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1-2 JULY 2021

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FOREWORD

Message from the Rector

Honorable Keynote Speaker, Mr. Ignasius Jonan, former Minister of the Energy and Mineral Resources, and previously Minister of the Transportation Ministry of the Republic of Indonesia, we are greatly honored to have you with us this morning.

Distinguished keynote speakers, Prof. Ahmad M. Ramli (represented by Ikhsan Baidirus, S.H., LLM, Director of Post, General Directorate of Post and Information Technology, Ministry of Communication and Information Technology), Prof. John Silke, Dr. Ferry Sandra, Prof. Takayuki Arai, Prof. Young Ho Kim, Prof. Susy Tjahjani, Prof. Pim Martens, Dr. Dwinita Larasati, Prof. Chien-Hsu Chen, Prof. Wilson Bangun and Prof. Marcellia Susan, as well as all participants in the international conferences at Maranatha University.

A very good morning and best wishes to you all, and good evening to our colleagues in the US. Greetings and a warm welcome to Maranatha Christian University (MCU), Bandung, Indonesia.

I am delighted to be here with you today for the opening of the first MCU international conferences. These are: (i) The International Conference on Emerging Issues in Technology, Engineering, and Science, and (ii) The International Conference on Emerging Issues in Humanity Studies and Social Sciences, with the themes of: Digital Ecosystems for Sustainable Health and Community Development towards an Intelligent Society, and Innovations for Sustainable Community Development - Research and Practices, respectively.

We thank the many participants from countries across the different continents: the USA, the UK, the Netherlands, Norway, Taiwan, Japan, Korea, Thailand, Singapore, Malaysia, India, Australia, and New Zealand.

These first international conferences will serve as a platform to enable speakers and participants to share their research results, drawn from up-to-date research work, to initiate and strengthen further collaboration.

Without further ado, I would like to thank all the participants who have joined us for these international conferences. Again, my sincere hope is that what we accomplish today will be beneficial towards establishing collaboration among all the participants of these conferences.

I hereby declare the first international conferences at MCU in 2021 officially open.

May God bless you all. Thank you.

Prof. Ir. Sri Widiyantoro, MSc., PhD., IPU.
Rector of Maranatha Christian University

Foreword

On behalf of the committee members, it is a great pleasure to welcome you all to our first two international conferences: Emerging Issues in Technology, Engineering, and Science (ICE-TES) and, Emerging Issues in Humanity Studies and Social Sciences (ICE-HUMS).

ICE-TES and ICE-HUMS are twin events which serve our passion in balancing technology and humanity issues in the world of science and share the core values of our university: Integrity, Care & Excellence (ICE).

This year's theme for both conferences focus on the United Nations' Sustainable Development Goals (SGD), which emphasize the following aspects: ICE-TES (Digital Ecosystem for Sustainable Health & Community Development: Towards the Intelligent Society) and ICE-HUMS (Innovations for Sustainable Community Development: Research and Practices). We believe research and initiatives that has pragmatic and multidisciplinary/interdisciplinary approaches allows us to unravel fundamental problems and answer related questions regarding sustainable development.

The logistics of both of the First ICE-TES and ICE-HUMS 2021 conferences consist of two general and five-scientific keynote speakers. Special tracks are designed in each conference which cover recent developments in: ICE-TES (technologies, engineering, medical, and dentistry), ICE-HUMS (psychology, languages & cultures, economics, arts & design, and laws). The ICE-TES tracks received 82 submissions and 51 are accepted in the proceedings, involving authors from five countries, and corresponding to an acceptance rate of 62.2%. At the same time, the ICE-HUMS has received 130 submissions and 73 are accepted in the proceedings, involving authors from four countries, corresponding to an acceptance rate of 56.1%. All submitted papers were peer-reviewed on the basis of their significance, state-of-the-art contributions, and technical qualities.

Since we are still in the midst of COVID-19 pandemic, the conference has been organized virtually. The organizing committee has been working intensively to ensure that the scientific sessions will be valuable and engaging for all presenters and attendees. The parallel session format is a mix of pre-recorded and synchronous engagement through in-person live videos and question and answer sessions.

We would like to express our sincere appreciation to all the keynote speakers, committee members and reviewers for their dedication. Last, but certainly not least, we would like to offer many thanks to all authors who submitted their papers and all participants who registered to join this conference. We believe that ICE-TES and ICE-HUMS 2021 will be an inspiring academic occasion and will become a great platform for many ideas as well as research initiatives in the scientific community. Have an inspiring conference!

Dr. Hapnes Toba, M.Sc., General Chair of ICE-TES and ICE-HUMS 2021
Dr. Wahjoe Widowati, M.Si., General Co-chair of ICE-TES 2021
Joni, Ph.D., Ak., CA., CPSAK., General Co-chair of ICE-HUMS 2021

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Taekwondo Poomsae-3 Movement Identification by using CNN

Novie Theresia Br. Pasaribu[1][a], Erwani Merry[1][b], Kalya Icasia[1][c], Jordan Eliezer[1][d], Che-Wei Lin[2][e] and Febryan Setiawan[2][f]

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Keywords: Taekwondo, Poomsae, OpenPose, Convolutional Neural Network (CNN).

Abstract: Taekwondo competition consists of three elements: Poomsae, sparring, and breaking. Poomsae is a set of movements consisting of punches and kicks and focuses on technique, breathing ability, balance, coordination and concentration. OpenPose is a library that can represent the human body, whether it's body, head, hands or feet. OpenPose is widely used in research related to the classification of human movement. This research will analyze the effect of OpenPose as an input for the identification of Taekwondo movements, especially in Poomsae-3 using a CNN. The image data of taekwondo movements were taken from video recordings. In this research, three types of classification models were designed to identify taekwondo movements, Model-1 with input in the form of taekwondo movement images, Model-2 with input in the form of taekwondo movement images and OpenPose, and Model-3 with input in the form of OpenPose. From the test results, Model-3 with input in the form of an OpenPose keypoint obtained the best accuracy results (amounting to 99.39%) compared to Model-2 (97.68%) and Model-1 (79.86%). For further research development, the identification of taekwondo movements can be done for input in the form of video, and analysis of the significant keypoints for the taekwondo movement.

1 INTRODUCTION

Taekwondo is one of the martial arts sports that was formed in 1962 (Kil, 2006). Taekwondo nourishes the mind and body by creating harmony between physical and mental exercises through the use of hands and feet. The word taekwondo derived from Tae stands for basic kick, the word kwon means "boxing that blocks and punches" (Kil, 2006). So if Taekwondo translates into philosophy, it is behavior instilled through discipline and training of body and mind (Kil, 2006). With the development of this sport, taekwondo is often competed. The formal Taekwondo competition consists of three elements: Poomsae, sparring, and breaking (Kil, 2006). Poomsae (shape) is a combination of basic movements such as blocking, punching, and kicking. Poomsae is a set of movements consisting of punches and kicks and focusing on technique, breathing ability, balance, coordination, and concentration (Lawofthefist.com, n.d.). In Taekwondo there are eight Poomsae. Each poomsae level is more complex than the previous poomsae. Therefore in doing a good poomsae techniques are required with accuracy and good coordination, because if the movement is not in accordance with the actual movement then the meaning will be different.

For the estimation of human poses in two dimensions in real time on an image using the Convolutional Neural Network (CNN) has been

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proposed by Cao et al, by extracting the 2D frame from the video using the Red Green Blue (RGB) camera (Cao et al., 2017). OpenPose is an open library that can represent the human body, consisting of bodies, heads, hands, and feet with a total of 135 keypoints, and the input can be in the form of images, videos, or real-time videos(G. Hidalgo, Z. Cao, T. Simon, S.-E. Wei, H. Joo, Sheikh, n.d.).

OpenPose is widely used as a form of step extraction feature and utilized as a classification. Researchers previously used OpenPose to classify several movements, such as Korean heart pose, child pose, KungFu crane, and so on with ResNet-50, ResNeXt-101, and PNASnet-5 architectures (Lau, 2019). The classification is based on 3 different datasets, namely original image, original image with OpenPose skeleton, and skeleton OpenPose only. From testing result of PNASnet-5 architecture with original image has an accuracy of 83% (Lau, 2019). In Deep Learning, Convolutional Neural Network (CNN) is a class of neural networks that is commonly applied to analyzing visual images.

This research will analyze the effect of OpenPose as an input for the identification of Taekwondo movements, especially in Poomsae-3 using a CNN.

2 METHODS

The following will be discussed about experiment scenario and design system of taekwondo Poomsae-3 movement identification using CNN.

2.1 Experiment Scenario

The experiment scenario was conducted by the Taekwondo Activity Unit, which was conducted by six respondents. Each respondent performs the same 4-set of poomsae-3 movements, which are recorded in the form of motion videos. The resulting video is 640 x 480 pixels in MP4 format and the video speed is 30 fps. The video was taken using cameras (there are two cameras) placed in the front position (Camera-1) and the rear position (Camera-2) of the respondent. Here is a layout of the camera placement and respondent (Figure 1).

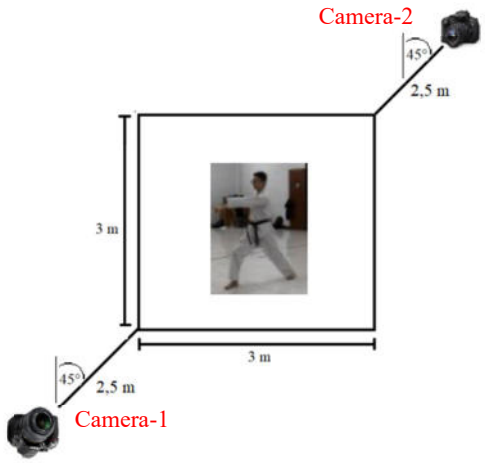

Figure 1: Layout experiment scenario.

2.1.1 Poomsae-3 Movement

In this research, the poomsae to be classified was Poomsae-3, formally known as Taegeuk Sam Jang (Kukkiwon, 2012). Generally, poomsae is trained by students in a group of 6 to rise to level 5. Poomsae is a combination of attack and defense movement and movement must be done vigorously, such as fire (Kukkiwon, 2012). The order of movement Poomsae-3 can be seen in Figure 2.

Figure 2: Poomsae-3 movement sequence.

From the sequence of movements, the Poomsae-3 movements are grouped into eight groups of movements, there are Chumbi, Are Maki, Ap Chagui, Montong Dubong Jirugui, Sonnal An Chigui, Jan Sonnal Maki, Montong Baro Jirugui, Montong An Maki, can be seen in Figure 3.

Figure 3: Poomsae-3 movement (Gimnasio Lee, 2014).

2.1.2 Poomsae-3 Dataset

Of the eight groups of Poomsae-3 movements, the research was separated between the left and right movements, so there are 15 classes of movement to be identified (see Table 1). The position and direction of movement obtained from Camera-1 and Camera-2 result in different appearances. In order for each movement obtained from the camera to show a detailed and clear posture of movement, the dataset used in this research is separated between the movement group and the imagery of which camera is used, see Table 1.

Table 1: Poomsae-3 movement class.

No	Class	Cam-1	Cam-2
1	Chumbi	v	
2	Are Maki (Left)		v
3	Are Maki (Right)	v	
4	Ap Chagui (Right)		v
5	Ap Chagui (Left)	v	
6	Montong D. Jirugui (Left)	v	
7	Montong D. Jirugui (Right)	v	
8	Sonnal An Chigui (Right)		v
9	Sonnal An Chigui (Left)	v	
10	Jan Sonnal Maki (Right)	v	
11	Jan Sonnal Maki (Left)	v	
12	Montong An Maki (Right)		v
13	Montong An Maki (Left)	v	
14	Montong. B Jirugui (Left)		v
15	Montong B. Jirugui (Right)		v

2.2 Design System Identification

In this research, three types of classification models were designed to identify taekwondo movements Poomsae-3. Broadly speaking the design of the Poomsae-3 taekwondo movement identification system using CNN, AlexNet architecture (see Figure 4). Details of each process will be explained in a later explanation.

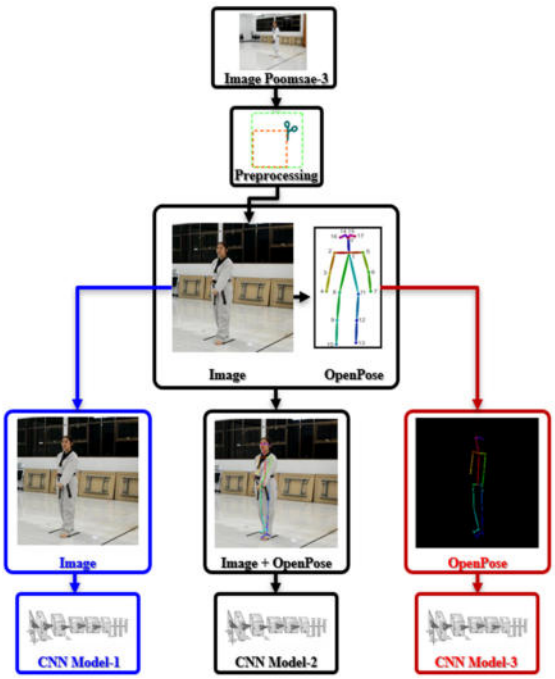

Figure 4: Design system identification Poomsae-3 Movement.

2.2.1 Preprocessing

From the video dataset obtained, a frame will be taken depicting each movement. Then the imagery in the left and right crop so that from the size of 640x480 pixels, to the size of 480x480 pixels. After that it will be resized to a size of 227x227 pixels. Specifically for Model-2 and Model-3, a dataset rendered with OpenPose is used. For Model-2, a combined dataset of the original image and the OpenPose image is used. For Model-3, the keypoints image dataset from OpenPose rendering is used (Figure 5).

a. Dataset Model-1

b. Dataset Model-2

c. Dataset Model-3

Figure 5: Example of dataset model for Ap Chagui Class (a. Model-1, b. Model-2, c. Model-3).

2.2.2 OpenPose

In this research, three types of data sets will be used in the form of images (Dataset Model-1), images and skeleton OpenPose (Dataset Model-2) and Skeleton OpenPose without background (Dataset Model-3). After the preprocessing process, the next is to perform the OpenPose process, to obtain the Model-2 Dataset and the Model-3 Dataset. Then the dataset is separated between the training and testing datasets. In this research, used 6-fold Cross Validation. For each model, there are 360 training data sets and 45 test data sets.

2.2.3 CNN Model

The CNN model that will be used in this research is AlexNet. AlexNet is a Neural Network created by Alex Kriszhevsky and his colleagues in 2012 (Krizhevsky et al., 2017), and published with Illya Sutskever and Geoffrey Hinton. This network has eight layers, seen in Figure 6. The first five layers are convolutional neural layers that act as filters for capturing features on the input (Khan et al., 2018), and followed by the max-pooling layer, and the last three layers are fully connected layers that multiply inputs by weight plus bias vector. In addition, the output layer used has a non-saturation ReLU activation function (Krizhevsky et al., 2017) and architecture as follows (Figure 6):

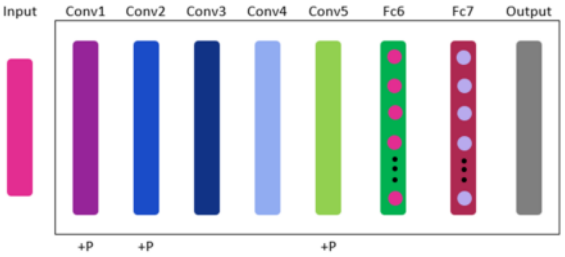

Figure 6: AlexNet architecture.

The first step will be the training process and validation of CNN architecture with different datasets. After the training model is obtained then testing is conducted. The last step done is confusion matrix calculation.

In the confusion matrix, there are six terms used to represent the results of classification, namely True Positive (TP) with positive observation value and positive prediction value, True Negative (TN) with negative observation value and negative prediction value, False Positive (FP) with negative observation value but positive prediction value, and False Negative (FN) with positive observation value but negative prediction value. Values TP, TN. FP, and FN obtained can be used to calculate accuracy values, sensitivity values (recalls), and precision values that can be calculated with the following formulas (Manliguez, 2016).

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \; x \; 100\% \quad (1)$$

$$Sensitivity = \frac{TP\ total}{TP\ total\ +\ FN} \; x \; 100\% \quad (2)$$

$$Precision = \frac{TP\ total}{TP\ total\ +\ FP} \; x \; 100\% \quad (3)$$

3 RESULTS AND DISCUSSION

The following are the training and testing results of the identification of the Taekwondo Poomsae-3 movement using CNN.

3.1 CNN Training & Validation Result

The following training results & validation from each model get the following results (Table 2).

Table 2: Training & Validation Accuracy.

Model	Accuracy each Fold (%)						AVG (%)
	1	2	3	4	5	6	
1	80.00	78.30	70.00	80.00	77.70	80.00	77.69
2	97.70	97.30	100.00	96.60	100.00	96.60	98.07
3	98.30	100.00	100.00	95.00	100.00	94.60	98.00

In Table 2, the accuracy of the Model-2 is 98.07%, then the Model-3 is 98.00% and the last is the Model-1 by 77.69%.

3.2. CNN Testing Result

After the training process & validation continued the testing process. From the test results obtained accuracy results Model-1 (Figure 7), Model-2 (Figure 8), and Model-3 (Figure 9). From the test results of Model-1, the lowest accuracy is in Montong An Maki class (Left) which is 62.5%, and the highest accuracy is 93.75% in Ap Chagui (Right) and Sonnal An Chigui (Right) classes.

From the test results of Model-2, the lowest accuracy is in Montong An Maki (Right) class which is 90.48%, and the highest accuracy is 100% in Chumbi, Are Maki (Left), Are Maki (Right), Ap Chagui (Left), Ap Chagui (Right), Jan Sonnal Maki (Left), and Jan Sonnal Maki (Right) classes.

From the test results of Model-3, the lowest accuracy is 97.37% in the Ap Chagui (Right), Ap Chagui (Left) and Montong An Maki (Right) classes and the highest accuracy is 100% in other classes.

In Table 3, it can be seen that from all tests, Model-3 showed the highest accuracy, sensitivity, and precision results compared to Model-1 and Model-2, which is 99.39% (Accuracy), 97.78% (Sensitivity) and 97.78% (Precision).

Table 3: Testing Accuracy, Sensitivity & Precision.

Model	Accuracy (%)	Sensitivity (%)	Precision (%)
1	79.86	41.67	61.51
2	97.68	86.67	87.78
3	99.39	97.78	97.78

In Model-3, which is an OpenPose image without the original image, it has the highest accuracy, because the features used in this model focuses on OpenPose without considering the background, body shape and clothing color of the taekwondo player, etc.

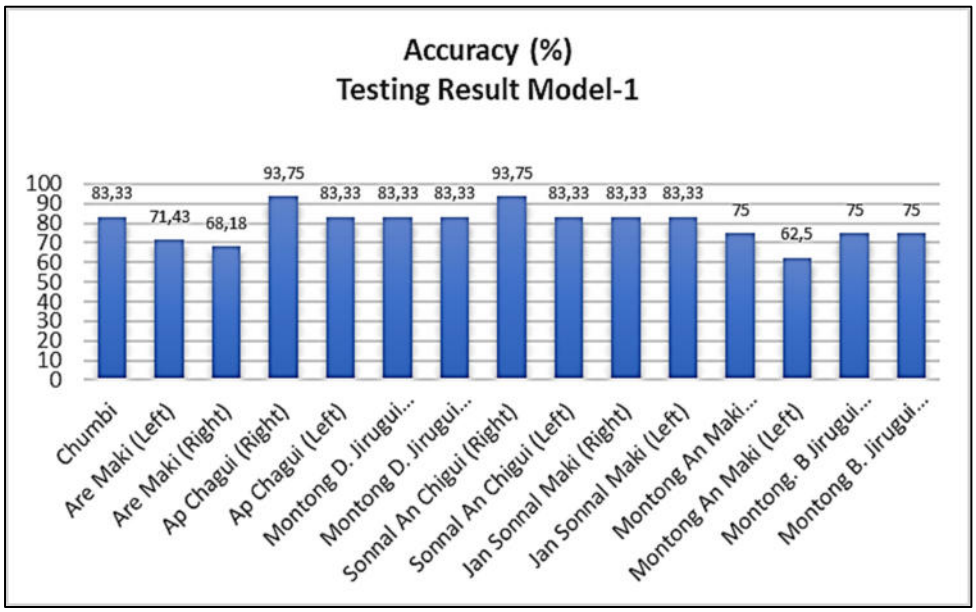

Figure 7: Accuracy Testing Model-1.

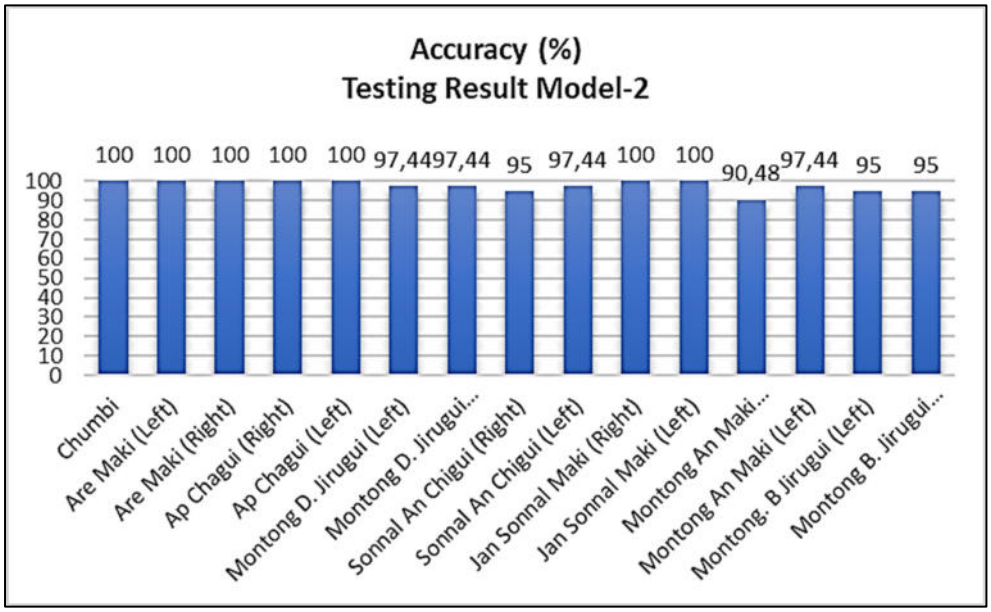

Figure 8: Accuracy Testing Model-2.

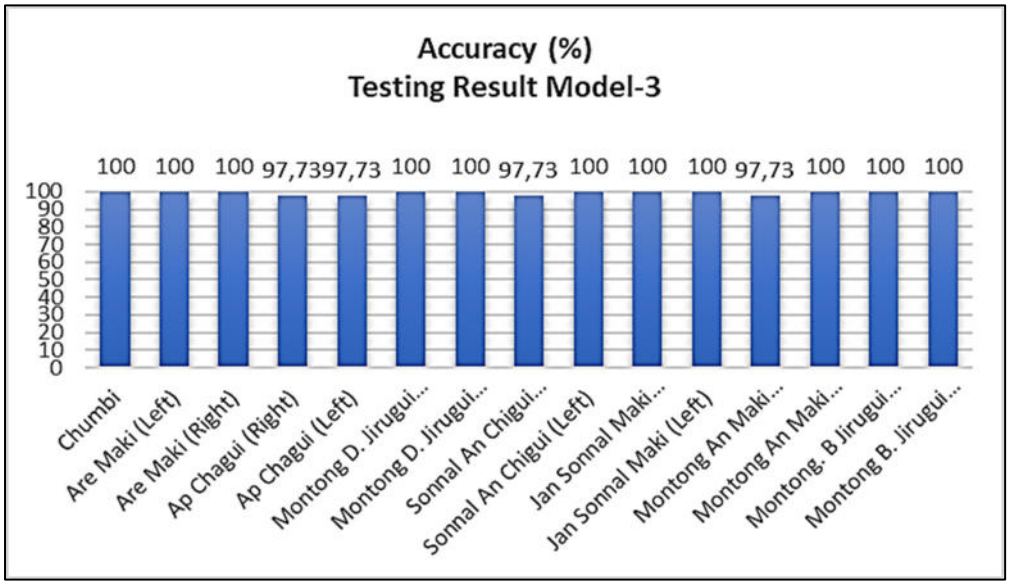

Figure 9: Accuracy Testing Model-3.

4 CONCLUSIONS

Identification of Taekwondo Movement Poomsae-3 is successfully realized by using CNN, by using 3 dataset models, namely datasets in the form of image (Model-1), datasets in the form of images with OpenPose (Model-2) and dataset OpenPose (Model-3). From each CNN test, Model-3 produced the best results compared to the Model-1 and Model-2, with the accuracy of 99.39%, precision of 97.78% and sensitivity of 97.78%.

For further research development, the identification of taekwondo movements can be done for input in the form of video, and analysis of the significant keypoints of the taekwondo movement. Moreover it can be implemented to support the sport of taekwondo by helping the training process for the participants, or by assisting to calculate values in a competition.

ACKNOWLEDGEMENTS

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