Copyright Protection of Line Drawings

Copyrighted Part Detection Using Cascade Classifiers

Weihan SUN† and Koichi KISE††

Graduate School of Engineering, Osaka Prefecture University
1-1 Gakuen-cho, Sakai, Osaka, 599-8531 Japan
E-mail: †sunweihan@m.cs.osakafu-u.ac.jp, ††kise@cs.osakafu-u.ac.jp

Abstract To protect the copyright of line drawings, we proposed an image retrieval method to detect both printed and handwritten partial copies. However, the enormous volumes of line drawing publications with copyright cause the problem of scalability. Since not the whole image requires copyright protection, a practical method should detect the copyrighted parts only. In this paper, we propose applying object detection technique to detect copyrighted parts. By using cascade classifiers, we achieved the detection of comic characters' faces, which are important copyrighted parts of line drawing publications. The experimental results show the effectiveness of this method.

Key words Copyright protection, Line drawing, Object detection, Copyrighted part detection.

1. Introduction

Line drawings, such as comics, logos and graphs, are a type of images that consist of distinct straight and curved lines in monochrome or few colors placed against plain backgrounds. As an important part of image publications, line drawings acquire more and more attention for the problem of illegal copies.

To protect the copyright of line drawings, we proposed an image retrieval method to detect suspicious images [1]. The method has been proved to have effectivenesses of detecting both printed and handwritten partial copies from complex backgrounds. In addition, we proposed applying a hash table method to speed up the detection [2]. However, since the whole images are stored in the database and a huge amount of line drawing publications that required copyright protection, the scalability of that method have been challenged.

In practice, only some important parts of line drawings require copyright protection rather than the whole image. In this paper, we focus on one of the most important copyrighted parts of line drawing publications: faces of comic characters.

To detect faces of comic characters, we proposed applying object detection technique. There are many researches about object detection, such as the detection of face, pedestrian, vehicle and so on [3], [4]. Viola et al. [5] proposed a framework which is effective for detecting rigid objects by cascade classifiers. However, since kinds of shape transformation in faces of comic characters (see Fig. 1), the effectiveness of Viola-Jones framework has not been proved. In this paper, we applied Viola-Jone framework to line drawings and proved it is available for detecting the faces of comic characters by experiments.

2. Copyrighted part detection

The processing of copyrighted part detection can be divided into two part: classifiers construction and object detection.

In the part of classifiers contruction, First, we collect positive samples (images bonding the objects) and negative samples (non-object images). Then, the samples are normalized as large as the size of detector (24×24 pixels in our method). From each detector, we extract 162,336 Haar-like features. Every feature can be seen as a decision tree with a certain threshold, which is called one classifier. To select the most discriminative classifiers, AdaBoost algorithm [6] has been applied. Finally, selected classifiers are arranged as a cascade construct by AdaBoost algorithm to achieve high detection speed with low false negative rate.

In the part of detection, we apply sliding window method to scan the whole image in different scales. All these sub-windows are normalized as large as the size of detector. By the cascade classifiers, all the sub-windows are classified. Union find algorithm is applied to cluster detected windows.

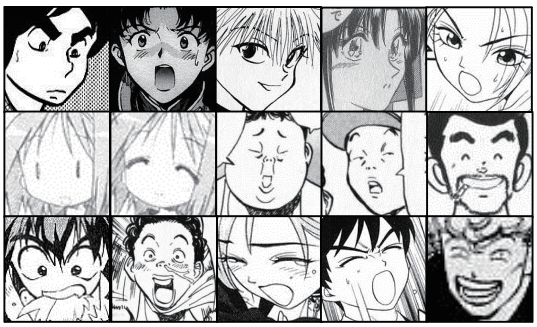


Fig. 1 Example of positive samples used for training. They are from Rurouni Kenshin, Neon Genesis Evangelion, Hoshin Engi, H2, Hunter × Hunter, Lucky Star, Master Keaton, Maison Ikkoku, Rosario + Vampire and Slam Dunk.

Table 1 Detection result with different sample set.

number of samples		number of detected parts	
positive	negative	true positive	false positive
1,000	1,000	22	5
1,000	3,000	18	1
3,000	1,000	31	26
3,000	8,000	25	5

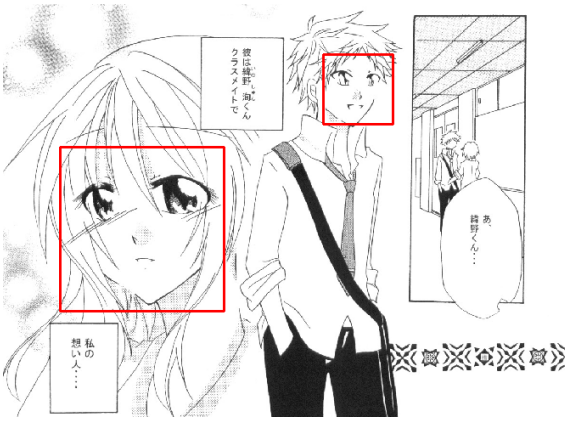
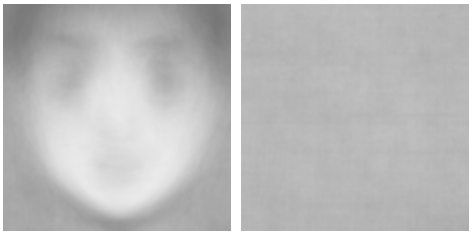


Fig. 2 Example of detection results.



(a) Mean image of positives. (b) Mean image of negatives.

Fig. 3 Mean images of training samples.

3. Experiments

3.1 Conditions

For the positive samples, 3,000 frontal faces of comic characters (cropped from 20 kinds of comics) are collected. As shown in Fig. 1, we take the noses of comic characters as the centers of the cropped regions, and normalized the regions to 24×24 pixels as our positive samples. For the negative samples, background images without faces are utilized. The validate set is another kind of comic which is not contained in the comics for training. It contains 15 comic pages ($700 \times 1{,}000$ pixels) with 32 frontal faces.

3.2 Results and discussions

Experimental results are reported by the number of true positives and false positives. As shown in Table 1, our training sample sets are divided into 4 categories depending on the numbers of positive and negative samples. Take the sample set with 1,000 positive and 1,000 negative as a reference, increasing the number of negative samples caused more rejections. In contrast, more positive samples led to more true positive and false positive. By increasing both positive and negative samples, we can obtain a better result. From the results, we can see the effectiveness of our classifiers for the detection of comic character's faces. Examples of detection are shown in Fig. 2. The average detection time for each image is 486 ms, based on a computer with 2.5 GHz CPU and 4 GB RAM.

In addition, we can see that there are some discriminiative features in faces of comic characters, although they contain more variations comparing with faces of human beings. As shown in Fig. 3, from the mean image of positive samples, we can recognize the shape of a face.

4. Conclusion and Future works

In this paper, we propose apply object detection method to detect the copyrighted parts of line drawings. In the experiments, we take faces of comic characters as copyrighted parts. By using cascade classifiers, which are constructed by Viola-Jones framework, we achieved the detection although there are kinds of transformations in the faces of comic characters.

In the future works, we will try to detect other non-face parts which require copyright protection.

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