BPBR: Serial Number Recognition from Bengali Prize Bond

***Abstract*—Prize bond serial number recognition adds a new dimension to the fields of image processing and natural language processing (NLP). The techniques for identifying Bengali serial numbers of prize bonds from images using the pre-trained model SSD MobileNet v2 were explained in this work. We were able to recognize bangla serial numbers with 92.83 percent accuracy from both high and low quality pictures. We also discussed further possibilities of practical implementation of this concept which will include the idea of automation in a minimal way in our regular life.**

***Index Terms*—Serial Number, Prizebond, Natural Language Processing, Automation**

I. Introduction

The applications of Natural Language Processing are increasing day by day in this modern era of technology. The definition of NLP can be given from many aspects, but the most generalized definition is given by Lutkevich B. [1]. He [1] stated that "Natural language processing (NLP) is the ability of a computer program to understand human language as it is spoken and written is referred to as natural language". It can be applied on different types of data such as voice, image, text etc. It has been used in many different areas such as email filtering, auto-correct feature, license plate detection or even in smart assistants like Siri and Alexa. NLP has been used for general purpose, research purpose or even in the field of automation. The idea of serial number detection from prize bonds comes from the aspect of automation. The images need to be pre-processed at the beginning. After that only the region of interest (ROI) in the images are identified and selected which are required for the next stage to operate smoothly. After these processing steps, finally the recognition procedure may begin after all the processing steps. That is why our research work incorporates the use of both applications of image processing and natural language processing.

Digit recognition using NLP has been studied in a variety of contexts and applications during the last few years. The types of character recognition systems that have evolved as a consequence of diverse research investigations are classified and elaborated. Character recognition has been one of the main topics for the past 30 years for the researchers. It has been using for recognizing the handwritten zip codes, cheque processing and many more. In the mentioned paper they compared the performances of neural networks with the k-Nearest Neighbors classifier [2]. In some other cases the neural network is trained and tested using the MNIST collection of handwritten digits. They also proposed Principal Component Analysis (PCA) for feature extraction, which can increase the neural network's performance and drastically reduce training time [3]. As for recognition of handwritten digits, a character recognition technique using convolutional neural network is suggested [4]. As the digital number designs on several objects is not the same, so the method of detecting them also gets to change every now and then and those specific methods needs to develop with technology too. There has been a huge difference between the online and offline recognition of the numbers. In online they are arranged and there is no chance to manage for the movement that needs to be handled very carefully. Different works regarding serial number detection from bank notes [5] [6] was done before and many ideas were proposed regarding its practical implementation in the real world. The paper by Ji Qian, Dongping Qian and Mengjie Zhang [6] described the use of image processing for the recognition of the serial number of the Chinese currency banknotes. The image processing techniques helped them to remove the noise from the picture by mean filtration technique i.e. by reducing the intensity variation between one pixel and the next one [6].

In this paper [9], they proposed a character extraction method based on the aspect ratio of banknotes and a character recognition method based on a CNN. To obtain the image of each character, the banknote image was binarized and then distortion removal was performed through affine change, and the serial number ROI was extracted using the aspect ratio of the banknote. Then, they designed and compared four types of CNN models and determined the best model for serial number recognition. Experimental results showed that the recognition accuracy of each character was 99.85%.

The authors in this research work [10], present a network architecture, called as serial number recognition network (SNRNet), which integrates the advantages of both CNNs and BRNNs, and results in appealing performance. It can be trained end-to-end to avoid character segmentation and intermediate error-accumulation. The experimental results demonstrate that the proposed method out-performs the state-of-the-art methods in both accuracy and efficiency: it achieves character and serial number recognition of the renminbi (RMB) with accuracies 99.96% and 99.56%, respectively.

Another work in [11], proposed a hybrid convolution

network model in which a dilated-based convolution neural network is employed to improve the recognition accuracy and a quantitative neural network method is developed to speed up the identification process. The proposed model was examined and tested on four different banknotes with 35,000 banknote images including RMB, HKD, USD and GB .The experimental results show that, the proposed model can efficiently improve the recognition accuracy to 99.89% and reduce the recognition time to less than 0.1 millisecond.

The other techniques that is followed by is Optical Character Recognition (OCR), is a process by which we convert printed document or scanned page to ASCII character that a computer can recognize. It can also decrease the degree of human error. OCR system approaches several system for the several page structures that they would like to work on [7]. OCR can have various approaches for it's system too, Matrix matching, Fuzzy Logic, Feature Extraction, Structural Analysis and Neural Network. According to the survey of OCR applications banking industry is one the most that uses this technology as human interaction in the core is very low. In this age of verification, we have to verify the program that we use the most in day to day life and that is CAPTCHA. As CAPTCHA always contains that distracting backgrounds and noises in the pictures also not highlighted, it can be removed using OCR technique [8]. For the banknotes, we have come to know about two processes, the Skew correction and orientation identification. Then detected the text region be in a binarized by a combined threshold technique. In recent years, the binarized approach has shown to be quite effective in extracting a large number of documents. This may be done using an Area-Ratio-Based Binarization technique, which creates a binary map using the area ratio method. Then there's Binarization based on Block Contrast. The proposed block contrast based threshold approach takes use of the stroke width information, eliminates interference such circles, wrinkles, and smears, and tends to provide a binary image without accounting for pixel intensity. Because the area-ratio technique ignores the stroke texture characteristic and the block contrast based method ignores pixel intensity, the combination approach can fix a few erroneous foreground pixels while also giving a more comprehensive solution [5].

Detecting serial number from prize bonds is similar to detecting serial number from bank notes in terms of concepts but much more different in terms of implementation. Automation decreases redundant work from daily life even if we use it in a smaller margin or for basic tasks. Automation is the key to revolutionize the industrialization where there will be lesser margin of errors. The idea of detecting serial numbers from prize bonds may sound ordinary but the idea behind its practical implementation unlocks a new scope of automation in our daily life.

II. Methodology

A. Dataset

The dataset for our work includes over two hundred images of different prize bonds which have been filtered out from the initial five hundred images that were taken. In Bangladesh, only Bangladesh Bank issues prize bonds and they are fully written in Bengali language including the serial numbers as well. That is why we needed a hefty amount of images to begin our work. Initially the five hundred images were captured using different mobile phones to bring variety in the qualities of the image files. From there we tried to detect the serial numbers. But due to some constraints faced during the image processing segment, three hundred images had to be dropped out. So, we ended up with two hundred images that did not have the constraints that were initially faced. Then, we tried to recognize the serial numbers from this filtered image dataset.

An example of the prizebond from the filtered dataset is given below:

Fig. 1. Bangladeshi Prizebond.

B. Procedure

From the filtered dataset, we randomly picked an image at first where the background had various objects alongside our object of concern. Then, we annotated our region of interest(ROI), i.e. the prize bond serial number. In this way we continued to annotate the training images in our dataset as well as the testing images. Then the pre-trained model Mobilenet V2 was trained using the annotated training images and then tested on the testing images.

Each image contains a unique serial number which is the key concern for us in this work. We don't need the whole image as there are many unnecessary information there, we only need the portion which contains the serial number, that will be the region of interest (ROI) for us. So for the detection process to begin we first needed to identify this ROI. To do that we used SSD Mobilenet V2 model

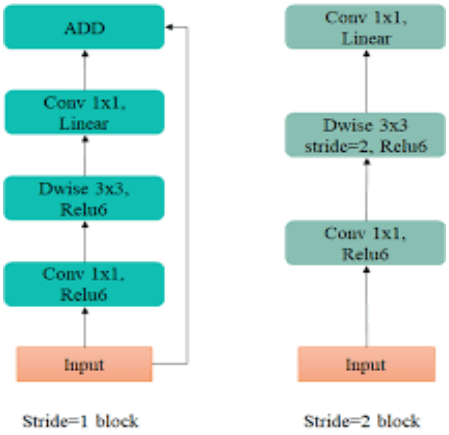

Fig. 2. Architecture of Mobilenet V2 model [12].

which is a pre-trained object detection model created using Tensorflow library of python.

This model uses lightweight deep neural networks which was built using depth-wise separable convolutions to detect different objects in a picture or even in a frame of a video. We needed to identify the regions of the pictures which contained the serial number so we used this pre-trained model to successfully identify the region and later scrapped the others. Then we were able to start the detection process on our selected ROI. We used EasyOCR to recognize the texts. EasyOCR is built using Pytorch deep learning library. The detection part uses CRAFT algorithm which is designed for situations where resource handling cost is the key concern and the recognition model that EasyOCR uses contains convolutional recurrent neural network (CRNN) [13] [14]. The whole model is composed of 3 components which are feature extraction, sequence labelling and decoding.

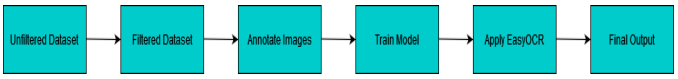

Fig. 3. Workflow of this research work.

Figure 3 shows the steps that we followed to reach our ultimate result. Another possible methodology could be to recognise the serial number digits simultaneously, then design a sequential ROI detection and classification system. The first CNN (the ROI detection CNN) detects the ROI for the serial number. Using the detected ROI, the second CNN (the classification CNN) classifies all characters in the ROI simultaneously. Because the size of the ROI is pre-determined depending on the kind of banknote and the input image is assumed not to be tilted, it is only necessary to detect a single point in the ROI.

III. Result and Analysis

At first, we took around 500 images of prize bond but we had to discard around 300 for haziness, wrong angle etc. then we ran an open-source pre-trained object detection model from tensorflow that is ROI detection model, SSD Mobilenet V2 model, and tested the model for test images and got ROI detection rate of 92.85% for images that did not have the first characters omitted.

And that we ran another open-source OCR library easyOCR on the images in which the ROI detection accuracy was higher than 70% and discarded the rest of the images. A sample output of the ROI detection and the serial number detection from the cropped ROI region is depicted in Figure 4.

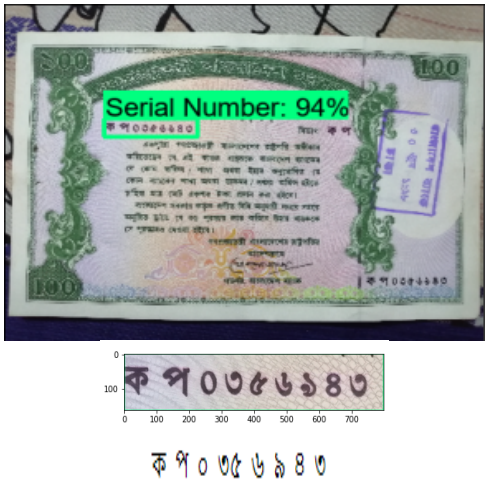

Fig. 4. Bangla Prizebond ROI and Serial Number detection.

After running easyOCR on the test images, we got an accuracy of 87.30%. The result is up to 100% accurate for clear images with high resolution but accuracy drops drastically for blurry images with low resolution. Then we tested the model on more images of prize bond with a different serial ('গঝ'). The object detection model omitted the first letter 57% of the time and the accuracy of the ROI detection for these images was 91.29% whereas the pictures which did not omit the first letters had an ROI detection accuracy of 92.85%. So, these lead us to achieving an ROI detection accuracy of 91.48% for all the testing images. The omission is because the ROI detection model detected the ROI slightly to the left. And the accuracy of the OCR for these left shifted images is 92.83%. We observed that the OCR confuses '৯' for '১' and vice versa. Similarly, it recognizes the bangla digit '০' as '৩' on 2-3 occasions. Alongside these, while recognizing the bangla alphabets, it also seemed that the model detected 'খ' as 'হ', 'ঝ' as 'ব', 'ক' as 'ব'. Evaluation of the model on random selection of 10 prizebonds in detecting the bangla characters of prizebond have been depicted in Table no. I.

IV. Conclusion

In this research work, we have made use of the SSD Mobilenet V2 model to recognize the serial numbers from bangla prizebonds. Other pre-trained models such as SSD

TABLE I
EVALUATION OF THE MODEL ON RANDOMLY SELECTED 10 PRIZEBONDS

Serial No.	Prizebond Serial	Detected	Accuracy
1	কট০৩২৯৯৩৩	কট০৩২৯৯৩৩	100%
2	কপ০৩৫৬৯৪৩	কপ০৩৫৬৯৪৩	100%
3	কপ০৩৫৬৯৪৫	কপ০৩৫৬৯৪৫	100%
4	গঝ০৪৫২৪৯৯	গঝ০৪৫২৪৯৯	90%
5	গঝ০৪৫২৪৯৪	গঝ০৪৫২৪৯৪	100%
6	গঝ০৪৫২৪৯৫	গঝ০৪৫২৪৯৫	89.89%
7	গঝ০৪৫২৫০০	গঝ০৪৫২৫০০	100%
8	গঝ০৪৫২৪৯১	গঝ০৪৫২৪৯১	100%
9	গঝ০৪৫২৪৯২	গঝ০৪৫২৪৯২	89.89%
10	গঝ০৪৫২৪৯৩	গঝ০৪৫২৪৯৩	80%

ResNet101 V1 FPN, Mask R-CNN Inception ResNet, etc. could be used for the purpose of serial number recognition from the prizebonds but at the cost of speed of computation. Keeping the speed of computation into account, other pre-trained models as well as different neural network(NN) models can be used as further research methodologies to better recognize the bangla serial numbers from prizebonds. There are lots of scopes and opportunities for extension of the research that we have done. Automation is one of the scopes for this work. The initial idea was to develop a mobile app which will detect the serial number from a prize bond and then it will match the retrieved serial number against the serial numbers that won the draw of the prize bonds. The app will send a notification if a match is found which means the user won a prize. It is a redundant work for the user to check each and every time if the result is published or if his or her number is there among several hundred numbers. So automating this part may cancel out all the redundant work and make life a little easier. People may want to make the detection process a bit smooth, people may want to reduce the challenges that we faced. In a word, there are room for improvements but we believe future researchers will find more effective ways to solve and address those issues.

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