Journal of Technology and Informatics (JoTI)
Vol. 5, No. 1, October 2023
P-ISSN 2721-4842
E-ISSN 2686-6102 DOI: 10.37802/joti.v5i1.384

Indonesian Sign Language (SIBI) Learning Media Application Based on Deep Learning Technology for Deaf Children

Harum Andhika F. R.[1], Hestiasari Rante[2], Sritrusta Sukaridhoto[3], Martianda Erste A.[4]
[1,2,3,4]Department of Creative Multimedia Technology, Politeknik Elektronika Negeri Surabaya, Surabaya, Indonesia
e-mail: harum77frizkyaa@gmail.com[1], hesti@pens.ac.id[2], dhoto@pens.ac.id[3], martianda@pens.ac.id[4]
* Corresponding author: E-mail: martianda@pens.ac.id

Abstract: *One of the main methods in teaching deaf children effectively is through visualization of learning materials. Previous research has developed augmented reality-based interactive learning media for deaf children. However, these learning media have limitations related to smartphone memory, dependence on certain flashcards, and limited amount of material due to flashcard limitations. Here, researchers innovate to develop SIBI learning media applications based on deep learning technology that material does not depend on a specific flashcard, but the application is able to detect real objects and various images. TensorFlow Lite is considered lighter but still allows the system to run deep learning on mobile devices with low latency. This application is designed to capture a real object or image through the camera, then the object or image will be processed and recognized using TensorFlow Lite. The object recognition process is carried out at the classification layer using switch-case syntax and global class synchronization with the YouTube API. After the image or object is recognized, the system will issue an output in the form of an Indonesian sign language video link from the object.*

Keywords*: Deaf Children; Deep Learning; Image Recognition; Indonesian Sign Language (SIBI); Learning Media Application*

INTRODUCTION

Indonesian survey data [1] shows that 7,87% of people suffer from hearing disorder. While 2,74% of people have speech and hearing disorders. As many as 1,307,094 hearing disorder people live in the province of East Java. Based on- field study at TKLB Karya Mulia Surabaya, learning media used for the teaching and learning process to hearing-impaired children using original objects, imitation objects, and images through flashcards. Even though [2], shows one of the key methods of teaching hearing-impaired children is through visualization of learning materials. Then the presentation of learning materials using technology and ICT is vital to support the teaching and learning process both during class activity and in the self-study process. Especially during the pandemic covid-19, direct meeting class activities are limited, so students are required to study independently.

The limited sense of hearing encourages hearing-impaired children to adapt by using other ways to communicate, such as using sign language. Which one of the National Sign Language standards in Indonesia is using the Indonesian Sign Language or SIBI [2]. The process of understanding sign language and mastering vocabulary for children with hearing impairment is the earlier the better. In this case, the role of parents is very influential for hearing-impaired children. Therefore, appropriate learning media are needed to help teachers, parents, and children with hearing-impaired to improve their communication learning skills from early stage.

Hearing-impaired children would learn more effectively through a learning system that is supported by as many visual displays as possible. The use of technology makes a major contribution to improving the quality of education in deaf schools [6]-[8]. The importance of technology in learning media for individuals with hearing loss was also investigated [9]. The results show that it is highly recommended that a mobile application based on the Android and iOS operating systems be developed as a learning medium for hearing-impaired children.

Quite a number of learning media technologies for deaf children have been developed, such as [10] who developed AR as a learning medium for deaf children in Arabic sign language. Meanwhile, researchers here have also developed AR as a learning medium for deaf children in Indonesian sign language (SIBI) [4] and [5]. The digital learning media is used by teachers and students in TKLB Karya Mulia Surabaya until now. However, these learning media have limitations tied to smartphone memory, dependence on certain flashcards, and the limited amount of material due to flashcard limitations.

Here researchers are innovating to develop SIBI learning media application based on deep learning technology for hearing-impaired children. The materials don't depend on certain flashcards, but the application would detect various real objects and images. That way, learning materials would be sustainably added and developed. We hope to give benefit and contribute for hearing-impaired children through the development of this application.

METHOD

In this study, learning media was developed based on deep learning so that learning materials were not limited and depended on the availability of flashcards. Deep learning systems teach computers to do the work humans are supposed to do, just as computers can learn from the training process. Deep learning uses a problem-solving approach in a computer learning system that uses the concept of a hierarchy. The concept of

hierarchy allows computers to learn complex concepts by combining simpler concepts. The architecture used consists of a visible layer and a hidden layer where the load of each perceptron unit is optimized using the backpropagation algorithm. In this research, we use TensorFlow Lite as a solution for best implementing deep learning to mobile devices. TensorFlow Lite is considered lighter but still allows the system to run machine learned models on mobile devices with low latency. Figure 1 is an overview of the design of the learning media application system that was built in this study. The application system requires a user interface design so that users are interested and easy to use. This application is designed to capture an object or image through the camera, then the object or image will be processed and recognized using TensorFlow Lite. This object recognition has been assigned to the classification layer. After the image or object is recognized, the system will issue an output in the form of a sign language video link from the object. All sign language videos are stored on YouTube cloud storage.

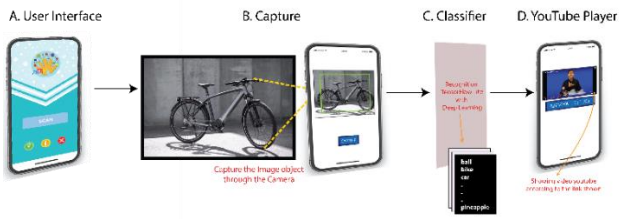
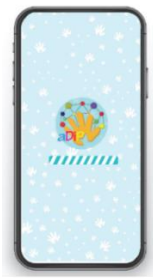


Figure 1. Application System Design

In the development of this application, we have set the appropriate color and text type for children aged 4-6 years which is the age range of deaf kindergarten children in Indonesia. The mockup design for the application consists of five parts, as follows: splash screen, home screen, instructions screen, information screen, and camera screen as shown in Table 1.

Table 1. Mockup Design

	**Splash Screen** The initial appearance when the android application is opened/run for the first time, its function is to make the application more attractive and professional.
	**Home Screen** The ADIP (Deep Learning Application) logo will appear on the home screen. There are five buttons that appear as vocabulary, wording, instructions, information and exit buttons, where each button is connected to another screen.
	**Instruction Screen** This screen displays instructions for using the application. This screen is equipped with an exit button to return to home screen.
	**Information Screen** This screen displays information regarding the application. This screen is equipped with an exit button to return to home screen.
	**Camera Screen** On this screen, users can scan images or objects to be studied sign language. The scanned image or object will be processed by the system. The system will provide output in the form of a link that leads to a sign language demonstration video of the image or object.

The working system of this application is presented in the flowchart in Figure 2. First, the user is asked to scan an image or object that he wants to recognize, using a smartphone camera; then the system will process the image or object via TensorFlow Lite; the system will provide output in the form of a sign language demonstration video link from the image or object so that users could watch it.

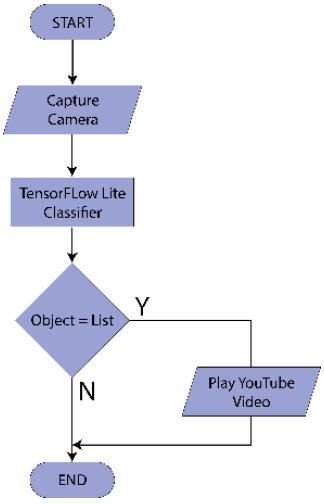


Figure 2. Flowchart System

In the classifier section, there is a recognition section which object classification using switch-case syntax, and global class synchronization with the YouTube API. Here we don't carry out the manual recognition of the asset input stage but uses existing assets from TensorFlow lite. The type of model used is mobilenet_quant_v1_224.tflite, with the number of label names originating from the TensorFlow Lite is 1001 words. However, with that many labels, it is not necessarily used entirely, since the output of this application is a video display of SIBI taken from previous research. The application would distinguish which one should be used or not. The application requires a class to classify objects then given the Switch and Case statements. The switch-case statement will execute the program if the value in the switch statement is the same as the value in the case statement. It makes easier for the system to display a video link to display the SIBI display results from recognizing objects and captured images. There are 14 Indonesian sign language demonstration videos that have been synchronized with Tensorflow Lite in this study. The addition of recognizable objects is very possible, by adding the number of Indonesian sign language demonstration videos in the next development as shown in Table 2.

There are several daily objects that are selected as SIBI objects. The selection of these objects refers to the TKLB Karya Mulia curriculum and is based on the results of consultations with teachers. These objects are included in the application program. In practice, if the application scans one of the objects, the application would display the SIBI video for learning Indonesia Sign vocabulary for deaf children.

Table 2. The Recognizable Objects for SIBI

Bus	Ship
Bike	Plane
Motorcycle	Shoes
Wall Clock	Hat
Clothes	Ball
Table	Bag
Chairs	Pineapple

RESULT AND DISCUSSION

There are four types of application testing that have been carried out in this study. They are functionality testing, objects testing, device testing, and user testing. The application testing process could be seen in Figure 3. The test results are discussed in the following sub-sections:

Figure 3. Image Recognition Experiments with Wall Clock as SIBI Object

Functionality Testing

Functionality testing aims to determine the functionality of each button on each application screen. There are seven types of buttons tested from six screens as follows:

- Scan button
- Hint button
- Information button
- Link code button
- Video playback button
- Exit button
- Decision (Yes/No) button

The main device that supports this test is an Android smartphone that has specifications as shown in Table 3. The functionality testing result can be seen in Table 4. The test results show that each button on every screen is running according to its function properly.

Table 3. Specification Device

Description	Specification
Device	Vivo Y12
Android version	Android 9 (Pie)
CPU	Mediatek MT6762 Helio P22 (12 nm) Octa-core Cortex-A53
RAM/ROM	3/32 GB
GPU	PowerVR GE8320
Screen Resolution	720x1544 px

Table 4. Result of Functionality Testing

User Interface	Testing Materials	Expected results	Test Result
Home Screen 	Button scan	Open to the camera screen	Valid
	Hint button	Open to the instructions page	Valid
	Information button	Open to the information page	Valid
	Exit button	Pop-up decision question box appears	Valid
Instruction Screen 	Exit button	Return to the home screen	Valid
Information Screen 	Exit button	Return to the home screen	Valid
Camera Screen 	Link code button	Open to the YouTube Player Screen	Valid
Youtube media player 	Video playback button	Playback the video	Valid
Decision Box 	Decision (Yes / No) button	If pressing "Yes" button would bring out and close the application. If pressing "No" button would return to the home screen	Valid Valid

Objects Testing

We tested the performance of the application with 14 different types of objects in-order-to determine the success rate of the application in recognizing objects and displaying Indonesian sign language demonstration videos correctly. The test results show the application could recognize all objects and display videos correctly as shown in Table 5.

Table 5. Result of SIBI Objects Testing

Objects	Link Code	Test Result
Bus	HwZcAsPMhmI	Valid
Bike	ifwVdog6zSo"	Valid
Motorcycle	HTJrmnkisk0	Valid
Wall Clock	HuT6Tn_pDBk	Valid
Clothes	uBdc16NJ6B0	Valid
Table	l1k_SLknkFw	Valid
Chair	SMute7FUqOA	Valid
Ship	A7EzNeQFd-A	Valid
Plane	PLrQVND_s_A	Valid
Shoes	ifwVdog6zSo	Valid
Hat	TOLZG-Yh2vs	Valid
Ball	DPsE_TZ3Pig	Valid
Bag	4jUj4CKcZfg	Valid
Pineapple	rHp0veex_3g	Valid

Devices Testing

Device testing aims to find out the recommended device specifications for this application, including the minimum device specifications required for the application to run properly. There are five types of devices tested in this study; they have specifications as listed in Table 6.

The device test results are listed in table VII, showing that device specifications also affect application performance. Device numbers 1,2,3, and 4 require an average processing time of less than 10 seconds. We recommend this app run on android device version 8 or above. Referring to the device testing that has been carried out on Android version 5, the application failed to recognize objects so that it could not display videos on the YouTube media player. The application also has an error when trying to exit the application as seen in Table VII.

Table 6. Specification Various Device

No.	Device	Android version	CPU	RAM/ ROM	Screen Resolution
1	Samsung A70	10	Octa-core (2x2.0 GHz Kryo 460 Gold & 6x1.7 GHz Kryo 460 Silver)	6/128 GB	2400 x1080 px.
2	Samsung j6+	9	Quad-core 1.4 GHz Cortex-A53	4/64 GB	720 x1480 px
3	Xiaomi redmi 8A	9.0	Octa-core (4x1.95 GHz Cortex-A53 & 4x1.45 GHz Cortex A53)	2GB /32GB	720 x1520 px
4	Oppo A5S	8.1.0	Eight Core	3/32 GB	720x1520px
5	Oppo Mirror 5	5.1.1	Quad-core 1.2 GHz Cortex-A53	2/16 GB	540x960 px

Table 7. Result of Device Testing

1. Samsung A70

	Trial-1 (second)	Trial-2 (second)	Trial-3 (second)	Average(second)
Installation	8,45			
Loading to open the application	9,16	8,67	8,51	8,78
Home screen	2,16	1,12	0,40	1,7
The appearance of the link code button	2,05	1,82	1,93	4,51
The appearance of the youtube media player	2,06	1,20	1,12	1,46
Information Screen	1,50	0,48	0,16	0,73
Instruction Screen	1,60	0.40	1	1
Decision (Yes/No) box	2	0,56	0,41	0,99

2. Samsung j6+

	Trial-1 (second)	Trial-2 (second)	Trial-3 (second)	Average (second)
Installation	5			
Loading to open the application	9	3	2	4.6
Home screen	8	8	7	7,7
The appearance of the link code button	7	5	5	5,7
The appearance of the youtube media player	8	4	4	5,3
Information Screen	7	5	2	4,7
Instruction Screen	6	5	2	4,3
Decision (Yes/No) box	4	0	0	1,3

3. Redmi 8A

	Trial-1 (second)	Trial-2 (second)	Trial-3 (second)	Average (second)
Installation	14			

Loading to open the application	11,4	11,01	11,04	11,15
Home screen	1,6	2,76	1,76	2,04
The appearance of the link code button	3,16	2,97	3,40	3,18
The appearance of the youtube media player	1,26	1,14	0,94	1,11
Information Screen	0,75	0,6	0,56	0,64
Instruction Screen	0,73	0,8	0,66	0,73
Decision (Yes/No) box	1,64	2,38	1,88	1,97

4. Oppo A5S

	Trial-1 (second)	Trial-2 (second)	Trial-3 (second)	Average (second)
Installation	8,05			
Loading to open the application	6,22	1,31	9,22	5,58
Home screen	2,42	1,71	2,04	2,06
The appearance of the link code button	2,56	1,71	2,36	2,21
The appearance of the YouTube media player	-	14,90	4,13	6,34
Information Screen	2,23	0,73	0,73	1,23
Instruction Screen	1,71	0,73	0,73	1,05
Decision (Yes/No) box	3,15	1,19	1,19	1,84

5. Oppo Mirror5

	Trial-1 (second)	Trial-2 (second)	Trial-3 (second)	Average (second)
Installation	8,05	8,05		
Loading to open the application	11,35	10,14	9,99	10,4
Home screen	4,33	3,28	3,47	3,69
The appearance of the link code button	0,5	0,5	0,5	0,5
The appearance of the YouTube media player	Return to the splash screen page	Return to the splash screen page	Return to the splash screen page	-
Information Screen	-	-	-	-
Instruction Screen	-	-	-	-
Decision (Yes/No) box	error	error	error	error

User Testing

User testing in this study used in-depth interviews method with users. We tested two users, each of whom had a different scientific background. The first is a teacher of deaf children at the Karya Mulia TKLB school in Surabaya, the second is a software developer. Users are asked to try using the application and all its features. Then we interviewed them to explore their experience of using the application and asked for their opinion according to their scientific field. User test results are summarized in table VIII, in which each aspect is rated using the Likert's scale (5 = excellent, 4 = good, 3 = fair, 2 = poor, and 1 = very poor, need improvement).

Table 8. Result of User Testing

Testing Materials	1st User	2nd User
Easy usage and navigation	4	3
The app running properly	3	3
Precise functionality of the buttons	5	5
Clear text and match color for kids	5	5
Appropriate language use	4	4
User satisfaction	3	4
Benefits of using the app	4	4

From the results of the expert assessment, it would be concluded that the application can run well, all buttons and features function properly. Users also feel that the selection of color and text themes is appropriate for children aged 4-6 years who are the targeted of the application. The 1st user is welcoming the presence of this learning media application for deaf children, she requests this application be developed by adding the

number of Indonesia sign language demonstration videos provided in the database to enrich learning materials. The 2nd user provide suggestion for application development, should add additional pop-up contained of instruction usage method on the camera screen.

CONCLUSION AND SUGGESTION

Based on the test results, it is concluded Indonesian sign language learning media applications based on deep learning could running properly. It's proven from button functional test and objects test result are 100% succeed. The results of user testing also show satisfaction and a good response to the presence of this application. The addition of the Indonesian sign language demonstration video in the database is expected to enrich the learning material. In practice, this learning media is recommended to run on Android version 8 or more. In the future, the application can be equipped with hundreds or thousands of objects connected to the SIBI video display so that a digital SIBI dictionary can be realized for Indonesian deaf children.

REFERENCES

[1] SUPAS, "Hasil Survey Penduduk Antar Sensus." Buletin, Badan Pusat Statistik, 2015.

[2] Krasavina Y, et al., "Research-Based Teaching of Hearing-Impaired Students," Proceeding IFTE-2019, 1387-1394.

[3] Departemen Pendidikan Nasional, *KAMUS Sistem Isyarat Bahasa Indonesia,* Direktorat Pendidikan Luar Biasa Proyek Pengembangan Sistem dan Standar Pengelolaan Pendidikan Luar Biasa, Jakarta. 2001.

[4] M. E. Anggraeni, W. Sarinastiti, S. Wati, "Indonesian Sign Language (SIBI) Vocabulary Learning Media Design Based on Augmented Reality for Hearing-Impaired Children" Jurnal EECCIS Vol. 12, No. 1, April 2019, pp 1-3, p-ISSN: 1978-3345, e-ISSN(Online): 2460-8122

[5] M. E. Anggraeni, I. Maulania, W. Sarinastiti, "Interactive Learning Media for Hearing-Impaired Children using Indonesian Sign Language (SIBI) – Simple Sentence Arrangement," IES 2020, Surabaya.

[6] Siegel, L. (2000). The educational and communication needs of deaf and hard of hearing children: A statement of principle on fundamental educational change. American Annals of the Deaf, 145(2), 63-78.

[7] Vesel, J. & Robillard, T. (2013). Teaching mathematics vocabulary with an interactive signing math dictionary. Journal of Research on Technology in Education, 45(4), 361-389.

[8] Wicha, S., Sharp, B., Sureephong, P., Chakpitak, N. and Atkins, A. (2012). An animated dictionary for hearing-impaired students in Thailand. Journal of Research in Special Educational Needs, 12(4), 234–244.

[9] B. Baglama., H. Uzunboylu., M. Haksiz. (2018). Technologies Used in Education of Hearing Impaired Individuals, International Journal of Emerging Technologies in Learning (Ijet), September 2018.

[10] Aziza Almutairi, etc. 2017. Augmented Reality for the Literacy Development of Deaf Children: A Preliminary Investigation. Proceeding of the 19th International ACM SIGACCESS Conference on Computer Accessibility Pages 359-360.