Cash Currencies Recognition Using k-Nearest Neighbor Classifier

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Abstract

The appearance of the currency is part of this development and it is affected directly, where there is exploited in incorrect form by copying the currency in a manner similar to the reality. Therefore, it became necessary to implement a proposal for being a suitable as solution not inconsistent with the different cultures, time and place, to reduce the risk of problem that represented in distinguish between real and fake currency. This clear through add the watermarks inside currency, which is difficult to be copied. At the same time, this watermarks may be visible to the naked eye so can easily inferred or it is invisible. However the high resolution imaging devices can copy these additions.

In this research, we have proposed a system to distinguish the currencies by the program that working a submission inferred to the watermark by feature extraction determined the type of currency and its reality. In addition to, the algorithm (k-NN) determined category of the currency. Benefit of it, is reducing as much as possible the spread of counterfeit currency and this system can be used by any user wants to make sure of the currency reality. The proposed model applied on 100 banknote, the success rate was 91% and the failure rate was 9%.

Keywords:

K- Nearest Neighbor**,** Image Processing, Kuwaiti Currency, Watermark, and Classifier.

1. Introduction

At present the Currency denomination recognition is becomes dynamic topic for researchers in different potential applications. Financial exchange is an essential piece of our everyday activities. They are not ready to adequately recognize different denominations and are frequently betrayed by other individuals. Hence a reliable currency recognition system could be utilized as a part of any division wherever money related exchange is of concern. Accordingly, there is a vigorous need to outline a framework that is useful in recognition of paper money notes accurately. Currency denomination detection is an immeasurable area of exploration and huge advancement had been accomplished through the years.

Jain and Vijay [9] , they used Image processing Technique to extract currency Denomination. The extracted ROI can be used with pattern Recognition and Neural Network matching technique. This recognition method used denomination numerals which can be extracted easily from paper currency.

In many practical problems such as visual recognition, microarray analysis and text classification, quantity number of features are extracted but not all of them are really discriminative, therefore the pattern recognition of images is challenging work in digital image processing [1]. Thus, we tried to make the main goal of this research is to discriminate between different paper cash currencies after being sure that is an original one by using one of the different technique for currency recognition that involve texture, pattern, color based and checking the paper watermark.

Feature extraction is holding procedure considerably for currency recognition, which effects on design and performance of the classifier direct. It can easily construct a classifier with good recognition performance when the features are so large. Otherwise, it is difficult to get it. There are three characteristics used to distinguish between different banknote denominations, these are the following [2]:-

- Size: - this point is important issue; the edges of banknotes are usually worn and torn because of circulations.
- Color: - the people used more than one color for distinguishing between different paper currencies, because there are alternative colors in each paper currency.
- Texture:- the size and color of some banknotes are very close to each other in different countries, thus the researcher used the texture in addition to other characteristics for distinguish between different banknotes.

The essential task of feature extraction is how to find the correspondingly effective features out of many features [3]. The feature types are:

- Structural features: It describes geometrical and topological characteristics by representing its global and local properties.
- Statistical features: it derives through the statistical distribution of pixels and describes the characteristic measurements.
- Global transformation: it transforms the pixel representation to a more compact, for reduces the dimensionality of the feature vector and provides feature fixed to like translation, dilation, rotation and so on.

The digital image watermarking considered one of the important techniques in image processing and pattern recognition, the benefit used of the watermarks is to prevent people from being able to make fake copies, and check if the banknote or document is authentic or not.

2. Classification Algorithm

The classification algorithm is one of the different types algorithm used in pattern recognition, therefore it is a very important research area especially in pattern recognition field. Classification of objects is the procedure for sorting pixels and assigning them to specific categories. Among several kinds of classification methods, k-Nearest Neighbor (k-NN) is one of the most popular algorithms because of its absence of training and implementation simplicity [4]. The classification is using a matter locating of the nearest neighbor in instance space that labeling unknown with the same class label as that of the located (known) neighbor. This approach is often referred to as a nearest neighbor classifier.

3. Kuwaiti Currency (KC)

We will take KC as an example and determine the soft money (Paper money) currency to identify properties that contain the currency. The Kuwaiti dinars have six printed editions till now. The first series was issued following the pronouncement of the K C law in 1960 which established the KC Board. This series was in circulation from 1 April 1961, the banknotes are contained six categories of ¼, ½, 1, 5, 10, 20 dinars with dimensions [5] as shown in Table 1.

Table 1 Kuwaiti Currency

Category	Size	Latent image	Image
¼ Dinar	**111mm x 68 mm**	**A chest.**	
½ Dinar	**121mm x 68 mm**	**A coffee pot.**	
1 Dinar	**131mm x 68 mm**	**An old lamp.**	
5 Dinar	**141mm x 68 mm**	**A Circular grinding stone.**	
10 Dinar	**151mm x 68 mm**	**An old storage jar**	
20 Dinar	**161mm x 68 mm**	**An old cannon**	

The focus on the latent image came from that the software use it as a major minor feature used to recognize the category of the KC. The KC has six categories which has a much close colors. When depend on color factor only, this case may be a failure. So must depending on another factor such as ratio of width/height, all Kuwaiti currencies have an aspect ratio of exact range then any currency paper out of this range is not a Kuwaiti one [6].Each KC has a special draw in the same place of the paper, latent image, so it can be the depending region to find the texture feature after calculating the edges which will give a feedback about the shape of draw through which the category of the currency can be determined. It's important to notice that each dedicated feature defines the internal feature which recognizes every KC category than the other categories. And the use of all these features together will recognize KC than the other currencies and define the external feature.

2. The Proposed Solution

This paper focused on dealing with the currency as one of the problems of image processing, and chose the Kuwaiti currency for application testing to prove the required results from the proposed method as the following:-

A- The suggested application calculated the real dimensions for currency and saved it for comparison in the next stages with use of k-NN algorithm, then used filters to see the colors through selecting the intensity of illumination. This point is useful to know the type of currency and class.
B- The picture is taken from the front of the currency and it can be watched the back of the currency at the same time. Which we watch the line from top to bottom and hidden printed falcon head that is suited at the left of the line in the middle of the first quarter of the currency. That is represented the watermark will help to know whether or not the valid currency and benefit used of the watermarks is prevented people from being able to make fake copies to be confident that the banknote authentic .

The used method in this paper can help in finding the valid currency or not, what the class and to whom it returnees at the same time. Benefits of this program will save on the cost of most people that are not able to finish off buying high-cost addition to the ease of use of the program, as shown in Figure 1.

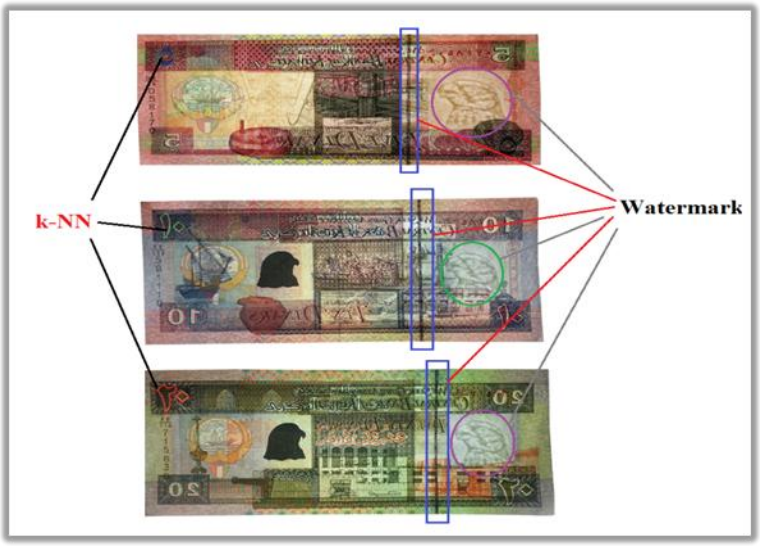

Figure 1. Original Currency

3. The proposed model

The proposed model is contained in two procedures:

- Initial value procedure.
- Testing value procedure.

Each procedure includes a number of algorithms, as shown in Figure 2.

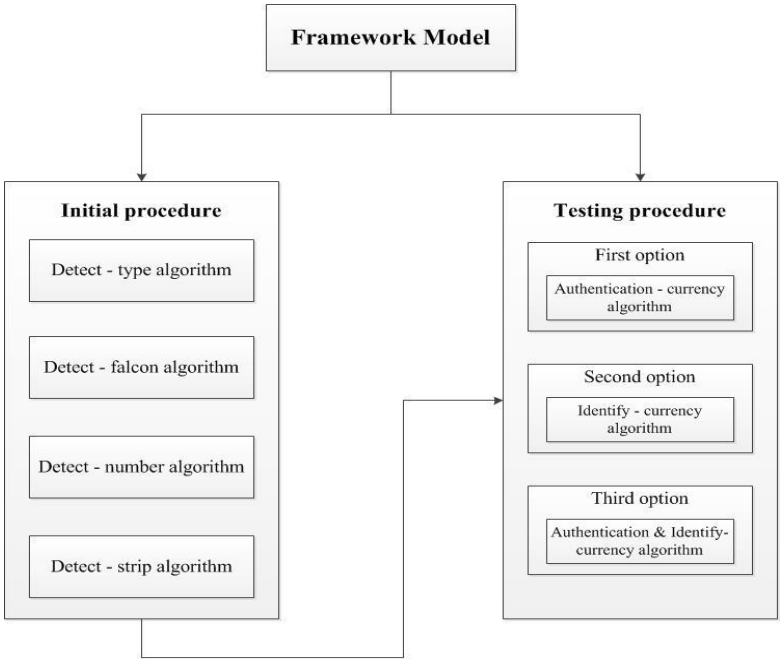

Figure 2… The Framework Model

3.1 Initial value procedure

This procedure is considered the basic in the proposed model. It is applied on the types of Kuwaiti currency (1/4, 1/2, 1, 5, 10, 20), and using it in the next procedure for comparison. Depending on the comparison can determine if the currency is correct or not, type and class of each currency. The first step in this procedure is scanning for all Kuwaiti currency by special hardware, and then applied several algorithms on all currencies to store the results of the following in system database.

1. Detected Type: Currency has similar colors but the different colors are varying degree of the terms are of clarity, intensity and lighting, so they preferred to rely on the HSL model.
2. Detected Falcon: It is applied for making group of the currency enhancement, the benefit of this point is falcon extraction of each currency.
3. Detected Number: It is making the morphology and filter, the benefit of this point is value number extraction of each currency, this step used susan filter which means that it preserves image structure by only smoothing over those neighbors which form part of the same region as the central pixel. The SUSAN filter works by taking an average over all of the pixels in the locality.
4. Detected Strip: It is making group of the currency enhancement, benefit of this point is strip (line) extraction of each currency, and this step used convolution filter, it is simple mathematical operation which is fundamental for many common image processing filters. The filter implements convolution operator, which calculates each pixel of the result image as weighted sum of correspond pixel and its neighbors in the source image.

All the detected symbols are stored in the system, waiting to be compared with each currency according to its value and its characteristics .

3.2 Testing value procedure

This procedure is special of the user, for checking currency that entered by user. There are three options when the proposed model is applied depending on the user's choice, then the result of each option is compared with the results stored in the database based on k-NN algorithm, as shown in Figure 3.

- The first option: - it is checking the currency is real or not.
- The second option: - it is identifying type and class of the currency.
- The third option: - it includes the above options, checking the currency then identifying type and class of the currency.

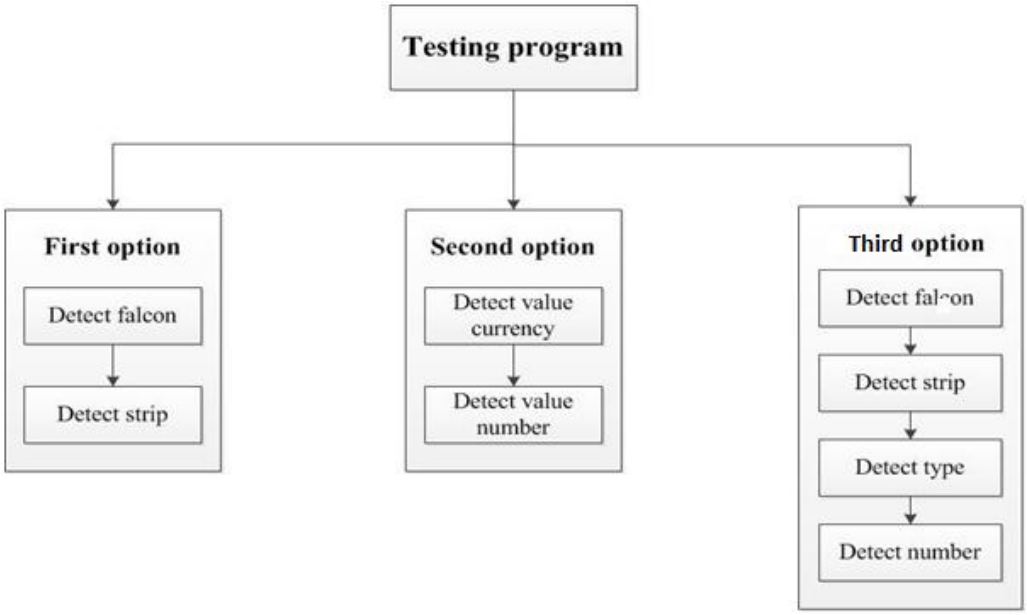

Figure 3… Testing value procedure

First option:- The first option is proved the currency authentication. When the user entered the currency desired, the model will check the originality of currency.

Algorithm: Authenticate-currency Algorithm (M,N)

// Input: currency for checking
Output: result of currency//
Step1: Begin Algorithm
Step2: M ← currency
Step3: C1← detect falcon (M)
Step4: IF C1! = original falcon then

Step5: N← the currency is Fake
Step6: Else
Step7: C2 ← detect strip (M)
Step8: IF C2! = original strip then
Step9: N← the currency is Fake
Step10: Else
Step11: N← the currency is original
Step12: End IF
Step13: End IF
Step14: Return (N)
Step15: End Algorithm

Second option:- The second option is to prove the currency identification. When the user entered the desired currency, the model will check the type and class of currency.

Algorithm: Identify-currency Algorithm (M,N)

// Input: currency for checking
Output: result of currency//
Step1: Begin Algorithm
Step2: M ← currency
Step3: C1← detect type (M)
Step4: IF C1== currency type in DB then
Step5: C11← determine currency depending on type
Step6: End IF
Step7: C2← detect number (M)
Step8: IF C2== currency number in DB then
Step9: C22← determine currency depending on number
Step10: End IF
Step11: IF C11== C22 then
Step12: N← identify currency
Step13: Else
Step14: N← the currency is not Real
Step15: End IF
Step16: Return (N)
Step17: End Algorithm

Third option:-The third option is to prove the currency authentication with identification. When the user entered the desired currency, the proposed model will check the currency is original or fake then the check type and class of currency, as shown in Figure 4.

Algorithm: Authenticate & Identify-currency Algorithm (M,N)

// Input: currency for checking
Output: result of currency//
Step1: Begin Algorithm
Step2: M ← currency

Step3: C1← detect falcon (M)
Step4: IF C1! = original falcon then
Step5: N← the currency is Fake
Step6: Else
Step7: C2 ← detect strip (M)
Step8: IF C2! = original strip then
Step9: N← the currency is Fake
Step10: Else
Step11: C3← detect type (M)
Step12: IF C3== currency type in DB then
Step13: C33← determine currency depending on type
Step14: End IF
Step15: C4← detect number (M)
Step16: IF C4== currency number in DB then
Step17: C44← determine currency depending on number
Step18: End IF
Step19: IF C33== C44 then
Step20: N← authenticate and identify currency
Step21: Else
Step22: N← the currency is not Real
Step23: End IF
Step24: End IF
Step25: End IF
Step26: Return (N)
Step27: End Algorithm

5. The Experimental works

In the currency systems should be focused on the accuracy factor when processing in systems. Therefore the paper currency recognition systems should be able to recognize banknotes from each side and each direction. Especially the banknotes may be defaced during circulation. The designed system should have a meaningful accuracy in detecting torn or worn banknotes. The proposed model choose the 5 dinar as example to testing the proposed model on it, when choose the 5 original dinar with all options, the main boundary of all objects in the currency will appear, and saved them in the database, as shown in Figure 4.

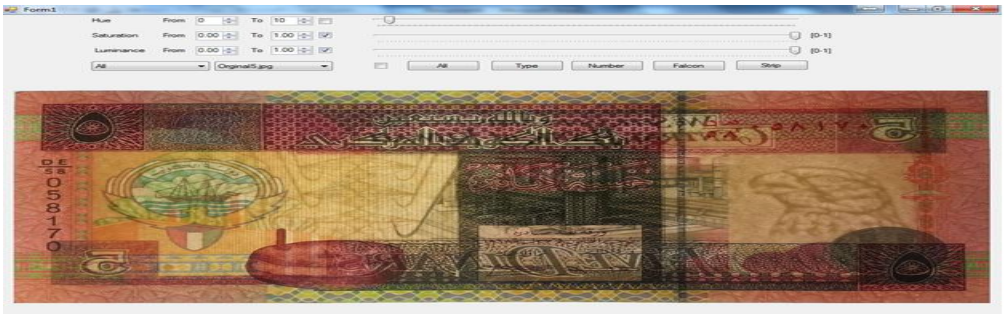

Figure 4 Detect All of 5 Original Dinars

When choose the 5 original dinars with falcon, the main boundary of falcon object in the currency will appear, and saved it in the database, as shown in Figure 5.

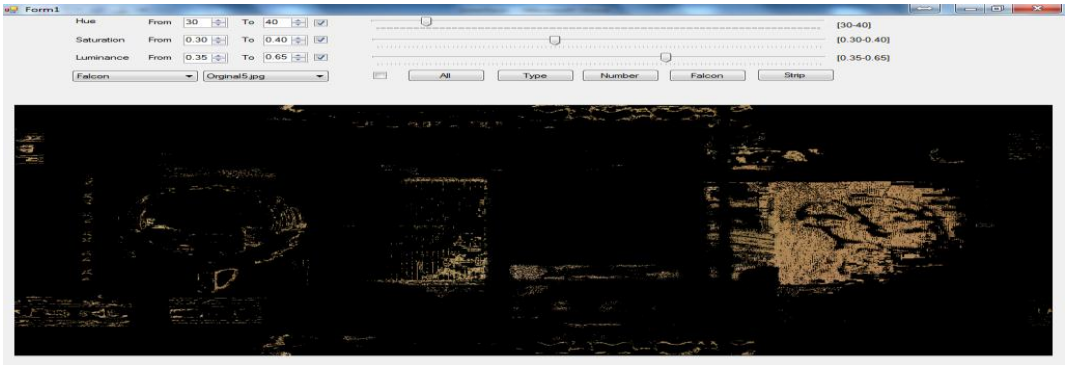

Figure 5 Detect Falcon of 5 Original Dinars

All the fake currency will be discovered when it compared with the original currency that stored in the database.

When the user entered the fake currency in the application, the system will refuse it as shown in Figure 6.

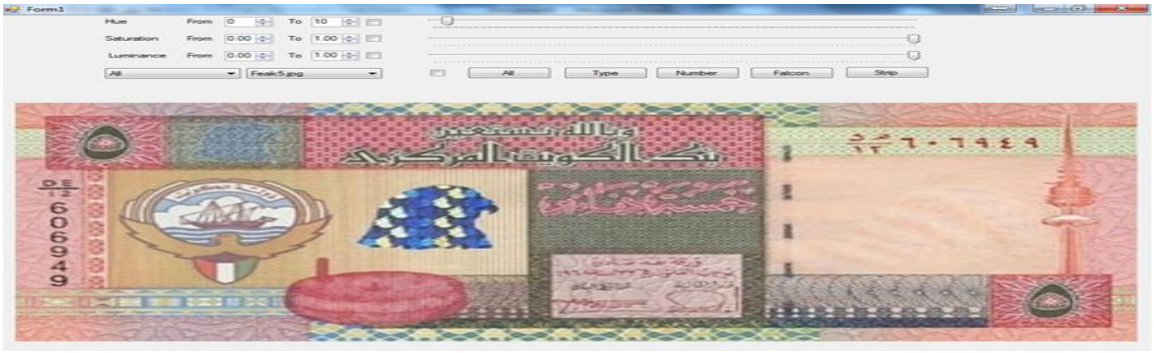

Figure 6 Fake Dinars

When the user entered non-Kuwaiti currency, for example, the one dinar of Jordanian currency, the system will refuse it as shown in Figure 7.

Figure 7 Jordanian Currency

6. Results and Discussion

The proposed model captures the images by hardware especially. The work of this model is similar to the scanner, where the currency placed horizontally on a table that is opened in the middle, and the highlight currency from the bottom for appearing all the objects of the paper currency. This device is not expensive and used to get more accurate results for testing, In addition, it is can recognize the banknote from each side or any size. The model is choosing the Kuwaiti currency as a major example for testing the model, and choosing some currencies from other countries. The performance results of applying the proposed methods on 100 banknote of Kuwait country and from other countries indicate that the technique has 91% accuracy, as shown in Table 2.

Table 2 the performance results

Category	Number of Currency Tested	Number of Successful Cases	Number of Failures Cases
¼ Dinar / original	8	6	2
½ Dinar / original	8	8	0
1 Dinar / original	14	11	3
5 Dinar / original	14	12	2
10 Dinar / original	18	17	1
20 Dinar / original	18	17	1
Fake currencies	10	10	0
Other currencies	10	10	0

The failure is rated that happening in the system, which was 9%, was caused by the currency is using old or shredded from each sides, so may be missing some of the features. Another reason the currency is very dirty thus it is affecting on the currency objects. Many of the researchers submitted different methods in the currency checked field, checking as an important field in pattern recognition and image processing.

In this paper, the general concepts explained about pattern recognition and image processing. Then focused on the main problem of check currency is fake or original, with determine the type and class of each currency. At the end, the model is summarized for working and suggesting some idea about the future work.

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