Scale recognition of non-electronic thermometers based on image features

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Abstract. At present, in terms of clinical temperature measurement in China, most hospitals use traditional mercury thermometers to obtain patient temperature data through human readings and records. In order to improve the work efficiency of medical staff and reduce the frequency of their contact with patients, machine vision is adopted. A scale recognition method of non-electronic thermometer based on image features is proposed. The reading data of clinical thermometers is calculated through pixels. The automatic reading record of the clinical thermometer is realized, and the relative error does not exceed 0.25% in the temperature range of 35.5 to 37.5°C, which has certain practical significance for the research in the field of intelligent medical treatment.

1. Introduction

Scientific and effective body temperature monitoring can detect changes of the patient condition in time to facilitate diagnosis and treatment of the disease. In China, in terms of clinical temperature measurement, most hospitals use traditional mercury thermometers. This kind of cumbersome mechanical work is common in clinical monitoring in hospitals, resulting in high work intensity and low efficiency of medical staff. The frequent close contact will also increase the risk of infection of medical staff and waste human resources. This situation urgently needs to be improved.

At present, there are many related literatures on the research of thermometer reading algorithm. Wang Xuezhi, Yang Guosong, et al.[1] realized the identification of the scale line and the liquid column by using the method of gray scale minima. However, when reading the liquid column, the gray value of the liquid column is different from the surrounding pixels. If the gray values are similar, problems may still occur. Wang Xiang, Xue Shenghu[2-3] performed filtering on the image of the thermometer, but due to the high complexity of the algorithm and low operation speed, it is not conducive to practical applications.

Based on machine vision[4-6], this paper proposes a scale recognition method of non-electronic thermometers based on image features. Using machine vision[7-11] instead of artificial vision to record the readings of glass thermometers can not only reduce the work intensity of medical staff and the risk of infection, but also improve the accuracy and speed of readings.
2. System Description
The system in this paper is mainly to process the thermometer image collected by the camera, and then acquire the scale indication of the thermometer. The schematic of the system is shown in Figure 1.

![Figure 1. Schematic of experimental device.](image)

In the image processing process, characteristic values corresponding to the thermometer (including: the profile data of the glass tube thermometer, the scale line data, and the liquid column (head) data) are used to perform relevant image processing on the temperature values represented by the thermometer image pixels collected by the camera. And then the thermometer reading is acquired.

The measurement process is shown in Figure 2.

![Figure 2. Measurement diagram of thermometer scale recognition system.](image)

3. Algorithm implementation

3.1. Pretreatment
The acquired image will be affected by the light source, and the noise influence of the light source must be eliminated. Therefore, the acquired image needs to be preprocessed.

The method used for pretreatment is:
(1) Gray-scale the entire image.
(2) Use the gray-scale minimum method to obtain the binarized image of the entire image.
(3) Perform horizontal projection to get the position of the upper and lower edges of the thermometer in the whole image.
(4) Extract the thermometer image from the original image according to the position of the upper and lower edges.

3.2. Target feature extraction
In the image processing process, only certain areas are concerned, and this part needs to be extracted for analysis and research. For example, the outline of the thermometer, the edge of the image, the gray distribution, etc., are all inherent information of the image. This article focuses on this part, and realizes the segmentation based on the feature part. The flow chart is shown in Figure 3.

![Flow chart of target feature extraction](image)

Figure 3. Flow chart of target feature extraction.

It mainly includes the following steps:
(1) Find the enclosing matrix of the contour.
(2) Obtain the tilt angle.
(3) Rotation correction based on angle.
(4) Extract the contour of the rotated image and image independently.

Perspective transformation is applied to project a two-dimensional picture onto a three-dimensional viewing plane, and then transform it to two-dimensional coordinates, so it is also called projection mapping.

3.3. Calculation
The segmentation algorithm is used to extract the mercury liquid column and the engraved lines in the image, and the pixels are read out through the temperature corresponding to the scale to obtain the length of the mercury column. According to the position information of the scale line, the thermometer reading is calculated through the change of the pixel point.

4. Experimental results and Discussions

4.1. Experimental results
In this experiment, five different temperatures were selected for identification, and the identification results are shown in Figure 4.
Figure 4. Measured temperatures and standard deviations of clinical thermometer.

The relative errors are shown in Figure 5.

Figure 5. Relative error of thermometer reading measurement.

5. Conclusion
Based on machine vision, this paper proposes a scale recognition method of non-electronic thermometer based on image features. The automatic reading record of the clinical thermometer is realized, and the relative error does not exceed 0.25% in the temperature range of 35.5 to 37.5°C, which has certain significance for the research in the field of intelligent medical treatment.

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References
[1] G. Yang, X. Wang. (2013) Automatic detection method of glass liquid thermometer. Journal of Hubei Water Resources Technical College, 9(2): 21-24.
[2] N. Li, R. Wang, X. Liu, et al. (2012) Design and application of temperature measurement system based on machine vision. Journal of Computer and Modernization, 2012(9): 57-60.
[3] X. Wang, S. Xue, P. Xu. (2009) Research on the Counting Display and Reading Device of Glass Liquid Temperature. Chinese Journal of Scientific Instrument, 30(6): 186-190.
[4] J. Shi, C. Hua and G. Li. (2010) "A simplifying method of vision attention simulating human vision in machine vision system," 2010 International Conference on Machine Learning and Cybernetics. Qingdao, China. pp. 3097-3100, doi: 10.1109/ICMLC.2010.5580723.
[5] X. Wang, X. Chang. (2014) Discussion on computer vision inspection technology. Journal of Digital Technology and Application, 2014(07): 196.
[6] J. Suriya Prakash, K. Annamalai Vignesh, C. Ashok and R. Adithyan. (2012) "Multi class Support Vector Machines classifier for machine vision application," 2012 International Conference on Machine Vision and Image Processing (MVIP). Coimbatore, India. pp. 197-199.
[7] W. Liu. (2013) Design of a machine vision system based on smart cameras. Journal of Chongqing Technology and Business University (Natural Science Edition), 2013(11): 66-69.
[8] K. Jin. (2019) Computer image recognition technology application and detailed problem analysis[J]. Journal of China New Telecommunications, 21(07): 100.
[9] W. Wu, J. Xie, G. Chen, H. Lin, L. Kong and C. Zhang. (2016) "Visualization automatic programming system of bending machine based on machine vision," 2016 IEEE International Conference on Information and Automation (ICIA). Ningbo, China. pp. 631-636, doi: 10.1109/ICInfA.2016.7831897.
[10] X. Wang, X. Chang. (2014) Discussion on computer vision inspection technology. Journal of Digital Technology and Application, 2014(07): 196.
[11] D. Fernández-López, R. Cabido, A. Sierra-Alonso, A.S. Montemayor, J.J. Pantrigo. (2014) A knowledge-based component library for high-level computer vision tasks. Journal of Knowledge-Based Systems, 70: 407-419.