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An intelligent paper currency recognition system

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Abstract

Paper currency recognition (PCR) is an important area of pattern recognition. A system for the recognition of paper currency is one kind of intelligent system which is a very important need of the current automation systems in the modern world of today. It has various potential applications including electronic banking, currency monitoring systems, money exchange machines, etc. This paper proposes an automatic paper currency recognition system for paper currency. A method of recognizing paper currencies has been introduced. This is based on interesting features and correlation between images. It uses Radial Basis Function Network for classification. The method uses the case of Saudi Arabian paper currency as a model. The method is quite reasonable in terms of accuracy. The system deals with 110 images, 10 of which are tilted with an angle less than 15°. The rest of the currency images consist of mixed including noisy and normal images 50 each. It uses fourth series (1984–2007) of currency issued by Saudi Arabian Monetary Agency (SAMA) as a model currency under consideration. The system produces accuracy of recognition as 95.37%, 91.65%, and 87.5%, for the Normal Non-Tilted Images, Noisy Non-Tilted Images, and Tilted Images respectively. The overall Average Recognition Rate for the data of 110 images is computed as 91.51%. The proposed algorithm is fully automatic and requires no human intervention. The proposed technique produces quite satisfactory results in terms of recognition and efficiency.

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1. Introduction

Object recognition¹⁻⁷ is an important and highly demanded area of pattern recognition. An object can be anything in real life. It can be text in a document, a license plate of a vehicle, an iris in a person's eyes, a sign in a sign language, a face of a person, and so on. Similarly, paper currency recognition^{8-15,17-20} is as important as any other object recognition.

Some authors, in the recent years, have contributed to the subject of paper currency recognition systems. For brevity, the reader is referred to⁹⁻¹⁵. These existing paper currency recognition methods, in the literature, mainly involve image processing and/or neural network techniques¹¹⁻¹⁵.

This paper deals with a simple, efficient and very accurate approach in the system design. In designing such a system, it considers different dimensions, areas, Euler numbers, correlations as features. A different method using radial basis Function networks, is utilized for developing an intelligent system which can recognize paper currency. This research is specifically designed for recognizing paper currency from the Kingdom of Saudi Arabia (KSA). It uses fourth series (1984–2007) of currency issued by Saudi Arabian Monetary Agency (SAMA)¹⁸ as a model currency under consideration. The proposed paper recognition technique has been designed in such a way that it can be used for recognizing paper currency form different values in KSA. To overcome the problem of recognizing dirty banknotes, the pre-processing stage is also considered.

The proposed scheme is different from various existing methods¹⁻²¹ because of its approaches in the recognition phases. Specifically, for example, symmetrical masks have been used in¹¹ for considering specific signs (images) in a paper currency. Using this method, the summation of non-masked pixel values in each banknote is computed and fed to a Neural Network (NN). The technique in²⁰ deals with Pakistani paper currency with very different feature set which is specific to regional currency marks and color of the currency. Similarly, the technique introduced in²¹ is different from the proposed technique as it introduces much more number of features than the ones introduced in the proposed method.

The organization of the paper is as follows. Section 2 introduces the overall mechanism for PCR, In Section 3, the pre-processing steps are briefly introduced. Section 4 describes the problem formulation for the Saudi PCR System (SPCRS). The proposed PCR approach, together with feature extraction method as well as classification has been completely discussed in Section 5. Section 6 describes details of demonstration for the case of KSA Paper Currency. Finally, Section 7 concludes the paper.

2. Structure of Typical PCR System

The system presented is designed to recognize paper currency. Input to the system is an image acquired by a scanner or a digital camera, containing the paper currency and its output is the features of the paper currency. The system consists of the modules: Image acquisition, pre-processing including noise removal, feature extraction, classification and recognition. The structure of the system is shown in **Fig. 1**.

3. Pre-processing

In the proposed system a high resolution scanner is used to acquire the image. The acquired image of a paper currency is first converted to gray scaled image. Conversion to gray scale facilitates further pre-processing. The task of pre-processing is achieved by converting colored currency images into grayscale, then black-white images. After that, the edge of the image is filtered using Prewitt method. Then, the image edge is detected using Canny's edge detection method. Different stages of an image are shown in **Fig. 2**.

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