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Counterfeit Currency Detection using Resource Efficient Neural Networks

Arunabha Mittra, Indranil Paul, S Sharanya

Abstract: ***One of the leading causes of economic instability is the large-scale counterfeiting of the paper currency notes. Several media reports bring to light the alarming cases and the humungous scales of currency counterfeiting and how this issue has become very serious now. A report on how the Government is coping with these threats with new and stricter rules however counterfeiters adapt to the new rules in an alarmingly fast pace. Criminals continue to find a loophole in the system despite such strict security features. There have been impressive discoveries in the field of counterfeit currency, and this coupled with new age digital technology, counterfeiting is being fought well. However, it is impossible to track all counterfeit notes and impossible to have them checked at a short amount of time. Existing systems involve filing a case with the police, sending the documents for verification and waiting for the results to come. This method is based on Deep Learning, which has seen tremendous success in image classification tasks in recent times. This technique can help both people and machine in identifying a fake currency note in real time through an image of the same. Traditional Deep Learning algorithms require tremendous amount of compute power and storage and hence it is an expensive and elaborate process. The main goal is to make a faster and simpler mechanism to detect a counterfeit note that can be implemented in any random place like an ATM dispenser or an android application. The success of this application will greatly help the quick identification of the threat and help law enforcement in finding the source of the threat faster.***

Keywords: Counterfeit Currency, One-Shot Neural Networks, Deep Learning.

I. INTRODUCTION

Currency is the backbone of a functioning society. Although the same society is moving towards cashless electronic transactions, India being a country of vast Socio-Economic backgrounds depend on cash majorly. India is also considered as a farmer intensive country where the farmers rely on cash to make their trade and business and runt their livelihood. Therefore, curbing the circulation of counterfeit notes by fast detection and blocking them at the source is very important. Also, both the paper authors being from the state of West Bengal which is a border state which has a considerable number of terrorists crossing over from neighboring countries and using counterfeit notes to fund their terror operations in the country and hence the check for counterfeit is a dire need for the welfare of this country in the broader aspect.

Previous approaches have mainly relied solely on Image detection techniques and deep learning algorithms individually to classify the currency notes and has made it a computation intensive or space intensive process. Some approaches are unable to remove some features associated which get associated with the authentic note as a result of wear and tear and hence get declared as counterfeit and hence it is not the case.

The whole idea of making it a faster and less resource hungry process is by applying Neural Networks which use minimal data sets and hence easier to build and modify on the go. This is done by dividing a single note into many features such as the Face of Gandhi, the font of the English letters and the font of the Hindi letters, the shade of the Numeric note in the corner and the texture and various shapes made in the background. After detecting these features, various filter will be applied to the nodes and detect feature points from it and train the neural network. The neural network after training will learn the features of an authentic note and on introduction of a new unknown note will be able to check for counterfeit or authentic.

II. STATE OF THE ART (LITERATURE SURVEY)

Various papers have been published to find new innovative ways to check for counterfeit. Some have used normal image detection techniques using MATLAB others have used basic machine learning techniques to check for the pictures of the image as a whole. Others have tried to train the model for single note, and have it decided on counterfeit or authentic based on a single feature. “Recognition of Fake Currency Note using Convolutional Neural Networks by Navya Krishna G, Sai Pooja G, Naga Shri Ram B. The CNN helps detect the most common patterns in the said authentic notes from the VGG-16 model dataset and using preprocessing, image rescaling, image shearing and perspective transformation to train the model and to have it detect the counterfeit notes [1].

“A Neural Network based Model for Paper Currency Recognition and Verification” by Angelo Frosni, Marco Gori and Paolo Priami have tried using multi layered perceptrons and have not been very successful with it. Their second approach has been an auto-associator model and the third has been a Pyramidal Multi-layered Neural Network. The paperwork has mentioned its own disadvantages of being slow but their technique is the cheapest so far [2]. Paper based on “Fake Currency Detection using Image Processing” by Ms Monali Patil, Jayant Adhikari,

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***** Correspondence Author
Arunabha Mittra*, SRM univercity, Kattankulathur, Chennai Tamilnadu,India.
Indranil Paul, SRM univercity, Kattankulathur, Chennai Tamilnadu,India.
S Sharanya, SRM univercity, Kattankulathur, Chennai Tamilnadu,India.

Rajesh Babu have proposed usage of SVM and KNN machine learning techniques to make a supervised and an unsupervised learning approach to make non-parametric as well as regressional analysis to have done on the data set chosen. The results have been compared with each other and found out that SVM is a better algorithm and it is actually two times the accuracy of KNN but none of them have been able to classify an image having a food stein or a fold mark which are not signs of counterfeit currency.

Having Mean error rate as 42% [3]. "Detection of Indian Counterfeit Banknotes Using Neural Network" by E. Haripriya and K. Anusdha has proposed treating the new image through a process called Smoothening to remove all the noise and convert it to grayscale from RGB. After converting it is expected to extract features like Black stripes and Identification marks to check for genuine or counterfeit with efficiency around 72% [4]. A paper based on "Paper Currency recognition method by a Small Size Neural Network with Optimized Masks by GA" by Fumiaki Takeda, Sigeru Omatu, Salzo Onami, have used the concept of slots to divide the whole note into a set of pixels like a matrix and cover parts of the matrix to make images and then make them as the training images for a Small Size Neural Network and have efficiency around 71% [5]. "Fake Currency Detection using image processing" by Tushar Agasti, Gajanan Burand, Pratik Wade and P Chitra from VIT Vellore, have proposed using simple MATLAB to classify notes based on their denomination and also check for counterfeit. Their work is based on Edge Detection, Image Segmentation, Characteristic Extraction, Calculation Intensity and finally concluding whether the note is fake or not. Their work mentions that classifier can only detect images having a minimum intensity threshold of 70% and more [6]. A research paper on "Machine Dating of Hand Written Manuscripts" by Utpal Garain, SK Parui, T Paquet and L Heutte has also been chosen as one of our reference papers to consider the sign of the RBI governor as a feature to be possibly extract and have the model decide whether the note as a whole is authentic or not as the printer finds it difficult to print the signature the exact manner found in the original note. Construction of fundamental hypothesis of the training model and tried out tests like Hypothesis Test and Multinomial Chi-Square Test to detect the authentic handwritten image. The paper has reported a mean efficiency of 62% [7]. "Using Hidden Markov Models for Paper Currency Recognition" By Hamid Hassanpur and Payam M Farahbadi proposes using a preprocessing filter by finding local mean and variance and then going for feature extraction like Size, Colour Histogram and Texture Based Feature Extraction and ending it with Grayscale quantization and ultimately having the accuracy of 82% of detecting the counterfeit note [8]. A paper on "Counterfeit Currency Note Detection Using Deep Learning" by Soo Hyeon and Hae Lee also proposes Neural Networks detecting the counterfeit notes but uses CYMK extraction instead of RGB because CYMK is the parameter for the printing of anything in the world and only soft copy images and classified by RGB. He also proposes a non-Machine Learning technique by studying the light refracted from the shiny strip of the note. The paperwork has shown a mean accuracy level of 54% [9]. "Machine Assisted authentication of paper currency: An experiment on Indian Banknotes" by Murdoch, S.J Laurie have proposed similar feature extraction of features like printing technique, ink properties and the artwork used in the foreground and background to check for counterfeit notes and making them as parameters on which counterfeit is decided. The paperwork have has claimed an accuracy of 72% on their model [10]. A majority of these processes are based on analyzing and capturing the note as a whole and then applying filters to it. As a result, the food steins and fold marks have been also taken into account during the processing of the image and are factored in as un-removable noise which affects the result of the model. Additionally, there have been no restrictions on compute power and space availability on any of the models. A model will be developed which will provide best possible results in limited and reasonable amount of resources such that it can be incorporated into quick and essential processes of everyday life.

III. PRPOSED WORK

A. Abbreviations and Acronyms

ANN – Artificial Neural Network, CNN – Convoluted Neural Network, SNN – Siamese Neural Network, ReLU – Rectified Linear Unit, LBS – Linux Based Server

B. Equations

- Non-negativity: $\delta(x, y) \geq 0$
- Identity of Discernible: $\delta(x, y) = 0 \iff x = y$
- Symmetry: $\delta(x, y) = \delta(y, x)$
- Triangle inequality: $\delta(x, z) \leq \delta(x, y) + \delta(y, z)$

$$\delta(x^{(i)}, x^{(j)}) = \begin{cases} min \left\| f(x^{(i)}) - f(x^{(j)}) \right\|, i = j \\ max \left\| f(x^{(i)}) - f(x^{(j)}) \right\|, i \neq j \end{cases}$$

This form also allows the Siamese network to be more of a half-twin, implementing slightly different functions.

$$\text{if } i = j \text{ then } \delta\left[f\left(x^{(i)}\right), g\left(x^{(j)}\right)\right] \text{ is small}$$
$$\text{otherwise } \delta\left[f\left(x^{(i)}\right), g\left(x^{(j)}\right)\right] \text{ is large}$$

The letter i and j are indexes into a set of vectors. The functions f(.) and g(.) are implemented by the half twin network. δ(.) function implemented by the network joining outputs from the One-shot Neural Network.

IV. IMPLEMENTATION(ONE SHOT NEURAL NETWORK)

The neural networks used before have been very large neural networks and have taken days of training and good amount of compute power to train them and a huge amount of data has been collected and stored in servers. The approaches that have not used CNN have been unable to ignore food stein marks, fold marks and wear and tear marks on a note and is using that as a measure to regard it as a counterfeit note. So, using a CNN is very crucial.

The platform we will be using is Python and the Libraries we will be focusing on are OpenCV, Matplotlib and most importantly TensorFlow. Our OpenCV will mainly have implement native and custom harrcasscades trained via a Linux Based Server with positive and negative images which make the harrcasscades to have them detect certain features. A separate classifier has to be made for making each feature and then the model will feed each feature into our Neural Network. Before these go into the NN they have to be passed through various custom filers which will selectively take them in combination and return with multiple results.

The fact of the matter is the neural networks used before have been very large neural networks and have taken days of training and good amount of compute power to train them and a huge amount of data has been collected and stored in servers. The approaches that have not used CNN have been unable to ignore food stein marks, fold marks and wear and tear marks on a note and is using that as a measure to regard it as a counterfeit note. So, using a CNN is very crucial.

A. Existing Work

All the existing work in this domain have either used MATLAB only or python only to determine the authenticity of the note and have mention facing trouble during old notes detection as The paperwork have food marks or fold marks which is also being detected as a feature which the paperwork is unable to remove. The other researchers have directly gone for neural networks where the paperwork is training from the note as a whole after image filtering and pre-processing. Our goal is to define our own features and detect only them from the note so that the neural network can ignore the unnecessary food marks and fold marks

B. Feature Extraction

Initially the whole currency note has been divided into features. Using OpenCV to initially detect the feature off the note, the normal full-scale image has been scaled down to a 20 X 20 image to make it easier to train the harrcascades. After the harrcascades have been trained the live image detects the features from the note and have been stored in a repository. These act as the input values for the input function in the SNN. The image by default has been converted to greyscale to make it easier for the model to learn.

C. Siamese Neural Networks

After the features have been detected via OpenCV these are fed in to the SNN independently. There will be a separate SNN for English font, a separate SNN for Hindi font, similarly for Gandhi's face signature of the Governor and the color-shade of one side of the note as well. Each model takes a minimum of 10 minutes or less or a maximum of an hour to train and can be successfully used them henceforth. Depending on the result of each SNN, a conclusion arises whether the final note is fake or authentic. As a result, any chance of a weak train on any feature can choose to omit that feature and determine the result via the other features.

V. RESULTS DISCUSSION

A. Data sets

As the whole idea of using this type of Network is to reduce the size of the data set and shorten compute time immensely. The data-set being used is roughly not bigger than 2 or 3 images.

B. Tools Used

Tools used in this process has primarily been OpenCV on Python platform on a LBS run by PUTTY Client Service, NSCP to access the File System of the server and Tensorflow mainly to train and run the SNN.

C. Result

The final model is being able to detect a counterfeit note by 75% efficiency but on using a note which has undergone extreme wear and tear efficiency is down to 40%, although such notes are often taken out of circulation by the Government itself and hence it can be ignored.

D. Validation Charts and Screen-shots

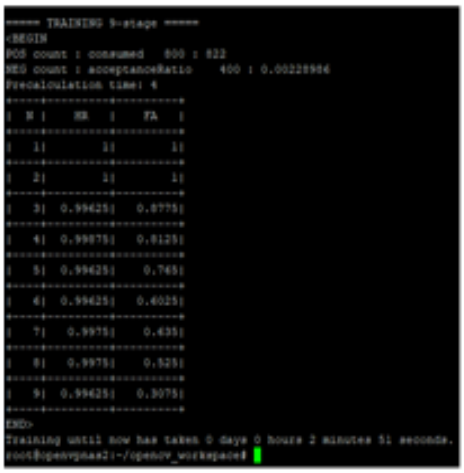

Figure 1: Training Harrcascades on LBS

Figure 2: Feature Detection

Figure 3: Colour Extraction

VI. CONCLUSION

The one-shot deep learning approach to the problem statement is unique because it reduces the time and compute power requirement to detect the counterfeit note and help saves time and the tedious process that is usually taken in a conventional bank to determine it through thorough examination and also in a large complicated Neural Network Thus, the counterfeit detection will help boost the economy and also stop terrorists from funding their own operations. The future aspects of this project can be to implement it in the Android Device or a phone so that notes can be checked on the go and the paperwork can prevent fraud from happening instantly and saving many businesses and livelihoods from financial threat.

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AUTHORS PROFILE

Arunabha Mittra, SRM univercity, Kattankulathur, Chennai Tamilnadu.

Indranil Paul, SRM univercity, Kattankulathur, Chennai Tamilnadu.

S Sharanya,SRM univercity, Kattankulathur, Chennai Tamilnadu.