Implementation Of Template Matching, Fuzzy Logic And K Nearest Neighbor Classifier On Philippine Banknote Recognition System

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Abstract: Currency recognition system is one of the most marked research topics at present. Lots of variety of applications triggered the researchers for a study like this. Monetary transaction is natural in human being for its daily transactions. The need to use an artificial intelligence to come up with determination and classifications of banknote may contribute to the improvement of artificial intelligence applications. An attempt was made in this study to apply image processing, fuzzy logic and K Nearest Neighbor for the improvement on the limitations of the existing currency recognition systems. The study has is divided into two parts: a template matching technique for feature extraction and comparison of accuracy between fuzzy logic algorithm and KNN based on the information gathered by the first part. Thus by implementing the Image Processing and FLC in the MATLAB with the help of MATLAB programming and fuzzy logic toolbox, recognition of Philippine currency will be more accurate. KNN shows it flaws to identify the features resulting to big errors unlike the first method.

Index Terms: Currency Recognition System, Fuzzification, Fuzzy Logic, Image Processing, KNN, Inference Method, MatLab, Mamdami,

1 Introduction

More than two million currencies are used by several countries around the world. A classification of the currencies may help person to identify the particular currencies and its values. Currency recognition was utilized to minimize the use of human eyes for currency identification to automatically identify the amount of monetary value of banknotes and convert to other currencies without human administration [1], [2]. In the Philippines, all economic activities relating to production, distribution, consumption etc. can be motivated by money. Savings and investments can be made in the form of capital information. Thus, money is important in the dynamic society for everything. As our economy is moving towards the development there are many other things which are downsizing it. One of those things is production and usage of forged bank notes. Feature extraction has something to do with currency recognition as it aims to determine essential features of the text image [3]. Recognition is one of the challenging tasks if you have not yet encountered the banknote of the currency, wherein the aim of such recognition system is to analyze and then identify the uniqueness of features of each denomination under several variations. In this study, template matching is used for getting features of the paper currency. It is an image processing technique based on getting the degree of Red, Blue and Green (RGB) of the object.

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After extracting the features of the paper currency samples it will undergo an intelligent recognition algorithm applying fuzzy logic. Fuzzy logic (FL) is a type of logic that includes more than just true or false values. It is the logic that deals with situations where you there is an unclear (yes or no) answer [4]. In FL, propositions are represented with degrees of truthfulness or falsehood. It is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation based data acquisition and control systems. This paper is divided into two processes which is the extraction of features using template matching characteristics and the fuzzy logic paper currency classifier. With the combination of image processing and fuzzy logic, necessity for the automation of recognition and sorting will be efficient and faster since people uses paper currency in places like stores, banks, buses, vending machine, etc. It also avoids fake money.

2 Research Methods

The proposed approach of the paper currency recognition system consists of five parts. After scanning the document digitally, it will undergo the process of pre-processing the image, image processing, and template matching which will then undergo the fuzzy logic algorithm to recognize and classify the currency accordingly.

2.1 Digital Image Scanning

In this process, three denominations namely 20 peso, 50 peso and 100 peso were scanned at EPSON Printer at 600 dpi (dots per inch) as shown in below Fig.2. The only precaution needed to take is, try to maintain a controlled environment so that the external factors will not affect the value.

Fig. 1 *Sample Image of Banknote*

2.2 Preprocessing

Preprocessing is the development of any optical character recognition (OCR) system which prepares images for the subsequent phases. Depending upon the application and the type of input images, preprocessing may involve binarization [5], noise removal and, skew and slant detection and correction [6] and [7]. The aim of image pre-processing [8,9]] is to minimize undesired distortions that are important for analysis. One of the processes happened on these stages are the image adjusting and image smoothing.

Fig. 2 *Digital Image of 100 Peso bill*

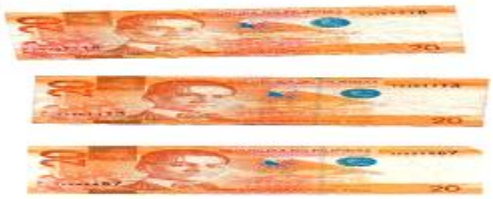

Fig. 3 *Digital Image of 20 Peso Bill*

2.3 Template Matching

It is the method that convert an image into digital form and perform some operations on picture or image, in order to obtaining an enhanced image or to extract some useful information from image or picture. Here, we use Template matching for finding small parts of image. A technique of template matching is considered in digital image processing to find out tiny parts of an image which matches a template image. It can be used in manufacturing as a part of quality control, a way to navigate a mobile robot, or as a way to detect edges in image.

2.4 Feature Extraction

Feature extraction is a special form of dimensional reduction. When the input data to an algorithm is huge to be processed and it is doubted to be repetitive in nature then the input data will be converted into a reduced illustration set of features. It will then transformed the processed data into the set of features is called feature extraction. If the features extracted are selected carefully, it is projected that the features set will extract the necessary information from the input data in order to predict the desired output using this reduced representation of features instead of the full size on the input part [10,11]. In this study, the extracted features are the degree of red, blue and green of the test points.

2.5 Fuzzy Logic Algorithm

Dr. Lotfi Zadeh Introduced the concept of fuzzy logic. .Fuzzy logic (FL) will considered not just true or false but uncertainties. In FL, propositions are characterized with degrees of truthfulness or falsehood. Fuzzy Logic uses linguistic variables to approximate human reasoning. This is all about the relative importance of precision. Furthermore, Fuzzy Logic can model nonlinear functions of arbitrary complexity and can be blended with conventional control techniques. In Fuzzy Logic, both of the two fundamental laws of classical logic can be broken, i.e., it is possible for an element to simultaneously be in its set and its complement but to different degrees, the sums of which add up to unity. The number of variety of application of fuzzy logic has increased significantly. Fuzzy logic doesn't necessarily attempt to replace a system model mathematically. In many instances, fuzzy systems finally simplify it rather than analyze. It is a rule based functions like IF X AND Y THEN Z approaches to solve several control problems. It is based for human communication and built on the structures of qualitative description used in everyday language. Describing a fuzzy set is a base for designing a Fuzzy Logic System. Fuzzy set is an addition of the classical set. In classical crisp set theory, the membership of elements complies with a binary logic --- either the element belongs to the crisp set or the element does not belong to the set. While in fuzzy set theory, it can contain elements with degree of membership between completely belonging to the set and completely not belonging to the set. This is because a fuzzy set does not have a crisp, clearly defined boundary, and its fuzzy boundary is described by membership functions which make the degree of membership of elements range from 0 to 1 [12].

2.6 K-Nearest Neighbor Classifier

KNN is a method that classified objects based on closest training examples in the feature space. It is the most basic type of instance-based learning. It assumes all instances are points in n-dimensional space. A distance measure is needed to determine the "closeness" of instances. KNN classifies an instance by finding its nearest neighbors and picking the most popular class among the neighbors. In KNN, the training samples are mainly described by n-dimensional numeric attributes [13,14]. The training samples are stored in an n-dimensional space. When a test sample (unknown class label) is given, k-nearest neighbor classifier starts searching the 'k' training samples which are closest to the unknown sample or test sample. Closeness is mainly defined in terms of Euclidean distance. Euclidean distance is also used by [15] in solving the closest pair of points in indoor positioning system.

2.7 Membership Function

The trapezoidal membership functions from the rule structure of peso bill recognition system are presented in figures 4 and 5.

Fig. 4 *Red Membership Function*

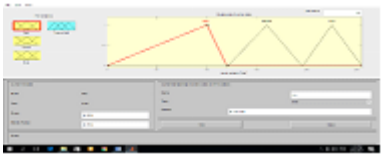

Fig. 5 *Green Membership Function*

2.8 Crips Output

The crisp output of inflation value of psi gives information that proves in the membership function editor and it is the crisp output for the fuzzy logic system.

Fig. 6 *Crisp Output of the Peso Bill*

3 Result and Analysis

Twenty (20) samples per paper denomination were used to test the accuracy of the fuzzy logic algorithm. It shows that the 20 pesos and 50 pesos have lower accuracy percentage than 100 since the color of these two were closely related. Some samples can't be distinguished correctly due to their similar features. On the other hand, sixty samples per paper denomination were used for the training data. The same numbers of test data were used in the KNN Classifier. 11 out 20 were classified by the KNN on the test data of twenty peso, 13 out of 20 for the fifty pesos and 14 out of 20 for the one hundred pesos. The result shows that the fuzzy logic algorithm can identify the paper banknote accurately than the K Nearest Neighbor Classifier.

4 Conclusion

An attempt was made in this study to apply image processing, fuzzy logic and K Nearest Neighbor for the improvement on the limitations of the existing currency recognition systems. The study has is divided into two parts: a template matching technique for feature extraction and comparison of accuracy between fuzzy logic algorithm and KNN based on the information gathered by the first part. Thus by implementing the Image Processing and FLC in the MATLAB with the help of MATLAB programming and fuzzy logic toolbox, recognition of Philippine currency will be more accurate. KNN shows it flaws to identify the features resulting to big errors unlike the first method.

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