Yemeni Paper Currency Recognition

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Abstract.

With the great technological advances in colour printing, duplicating and scanning, counterfeit notes haves posed an increasing threat to currency markets all over the world. Yemeni Currency Recognition System (YCRS) is type Pattern Recognition technology that used to identify Paper Currency of Yemeni country. Due to used currencies in day life, Automatic methods for currency recognition has been increasing. The applications of YCRS is pivotal for banking automation in many sections such as Cash counting machine and ATM machine. However, there is a rare research done towards designing and implementing recognition of Yemeni currency. The absence of such currency recognition is a big gap in Yemen. In this paper, Yemeni Currency Recognition System (YCRS) proposes for recognize all denominations of Yemeni currency notes and enhance the bank system such as counting machines by adding some currency notes.

This paper offers a technical remedial solution to this problem for all denominations using image processing and machine learning techniques.

The system structure consists of five phases: currency image brings, pre-processing, feature extraction, classification and validation.

This research done in software engineering lab, faculty of engineering and information technology, Taiz University from period Dec 2019 until March 2020. In this research, we used different methods in Image Processing such as GLCM, SURF and HSV and Machine learning such as SVM. The Accuracy of this system is very high, it was 99% with fast processing speed.

YCRS must be accurate and highly-efficient. It will be the second project taken Yemeni currency, however we are the first people used this technique.

Keywords: Yemeni currency recognition, image processing, SURF, SVM, GLCM and WED. **INTRODUCTION**

There are more than 50 currencies all over the world. The appearance of currencies is totally various. Such as, the size, color and texture of the currency are various. The bank staffs distinguished different types of currencies with high speed and accuracy. Confused recognition of Currency categories is a huge problem. Therefore, we need an

efficient and fast system to solve their problem. There are many researchers studied this kind of title but there is a rare research study Yemeni currency for recognizing Yemen currency. The Yemeni Currency Recognition System (YCRS) goal help bank staffs to recognize different currencies in the word. There are many kind of systems used in YCRS, such as cash counting Machine that helps accountant to recognize different types of papers currency in high speed [1].

YCRS is type of pattern recognition manner. Many homogeneous recognition systems, such as face recognition, currency recognition, Iris recognition and fingerprint recognition systems. However, the metrology is similar but the techniques and approaches are various. The main technique used in this system is image processing. It is the process which make the input and output are image. There are many steps apply in this technique such as image acquisition, image preprocessing, image segmentations feature extraction, classifications and validation [12].

An image acquisition is the major steps in Currency Sorting Machine which showed the source of image. For instance, Scanner, Digital Camera, etc. Scanner is the main accuracy device that used to bring input image. An image preprocessing is process which used to enhance an image after acquired it. It is applying filters to remove noises from image. Segmentation is process of segment background of currency image.

Extraction of Features is process for extracting the main statistical features from image using different algorithms such as, Speeded Up Robust features (SURF) and Gray-Level Co-Occurrence Matrix (GLCM). Classification is type of categorization, that recognized object in to main categories (Classes) using a varies techniques such as Support Vector Machines (SVM), Artificial Neural Network (ANN) and Neural Network(NN).This procedure applied after built dataset from statistical features.

The process after classification, that used to validate the input image in the nearest class located in dataset called Validation. It used different algorithms such as weighted k-nearest neighbor's algorithm (KNN) and Euclidean distance (WED) and. YCRS must be accurate and highly-efficient. The rate of confident of Manual recognition not be 100 per cent so we must create automatic system [2].

LITERATURE SURVEY

There are numerous Technologies for recognizing denominations of currency banknotes, so the technical researchers created different algorithms to recognize the different types of paper currencies in the universe. So we started to do many researches and experiments until to reach to the first work entitled of Yemeni Paper Currency Detection System [11] and published it. After that we enhanced techniques to build other part called YCRS.
We studded many old research papers according this fields such as:

1. Paper currency recognition using neural networks with high speed (1995). The study was applied to Japanese and US currency note. The System used neural network techniques with old algorithm in feature extraction such as time series data and Fourier power spectra for building datasets. The accuracy was low with old techniques [3].
2. Indian Paper Currency Recognition by LBP (2012). The research was applied to India currency note in a varies types of currency categories. The System used image processing techniques only and old algorithm such as Local Binary Pattern (LBP) without used any classification techniques [4].
3. Yemeni Mobile Counterfeit System detections used Fuzzy Logic, Support Vector Machines, and Image Processing Techniques. This study is the first studies in Yemeni Currency however it used only two old Yemeni currency denominations, (500 and, 1000). They didn't used high accuracy algorithms in classification or feature extractions. So the we tried to enhance this study in new techniques with high accuracy results [5].
4. Recognition Currency using a smartphone: Comparison between color SIFT and gray scale SIFT algorithms (2016). It examined the recognition of Saudi Arabia Currency. They study consists of four steps: smart phone camera acquisition, preprocessing, extraction of texture features and matching. The main algorithm in feature extraction is SIFT. But the accuracy was low with high processing time [6].
5. Recognition of Currency Denomination (Invariant Image-Based) using a Local Entropy and Range Filters (2019) it examined the recognition of Pakistani Currency. They study creates of some states: acquisition, preprocessing, feature extraction and recognizing. The major techniques in feature extraction called local entropy and range filters [7].

MATERIAL AND METHODS

The adopted system based on machine learning and an image processing technique. In order to make the system more thorough, we needed to create database for storing the characteristics of the currency. In this system, we take Yemeni currency as an example.

The system built by using MATLAB program and included a user-friendly interface.

The system structure consists of five phases:

1. Currency image acquisition using Scanner.
2. Currency image pre-processing, Edge Detection Segmentation.
3. Extraction of Texture and color features.
4. Classification using SVM.
5. Validation

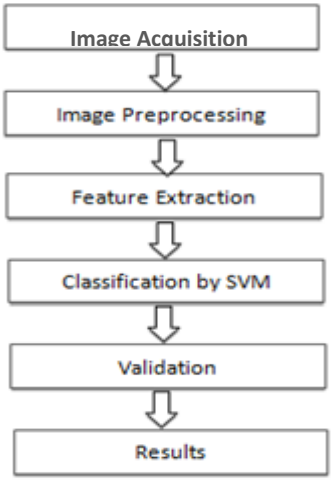

Fig. 1. Design flow of proposed methodology.

Image Acquisition

Image acquisition is a manner for acquiring an image. It converts an image into a digital form using a specific hardware such as scanner or camera. It is the first step in currency recognition. It is a very basic process because without the currency image the other processes will not follow. The source of an image is scanner with size of 128*128 and JPEG format. The goals of image acquisition process are controlled and measured guideline of an operated source input image [8].

Image Pre-processing

It is a main process that applied at an initial level of images where both input and output are intensity images. The object of this process is enhancing an image, removes background, removes unnecessary noises and enhances main visible features that are important in recognition process. The main activities in this operations are image enhancement and image restoration. This steps includes two parts:

- Image background removing and resizing.

It is a process of removes background from image Using morphological opening protocol and resizes the original image into 128×128 pixels to make process easier.

- Image smoothening (removing noise).

It is a process for removing noise from an image using many filters such as mean, average, median filters, ets. In this system, we needed to use all filter and chose the best one. We chose the median filter in Yemeni currency image because the image appearance was clear instead of other filters.

Feature Extraction

It is an operation for analyzing and extraction the depth characteristics from image

for solving Wrong recognition of Currency categories problem. We applied many types of algorithm in feature extraction such as color and texture algorithms. The color algorithms used to define and extract color from an image. The color algorithms applied in this operation is Hue Saturation Value (HSV) with 9 feature vectors are derived. The texture algorithms applied in this operations are Speeded up robust feature (SURF) and Gray Level Co-Occurrence Matrix (GLCM). In adopted system we tried to use all color and textures features.

1) GLCM algorithm

The Gray Level Co-occurrence Matrix (GLCM) method is a way of extracting second order statistical texture features. Due to their large dimensionality, GLCM is very sensitive to the size of the texture samples on which they are estimated. It is the main algorithm for extract Texture Features. It is built matrix make the number of row and column are equal such as (3*3, 4*4). Thus, the number of gray levels is often reduced. Four important features are Angular Second Moment (energy), (inertia moment), Correlation, Contrast, and homogeneity that created after applying this algorithm. For each image, 64 features vectors of GLCM are derived.

2) SURF algorithms

Speeded up robust feature (SURF) is a main technique for detecting and descripting feature in currency Image. The interest points with descriptors that created based on SUFR are scale-invariant and rotation-invariant. It is robust, fast and secure algorithm for extract texture features in currency image [15]. The targets for electing SURF algorithm as the interest point detector and descriptor are:

1) Banknote image could be taken under the surroundings of scaling change and rotation. Interest points with descriptors created by SURF are invariant to rota-tion and scaling changes.

2) The SURF computational cost is limited, with rapid interest point localization and matching.

The SURF detector based on the great performance in computational cost and accuracy called Hessian matrix. Given a point (x,y) in an image I, the Hessian matrix H (X, σ) at (x, y) with scale σ can be defined as:

$$H(X.\ \sigma) = \begin{bmatrix} Lxx(x.\ y.\ \sigma) & Lxy(x.\ y.\ \sigma) \\ Lxy(x.\ y.\ \sigma) & Lyy(x.\ y.\ \sigma) \end{bmatrix} \quad (1)$$

Where Lxx(x,y,σ) is the convolution of the second order derivative of Gaussian with image I at (x,y). This also applies to Lxy(x,y,σ) and Lyy(x,y,σ)[9]. For analysing a scale-space we use the best way called Gaussians .The Gaussians have to be cropped and discretized in real applications.

The box filters such as mean or average filter used to derivate second order Gaussian, and calculate through integral images vastly. Because of using integral images that this process is very fast. For constructing the SURF descriptor, a square patch around an interest point is extracted after the estimation of the dominant orientation. For constructing the final descriptor

vector, the square patch is divided into a 4×4 sub-blocks then gradients of each sub-block construct final vector. For each image, 64 features vectors of SURF are derived.

Classification

It is process of classifies an image into nearest class in datasets using Support Vector Machine (SVM) [17]. SVM is a best technique for data classification. SVM is the type of Supervised Learning. A classification process usually associates with training and testing data. Each dataset contains the training set vectors with target set vectors. The aim of SVM is to efficiently deal with a two or more than two classes classification problem. In the adapted system we used SVM with four target classes. The main advantages of SVM is solving the problems of image classification are:

(1) Capacity to work with huge dimensional data

(2) The generalization performance is high without need to add a prior knowledge, even when the dimension of the input space is very high. SVM is correctly classifies data points by separating the points of two classes as much as possible so that SVMs is an optimal hyper plane that [10].

Validation

1) Weighted Euclidean distance (WED)

In the field of Mathematics, the most critical concept called The Euclidean distance. The approach depend on the weighted distance of alternatives from the least and the most favorable position called the weighted Euclidean distance (WED). In this method, the most favorable position is described by the optimum point and the least favorable position is described by the non-optimum point.

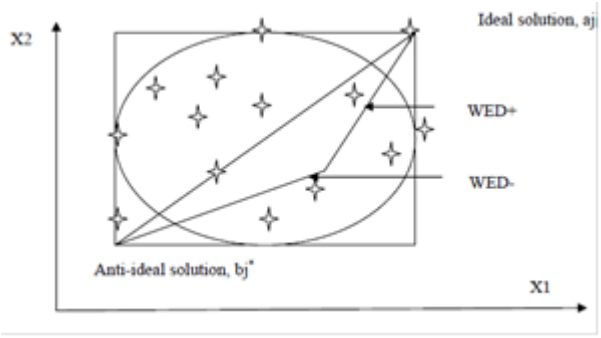

Fig. 2. An ideal and anti-ideal an alternative to solutions for Euclidean distance in 2D space in case of two attributes X1 and X2.

The target of this step is selected an ideal and anti-ideal points are defined as the best and the worst values in the dataset. The anti-ideal point has all the worst values of attributes and the ideal point has all the best values of attributes. Hence, here, the decision problem is to find a feasible solution, which is as close as possible to the ideal point.

The real domain is shown inside the rectangular box. The Euclidean distance between points

X and Y in ‘n’ dimensional space is the length of the line segment, XY. In Cartesian coordinates, if X = (x1, x2, ..., xn) and Y = (y1, y2, ..., yn) are two points in Euclidean n space, then the distance from X to Y points are :

$$\boldsymbol{WED} = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \qquad (2)$$

EXPERIMENT

3.1 Currency Image Collection

Due to recognizing and testing prototype of different denominations of Yemeni currencies, we collected Genuine fifty 100 really simple, fifty 250 really simple, fifty 500 really simple and fifty 1000 really simple of Yemeni currency. These notes included a new, old, very old and worn. The scanner is the main device for acquiring currencies images simples. The scanner type is HP Scan jet G2710. Each currency image is scanned with a resolution of 200 dpi, size of image is 1122 x 570 pixel and saved in a jpg image. Each simple stored as a vector in dataset. The size of dataset in totally is 200 vectors as input and output with four denominations (100 RY, 250 RY, 500 RY, and 1000 RY).

Fig. 3. Scanned Image of Yemeni Currency

3.2 Implementation Environment

For this adapted system, the environment of development are MATLAB tool. MATLAB® is a high-level language and interactive environment for numerical computation, visualization, and programming. The version of MATLAB tool used in this research work is MATLAB 2018a. Its language and built-in math functions are used for the implementation

Fig. 4. GUI in MATLAB Environment

RESULTS AND DISCUSSION

The prototype's denominating capability is evaluated. The denominating capability is concerned about measuring the effectiveness of the system in classifying a test currency image into one of the four Yemeni currency denominations, which are 100 RY, 250 RY, 500 RY and 1000 RY Real. Therefore, the prototype for its accuracy in denomination is evaluated. The denomination rate is calculated for each denomination of Yemeni currency.

$$\text{Denomination rate (\%)} = \frac{\textbf{Correctly denomination currency Image}}{\textbf{Total Test currency Image}} \quad (3)$$

The denomination accuracy of the system is tested with a total of 200 sample currency notes. In the sample both new and worn out genuine paper currency are included. The accuracy of the classifier is evaluated for genuine Yemeni currencies of each denomination.

Accuracy	HSV+ Edge+ GLCM	HSV + SURF	LAB + SURF	SURF	GLCM + SURF	HSV+GLCM +SURF
Linear SVM	98.571 %	98.928 %	98.57 %	98.214 %	99.285 %	99.159%
Quadratic SVM	95.892 %	95.357 %	94.46 %	96.071 %	97.678 %	94.285%
poly-nomial SVM	94.642 %	93.392 %	93.21 %	93.392 %	97.857 %	95.714%

Gaussian SVM	45.178 %	44.464 %	46.07 %	59.821 %	42.50%	41.250%

Table 1. Accuracy of the classifier is evaluated for genuine Yemeni currencies of each denomination.

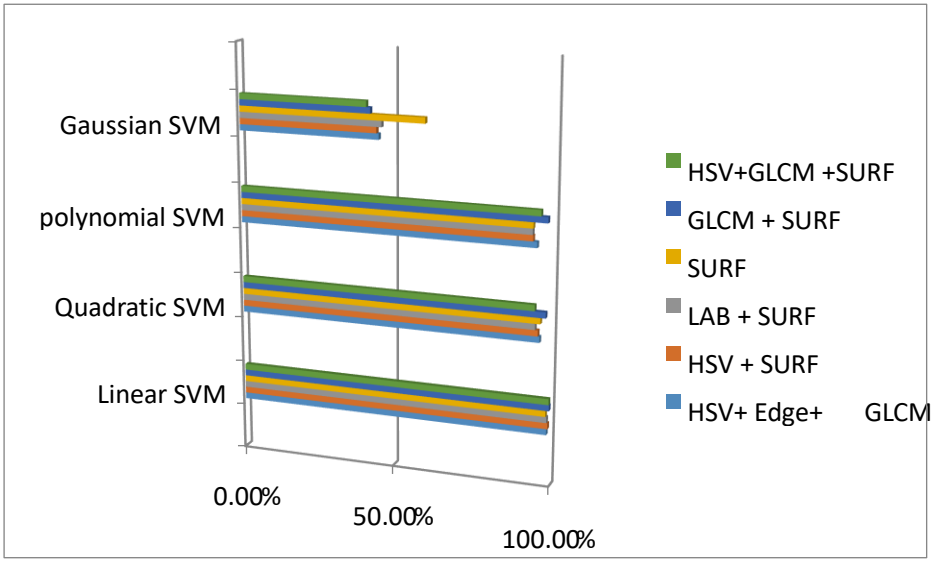

Fig. 5. SVM Algorithms Accuracy using a various Feature extraction algorithms

Conclusion

In this study, the proposes algorithms or recognizing of Yemeni currency using image processing and machine Learning. The proposed algorithms used texture features of currency for recognition. We used strong and fast algorithm such as SURF. Our system can recognize currency images with any rotation not only standard, it scanned with different angles. However, adapted system had high accuracy in classification. In the future, we are going to update our system, built hardware system such as Counting machine and apply new algorithms in feature extractions and classifications.

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