# Motion Classifier Using Deep Learning Architecture

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## Abstract

Taekwondo is a Korean martial art characterized by different types of blocks, punches, and kicks. This martial art plays a significant role in Korean culture, and most Koreans learn Taekwondo from their childhood. Amidst the covid-19 pandemic, Taekwondo martial art faces many challenges, and the Taekwondo players had to change the offline training to online classes. During the online training classes, the players are at home, and the master gives the instructions from his/her house. In such situations, practical Taekwondo training is complex, and it reduces the proper Taekwondo forms. To solve this issue during the online training classes, in this paper, we propose a Taekwondo motion classifier that classifies the Taekwondo motions and can assist the master for better Taekwondo training. The proposed motion classifier uses a visual geometry group (VGG)-13 model as the deep learning model and classifies the Taekwondo blocks and kicks. The experiment result and analysis show that the VGG model-based motion classifier archives 90.51% classification accuracy and 0.255 model loss for Taekwondo online training.

## Ⅰ. Introduction

Taekwondo is the most popular martial art in Korea that provides much value to a person. Taekwondo is not only a physical skill; but also, a way of living with respect, discipline, concentration, and self-interaction [1]. The main advantages of Taekwondo include flexibility, strength, posture, stamina, and stress relieves. In addition to the physical health benefits, Taekwondo also improves a person's mental health through increased confidence, self-esteem, focus, and concentration levels [2]. During the covid-19 pandemic in our community, Taekwondo training is a challenging task, and most Taekwondo academies shut down for a long time. The covid-19 situation is not completely over and most of the Taekwondo academies started their Taekwondo training through online portals. Taekwondo training using online portals is a short time solution and the trainer faces many challenges during the online classes. The trainer faces difficulties in correcting the forms of the Taekwondo player. When the Taekwondo player performs a wrong move, it is not easy to correct the motion with correct instructions [3]. We propose a motion classifier that can assist the trainer in his/her online classes to address this issue. The proposed motion classifier has a Taekwondo motion dataset with a deep learning model that classifies the Taekwondo blocks and kicks. The motion classifier can notify the trainer when the Taekwondo player performs a wrong motion. The results from the motion classifier can help the Taekwondo trainer to effectively correct the form of the player. The experiment results from our proposed motion classifier show the significance of the proposed classifier for the online tutoring of Taekwondo.

In this paper, we proposed a motion classifier that classifies the Taekwondo blocks and kicks. The classifier uses a Taekwondo motion dataset from Taekwondo videos and this dataset is used for training the model. The proposed system utilizes a VGG-13 architecture [4] for Taekwondo motion classification. During the Taekwondo online training classes, the motion classifier differentiates different Taekwondo motions such as low block, inner block, face blocks, front snap kick, roundhouse kick, sidekick, and back kick. The experiment results from our proposed classifier show that the VGG-13 based Taekwondo motion classifier is a practical approach to assist the Taekwondo trainers for their online training classes. We also analyzed the impact of the different deep learning models such as Xception, and convolutional neural network (CNN) for our Taekwondo motion dataset and compared the performance of each model in terms of accuracy, precision, recall, and F1 score.

The rest of the paper is organized as follows. Section II presents the proposed Taekwondo motion classifier using a deep learning approach, and its experiment results and analysis are discussed in Section III. Section IV concludes our research with future research directions.

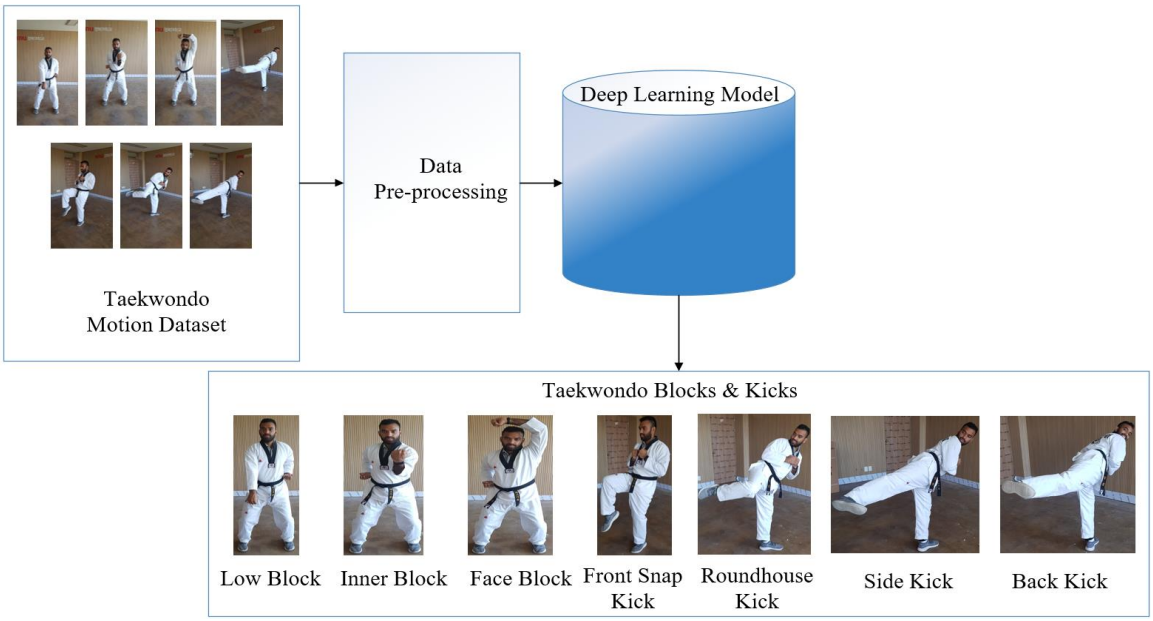


Fig. 1 Proposed Taekwondo motion classifier.

## Ⅱ. Proposed Taekwondo Motion Classifier Using Deep Learning

The proposed Taekwondo motion classifier takes advantage of the VGG-13 architecture for its blocks and kicks classification. Fig. 1 shows the proposed Taekwondo motion classifier.

The proposed system consists of a Taekwondo motion dataset, data preprocessing, and VGG-13 architecture as the deep learning model. In the Taekwondo motion dataset, we created a dataset that includes different Taekwondo blocks and kicks. In the data preprocessing stage, the system performs image cropping followed by a resizing process [5]. After the cropping and resizing process, the dataset is ready for the model training. A VGG-13 architecture is used as the deep learning model, and it can classify the Taekwondo motions. The classification labels of the VGG-13 architecture include the low block, inner block, face blocks, front snap kick, roundhouse kick, sidekick, and back kick as the Taekwondo motions. Fig. 2 shows the VGG-13 model used in the proposed motion classifier.

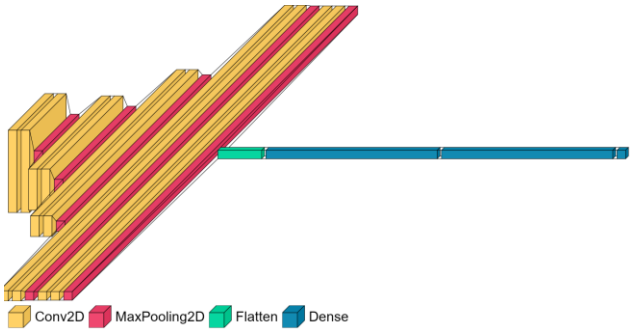


Fig. 2 VGG-13 model used in the motion classifier.

The VGG-13 model uses the input Taekwondo motion images of size 48 × 48 pixels. It uses stochastic gradient descent (SGD) as the optimizer. The color images are converted into greyscale before feeding them to the deep learning model thus reducing the number of input channels to one. This, in turn, reduces the computational complexity for training the model. The learning rate of the model is set to 0.02 with a batch size of 128. The model uses 25 epochs for training with an early stopping approach.

## Ⅲ. Experiment and Result Analysis

To validate our proposed Taekwondo motion classifier for online training classes, we started with data collection. We recorded a 60-seconds video of each Taekwondo block and kick from different players and created a dataset for training the model. Fig. 3 shows our Taekwondo motion dataset.


Fig. 3 Taekwondo motion dataset.

Our dataset has 4,336 images from the low block, inner block, face blocks, front snap kick, roundhouse kick, sidekick, and back kick. The VGG-13 architecture from the motion classifier takes these Taekwondo images for its training and testing. The Taekwondo motion dataset is divided in the ratio 7:3 for training and testing respectively. Fig. 4 shows the result in the form of a confusion matrix from the VGG-13 model for the Taekwondo motion dataset.

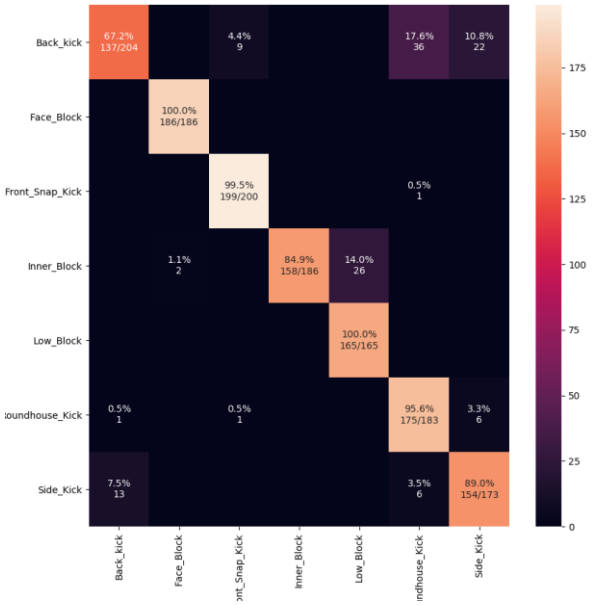


Fig. 4 Confusion matrix result from VGG-13 model.

As shown in Fig. 4, the proposed Taekwondo motion classifier achieved a classification accuracy of 90.51% and a model loss of 0.255. To validate our proposed classifier further, we also tested our Taekwondo motion dataset with the Xception and CNN deep learning models. Table 1 summarizes the performance of these deep learning models along with the VGG-13 architecture.

Table 1: Performance of deep learning models.

| VGG Models | Accuracy (%) | Precision | Recall | F1 Score |
|---|---|---|---|---|
| VGG-13 | 90.51 | 91.08 | 90.51 | 90.26 |
| Xception | 61.21 | 84.77 | 61.21 | 57.37 |
| CNN | 67.61 | 70.47 | 67.61 | 65.54 |

From Table 1, we can see that the VGG-13 model shows accurate classification results for our Taekwondo motion dataset. The accuracy, precision, recall, and F1 score from the VGG-13 model have better classification results than the Xception and CNN models. The results from the CNN architecture show better classification results than the Xception model with a better model loss. The experiments and results analysis of the VGG-13 based Taekwondo motion classifier shows that the proposed approach is suitable for online Taekwondo classes. The Taekwondo trainer can easily use the advantages of the proposed motion classifier for his/her online Taekwondo classes.

## IV. Conclusion

In this paper, we proposed a Taekwondo motion classifier using a deep learning architecture. The Taekwondo motion classifier can assist the Taekwondo master during his/her online training class. The classifier can effectively differentiate the Taekwondo blocks and kicks, and the Taekwondo master can quickly correct the students' blocks and kicks during an online class. The experiment and results show that the proposed approach classifies different blocks and kicks such as low block, inner block, face blocks, front snap kick, roundhouse kick, sidekick, and back kick with accurate classification results. In future work, we can create a Taekwondo training model which will be able to classify all physical activities during Taekwondo training.

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## References

[1]H. Barnamehei, M. Razaghi, S. Panahi, M. Modabberibejandi, M. Lashgari, M. A. Safaei, et al., "Identification and quantification of modular control during Roundhouse kick executed by elite Taekwondo players," in 2018 25th National and 3rd International Iranian Conference on Biomedical Engineering (ICBME), 2018, pp. 1-6.

[2]U. Rahardja, M. Hardini, A. L. Al Nasir, and Q. Aini, "Taekwondo sports test and training data management using blockchain," in 2020 Fifth International Conference on Informatics and Computing (ICIC), 2020, pp. 1-6.

[3]X. Pang, "Taekwondo Video Event Detection Considering Integrated Integration Valuation Method And Its Application In Physical Education Teaching," in 2019 International Conference on Robots & Intelligent System (ICRIS), 2019, pp. 386-390.

[4]K. Simonyan and A. Zisserman, "Very deep convolutional networks for large-scale image recognition," arXiv preprint arXiv:1409.1556, 2014.

[5]J. H. Kim, A. Poulose, and D. S. Han, "The extensive usage of the facial image threshing machine for facial emotion recognition performance," Sensors, vol. 21, p. 2026, 2021.