Image Location Algorithm by Histogram Matching

Xiaoqiang Zhang[1(✉)] and Junzhang Gao[2]

[1] School of Information and Electrical Engineering, China University of Mining and Technology, Xuzhou 221116, Jiangsu, China
grayqiang@163.com
[2] Guangzhou ZLGMCU Development CO., LTD., Guangzhou 510000, China

Abstract. Image location affects the accuracy of image recognition. To improve accuracy and efficiency of the object location, the histogram matching method is designed, and a new common image location algorithm based on histogram matching is proposed. The algorithm uses the statistical characteristics of the histogram and determines the object location in the sequence image by calculating the histogram correlation between the object image and the pixel block of the image sequence. To verify the feasibility of the new algorithm, this paper locates the bird position in the sequence image of Flappy Bird (a popular mobile game) with the new algorithm. Experimental results show that the object in sequence images with the same size or almost the same size (such as direction variation), the algorithm is efficient and accurate. By testing 100 sequence images, the recognition rate of the new algorithm is 100%.

Keywords: Image location · Image recognition · Mobile game · Flappy Bird · Automatic operation

1 Introduction

With the rapid development of the computer vision and pattern recognition technology, how to quickly and accurately locate and identify the objects in a digital image becomes very important. Image location is the most important part of the image recognition technology. The result of image location can directly affect the accuracy of image recognition. At present, image location technology has been widely used in military cruise [1], oil leak detection [2], vehicle management [3–5], video surveillance [6] and medical diagnosis [7, 8] and other fields.

To protect the copyright of the digital image works and prevent the illegal attacker's malicious damage, Refs. [9–11] use the image watermarking technology to locate the image tampered area. To identify the vehicle license plate and realize the intelligent traffic management, Jianguo, et al. [5] proposed a vehicle license plate location algorithm based on the three-value image. In this algorithm, the color image is converted to the three-value gray image, and then using the color consistency among of characters in the vehicle license plate, the vehicle license plate is located by the character space line. For the implementation of maritime cruise monitoring, Lv, et al. [1] proposed a maritime target location algorithm based on the aerial image.

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By establishing the relationship between the pixels of the aerial image and the object marked points in three-dimension space, this algorithm establishes the geometric model of the center of the video camera, the image pixel and the sea target. For the realization of apple picking automation, Li, et al. [12] proposed a ripe apple location algorithm. This algorithm is mainly based on the three-point determination method of the circle, and the image removing noise technology. However, these existing algorithms are located for the specific object. To the best of our knowledge, few common image location algorithm has been proposed at present.

To improve the accuracy and efficiency of image location technology, a new common image location algorithm based on histogram matching is proposed in this paper. Experimental results show that the new algorithm is efficient and accurate.

The organization structure of this rest paper is as follows. Section 2 designs the histogram matching method; Sect. 3 designs an image location algorithm based on histogram matching; In Sect. 4 tests the new image location algorithm on Flappy Bird (a mobile game) and analyzes the algorithm performance; the conclusion and outlook are drawn in Sect. 5.

2 Histogram Matching Method

The image histogram indicates the statistical characteristics between each gray level and the occurrence frequency in a digital image [13]. Gray image histogram is used to count the occurrence frequency of 256 gray levels including 0, 1, 2, $\cdots$, 255 in the gray image. The histogram of Lena's gray image in Fig. 1 is as shown in Fig. 2.

Fig. 1. Lena

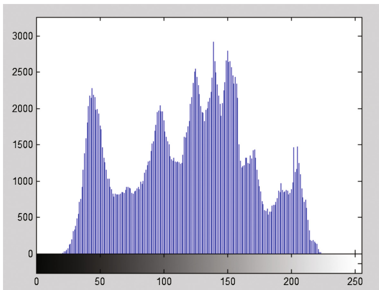

Fig. 2. Lena's histogram

The histogram has the following three properties.

(1) If two images are exactly the same, then their corresponding histograms are exactly the same;
(2) If two images are similar, then their corresponding histograms are also similar;
(3) Two images are different, but their corresponding histograms may be the same. However, the probability of this case is very low. If the image size is $m \times n$, then the occurrence probability of this case is $\left(\frac{1}{m \times n}\right)^{256} \approx 0$.

Using the above properties, this paper determines whether the two images are the same or not by making a comparison on their histograms. To achieve the purposes of image location, the histogram matching method is designed. For example, to locate the girl's head in Fig. 3 (called the location image), the specific steps are as follows.

Fig. 3. Girl

Fig. 4. Girl's head

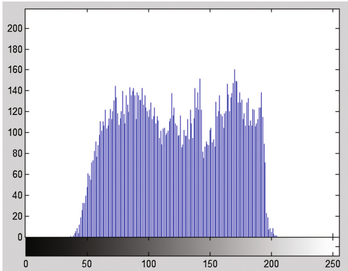

Fig. 5. Girl head's histogram

Step 1: Drawing the histogram of the object image

The histogram of Fig. 4 is as shown in Fig. 5.

Step 2: Drawing the histogram of the pixel block in the location image

Select a pixel block with the same size of the object image from the location image. The selected two pixel blocks are as shown in Fig. 6. The histogram of the pixel block 1 (i.e., the left selected area) is as shown in Fig. 7. The histogram of the pixel block 2 (i.e., the right selected area) is as shown in Fig. 8.

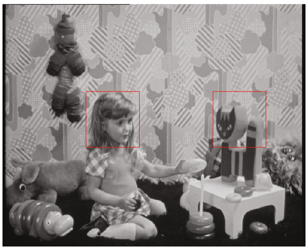

Fig. 6. Selected pixel blocks

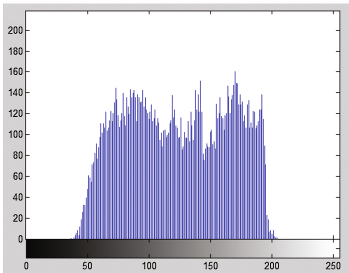

Fig. 7. Pixel block 1's histogram

Step 3: Calculating the correlation of two histograms

Suppose two images are $A_{m \times n}$ and $B_{m \times n}$ respectively, and the correlation of their histograms is defined by

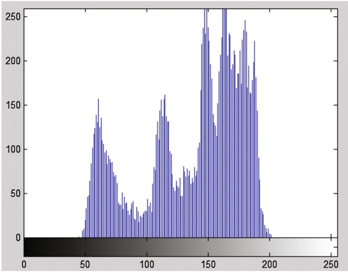

Fig. 8. Pixel block 2's histogram

$$r = \frac{1}{m \times n} \sum_{i=0}^{255} |a_i - b_i|, \quad (1)$$

where a_i is the pixel number of the i th gray level in $A_{m \times n}$, and b_i is the pixel number of the i th gray level in $B_{m \times n}$. Therefore, if $A_{m \times n}$ and $B_{m \times n}$ are exactly the same, then $r = 0$. Conversely, if $A_{m \times n}$ and $B_{m \times n}$ are different, then the value of r is larger and $r \leq 1$.

Using Eq. (1), the correlation between two histograms can be computed, which correspond to Fig. 4 and the selected pixel block 1 (or 2) is $r_1 = 0$ (or $r_2 = 0.5646$). Therefore, the selected pixel block 1 is the position of the girl's head in Fig. 3.

3 Algorithm Design

To locate the same object in sequence images, this paper proposes a new common image location algorithm based on histogram matching. The specific steps are as follows.

Step 1: Producing the object image

Choose an image $I_{m \times n}$ from sequence images, and then save the object pixel block in $I_{m \times n}$ as a separate image file, which is called the object image and denoted by $O_{s \times t}$.

Step 2: Drawing the histogram of the object image

Count the pixel number of each gray level in $O_{s \times t}$, and then draw the histogram H_o of $O_{s \times t}$.

Step 3: Locating the object in the first image of sequence images

Locate the object in the first image of sequence images. The specific steps are as follows.

Step 3.1: Selecting pixel blocks for the location.

Choose t continuous pixel columns including the object image in the first image $\{k, k+1, \cdots, k+t-1\}$, where k is an integer and $0 \le k \le n-t+1$. From the chosen t pixel columns, we segment the pixel blocks B_i with the size of $s \times t$ line by line from the t th row to the m th row, $i = 1, 2, \cdots, m-s+1$.

Step 3.2: Drawing the histograms of selected pixel blocks

Draw the histogram H_i of B_i, $i = 1, 2, \cdots, m-s+1$.

Step 3.3: Calculating the correlation between two histograms

Using Eq. (1), calculate the histogram correlation r_{oi} between H_o and H_i, $i = 1, 2, \cdots, m-s+1$.

Step 3.4: Locating the object

Select the minimum value $r_{\min}$ in the set $\{r_{oi}\}$, i.e.,

$$r_{\min} = \min\{r_{oi}\}. \tag{2}$$

The pixel block $B_{\min}$ which corresponds to $r_{\min}$ is the object position in the first image.

Step 4: Locating the object in the subsequent images of sequence images

The video playback standard requires 25 frames per second. Therefore, the object displacement in two adjacent images of sequence images is very small. When select the location pixel area, we enlarge the boundary of $B_{\min}$ with p adjacent pixels. The other steps are the same to Steps 3.2, 3.3 and 3.4.

4 Verification Experiment and Algorithm Analysis

Flappy Bird is a simple but a little difficult mobile game developed by a Vietnamese named Dong Nguyen. The game was online on May 24, 2013, and it was very popular in February 2014. However, it was removed from Apple and Google App Store by developer himself in April 2014. The game officially returned to App Store in August 2014 [14]. In this game, players must control a fat bird through different water pipes which are viewed as obstacles. Game players generally believe that the game is easy to learn, but it is a little difficult to get a high score. Therefore, how to achieve the automatic operation of this game attracts researchers and game players' attention.

4.1 Verification Experiment

Image location is the core technology to realize the automatic operation of this game. For Flappy Bird, the bird location becomes very meaningful. By analyzing the characteristics of game images, we adopt the image location algorithm based on histogram matching to realize the bird location. The experiment object is the gray image of the game image. The experiment target is to locate the bird in sequence images. The process of the bird location is described in detail as follows.

Step 1: Producing the bird image

Randomly choose a game image as shown in Fig. 9, whose size is 600×400. Let the gray image of Fig. 9 be $I_{600 \times 400}$, which is as shown in Fig. 10. Saved the pixel block of the bird in Fig. 10 as a single image, which is called the bird image and denoted by $O_{32 \times 46}$, as shown in Fig. 11.

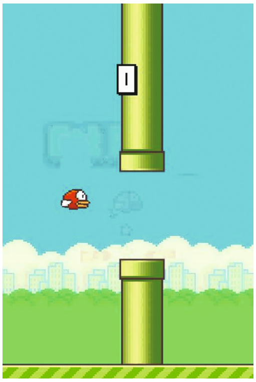

Fig. 9. Game image

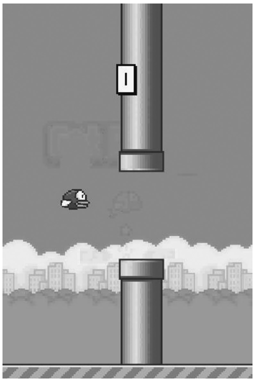

Fig. 10. Gray game image

Fig. 11. Bird image

Step 2: Drawing the histogram of the bird image

The histogram of the bird image H_o is as shown in Fig. 12.

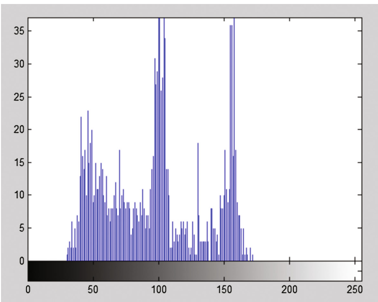

Fig. 12. Histogram of the bird image

Step 3: Locating the bird in the first image of sequence images

The first gray game image of Flappy Bird is as shown in Fig. 13. To locate the bird, the specific steps are as follows.

Step 3.1: Selecting pixel blocks for the location

Choose 46 continuous pixel columns including the bird image in the first image $\{94, 95, \cdots, 139\}$, which is marked with the dark gray color in Fig. 14. From the selected 46 pixel columns, we segment the pixel blocks B_i with the size of 32×46 line by line from the 32nd row to the 600th row, $i = 1, 2, \cdots, 569$.

Step 3.2: Drawing the histograms of selected pixel blocks

Draw the histogram H_i of B_i, $i = 1, 2, \cdots, 569$.

Step 3.3: Calculating the correlation between two histograms

Using Eq. (1), calculating the histogram correlation r_{oi} between H_o and H_i, $i = 1, 2, \cdots, 569$.

Step 3.4: Locating the bird

Select the minimum value $r_{\min} = 0$ in the set $\{r_{oi}\}$, which corresponds to the pixel block $B_{\min} = [94, 298, 32, 46]$ in Fig. 13, where $(94, 298)$ is the coordinate value of the upper-left corner pixel of $B_{\min}$, 32×46 is the size of $B_{\min}$. The location result is as shown in Fig. 15.

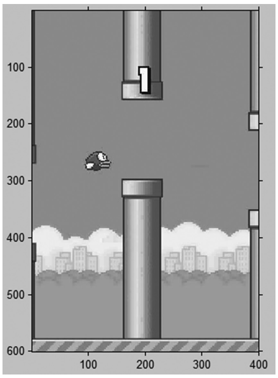

Fig. 13. The first game image

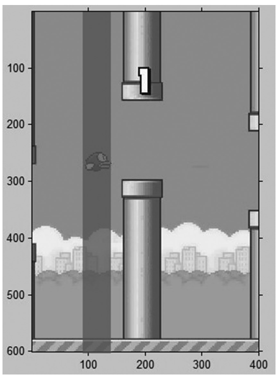

Fig. 14. The first marked game image

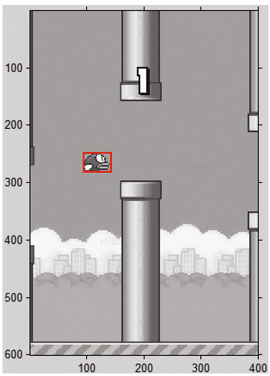

Fig. 15. Location result of the first game image

Step 4: Locating the bird in subsequent images of sequence images

By analyzing many game images of Flappy Bird, we can get the following features.

(1) The bird doesn't move in the left and right directions in essence, and only moves in the up and down directions. However, the water pipes move in the left and right directions;
(2) For two adjacent game images, the bird only moves a very short distance.

Considering these features, we enlarge the up and down borders of $B_{\min}$ with $p = 50$ adjacent pixels as the selected location pixel area. Therefore, the selected location pixel area is $[94, 298, 32 + 100, 46] = [44, 298, 132, 46]$, where $(44, 298)$ is the coordinate value of the upper-left corner pixel of the selected location pixel area, 132×46 is the size of the selected location pixel area. The other steps are the same to Steps 3.2, 3.3 and 3.4.

4.2 Algorithm Analysis

(1) Location accuracy analysis

By testing 100 continuous game images of Flappy Bird, the accuracy rate for the bird location is 100%. The location result of the second game image is as shown in Fig. 16. The location result of the 100th game image is as shown in Fig. 17. Figures 16 and 17 show that the location results are very correct.

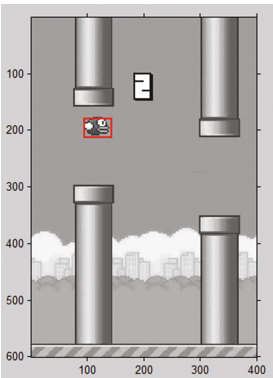

Fig. 16. Location result of the second game image

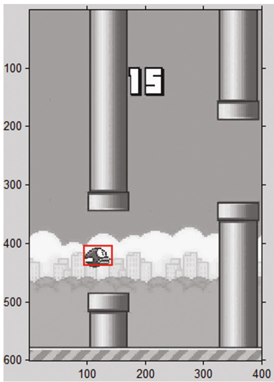

Fig. 17. Location result of the 100th game image

(2) Algorithm efficiency analysis

The algorithm efficiency is an important index to reflects whether an algorithm is practical or not. Meanwhile, the high execution efficiency is required for sequence images. Experimental result show that the execution time for bird location in the first game image is 0.3048 s, and the execution time for the bird location in the subsequent images is 0.05765 s on average. In all, the efficiency of our proposed algorithm is fast to satisfy the requirement of sequence images.

5 Conclusion and Outlook

Firstly, by studying the properties of image histogram, this paper design a histogram matching method; secondly, a new common image location algorithm based on histogram matching is proposed; finally, the bird of Flappy Bird is located with the new algorithm. Experimental results show that our proposed algorithm is feasible and efficient. Meanwhile, the location accuracy is desirable. By testing the new algorithm on 100 sequence images, the accuracy rate is 100%.

Our future work is as follows.

(1) Analyze the features of water pipes in Flappy Bird, and try to design a water pipe location algorithm;
(2) On the bases of the bird location algorithm and water pipe location algorithm, we will combine with the software and hardware to really realize the automation of Flappy Bird.

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References

1. Lv, Y., Lan, P.: Sea target positioning algorithm using aerial image. J. Shanghai Marit. Univ. **32**(4), 28–31 (2011). (in Chinese)
2. Suresh, G., Melsheimer, C., Koerber, J.-H., et al.: Automatic estimation of oil seep locations in synthetic aperture radar images. IEEE Trans. Geosci. Remote Sens. **53**(8), 4218–4230 (2015)
3. Liu, W.B., Wang, T.: Anti-noise car license plate location algorithm based on mathematical morphology edge detection. In: International Conference on Advances in Materials Science and Information Technologies in Industry. Xi'an, China, 11–12 January 2014
4. Hu, H.P., Bai, Y.P.: A kind of car license plate location based on color feature and mathematical morphology. In: International Conference on Structures and Building Materials. Guizhou, China, 09–10 March 2013
5. An, H., Jiang, J., Qi, M., Liu, H.: License plate location algorithm based on three-valued image. J. Electron. Measur. Instrum. **16**(1), 68–71 (2012). (in Chinese)
6. Ruffell, J., Innes, J., Bishop, C., et al.: Using pest monitoring data to inform the location and intensity of invasive-species control in New Zealand. Biol. Cons. **191**(11), 640–649 (2015)
7. Moon, W.K.: Location of triple-negative breast cancers: comparison with estrogen receptor-positive breast cancers on MR imaging. In: IMPAKT Breast Cancer Conference. Brussels, BELGIUM, 07–09 May 2015

8. Kim, W.H., Han, W., Chang, J.M., et al.: Location of triple-negative breast cancers: comparison with estrogen receptor-positive breast cancers on MR imaging. PLoS ONE **10** (1), e0116344 (2015)
9. Ouda, A.H., El-Sakka, M.R.: Correlation watermark for image authentication and alternation locations detection. In: 4th Conference on Mathematics of Image and Data Coding, Compression, and Encryption, San Diego, CA, 30–31 July 2001
10. Wu, F., Rui, G.S.: A digital image watermarking technique with detecting the location of any image interpolation. In: 6th International Symposium on Test and Measurement, Dalian, China, 01–04 June 2005
11. Lim, J., Lee, H., Lee, S., Kim, J.: Invertible watermarking algorithm with detecting locations of malicious manipulation for biometric image authentication. In: Zhang, D., Jain, A.K. (eds.) ICB 2006. LNCS, vol. 3832, pp. 763–769. Springer, Heidelberg (2005). doi:10.1007/11608288_102
12. Li, H., Liu, Q.: Study on technology of location of apples. J. Agric. Mech. Res. **105**(2), 54–57 (2016). (in Chinese)
13. Zhang, X., Wang, X., Cheng, Y.: Image encryption based on a genetic algorithm and a chaotic system. IEICE Trans. Commun. **E98-B**(5), 824–833 (2015)
14. Baidu Baike. Flappy bird, 4 May 2013. (in Chinese). http://baike.baidu.com/link?url=PCwedUn_N-oRCR7CeworTEptqi5mljHcTqitO6LY0Evr0OHTlK-svcCCcha-ng0nr9gGaNYmDAIPLO-XrMOyzK