A Feasibility Test on Preventing PRMDs Based on Deep Learning

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Abstract

This study proposes a method to reduce the playing-related musculoskeletal disorders (PRMDs) that often occur among pianists. Specifically, we propose a feasibility test that evaluates several state-of-the-art deep learning algorithms to prevent injuries of pianist. For this, we propose (1) a C3P dataset including various piano playing postures and show (2) the application of four learning algorithms, which demonstrated their superiority in video classification, to the proposed C3P datasets. To our knowledge, this is the first study that attempted to apply the deep learning paradigm to reduce the PRMDs in pianist. The experimental results demonstrated that the classification accuracy is 80% on average, indicating that the proposed hypothesis about the effectiveness of the deep learning algorithms to prevent injuries of pianist is true.

Introduction

Playing-related musculoskeletal disorders (PRMDs) are a frequent occurrence among musical instrument players; such disorders can profoundly affect the technique of piano players (Dommerholt 2010). The medical community and piano player association have long noted that utilizing a wrong or a stiff posture can be a major cause of PRMDs (Zaza 1998). To prevent PRMDs, a variety of methods have been proposed including the analysis of players' posture through wearable and physical sensors. However, the dataset used in these studies (Winges and Furuya 2015), (Park et al. 2016) do not consider various situations of the pianist, and are thus biased in posture classification.

This paper proposes the following contributions. (1) A classical piano performance posture (C3P) dataset, which unlike existing datasets contains various data, such as diverse environments, pianists, songs, and information of major/minor students. (2) We applied the state-of-the-art deep learning algorithms on video classification to the C3P dataset and performed a feasibility test that recommends a suitable algorithm to determine the correct posture for a pianist.

Our Approach

In this section, we first describe the details of the proposed C3P dataset, and then explain posture classification.

C3P Dataset

The total number of clips is 102 and the mean clip length is 7.5 s. The numbers of pianist and music pieces are 15 each. The clips in one part have the same features, such as the pianist. The videos are obtained via YouTube, where the clips contain a fixed frame rate of 25 frame per second and resolution of 720×576, respectively. The videos are stored as .avi files processed using DV PAL codec existing in Adobe Premiere Pro. We intentionally removed the audio. The dataset contains web videos obtained from various environments that include camera motion, various lighting conditions, partial occlusion, low-quality frames, etc. Table 1 shows the summary of proposed C3P dataset.

Number of players	15
Mean clip length	7.5 sec
Clips	102
Min clip length	5 sec
Max clip length	12 sec
Number of music piece	17
Frame rate	25 fps
Resolution	720×576
Total duration	766 sec
Audio	no

Table 1: Summary of characteristics of C3P

The purpose of this study is to classify the postures of pianists into two kinds, correct and incorrect, as shown in Figure 1, presenting sample frames of two action classes from C3P. The injury-related poses were classified with the help of a specialist who had more than 10 years of experience in piano education field.

Video Classification

Figure 2 shows the posture classification procedure. We used four deep learning algorithms that stand out in the field of video classification. That is, we used 2D Convolutional Networks (2D CNN) that classifies the image frame by frame,

Figure 1: Sample frames for PRMDs posture classes of C3P

and uses Inception V3 pretrained with the ImageNet dataset. Next, we used a transfer learning procedure to retrain the inception according to the proposed C3P dataset. Further, we used Convolutional 3D (C3D) (Tran et al. 2015) and long-term recurrent convolution network (LRCN) models that utilize temporal features as well as spatial features of videos. In the case of the LRCN model, the spatial feature extracted from the 2D CNN is converted into a sequence form, which is then passed to the long short-term memory. Lastly, we used the multi-layer perceptron (MLP) model, which shows excellent performance for classifying two classes, in combination with 2D CNN. This model, similar to the LRCN model, converts features extracted from 2D CNN into a sequence form and passes them to the MLP.

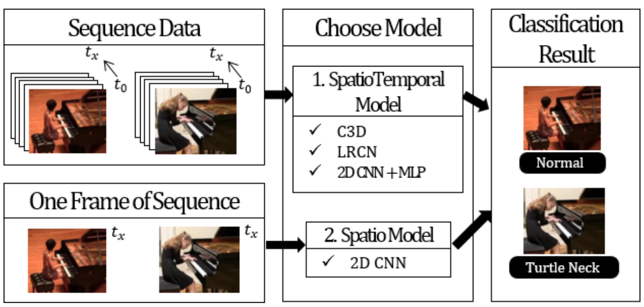

Figure 2: PRMDs posture classification procedure

Experiment Results

We conducted experiments that applied the four aforementioned deep learning algorithms on the C3P dataset and compared the classification accuracy. The C3P dataset was divided into the validation and training datasets, which were set at 33% and 67%, respectively. In addition, we divided the dataset for performing k-fold validation. The accuracy range was between 0 and 1. Table 1 demonstrates the results of the experiments on the accuracy of injury-related posture classification by using various deep learning models. Moreover, the table shows the result of the feasibility test. For experiments, we executed 3-fold validation. According to the experimental results, the 2D CNN and 2D CNN + MLP models show competitive accuracy results of 0.8254 and 0.8771, respectively.

Model	Iter. 1	Iter. 2	Iter. 3	Average
2D CNN	0.99	0.7544	0.7319	0.8254
C3D	0.7031	0.7424	0.7222	0.7225
LRCN	0.66	0.7424	0.75	0.7174
2D CNN + MLP	0.875	0.9091	0.8472	0.8771

Table 2: The result of PRMDs posture classification accuracy

Conclusion

This study verified the feasibility of a piano-playing injury prevention system using deep learning. For effective analysis, a C3P dataset, including diverse environments, was proposed; it solves the problems of models presented in previous related studies, in which the type of data was limited. We also applied state-of-the-art video classification deep learning models to the C3P dataset. The experimental results show an average classification accuracy of 80%, which indicates that the proposed hypothesis about the effective use of deep learning algorithms to prevent PRMDs is acceptable. The proposed method is the first in our knowledge that uses deep learning to prevent injuries to pianists playing a piano, and this is the first study that systematically uses deep learning in the field of art. Future studies will be conducted to improve the accuracy of additional data acquisition and deep learning models.

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