Image Acquisition Based on Handheld Portable Printer - Image Tilt Correction

Zhao He\textsuperscript{a}, Fengkai Luan and Mange Huang

School of Information Engineering, Wuhan University of Technology

\textsuperscript{a}xyz_hcy@163.com

Abstract. At present, there are various algorithms for image tilt correction. However, there are some shortcomings and shortcomings in the current application of images acquired by handheld portable printers. The research in this paper is mainly aimed at the image acquired based on the handheld portable printer, which has the reason that the angle of the image acquisition angle is artificially manipulated or the image itself is tilted, which leads to the problem of tilting or see-through deformation. Other uncertain factors such as the light source during the shooting process result in low signal-to-noise ratio, low definition and low contrast, and the image is preprocessed first. The histogram equalization method is used to enhance the image, and the maximum inter-class variance is used to calculate the optimal threshold for binarization. The preprocessed image is subjected to image tilt correction based on projection analysis. The result proves that this method has high accuracy and adaptability to the image tilt correction of the printer.

1. Introduction
With the development of the times, the sales volume of printers is increasing at an 8% speed. Everything indicates that the printer is developing faster and faster, and the functions and quality requirements of the printer itself are getting higher and higher. The handheld portable printer captures images through the camera and uses image processing technology to process the image. It is an effective solution to improve the function and quality of the printer from the source of the scanner. Due to the uncertainty of human operation or the tilting of the image itself, the acquired image has problems such as low signal-to-noise ratio, low definition, low contrast, perspective and tilt deformation, so the image acquired based on the handheld portable printer is pre-processed. Research on methods of processing and image correction is of great significance.

2. Algorithm principle and implementation

2.1. Overall process
The algorithm is mainly composed of three parts, mainly for contrast enhancement, image binarization and projection analysis for image correction. The overall block diagram of the system is shown in Figure 1.
The portable handheld printer acquires images through the camera. Firstly, the histogram equalization method is used to improve the image intensity unevenness, enhance the image contrast, and distribute the pixels in the image at each gray level. The nonlinear mapping process of the image recalculates the gray value of one pixel to obtain a contrast enhanced image. The contrast-enhanced image is binarized to reduce the amount of data and simplify the image information, which is convenient for subsequent image processing. The emphasis is on the threshold selection of threshold segmentation. This paper adopts the maximum inter-class variance method, which is automatically adapted to the bimodal situation. The threshold is obtained, the calculation amount is small, the misclassification probability is low, and a binarized image is obtained. Finally, the optimal tilt angle is obtained by the projection analysis method, and the final tilt corrected image is obtained by the horizontal correction formula.

2.2. Contrast enhancement

Due to the complex and varied working environment of the handheld portable printer, the images collected by the camera are prone to problems such as light emission, uneven illumination and exposure. Therefore, it is necessary to enhance the contrast by increasing the contrast of the gray levels between the pixel points in the original image, that is, changing the gray value of the image pixel points to achieve contrast enhancement.

In this paper, the method of histogram equalization [1] is used to enhance the contrast of images acquired by a portable printer, which acts on the spatial domain and directly processes images. The number of pixels concentrated in a certain brightness 1 area is allocated to pixels with few pixels under limited contrast to maintain the contrast between light and dark in the original image.

First, the input image function is defined by \( r \), and the image function after the histogram is averaged is represented by \( s \). The transformation function of the image can be expressed as:

\[
s = T[r]
\]  

(1)

When the gray image is continuous in the 0-1 interval, the image probability density function is set to \( P(r) \). Then, by the equation (1), the histogram equalization processing image density function \( P(s) \) can be obtained, and the enhanced image cumulative probability density is:

\[
s = T[r] = \int_0^r P(x)dx
\]  

(2)

The above analysis is based on the continuous situation of the gray image in the 0-1 interval. For the image distribution interval \([0, 255]\), it is only necessary to multiply the integral by the maximum gray value in the image. (3) as the final expression.

\[
M_s = T[M_r] = M_{\text{max}} \int_0^{M_r} P_{M_r}(x)dx
\]  

(3)
2.3. Binary image

The image acquired by the camera is generally color, and the image is directly processed. The rich color information makes it run and time-consuming. By image binarization, the comparison between the threshold and the pixel point, and the pixel point whose gray value is within the threshold belongs to the target is to mark the matching image pixels as 0 and the other is 255, which can reduce the amount of data and simplify the image information, and facilitate subsequent image processing.

Image binarization focuses on the selection of thresholds. This paper uses the largest inter-class variance method proposed by Japanese scholar Otsu in 1979 \[2\]. This is a method of adaptive threshold calculation. Under certain conditions, it is not easy to be affected by image brightness and contrast change, and the operation process is simple. First, a threshold is assumed, and the original image is divided into two images, foreground and background. The variance between corresponding classes is obtained by calculation, and the maximum inter-class variance is obtained by continuously changing the threshold. At this time, the foreground and the background have the largest difference, which is the optimal threshold \[3\].

The function \( F(x,y) \) is used to represent the image acquired by the portable printer. There are a total of \( L \) gray levels, \( N \) pixels, and the gray value is the number of \( i \) pixels, which is \( N_i \), and the probability of occurrence is \( P_i \). Presetting a threshold with a gray level of \( k \), the pixel points in the image can be divided into the target \( C_1 \) and \( C_0 \), the collection of \( C_1 \) is \((1, 2, ..., k)\), and the combination of \( C_0 \) is \((0, 1, 2, ..., k)\), and the probability of occurrence and the average gray value are:

\[
\begin{align*}
    w_0 &= \sum_{i=k+1}^{L} P_i = w(k), \\
    w_1 &= \sum_{i=1}^{k} P_i = 1 - w(k) \\
    u_0 &= \sum_{i=k+1}^{L} \frac{iP_i}{w_0} = \frac{u(k)}{w(k)}, \\
    u_1 &= \sum_{i=1}^{k} \frac{iP_i}{w_1} = \frac{U_f - u(k)}{1 - w(k)}
\end{align*}
\]

The variance between the classes of the two types of sets \( C_1 \) and \( C_0 \) is represented by \( \sigma^2 \), and \( \sigma^2 \) is:

\[
\sigma^2 = w_0(u_0 - u_f)^2 + w_1(u_1 - u_f)^2 = w_0w_1(u_f - u_0)^2
\]

The threshold \( k \) is adjusted by continuous feedback, and when \( \sigma^2 \) is taken as the maximum value, the optimal threshold is obtained. Through the calculation of the optimal threshold, the printer acquires images to segment the target and background of the image more accurately, and achieve image binarization.

2.4. Image Tilt Correction

The tilt correction of the handheld portable printer image can be divided into two parts: one part is the image tilt angle acquisition; the other part is the image transformation according to the angle, and the corrected image is obtained.

Hough transform method \[4-6\] mainly uses line detection to find the straight line in the image to determine the tilt angle by threshold elimination. Since the image acquired by the printer is complex and varied, the projection method \[7, 8\] is used for image correction. The projection method obtains a tilt angle by counting the binarized images of different rotation angles in the horizontal and vertical directions respectively. A feature is largest along the oblique direction of the image, and the direction accumulates the number of black pixels in the image in a certain direction to take the largest black area, and counts the number of black dots per row or column. According to the selected image points, the optimal tilt angle is obtained from the maximum conversion angle with the smallest mean square error of the projected image. The flow chart is shown in Figure 2.
Figure 2. Projection flow chart.

The implementation steps are as follows. Randomly divide the region and take the most black points:

$$P = \arg \max \sum f(x, y) \in P \sum f(x, y)$$  \hspace{1cm} (7)

Count the number of black points per line in the selected area:

$$\arg = \frac{\sum \sum f(x, y)}{h}$$ \hspace{1cm} (8)

When the image is rotated by $\theta$, the coordinates in the image are represented by $(x, y)$ corresponding coordinates, and the binarized pixel values of the corresponding points are represented by $f_\theta(x, y)$. The average number of black dots per line is represented by $\text{avg}(\theta)$, and the mean square of the corresponding projected image the error can be expressed as:
\[
\sigma^2(\theta) = \sum_{y=0}^{W} \sum_{x=0}^{H} (f(x, y) - \text{avg}(\theta))^2
\]  

(9)

Preset a suitable rotation step in the range of \([-90°, +90°]\), rotate the image left and right in turn to rotate the angle, compare the size of \(\sigma^2(\theta)\) and \(\sigma^2(-\theta)\) obtained each time, and rotate in the direction of small mean square error to find the best rotation at this time. A rough range of angles. Through many experiments, the initial stepping time is in the range of 5°~10°, and the program time complexity is the best: if the initial step is too large, the optimal rotation angle range will be inaccurate; if the step is too small, the data volume will be too large. The program time complexity is too large. Reduce the rotation step in the new range, solve the minimum mean square error, and get the final determined optimal rotation angle.

Through the above method, the optimal rotation angle is found, and the image is horizontally corrected according to the angle to obtain a corresponding image. The horizontal correction formula is:

\[
\begin{pmatrix}
x' \\
y' \\
1
\end{pmatrix} =
\begin{pmatrix}
1 & 0 & c \\
0 & -1 & d \\
0 & 0 & 1
\end{pmatrix}
\begin{pmatrix}
\cos(\theta) & \sin(\theta) & 0 \\
-\sin(\theta) & \cos(\theta) & 0 \\
0 & 0 & 1
\end{pmatrix}
\begin{pmatrix}
x \\
y \\
1
\end{pmatrix}
\]  

(10)

3. Experimental results and analysis

This experiment is based on a handheld portable printer to capture images using a camera. The image obtained by the handheld portable printer is shown in Figure 3. The image obtained by the histogram average is shown in Figure 4; the maximum inter-class variance is used to calculate the threshold for binarization, and the image is shown in Figure 5, and the image is passed. The image tilt correction based on the improved algorithm of projection analysis is shown in Figure 6.
4. In conclusion

Based on the algorithms of image tilt correction, a tilt correction algorithm based on images acquired by handheld portable printers is proposed. Through the three steps of contrast enhancement, image binarization and image horizontal correction, the image is processed by a large number of images, and the correct correction rate of the algorithm is %, which is suitable for the tilt correction of the image obtained by the handheld portable printer.

References

[1] Wu Chengmao. Study on Mathematical Model of Histogram Equalization [J]. Acta Electronica Sinica, 2013, 41 (03): 598-602.
[2] Otsu N. A threshold selection method from gray-level histograms. IEEE Transactions on Systems, Man, and Cybernetics, 1979, 9 (1): 62-66.
[3] LI Hong, ZHANG Dongsheng, LIN Yigang, WANG Lanlan. Research and improvement of gray image segmentation algorithm based on Otsu theory [J]. Science Technology and Engineering, 2010, 10 (22): 5437-5440.
[4] A new curve detection method: randomized Hough transform (RHT. Xu L, Oja E, Kultaned P. Pattern Recognition. 1990.
[5] Randomized Hough Transform (RHT): Basic Mechanisms, Algorithms, and Computational Complexities. Xu Lei, Oja Erkki. CVGIP Image Understanding. 1993.
[6] HOUGH P V H. A New Method and Means for Recognizing Complex Pattern: US, 3069654 [P]. 1962-12-18.
[7] Jianbin Jiao, Qixiang Ye, Qingming Huang. A configurable method for multi-style license plate recognition [J]. Pattern Recognition, 2008, 42 (3).
[8] Du Y, Wu Z. An Approach to Horizontal Tilt Correction of Vehicle License Plate Based on Matchstick Model [M]. IEEE Computer Society, 2009: 1124-1127.