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Detection of counterfeit banknotes using multispectral images

Sangwook Baek [a], Euison Choi [b], Yoonkil Baek [b], Chulhee Lee [a,*]

[a] Dept. of Electrical and Electronic Engineering, Yonsei Univ., 134 Shinchon-Dong, Seodaemun-Gu, Seoul, Republic of Korea
[b] Advanced Development, R&D Nautilus Hyosung Inc., Seoul, Republic of Korea

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In this paper, we propose counterfeit banknote detection algorithms using low resolution multispectral images. It has become increasingly difficult to detect professionally produced counterfeit banknotes, so more sophisticated features have had to be implemented in banknotes. However, sensors that are capable of reading these counter-fake features are rather expensive. On the other hand, multispectral images can be used to tackle the counterfeit banknote problem. Recently, multispectral sensors have been developed for ATM applications. We developed efficient counterfeit banknote detection algorithms and the proposed algorithms were tested using 20 different denominations of European Euro (EUR), Indian rupee (INR), and US Dollars (USD). The experimental results show that the proposed methods provided 99.8% classification accuracy for genuine banknotes and 100% detection accuracy for counterfeit banknotes.

1. Introduction

As financial transactions have greatly increased between countries, a large amount of cash transactions are conducted through automated systems. Financial automation systems are widely used in many applications such as automated teller machines (ATM). It is vitally important for these machines to be able to detect counterfeit banknotes. With global economic integration and expanding international trade, there is an increasing need for counterfeit banknote detection. Furthermore, with advanced image capture and reproduction systems, it is now possible to relatively easily produce sophisticated fake banknotes.

On the other hand, algorithm complexity is also an important factor in ATM systems. Typical ATMs perform a variety of functions, which include banknote classification, fitness determination, fake banknote detection, etc. Due to the limited computing power of ATMs, the complexity of the counterfeit banknote detection algorithms must be kept to a minimum.

In this paper, we propose counterfeit banknote detection algorithms for low resolution multispectral images with a resolution of 50 dots per inch (DPI). The image sensor produces RGB images of the front and back sides, and IR (infrared) images at three different frequencies.

There has been previous research into counterfeit banknote detection using multispectral images [1–3]. Compared to single channel inspection, multispectral imaging has advantages over the detection capabilities of machine vision [1]. In [2], the authors divided a banknote into a number of blocks and extracted the features from the blocks using the Bhattacharyya distance and correlation coefficients. Then, linear and quadratic classifiers were used for counterfeit banknote detection. In [3], the authors used multispectral imaging of polymer banknotes to build spectral libraries using pushbroom hyperspectral imaging systems. Then, principal component analysis was used for dimension reduction.

Several other methods for counterfeit banknote detection have been employed, such as holograms (watermark), magnetic ink, security thread, etc. [4]. To use these kinds of anti-fake banknote methods, ATMs need special sensors. Also, several techniques have been proposed to detect fake banknotes using ultraviolet (UV) channels. Fluorescence detectors for UV channels have been employed for counterfeit banknote detection [5]. Because few features are available except for security threads in the case of the dollar, UV fluorescence features may not efficiently detect counterfeit banknotes. In addition, the UV method requires rather expensive fluorescence light-emitting diodes (LED).

Several authors have proposed counterfeit banknote detection algorithms. The support vector machine (SVM) approach was used to detect counterfeit banknotes [6,7]. In [6], spectral analyses were applied to banknote images for feature extraction and SVM was used for classification. In [7], a banknote was divided into

* Corresponding author.
E-mail addresses: bsw123@yonsei.ac.kr (S. Baek), eschoi@hyosung.com (E. Choi), yoonkil.baek@hyosung.com (Y. Baek), chulhee@yonsei.ac.kr (C. Lee).

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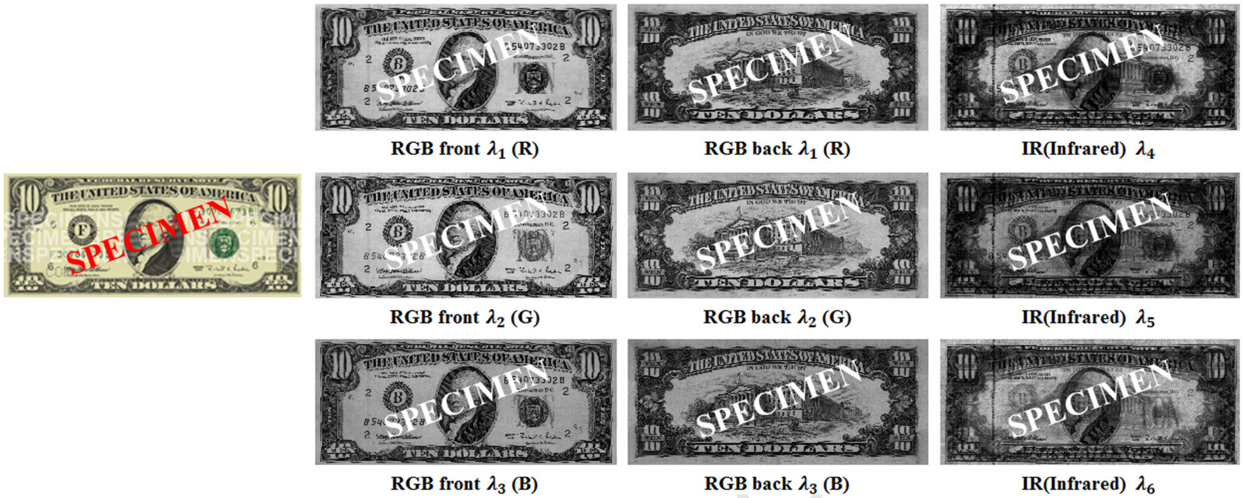

Fig. 1. Example of USD $10 banknote (issued in 1990).

Fig. 2. Four different directions of banknote images: (a) front-bottom (FB), (b) front-top (FT), (c) back-bottom (BB), (d) back-top (BT).

partitions and the luminance histograms of the partitions were used as the input features of a multi-kernel SVM system.

Stochastic algorithms such as genetic algorithms (GA) also have been used for counterfeit banknote detection. In [8], the authors used one-class classifiers for counterfeit banknote detection. Each banknote was divided into $m \times n$ partitions. An individual classifier was designed for each partition and then the classification results were combined to make the final decision. Neural network (NN) algorithms have also been used in currency validation [9–13]. In [9–12], NN algorithms were used to verify banknotes. In [13], a mask optimization technique using GA and NN algorithms was proposed.

Similarity measurement has also been used to detect counterfeit banknotes. In [14], several specific regions were selected and divided into $m \times n$ partitions. Then, the fuzzy Hamming distance was used as a similarity measurement. Also, texture information was used to produce feature vectors from the banknote images. In [15], the texture roughness parameters obtained from illumination transmission images were used for counterfeit banknote detection.

Several authors have studied counterfeit banknote detection using optical inspection. In [16], the authors acquired banknote images with a near-infrared camera and this prototype system was implemented by both hardware and software modules. In [17], a counterfeit banknote detection procedure based on the analysis of several areas of euro banknotes using microscopic ATR-infrared spectroscopy was proposed.

In this paper, multispectral images obtained by recently developed ATM sensors are used to detect counterfeit banknotes. The multispectral images include RGB images and three IR images. The rest of this paper is organized as follows: Section 2 describes the data acquisition. Section 3 provides the proposed classification algorithm for counterfeit banknote detection. In Section 4, experimental results are provided along with analyses and concluding remarks are drawn in Section 5.

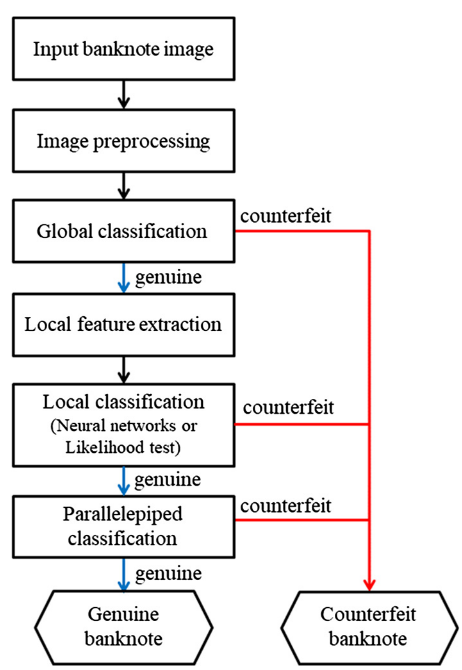

Fig. 3. Flow chart of the proposed method.

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