THE APPLICATION OF COMPUTER VISION TO BUILD A PROGRAM FOR DETECTING STAINS ON BANKNOTES

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***Abtract*:** In recent years, the term Computer Vision has become very familiar and has been applied in many areas of social life such as detecting production errors, predicting natural disasters, monitoring traffic violations, etc. However, in the field of identifying anomalies on banknotes, there are not many sources of implementation. Stains on banknotes are a practical issue in cash management and can cause errors in the process of counting money or reduce the reliability of automated money counting machines. In this article, we present the results of banknote stain recognition using C++ programming language along with the OpenCV library..

Keywords: OpenCV, C++, Computer Vision, Paper money process

I. Introduction

Paper money is a common means of payment in daily financial transactions. However, during usage and storage, paper money can be contaminated or stained, which reduces its aesthetic appeal and affects its usability. Therefore, the identification and removal of stains on banknotes is an important issue in automated cash management systems, banks, convenience stores, or organizations managing

important documents. The goal of this research is to develop a stain recognition method for banknotes using C++ programming language and the OpenCV library, achieving high accuracy and fast processing time. The proposed method also contributes to enhancing the ability to identify and remove stains on paper money in real-world applications, while reducing the resources and effort needed to deploy this technology in practice.

II. Related works

In "Currency Recognition System for Visually Impaired People Using CNN with Multilevel Classifiers" - Tiwari, S., Pandey, S., Ramesh, K. (2019)[1] proposed a CNN-based currency recognition system that utilizes multilevel classifiers to achieve better accuracy and robustness. The authors review previous research in currency recognition, highlighting limitations of existing methods and the need for improved accuracy and robustness, especially for visually impaired users.

In addition, "Automatic banknote recognition using SIFT and SURF features" - Mohapatra, S., Patra, M.R. (2019)[2]: This paper introduces an automatic money identification method using SIFT and SURF features, implemented in C++ and OpenCV. The proposed method achieves good identification results on different coins and is resistant to automated coin counterfeiting techniques.

III. Proposed approach

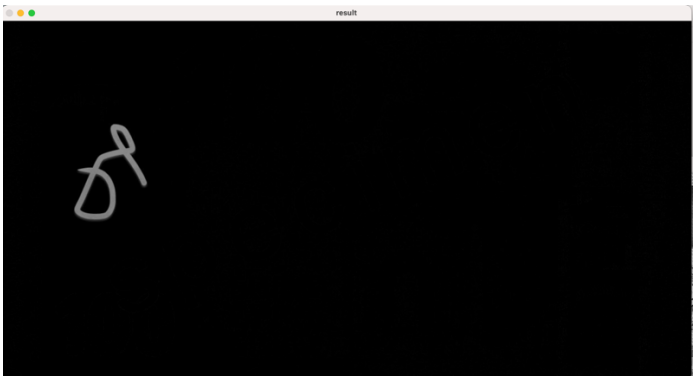
1. Detect on normal banknote

The idea in this part is very basic. We only subtract pixel between two images. This technique requires one sample image which is a clear banknote. The mask is created by subtracting two image and it is difference point between two banknotes. The resulting difference image will contain positive and negative values, where positive values indicate areas where the pixel values in the second image are greater than the

pixel values in the first image, and negative values indicate areas where the pixel values in the first image are greater than the pixel values in the second image. You can threshold the difference image to obtain a binary mask that highlights the areas with significant differences.

Picture 1.1: The normal money

Picture 1.2: The banknote contains stain



Picture 1.3: The stain is detected

2. Detect the stain on two different brightness banknote images.

In fact, photos taken under different conditions will produce different brightness on each photo. The idea to detect differences between two images with different brightness levels can be implemented as follows:

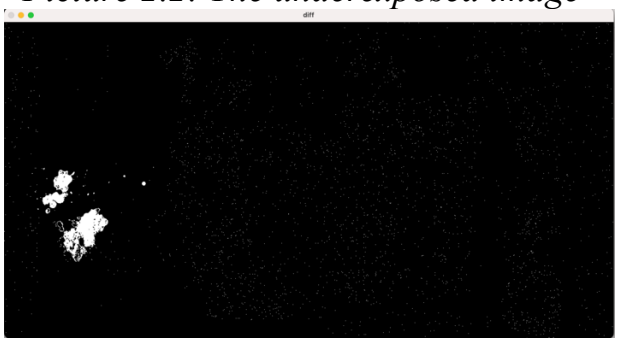
Before subtract two images, darker photo will be normalized brightness by Scale Histogram method. ScaleHistogram was implemented by passing the scale parameter as the ratio of the maximum pixel value of normal image divided by the maximum pixel value of danker image.

Brightening before subtracting two images for each other also has a small disadvantage. If the brightness is not dynamically adjusted between the two images, the bright and dark areas will have the same degree of difference in the process of subtracting the two images, which means that more noise and small differences may be detected. However, if the brightness is adjusted before subtracting the two images, it may reduce the impact of brightness differences between the two images, thereby increasing the ability to detect actual differences.

Picture 2.1: The normal banknote

Picture 2.2: The underexposed image

Picture 2.3: The stains was highlighted



Picture 2.4: The stains were detected

3. Detect the stain with the image of the banknote contains noise.

In real-world conditions, paper currency images can have various errors, such as noise. We proposed a Gaussian filtering method to reduce noise before detecting stains on the banknote by subtracting two images.

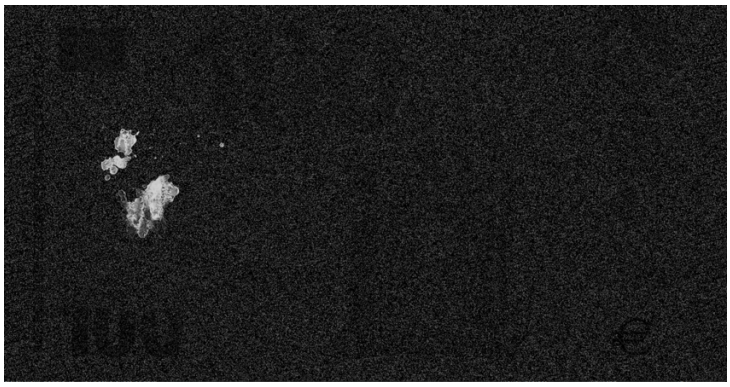
In the frequency domain, Gaussian filter reduces the high-frequency components in an image, or in other words, it acts as a high-pass filter (retaining only the low-frequency components). Mathematically, applying Gaussian Blur to an image is equivalent to convolving the image with a Gaussian function. Visually, it is like applying a translucent blurry layer over the image. It is different from cases where

the image is blurred due to out of focus lens or shadows of objects under regular lighting. Gaussian blur can help reduce noise and unwanted level of details in an image.

There are a few potential limitations of using Gaussian filtering followed by image subtraction to detect differences. Gaussian filtering can blur an image and result in the loss of fine details, which may be important for detecting subtle differences between two images. This can lead to a decrease in the accuracy of the difference detection process, particularly if the differences are small or intricate.

Picture 3.1: The noise banknote

Picture 3.2: Banknote after gaussian filter



Picture 3.3: The stain were detected

4. Detect the stain between two images in opposite direction.

In addition to the disadvantages of lighting, detecting stains on banknotes also faces difficulties in cases where the orientation of the banknote is not consistent. The above issue can be solved by using the method of selecting the reference coordinates of the original image and the rotation angle of the original banknote, and then

aligning the rotated banknote to the same coordinate values. The process can be carried out as follows:

Choose 2 arbitrary points on the banknote before and after rotation: This can be done by selecting 2 points on the banknote, the first point being the point before rotation, and the second point being the point after rotation. These points should be easy to determine, such as the 2 corners of the banknote.

Use the formula to calculate the rotation angle: Use the formula

$$\alpha = \arctan\left(\frac{x}{y}\right)$$

where α is the rotation angle of the image

y is the deviation along the y-axis

x is the deviation along the x-axis

This formula helps calculate the rotation angle needed to bring the banknote back to its original position.

Bring the rotated point back to the original position: After calculating the rotation angle α, we can apply the reverse rotation to bring the point on the banknote after rotation back to its original position. This process helps synchronize the orientation of the banknote in the two images before performing the subtraction.

This method helps synchronize the orientation of the banknote with a rotated angle before performing the subtraction, thereby improving the accuracy of the difference detection process. However, it is important to note that the selection of reference points and the calculation of the rotation angle should be done accurately to ensure the correctness of the results.

Picture 4.1: Normal banknote

Picture 4.2: Banknote different rotate

IV. RESULTS AND REVIEWS

In general, all cases have been resolved. However, the results are not entirely accurate. In cases where the images contain noise and different orientations, further development is needed for optimization. Most of the test samples were able to detect the dirt on the banknote.

V. CONCLUSION

In this paper, a simple banknote stain identification system has been proposed. The proposed system starts with capturing still images. Simple image processing techniques such as thresholding, noise removal, histogram equalization, and segmentation are used. This will be a premise for the development of applications serving cash handling in vending machines, money counting machines, etc.

VI. REFERENCE

1 *"Currency Recognition System for Visually Impaired People Using CNN with Multilevel Classifiers"* - Tiwari, S., Pandey, S., Ramesh, K. (2019)

2 *"Automatic banknote recognition using SIFT and SURF features"* - Mohapatra, S., Patra, M.R. (2019)