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Survey on Vision Based Banknote Recognition Systems using Machine Learning and Deep Learning Methods

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Abstract - *Visually impaired people faced a problem in identifying and recognizing the different types of banknote due to some reasons. This problem draws researchers' attention to introduce an automated banknote recognition system that can be divided into a vision-based system and sensor-based system. As Sensor based system requires many hardwares and it get costly, so Vision based systems are more convenient, the main aim of this study is to have deeper analysis on the effect of region and orientation on the performance of Machine Learning and Deep Learning respectively in recognizing banknotes. The different region and orientations of banknotes is captured by using handphone camera in a controlled environment. Feature extraction of the RGB values called RB, RG, and GB from banknote image with different region were used to the machine learning classification algorithms. Banknote image with different orientation was directly feed to AlexNet, a pre-trained model of Convolutional Neural Network, the most popular image processing structure of Deep Learning Neural Network. It also can be concluded that AlexNet can only perform great in testing new data if only the data had previously been trained with similar orientation. The performance of AlexNet model varies according to orientation of banknote. Deep Learning approaches can give more powerful, accurate and error-free system.*

Key Words: **Banknote Recognition, Orientation, AlexNet, Machine Learning**

1. INTRODUCTION

Banknote Identification is relatively easy job for the human with normal eyesight but for the visually impaired people, to identify Banknote is quite difficult task. As money has an important role in daily lives for any business transaction, real-time detection and recognition of banknotes become a necessity for a person especially who is blind or visually impaired. Identification of Paper Currencies is mainly problematic due to the similarity of the paper texture and size between the different categories and easily fade away marking on surface of a note.

The main goal of this study is to evaluate efficiency of Machine Learning and Deep Learning approaches in recognition of Malaysian Ringgit Banknote.

This study is divided in two parts 1) the analysis on the effect of different region of Malaysian Ringgit banknote on conventional machine learning approaches and 2) the effect of different banknote orientation on deep learning approaches. Hence, role of technology is to develop a solution to resolve problem of note recognition to make visually impaired people feel safety and confident about financial dealings.

In broader view there is need to build a device that will help blind and visually impaired people in everyday navigation, orientation and recognition tasks which require visual input[1]. Moreover in cash society, where circulation of cash is very big. The damaged banknotes in circulation can cause serious problem to finish work of arrangement, counting, selection, elimination of banknotes. The technology which helps in mechanization of banknote sorting is the most effective way to solve the above problem. Main functions such as authenticity, version, denominational value, direction, serial number, new or old degree, stain, damage, tear and tape etc., and separating these banknotes from many banknotes automatically [2].

2. LITERATURE SURVEY

The work in Paper [1] focuses on the developing a system which can work sort of a bionic eyeglass that's mobile platform which integrates visual detection and recognition functions. Dataset images of banknotes were taken by mobile camera, relevant shapes are extracted from images using adaptive thresholding and morphological shape filters. In order to design a reliable and robust banknote recognition algorithm system had the goal to determine object or set of visual objects that are easy to detect and diverse enough to function as a basis of further recognition. The system is trained to use multiple features for classification of banknotes and subjects easily get to understand the way to use system confidently. Typical causes for errors were happened when executing the system like covering the region of interest with one or more fingers, can cause problems in detection.

Along with the Identification of Banknotes it's necessary to detect the counterfeit banknotes as well , paper [2] proposes a system which will recognize not only counterfeit notes but also partially visible, folded, wrinkled or maybe worn by usage. This project uses Computer vision system for

recognizing multiple banknotes with different view, scales and environment having variable light intensities. It used Computer Vision(OpenCV) for speeding up the process then by reducing noise and CLAHE for increasing contrast, Recognition process done by Scale Invariant Feature Transform(SIFT), sped up Robust Features (SURF), Features from Accelerated Segment Test(FAST), Oriented FAST and Rotated BRIEF (ORB), Binary Robust Invariant Scalable Key points (BRISK).This system achieved better contour estimation. Disadvantage of system is that for test images during which most of the banknotes regions were occluded, the local inliers ratio performed better. This happened due to local matching of patches avoids the removal of results of identification that have low inliers ratio.

The Paper [3] proposed a modular approach to review the model which will use feature detection and recognize Indian Currency notes. The main features of Indian currency are studied briefly in order that built system are going to be advantageous for the visually impaired people to detect particular feature of particular note. For central numerals, a visible word vocabulary and training a classifier generated by binary Support Vector Machine (SVM) classifiers. The proposed system detects the emblem by training a cascade object detector in MATLAB and therefore the HOG descriptor used for recognizing the Ashoka Pillar emblem on currency where CIE LAB Color Space model has been worked for color analysis of the banknotes. The delta-E distance between training and testing of data to classify the currency and template matching for recognition of identification mark, both gives end in 100% accuracy. However, image histogram for color and Markov chain for texture analysis yielding a rather lower accuracy as various banknotes could have similar colors and textures, thus reducing the efficiency.

The lifetime of a banknote can't be predefined but it can have physical damages like dirtiness caused by sweaty touch of the many people, oil and mud carrying bacteria may accumulate on them. So as to prevent these damaged notes getting older and to stop them from circulating, the dataset for brand spanking new and old banknotes get studied in paper [4]. Image acquisition and pre-processing, feature selection and extraction, and classification model construction were the stages of project. Modified SMOTE Algorithm is employed to reinforce old banknotes. Banknote classification model is made using traditional Support Vector Machine (SVM) algorithm. By analyzing the study, the most advantages are that approach can improve the popularity accuracy ratio by about 20% and solve recycling problem up to some extent. But main problem is both absolutely the and therefore the relative quantities of samples of old banknote are far but those of latest banknote so dataset is usually imbalanced.

In banking sector, arrangement, count, selection, sorting and elimination may consume huge time. The paper[5] has proposed an answer which uses TMS320C6416 DSK as DSP development platform, SV253A4 as image sensor, XRD98L23 as sensor processor and may finish quick collection of banknote image signals and uses image/video development library for TMS320C64x+DSP of TI company to pre-process the banknote image like median filter and Sobel operator edge detection to satisfy requirement of image quality and collection speed to end characteristics identification further. But this technique is more complex thanks to involvement of the many complex sensors and hardware systems.

There are devices already available within the market but they are doing not serve for Malaysian currencies and devices are very expensive. The target of this project [6] is to develop a reasonable low-cost compact device to help blind people to differentiate Malaysian bank notes. Currency Note Recognizer (CNR) detects different features of Banknote and gives output respectively in the form of beeping sounds of buzzer. The ATMega328P-PU microcontroller will identify the various notes from the input given from TCS230 and send a programmed sound pattern to a buzzer as a sign. Thanks to shielding the color sensor using light shield, the output frequencies were during a much smaller range and therefore the programming had been easier. But considering large range, this technique isn't that much effective, since the project prototype has some limitations.

3. LIVE SURVEY

Ke Cui, Zhangqin Zhan, Chuanchao Pan had research in 2020 where along with denomination recognition using convolutional neural network (CNN) methods, a method based on Radam optimizer and improved LeNet neural network has been proposed to gain the accuracy and efficiency over many problems addressing further. Also, for extraction and recognition purpose, they used the method of transfer learning to achieve stability and accuracy of input data to improve the training efficiency. Image Normalization Method, Data Enhancement Method and Geometric Transformation is also used. They successfully improved the stability and accuracy from the 95% to 99.97% [8].

In the recent years various studies and researches highlighted this topic with the use of different technologies. In early 2020, paper under National Research Foundation Korea (NRF) studied the classification of fake and genuine banknotes using visible-light images captured by smartphone cameras based on Convolutional Neural Networks (CNN). Experimental results on a self-collected dataset of various banknotes proved that this method's performance is lot better in terms of fake detection than the state-of-the-art methods [7].

Recent study shows that the model proposed by Rakesh Chandra Joshi, Saumya Yadav, Malay Kishore Dutta used YOLO-v3 CNN model based banknote detection and recognition system. It is Fast an accurate. Initially the images

of different denominations and in different conditions are collected afterwards these images are augmented with different geometric and image transformations on images so as to make the system robust. Then these images annotated manually, from which preparation of training sets and validation image sets is get done. Then, the trained model's performance has evaluated on a real-time scene as well as a test dataset. The Result showed that the proposed YOLO-v3 model-based method has detection and recognition accuracy of 95.71% and 100%, respectively. The whole system is standalone and works in real-time.[9]

A model comprised of Optical Character recognition (OCR), Face Recognition and Hough transformation algorithm is given lately in 2019 by Adiba Zarin, Jia Uddin. The features of Bangladeshi notes such as microprinting, water-mark, and ultraviolet lines are extracted and tested for genuine notes. The experimental results of the given model gained the success to get the accuracy as high as 93.33% which makes it suitable for deployment on a mobile application. Furthermore, the obtained results are compared with the output from individual algorithm of OCR, Face Recognition and Hough transformation, to show that the proposed algorithm gives the highest accuracy [10].

4. METHODOLOGY SURVEY

A. MATLAB

It is also called as "Matrix Laboratory". An interactive system which has a high-performance programming language by MathWorks. It mainly includes features such as:

- Math and Computation
- Algorithm Development
- Modeling, Simulation, and Prototyping
- Data analysis, exploration and visualization
- Application Development (API) and GUI building

B. AlexNet

It is the name of convolutional neural network (CNN) and it is designed by Alex Krizhevsky. AlexNet is 8 layers deep and has 60 million parameters with 650,000 neurons. It has a pretrained version of the network trained on more than 1 million images from the ImageNet database. Resulting in the network has learned high quality feature representations for a huge range of images. AlexNet is always considered as a model with high performance.

C. Machine Learning Classifier Models

K-Nearest neighbors (kNN)

Decision Tree Classifier (DTC)

Support Vector Machine (SVM)

Bayes Classifier (BC)

D. Synthetic Minority Oversampling Technique (SMOTE)

SMOTE is a technique which used to increase the number of cases in particular dataset in a balanced way. It is referred as a statistical technique. Input taken by SMOTE is the entire dataset, but only the minority cases has their percentage increased.

E. Optical Character recognition (OCR)

OCR is technique where images of handwritten/typed text or printed text is electronically or mechanically converted into machine-encoded text (for example the text on signatures and billboards in various photos) or from subtitles in different languages superimposed on an image. [10]

F. Convolutional Neural Network (CNN)

CNN is designed to map image data to an output variable. For any type of prediction problem which involves the image data as an input, CNN is always proven so effective and they are go-to method. The CNN automatically detects the important features without any human intervention, and this the most advantageous fact of CNN over its predecessors. ConvNets are more powerful than machine learning algorithms and are also computationally efficient [7].

G. YOLO-v3

It is extremely fast and accurate. In mAP measurement, YOLOv3 is on par with Focal Loss but about 4x faster. Moreover, you can easily tradeoff between speed and accuracy simply by changing the size of the model, no retraining required [9]. Three bounding boxes for every cell is predicted by YOLO v3.

H. Class Activation Mapping (CAM)

It is a simple technique to get the discriminative image regions used by a CNN to identify a specific class in the image. The network is need to be trained with a GAP layer for making CAM work. After that layer, we maintain a totally connected network followed by a SoftMax layer, providing a class.

5. CONCLUSION

By all counts, and with the proven results, it can be concluded that use of Deep Learning approach gives more accuracy to the proposed system than Machine Learning approach. As Deep Learning doesn't include any human intervention, system is can be error-free and more accurate. So that developed system can improve the standard of lifetime of visually impaired people by reducing the dependency and giving more security to other especially during billing & financial activities.

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