like as in the Table 2.

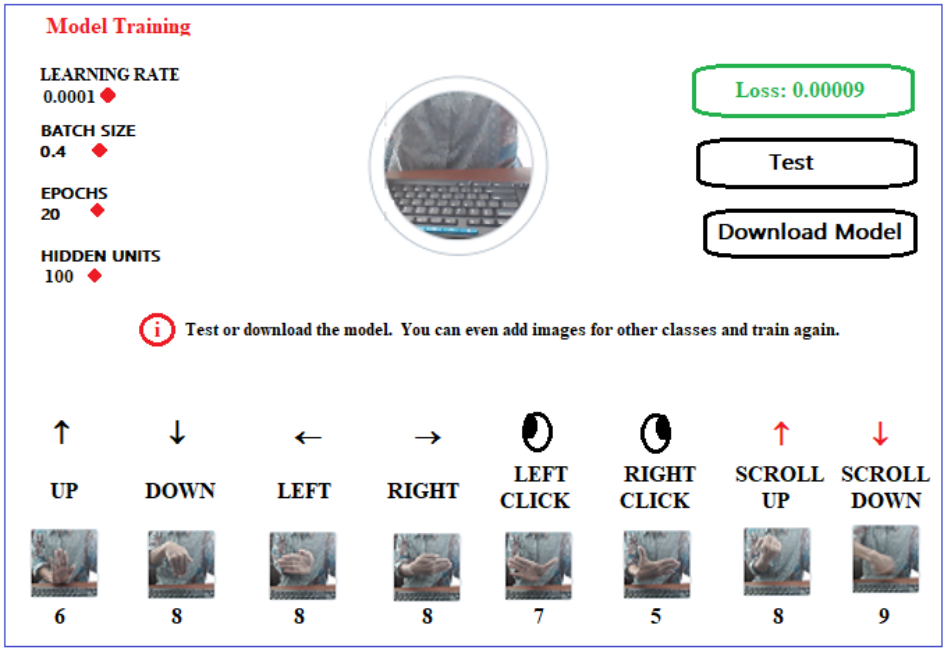


Figure 12: The next train process in TensorFlow lite

Table 2: Sample of Gesture Recognitio Train with TensorFlow Lite

TRAIN FREQUENCY (times)	LOSS	WARNING or NOTES
1	8,05905	Model is not trained well. Add more sample and try again.
10 - 19	Not displayed	Add more images or train the model. There are inconsisten gestures.
5 - 6	15,11071	Add more images or train the model.
5 - 6	12,89448	Model is not trained well. Add more sample and try again.
5 - 9	0,00009	There is learning rate 0,0001. Test or download the model. We can even add images for other classes and train again.

Based on Table 2, by default value of batch size 0,4; epoch 20; and hidden units 100, researcher conclude that the total of frequency is very important to produce lower loss and potentially to make testing button active. While download button will be active if train and test are successful.

The next step that researcher will continue this project is applicate algorithm in CNN. There is technique to use feature extraction from data training and algorithm of special learning for image classification and voice recognition. CNN is improvement of Multilayer Perceptron (MLP) designed to process 2-dimension. Convolution operation is operation in 2 real argument functions [**?**]. The operation implements output function as feature map from image input. These input and output can be seen as 2 argument with real value. Formally, convolution

operation can be written by (1).

$$S(t) = (x * w)(t) \tag{1}$$

Based on Equation 1, *s(t)* function gives single output in feature map. The first argument is input or x and the second argument is w as kernel or filter. If input as 2-dimension image, so it can be assumed that t is pixel and it can be changed by i and j. Thus, the operation for convolution to input with more than 1-dimension is like (2).

$$S_{i,j} = (K * I)_{(i,j)} = \sum\sum I_{(i-m,j-n)} K_{(m,n)} \tag{2}$$

Equation 2 is a basic formula in convolution operation that i and j are pixel from image. The calculation has commutative characteristics. While K is kernel and I is input. The convolution operation is also can be calculated by multiplication of matrix between input image and kernel which is dot product as the output. CNN consists of neurons that have weight, bias and activation functions. Supervised learning using neural network that consists of two stages (training and evaluation). Sometimes there are additional stages, namely testing, but it is not mandatory. In the training phase, each weight and bias for each neuron will be updated continuously until the output produced is in line with expectations. In each iteration, an evaluation process will be carried out which is usually used to determine when to stop the training process (stopping point).

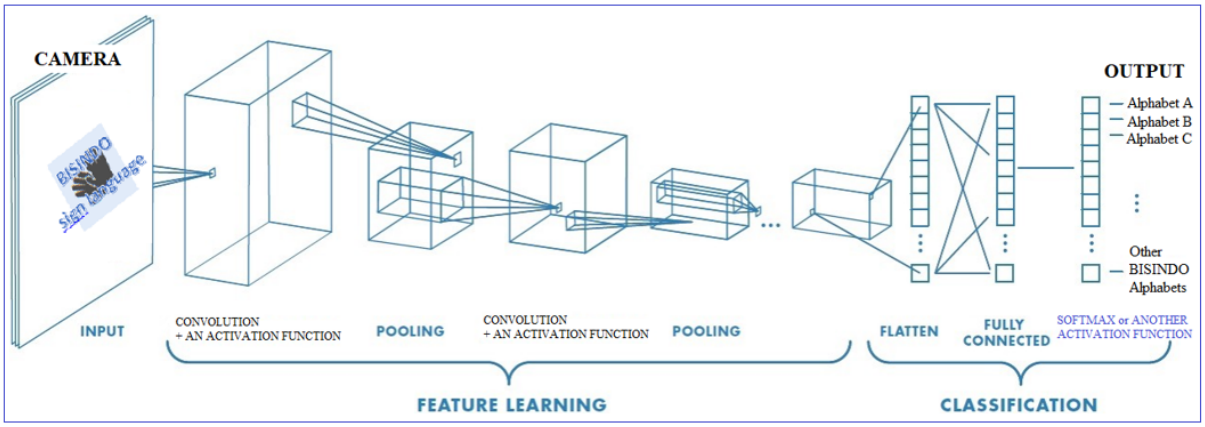


Figure 13: Illustration of CNN process in *BisAndro*

Based on Figure 13, it can be shown that inputs from *BISINDO* hand gestures will be captured by mobile phone camera and processed in feature learning and classification in CNN method until get the results, for example in *BISINDO* alphabets. In this study, researcher will implement the algorithm and create a neural network using Python programming languages and Tensorflow as deep learning framework supported by Google. The next analysis, researcher will use Matplotlib to make graphs and see the comparison among the results especially about the target and prediction. Illustration of the first step to make relationship between Android and Tensorflow can be seen in Figure 14.

While in hear people side, in this research will use feature speech to text by Android mobile phone. The scheme of it can be shown in Figure 15.

In Figure 15, the first step to build a voice based application is to listen for user voice constantly and then transcribe the voice to text. Then theory of deep learning will be processed in second step before it shows output. According to the research plan, process in BisAndro application should be simultaneously and reciprocal. Thus, test about the process will be conducted to check the performance of BisAndro application before releasing to the public.

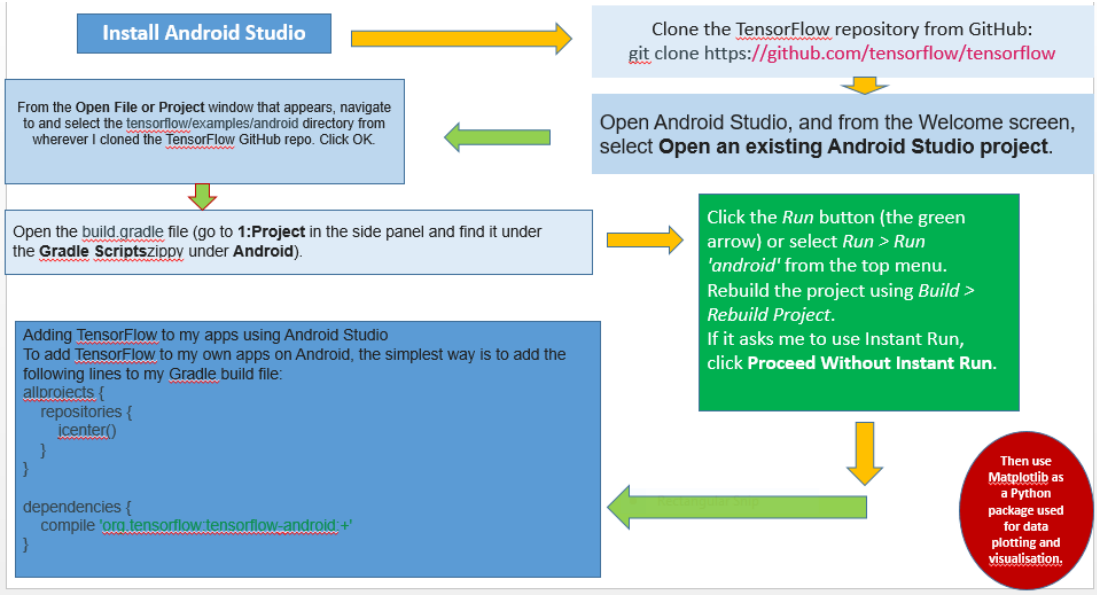


Figure 14: The first building process to connecting Android and Tensorflow

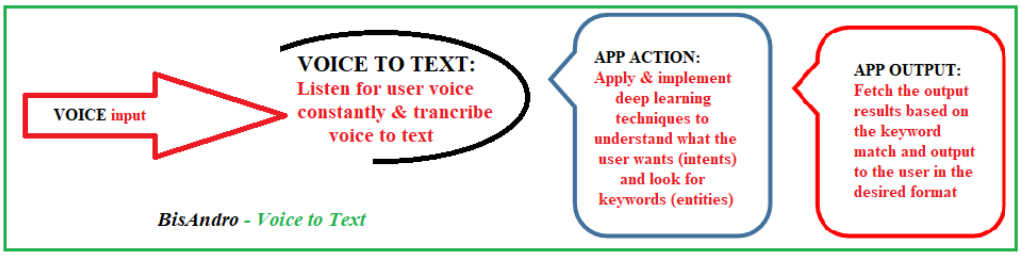


Figure 15: Scheme of *BisAndro* - Voice to Text

4. Conclusion

Researcher prepare to build *BisAndro* step by step using *BISINDO* as the main content of *BisAndro* application. There are some basic vocabulary of *BISINDO* that are displayed in *BISINDO* website to making easier to learn it. Researcher also learn about recognition in TensorFlow lite that try to modelling in some gestures. The gestures are about 8 simple directions with difference training frequency. More frequency, lower in loss value. In summary, *BisAndro* project is not finish yet. So, the future work, researcher will continue to make gesture, image, object, and speech recognition modeling using TensorFlow lite, entering the modeling results into an Android smartphone, testing the results to deaf and hearing people, and repeating or improving modelling. Researcher also will improve BisAndro application using CNN formula that support TensorFlow programming.

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