Statement

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Computer Engineering.

The work included in this thesis was carried out by the author at the Computer and Systems Engineering Department, Faculty of Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or qualification at other university or institution.

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ABSTACT

Automatic Coin Classification

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We present an automatic coin classifier. It is a multi-stage system that depends mainly on visual features. Our multistage system starts out by segmentation of coins using circular Hough Transform, followed by features extraction phase through two complementary cues, and finally classification phase by two different classification techniques, the first is simple nearest neighbor measure and the second is a neural network. Our feature extraction process relies on rotation invariant edge orientation followed by a multi-resolution image processing technique; i.e. Gabor wavelet convolution. We related the wavelet kernel to some mean of texture measurement that depends on entropy computing to relate the kernel size with density of textures in our circular coins. Testing on the publicly available portion of a benchmark European coins database, we can correctly classify 93.5% and 98% of the coins using single face and double faces images

respectively. We also show that our correct classification rate can reach 99.8% when adding the coin thickness measurement (which is available for this database). We also tested the system on our own database of Arabic coins, the system correctly classify 92% of the coins using single face images and a simple nearest neighbor measure in the classification phase. Using the Hamming Competitive neural network in the classification phase on the Arabic database improves the system performance to 95.8%.

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Chapter 1: Introduction

1.1 Introduction

The domain of coin classification has an important role in many fields nowadays. It is important in charity organizations, cultural heritage domain and financial institutions. It is used in sorting heterogeneous coin collections (modern and historical) automatically, and for building automatic cash machines and currency counters, and for saving our authentic Arabic currencies associated with historical events. In order to automate monetary transactions, it is necessary to enable computers to perform such recognition as well. Many systems were built over the last years serving this field, depending on visual features in addition to other sensor measurements like radius, thickness and weight. Since 2006, a competition is organized annually, with a prize sponsored by the Muscle Network of Excellence to find the best automated coin classification algorithm to deal with large volumes of mixed coin collections. The training and test images for the competition are from the Coin Images Seibersdorf (CIS) database[7]. This database was created as a result of the changeover from twelve European currencies to the Euro, when large volumes of mixed coin collections collected by charitable organizations had to be returned properly sorted to the national banks of the originating countries. In Austria alone, which is a medium sized country (by European standards) with a population of 8 million [1], the charitable donations amounted to several hundred tons of cash. The large volume of coins rules out any attempt to separate the money manually and calls for an automatic processing device.

1.2 Problem Discussion

Existing coin sorting machines usually work with only one currency at the time, but for nowadays applications two to three thousand different coin faces have to be recognized. Many systems were built over the last years serving this field, but most of the systems depend on visual features in addition to other sensor measurements like radius, thickness, etc., and all the previous systems were tested on western coins either European or American. The problem is that we need a system that works effectively in case there is lack of sensor measurements, a recognition system that depends basically on visual features; also we found that none of the systems were tested on any Arabic database. We propose a new approach serving this field. Our approach depends basically on visual features, trying to achieve the same goal. Our goal was the recognition of large set of coins with high success rate without the supply of any sensors measurement. For the first time we collect a large set of Arabic coins. Our Arabic database is a combination of recently used ones and some of the ancient and rare historical ones. We configured the first electronic Arabic database and tested our system on it

1.3 Approach

Our proposed system is composed of three main phases; segmentation phase followed by the feature extraction phase and passing finally through the classification phase. We tested the system on two different databases; one is the publically available part of the European database [7], and the second is our Arabic database. We present an automatic coin classifier mainly depending on visual features. It is a multistage system that starts out by segmentation using circular Hough Transform, features extraction by two complementary cues and finally classification phase. We implemented more than one classification algorithm, finding that the most effective one based on applying a defined voting function in the first phase and finally building a hamming competitive neural network in the second feature extraction phase. Our features extraction process relies on rotation invariant edge orientation followed by Gabor wavelet convolution. We related the wavelet kernel to some mean of texture measurement. Testing on the publicly available portion of a benchmark European coins database, we can correctly classify 93.5% and 98% of the coins using single face and double faces images respectively. We also show that our correct classification rate can reach 99.8% when adding the sensor measurement of coin thickness (which is available for this database). We also tested the system on our own database of Arabic coins, the system correctly classify 95.8% of the coins using single face images.

1.4 Thesis Organization

In chapter one there is an introduction to the thesis and our problem definition, and then there is an overview over our proposed approach, and how the thesis is organized.

Chapter two summarizes our literature survey; this chapter starts with an overview over the previous work, and then a description of all the previous coin classification systems.