Restoration of Guqin Music by Deep Learning Methods

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Abstract

Guqin （古琴）music played an important role in the history of Asia cultures. The notation of Guqin ancient music remained more than 600, however, only about 100 of them are played in nowadays. The reason is that the handwritten Guqin notations named “Jianzi Pu” is hard to be understood, however, we challenge to restore the Guqin music by deep learning methods and few Jianzi Pu images. VGG16 and YOLOv5 were adopted in the recognition experiment for Guqin music restoration. For a well-known Guqin music “Sen-O-So”（仙翁操）, 55 kinds of single characters of Jianzi Pu and 4,951 images of them were collected from 23 kinds of Sen-O-So version found by the Internet or obtained by image processing such as rotation, enlarge (zoom-in), reduce (zoom-out), filtering, etc. The average accuracies of VGG16 and YOLOv5 were 87.50% and 88.47% for the test data, respectively. Additionally, it was realized an online output of Guqin music as its output of audio or video forms by YOLOv5 in this study.

Keywords: deep learning, VGG16, YOLOv5, SVM, Guqin, Jianzi Pu, AI music

1. Introduction

Many kinds of ancient cultures and civilizations have disappeared in the past. A Chinese stringed instrument named “Guqin” （古琴）(or “Qin”（琴）) (Figs. 1 and 2) has a history more than 3,000 years, however, few players in the world exists in the last century. Recently, more Chinese youngers are learning this ancient musical instrument, however, it is very difficult to use its notation, named “Jianzi Pu”, which is a kind of handwritten character using Chinese character and its original characters (see Figs. 3 and 4). There are more than 600 Guqin musical pieces in the history, meanwhile, the performed pieces in nowadays only about 100 [1], [2]. These Guqin music are translated from Jianzi Pu to modern staff notation by experts of Guqin players, and this translation process is called “Dapu” [3].

Jianzi Pu recognition by computer has been studied since last century in China [4], [5], [6], however, the practical results are not obtained.

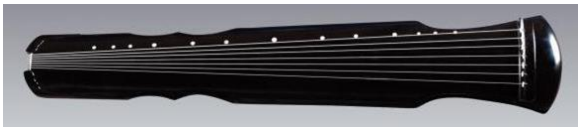


Fig. 1 A musical instrument: Guqin (7 strings Qin).

Fig. 2 Playing Guqin.

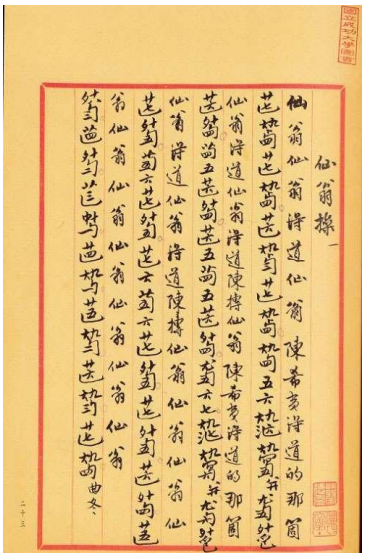


Fig. 3 A sample of Guqin musical notation “Sen-O-So”.

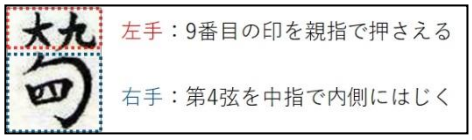


Fig. 4 A sample of a single Jianzi Pu and its meaning in Japanese.

In our previous work [7], [8], machine learning methods such as support vector machine (SVM), deep learning models VGG16, ResNet50, and the hybrid models VGG16 with SVM, ResNet50 with SVM were adopted to be classifiers of single character of Jianzi Pu. In the comparison experiments using a dataset of a well-known Guqin music “Sen-O-So”（仙翁操）, VGG16 with SVM had the highest average accuracies to 15 kinds of single characters data which were the first and the second line of Sen-O-So Jianzi Pu in 1,500 images, i.e., 99.11% in training and 88.33% for unknown data.

In this study, we built a bigger dataset for total single characters of Sen-O-So Guqin notation. 55 kinds of images of single characters were collected from 23 kinds of original Jianzi Pu from the Internet, and 4,951 single characters were obtained including data augmentation by image processing such as rotation, reversion, size enlargement (zoom in), size reduction (zoom out), and filtering. To realize online recognition, deep learning model YOLOv5 [9], [10] was adopted into the system as a classifier. The validation accuracy of YOLOv5 after 300 training arrived at 88.47% which was higher than the case of VGG16 87.50%. Additionally, audio/video data of single characters of Sen-O-So were created by Japan Society for the promotion of Guqin [2], and they were matched to the recognition results by YOLOv5.

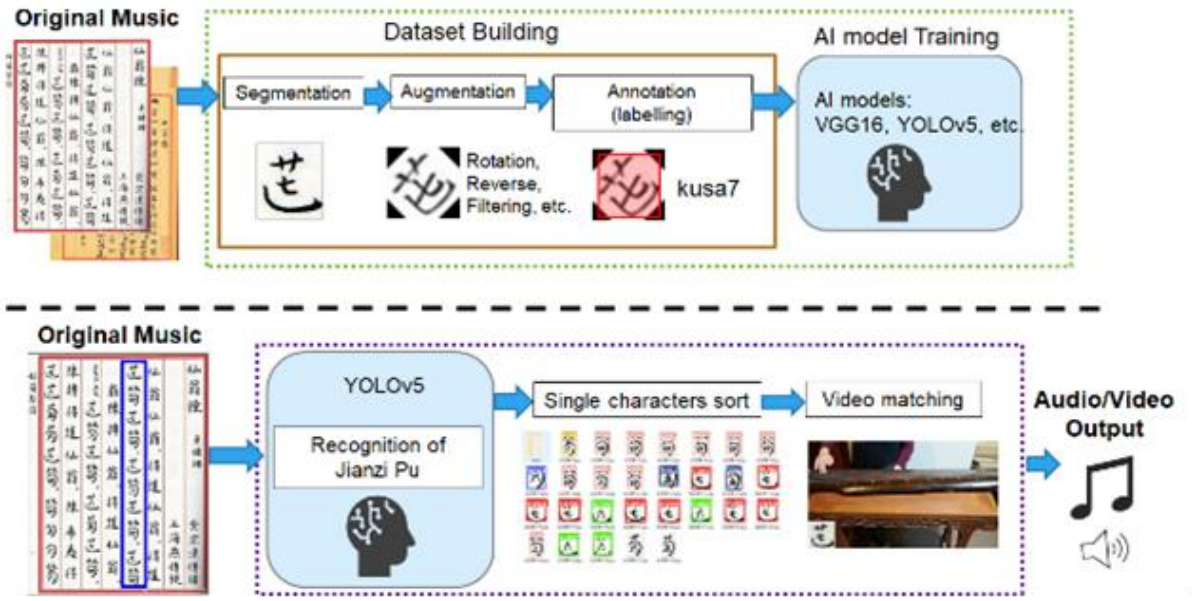


Fig. 5 A restoration system of Guqin music.

2. A Guqin Music Restoration System

A Guqin music restoration system, as shown in Fig. 5, is proposed in this study. It is aimed to realize that when a Jianzi Pu image is presented to the system, Guqin music in audio/video forms are output. The system is constructed by a fine-tuned deep learning model YOLOv5 [9], [10] and a matching process of the output of YOLOv5 and a single character database in audio and video forms.

Fig. 6 A sample of 55 single characters of Sen-O-So.

2.1. *A Database of Jianzi Pu*

To train the deep learning models, a database of single characters of a well-known Guqin music “Sen-O-So” in Jianzi Pu form is built at first. 23 versions of Sen-O-So Jianzi Pu images were collected by the Internet. 55 kinds of single characters were segmented from the Sen-O-So notation, and totally 343 images of single characters were obtained. Data augmentation is adopted by image processing such as rotation, reflection, parallel translation, enlarge (zoom-in), reduce (zoom-out), filtering to the original single character images. As the result, 4,951 images of single characters were obtained as a database of Jianzi Pu. A sample of the original single character images and a sample of data augmentation were shown in Fig. 6 and Fig. 7, respectively.

ファイル名	画像	画像処理の詳細
7 (14).jpg		元の画像
7 (14).jpg_**30**.jpg		高さと幅を30pxに変更
7 (14).jpg_**100**.jpg		高さと幅を100pxに変更
7(14).jpg_**200**.jpg		高さと幅を200pxに変更
7 (14).jpg_**blur**.jpg		カーネルサイズ（7，7）標準偏差1.5で平滑化
7 (14).jpg_**brighter**.jpg		色の値を1.5倍
7 (14).jpg_**darker**.jpg		色の値を0.9倍
7 (14).jpg_**noise**.jpg		ランダムな場所を対象にRGBランダムに選んでその値をランダムな少数分±する
7 (14).jpg_**r45**.jpg		反時計回りに45度回転
7 (14).jpg_**r90**.jpg		反時計回りに90度回転
7 (14).jpg_**r135**.jpg		反時計回りに135度回転
7 (14).jpg_**r180**.jpg		反時計回りに180度回転
7 (14).jpg_**r225**.jpg		反時計回りに225度回転
7 (14).jpg_**r270**.jpg		反時計回りに270度回転
7 (14).jpg_**r315**.jpg		反時計回りに315度回転

Fig. 7 A sample of data augmentation.

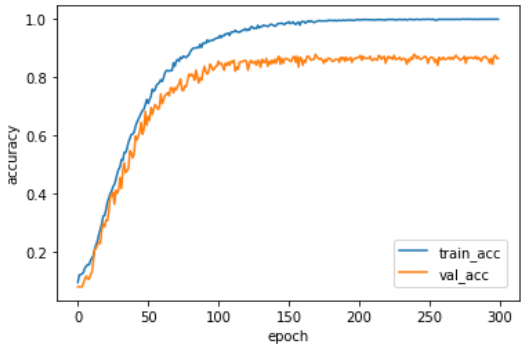
2.2. *Deep Learning Models*

A well-known deep learning model VGG16 [7], [8] and an online object recognition model YOLOv5 [9], [10] were investigated their recognition accuracies to single characters of Jianzi Pu. The state of art of YOLO is YOLOv8, and we are investigating its performance for Jianzi Pu recognition recently.

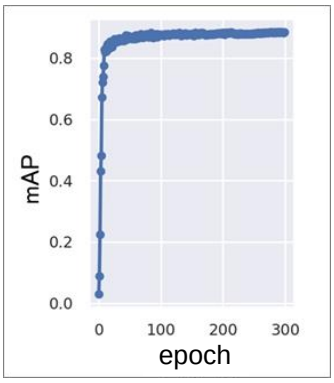
3. Experiments and Results

Using the database of Sen-O-So described in Section 2, VGG16 and YOLOv5 were fine-tuned with 300 epochs. The average recognition accuracies of the single characters were 87.50% and 88.47% respectively.

The change of accuracies in training of two models is shown in Fig. 8. It can be confirmed that the accuracies (training accuracy and validation accuracy) of VGG16 were converged from 200 epoch (Fig. 8a), meanwhile, it converged from 100 epoch in the case of YOLOv5 (Fig. 8b).



a. VGG16



b. YOLOv5

Fig. 8 Learning curves of VGG16 and YOLOv5.

Fig.9 A sample of audio/video data matched to a single character of Jianzi Pu.

Fig.10 A sample of the processing result of the proposed system.

Single characters of Jianzi Pu were played by a professional Guqin player, Mrs. Yuki Takei [2] and recorded in audio/video forms as shown in Fig. 9. The order of single characters in a Guqin musical notion was given by their position detected by YOLOv5. By matching the recognized single characters to audio/video data, the system output music and videos as shown in Fig. 10.

4. Conclusion

To restore Guqin （古琴）music written in Jianzi Pu notation, a deep learning system constructed by YOLOv5 was developed in this study. The main contribution includes the making of dataset of a well-known Guqin music Sen-O-So (仙翁操) and the restoration system developed with artificial intelligence (AI) technology. The experiment results showed the effectiveness of the proposed system, and the future work of this study is to build more single character datasets of Jianzi Pu using more Guqin musical notations.

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References

1. China Script, “The difference between Qin and So”, http://chugokugo-script.net/chugoku-bunka/kin.html (2016) (in Japanese)
2. Japan Society for Promotion of Guqin: https://www.guqin.jp/about
3. R. Takao, “A survey and analysis of the Dapu process in Qin music”, Journal of the Musicological Society of Ochanomizu University, No. 10, 2008 pp.40-45 (in Japanese)
4. Z.X. Pan, C. L. Zhou: “Text Segmentation and Extraction from Images of Guqin Jianzi Pu”, Mind an Computation, Vol.1, No.2, pp. 286-295 (2007) (in Chinese)
5. Chen Shi: “Guqin Notation and Music Style Recognition”, Computer Science (2016)
6. 王 利，孫 洋， 罗 兆麟， 張輝：「AI 自动翻译“减字谱”——以《流水》和《不染》为例」， Art Education, Vol.3 (2019) (in Chinese)
7. B. Yang, M. Sato, S. Kuremoto, M. Koshiba, S. Mabu, H. Hieda, T. Kuremoto, “Recognition of Guqin music by deep learning methods”, Proceedings of the Electronics, Information and Systems Conference Electronics, Information and Systems Society, I.E.E. of Japan，pp.512-515 (2022) (in Japanese)
8. Bowen Yang, Shun Kuremoto, Mamiko Koshiba, Shingo Mabu, Hiroo Hieda, Takashi Kuremoto, “Recognition of Guqin Notation using Deep Learning”, in Proceedings of Innovative Application Research and Education (ICIARE2022), pp.61-64 (2022)
9. J. Redmon, S. Divvala, R. Girshick, A. Farhadi, You Only Look Once: Unified, Real-Time Object Detection, aiZiv:1506.02640v5 (2016)
10. G. Jocher, https://github.com/ultralytics/yolov5/ (2020)

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