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# Indian Currency Recognition for Visually Challenged using Machine Learning and Deep Learning

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***Abstract-*** Vision Impairment has been treated as a deterrent to normal functioning in human beings, so for such people, it is difficult to recognize the notes. The current system uses Malaysian Ringgit banknotes and extracts RGB values from the banknotes. The algorithms used were KNN, SVM, Naive Bayes, Decision Tree, and deep learning Alexnet. The proposed system uses Indian Currency and is divided into 3 phases. In phase I four features are extracted, phase II RGB values are extracted, and finally, in phase III, phase I and phase II are concatenated to produce better results. The algorithms used are KNN, Decision tree, SVM, Naive Bayes and deep learning VGGnet. Our system provides an accuracy of 98 percent in KNN, 95 percent in Decision Tree, 100 percent in SVM and 90 percent in Naive Bayes.

***Keywords-*** Banknote Recognition, Deep Learning, Machine Learning

## I. INTRODUCTION

Recognizable proof of banknotes is a moderately simple activity for the human with typical eyes as the cerebrum is equipped for retaining distinctive data and remembering them with less exertion. Yet, for outwardly debilitated individuals, banknote detection has become one of the irksome things to be looked at according to the nature of the banknote itself. The outwardly impeded are isolated into three subgroups: visually challenged, in part located furthermore, daze individuals. Their need is to recognize the category as opposed to safety efforts, as they help them in deciding the kind of banknote. As yet, the nearly no differentiation in size of banknote and a viably obscure away material imperfection outwardly of banknote reliably offer difficulty to outwardly impeded people to distinguish and describe banknote fittingly.

The World Health Organization reports states, 285 million individuals overall are determined to be outwardly debilitated which incorporates 39 million individuals thoroughly visually impaired and 246 million individuals have low vision. Visual impedance is characterized as extremely limiting in vision that can't be adjusted with the contact focal points or even standard glasses and lessens an individual's capacity to play out certain or all undertakings. Visual weakness may cause individuals to experience issues and cutoff their exercises of day to day living, for example, doing housework, cooking, shopping, observing TV, perusing, strolling, associating with others thus on. Herefore assistive innovation is expected to push them to beat these difficulties. In the current system, the feature set chose is RGB values.

Our project is divided into three phases such as Phase I, Phase II, and Phase III. In phase I four features are considered namely, variance, kurtosis, entropy, and skewness. In phase II RGB values are considered and in the last phase, phase I and phase II are concatenated. In the current system for deep learning, banknote images with different orientations was directly feed to AlexNet, a pre-trained model of Convolutional Neural Network (CNN), the most popular image processing structure of Deep Learning Neural Network. Ten-fold cross-validation was used to select the optimized KNN, DTC, SVM, and BC which was based on the smallest cross-validation loss. Our system recognizes Indian currencies for visually impaired people using machine learning algorithms namely, k-nearest neighbour, decision tree classifier, support vector machine and Bayesian classifier and for deep learning, VGG16 is considered which is a pre-trained model and is used where the automated feature extraction and modelling steps are performed directly without human intervention. This automated feature extraction makes deep learning highly accurate for computer vision tasks especially image classification.

Rest of the paper is organized as follows, Section I contains the introduction of Indian Currency Recognition for Visually Challenged, Section II contains the related works, Section III contains the materials and methods used to implement our project, Section IV explain the methodology with a flowchart, Section V describes results and discussion, Section VI concludes research work with future directions and the last section provides the acknowledgment.

 

## II. RELATED WORKS

[1]Kamal, et al., proposed feature extraction and identification of Indian currency notes. They propose a unique technique for recognition of Indian currency banknotes by adopting a standard approach. Their works extracts distinct and distinctive features of Indian currency notes like central numeral, RBI seal, color band, and identification mark for the visually impaired and employs algorithms optimized for the detection of each specific feature. The technique has been evaluated over oversized information set for recognition of Indian banknotes of various denominations and physical conditions as well as new notes, wrinkled notes and non-uniform illumination. The analysis gives a high true positive rate (the desired feature known correctly) of 95.11% false positive rate of 0.09765% for emblem recognition, associate degree accuracy of 97.02% for central numeral detection, and 100% accuracies for each recognition of identification mark and color matching in CIE work color space confirming the potency and strength of the planned scheme.

[2]Gouri Sanjay Tele, et al., proposed detection of Fake Indian Currency. Security measures of a currency area unit vital for determinant real and faux currency. Common security features embrace watermarks, latent pictures, security thread, and optically variable ink. During this associate degree approach for pretend currency detection extracts the overall attributes latent pictures and identification mark from the image of currency. Extracting attributes from pictures of currency notes will get quite complicated as it involves the extraction of some visible and invisible features of Indian currency. when conclusion five hundred and 2000 area unit the high valued currency notes existing until date so there's a most chance that these notes may be counterfeited to avoid this they use a software system to observe the pretend notes mistreatment image process technique.

[3]Navya Krishna G, et al., proposed Recognition of fake currency note using CNN. Within the Automatic pretend Currency Recognition System (AFCRS) is meant to observe the counterfeit paper currency to envision whether or not it pretends or original. The existing counterfeit downside thanks to the conclusion affects the industry and conjointly in different fields. A replacement approach of Convolution Neural Network towards the identification of faux currency notes through their pictures is examined during this paper. It's supported Deep Learning that has seen tremendous success in image classification tasks in recent times. this method will facilitate each individual and machine in characteristic a pretend currency note in real-time through an associate degree image of constant. The planned system, AFCRS also can be deployed as associate degree application within the smartphone which may help the society to differentiate between the pretend and original currency notes. The Accuracy within the project may be increased through the first pretend notes.

[4]N. A. J. Sufri, et.al., propose a vision Based System for Banknote Recognition Using Different Machine Learning and Deep Learning Approach. They used the RGB values as features and used algorithms DT, NB, KNN, SVM, and deep learning alexnet. Both KNN and DTC achieved 99.7% accuracy but both SVM and BC perform better by succeeded to achieve 100% accuracy.

Table 1. Comparative Analysis of Literature Survey

| Method | Existing System Accuracy |
|---|---|
| SVM | 97.02% |
| CNN | - |
| CNN VGG Net | 80% |

The literature survey concludes that there are many disadvantages with the existing systems. Our proposed method of banknote recognition extract features from bank notes using Machine learning algorithms such as, KNN, DTC, SVM and BC and in deep learning, deep features are extracted from banknotes using deep learning VGG 16 Model network. The comparative analysis of the literature survey is shown in Table 1

## III. MATERIALS AND METHODS

### *A. Dataset*

The dataset used is Indian currency. The dataset contains various Indian currencies of Rs20, Rs50, Rs100, Rs200 and Rs500. It has various security features of Indian currency. Our dataset has Rs20, Rs50, Rs100, Rs200 and Rs500 notes (5 classes of notes).Then random snaps are taken out of these classes of notes. 15 images of 11 positions are considered. These positions are at random angles so that when the user inputs the image, the denominations are correctly predicted. The 11 positions are discussed below:

P1: Image at straight focus (horizontal or vertical)
P2: Image at backside focus (horizontal or vertical)
P3: Image at left flip (front side)
P4: Image at right flip (front side)
P5: Image at left flip (back side)
P6: Image at right flip (back side)
P7: Image folded to half from upper side at straight focus
P8: Image folded to half from lower side at straight focus
P9: Image folded to half from upper side at backside focus
P10: Image folded to half from lower side at backside focus
P11: image folded to 1/4th from lower at straight focus.

So from the above, a total of 165 images for each of the currencies is taken.

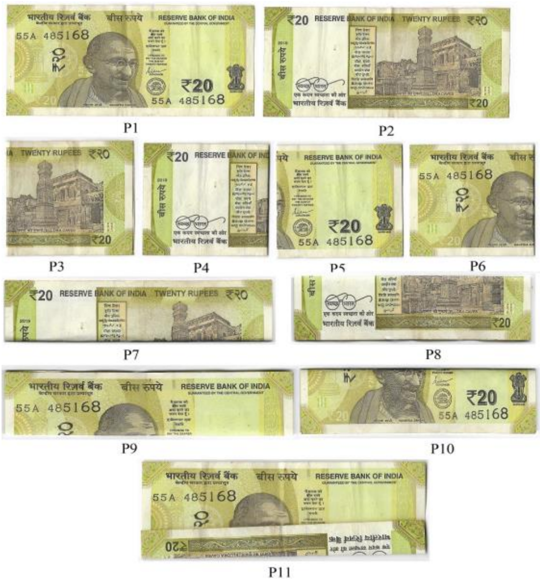


Figure 1. Shows 11 positions

### B. *Features*

*1)Entropy:* Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy, h can also be used to describe the distribution variation in a region. Overall Entropy of the image can be calculated as:

$$h = -\sum_{k=0}^{L-1} Pr_k(\log_2 Pr_k) \quad (1)$$

where, Pr is the probability of the k-th grey level, which can be calculated as Zk /m x n, Zk is the total number of pixels with the kth grey level and L is the total number of grey levels.

*2)Skewness :* Skewness S characterizes the degree of asymmetry of pixel distribution in the specified window around its mean. Skewness is a pure number that characterizes only the shape of the distribution. The formula for finding Skewness is given in the below equation:

$$h = \frac{1}{MN}\sum_{i=1}^{M}\sum_{i=1}^{N}\frac{(p(i,j)-\mu)^3}{\sigma} \quad (2)$$

where, p(i, j) is the pixel value at point (i,j), m and σ are the mean and standard deviation respectively.

*3)Kurtosis :* Kurtosis K measures the Peakness or flatness of a distribution relative to a normal distribution. The conventional definition of kurtosis is:

$$h = \{\frac{1}{MN}\sum_{i=1}^{M}\sum_{i=1}^{N}\frac{(p(i,j)-\mu)^4}{\sigma}\} - 3 \quad (3)$$

where, p(i,j) is the pixel value at point (i,j), m and σ are the Mean and Standard Deviation respectively. The -3 term makes the value zero for a normal distribution.

*4)Variance :* Varience is the square root of standard deviation. The formula for finding Variance is:

$$Var = \sqrt{SD} \quad (4)$$

where SD is the Standard Deviation.

*5)RGB Values:* Each of databases were used in the extraction of colour features: red, green and blue intensity average values called as RB, RG, and GB using equations (5) to (7):

$$RB = \bar{r} - \bar{b} \quad (5)$$

$$RG = \bar{r} - \bar{g} \quad (6)$$

$$GB = \bar{g} - \bar{b} \quad (7)$$

whereby $\bar{r}$ is the average intensity value for the red channel, $\bar{b}$ is the average intensity values for the blue channel, and $\bar{g}$ is the average intensity values for the green channel of the pixels inside the cropped region.

### C. *Algorithms Used*

*1)Machine Learning*

a. *K Nearest Neighbour:* In pattern recognition, the k-nearest neighbor algorithm (k-NN) is a method used for both classification and regression [4]. In each case, the input consists of the k closest training examples in the feature space. The output depends on whether kNN is used for classification or regression:

- In kNN classification, the output is a class membership.
- In k-NN regression, the output is that the property price for the object.

b. *Support Vector Machine:* Support-vector machines are supervised learning models with associated learning algorithms in ML that analyse data for classification and regression analysis [9]. Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier [9].

c. *Naive Bayes classifier:* In machine learning, Naive Bayes classifiers are a family of simple “probabilistic classifiers” based on applying Bayes' theorem with strong (Naive) independence assumptions between the features. They are among the simplest Bayesian network models. Naive Bayes has been studied extensively since the 1960s. It was introduced in the early 1960s and remains a popular method for text categorization, the problem of judging documents as belonging to one category or the other with word frequencies as the features. It helps in automatic medical diagnosis.

d. *Decision tree:* A decision tree utilizes a tree-like model of choices and their potential results, including chance event outcomes, resource costs, and utility. It is a decision-making tool. They generally utilized in task research, especially in decision making and analysis. A decision tree is a flowchart-like structure in which each internal node represents a “test” on an attribute each branch represents the outcome of the test, and each leaf node represents a class label. The way from root to leaf represents classification rules. In decision analysis, a decision tree and the firmly related impact outline are used as a visual and expository choice help support tool, where the expected values of competing alternatives are calculated.

*2) Deep Learning:*

a. *CNN:* A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm that can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image, and be able to differentiate one from the other.

b. *VGGNet:* It is a pre-trained model of a deep convolutional network for object recognition developed and trained by Oxford’s renowned Visual Geometry Group (VGG), which achieved very good performance on the ImageNet dataset. VGGNet consists of 16 convolutional layers and is very appealing because of its very uniform architecture. In AlexNet, there are 3x3 convolutions, but lots of filters and trained on 4 GPUs for 2–3 weeks. The weight configuration of the VGGNet is publicly available and has been used in many other applications, and challenges as a baseline feature extractor. VGG Net it is better because it consists of 16 layers with learnable parameters, i.e. weights and biases. The pooling layers don’t count as they do not learn anything. To reduce the number of parameters in such very deep networks, small 3x3 filters are used in all convolutional layers with the convolution stride set to 1. At the end of the net- work are three fully-connected layers. The VGG networks use multiple 3x3 convolutional layers to represent complex features. Therefore, here we chose VGG Net architecture similar to Alex Net for the network which is going to produce a minimum error rate and is in the top 5 error rate architectures.

### D. Standard Measures

- Precision: Precision is defined as follows:

$$Precision = \frac{TP}{TP + FP} \quad (8)$$

- Recall: Recall is defined as follows:

$$Recall = \frac{TP}{TP + FN} \quad (9)$$

- Accuracy: Accuracy can be calculated in terms of positives and negatives as follows:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (10)$$

- F1 Score: It can be calculated as follows:

$$F1score = 2 \times \frac{Recall \times Precision}{Recall + Precision} \quad (11)$$

## IV. METHODOLOGY

Our system is divided into three phases - Phase I, Phase II, and Phase III. phase I extracts features such as variance, kurtosis, entropy, and skewness. Phase II extracts RGB values and in phase III all the five features including variance, kurtosis, entropy, skewness, and RGB values are considered for machine learning. In deep learning VGG16 extracts deep features from the inner layers.

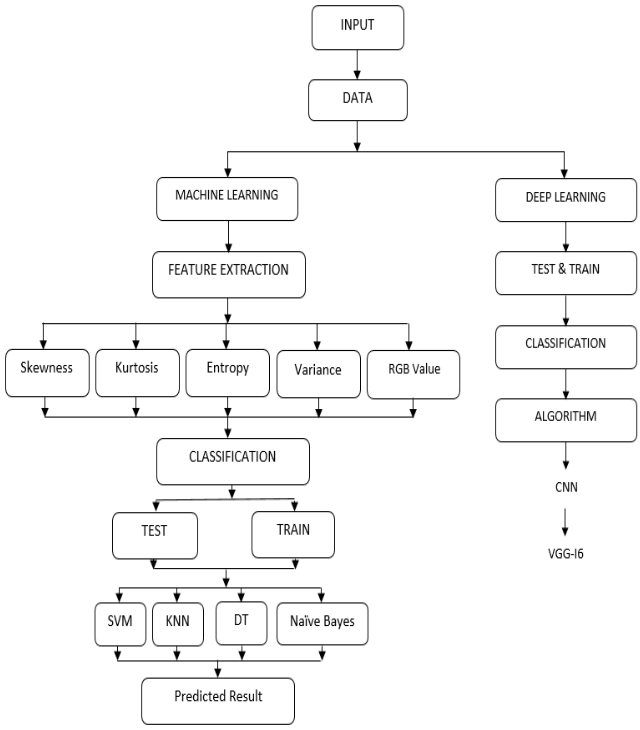


Figure 2. Methodology

### A. Classification

Classification helps in classifying to which of a set of categories an observation belongs, based on training set of data containing observations whose category participation is known.

### B. Test & Train Set

A training dataset is a dataset of models used for learning, which is to fit the parameters. A test dataset is a dataset that is free of the training dataset, however, follows a similar probability distribution as the training dataset. If a model fit to the training dataset likewise fits the test dataset well, negligible overfitting happens. A superior fitting of the training dataset as opposed to the test dataset usually points to overfitting.

### C. Algorithm

Finally, the Machine Learning Classification models such as k-Nearest Neighbor (kNN), Decision Tree Classifier (DTC), Support Vector Machine (SVM), and Bayesian Classifier (BC) was used to recognize and classify the different values Indian Currency based on the above-discussed features.

 

And in Deep Learning, VGG16 extracts deep features from the currencies by itself and then trained and tested. VGG16 is one of the preptrained models of CNN and the name “convolutional neural network” (CNN) indicates that the network employs a mathematical operation called convolution. Convolution is a specialized kind of linear operation. Convolutional networks are simply neural networks that use convolution in place of general matrix multiplication in at least one of their layers.

## V. RESULTS AND DISCUSSION

In the existing system the algorithms KNN, DT, SVM, and NB show higher accuracy compared to our proposed system because they use Malaysian ringgits banknotes that have fewer security features compared to Indian currency banknotes. In addition to that, the existing system only takes into account a single feature i.e, RGB values but our proposed system considers 5 features. From the result and discussions, we can conclude that our system is better than the existing system. The ROC curve for the algorithms are shown in figure 4

Table 2. Accuracy table for ML

| Algorithm | F1-Score | Precision | Recall | Accuracy | |
|---|---|---|---|---|---|
| | | | | Existing | Proposed |
| KNN | 0.982 | 0.983 | 0.982 | 0.995 | 0.988 |
| Decision Tree | 0.951 | 0.953 | 0.952 | 0.988 | 0.952 |
| SVM | 1.000 | 1.000 | 1.000 | 0.997 | 1.000 |
| Naïve Bayes | 0.903 | 0.903 | 0.903 | 0.871 | 0.903 |

In deep learning, an accuracy of 99% is attained but the existing paper is based on the orientation of Malaysian ringgit by using Alexnet. our system is better because VGGnet extracts more deep features than alexnet. The accuracy is shown in Table 3.

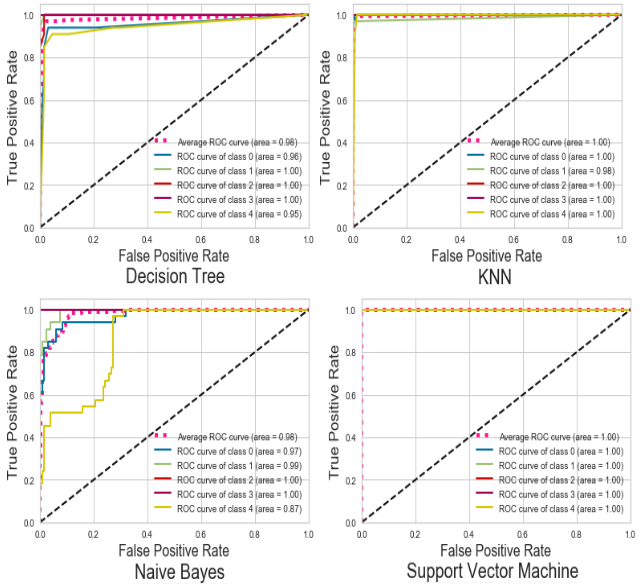


Figure 3. ROC curve for ML

Table 3. Accuracy table for DL

| No. of Epochs | Accuracy |
|---|---|
| 1 | 98.93 |
| 2 | 98.80 |
| 3 | 99.07 |
| 4 | 99.07 |
| 5 | 99.07 |
| 6 | 98.73 |
| 7 | 98.40 |
| 8 | 98.93 |
| 9 | 99.33 |
| 10 | 99.07 |

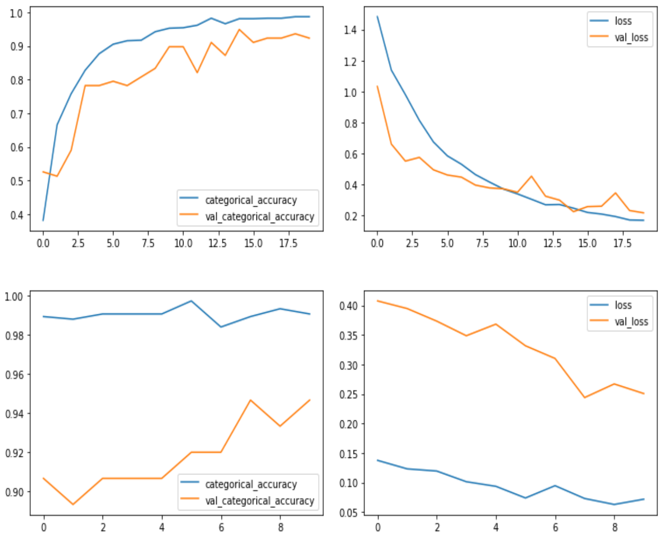


Figure 4. Plot between categorical values and validation categorical value

## VI. CONCLUSION

A vision based automated algorithm that can recognize and classify Indian Currencies using machine learning was well developed. SVM was found to give best result in Machine Learning with an accuracy of 100% and the Deep Learning algorithm obtained an accuracy of 99%. From our project, the visually impaired people would be able to improve their quality of life by reducing the dependency on others especially during outside activities.

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## REFERENCES

[1] Snigdha Kamal, Simarpreet Singh Chawla, Nidhi Goel, and Balasubramanian Raman, "Feature extraction and identification of indian currency notes", In 2015 Fifth National Conference on Computer Vision, Pattern Recognition, Image Processing and Graphics (NCVPRIPG), pages **1–4**, IEEE, **2015.**

[2] Gouri Sanjay Tele, Akshay Prakash Kathalkar, Sneha Mahakalkar, Bharat Sahoo, and Vaishnavi Dhamane, "Detection of fake indian currency", International Journal of Advance Research, Ideas and Innovations in Technology, 4(2):**170**–**176**, **2018**.

[3] Naga Sri Ram B Yamini Radha V Rajarajeshwari P Navya Krishna G, Sai Pooja G, "Recognition of fake currency note using convolutional neural networks", 4(2):**182**–**186**, **2018**.

[4] NAJ Sufri, NA Rahmad, NF Ghazali, N Shahar, and MA As'ari, "Vision based system for banknote recognition using different machine learning and deep learning approach", In 2019 IEEE 10th Control and System Graduate Research Colloquium (ICSGRC), pages **5–8**, IEEE, **2019**.

[5] Carlos M Costa, Germano Veiga, and Armando Sousa, "Recognition of banknotes in multiple perspectives using selective feature matching and shape analysis", In 2016 International Conference on Autonomous Robot Systems and Competitions (ICARSC), pages **235**–**240**, IEEE, **2016**.

[6] NA Jasmin Sufri, NA Rahmad, MA As'ari, NA Zakaria, MN Jamaludin, LH Ismail, and NH Mahmood, "Image based ringgit banknote recognition for visually impaired", Journal of Telecommunication, Electronic and Computer Engineering (JTEC), 9(3-9):**103**–**111**, **2017**.

[7] Hemant Kumar Soni, "Machine Learning aˆC" A New Paradigm of AI," "International Journal of Scientific Research in Network Security and Communication", Vo**l.7**, Issue.**3**, pp.**31-32**, **2019**.

[8] Jesse Davis and Mark Goadrich, "The relationship between precision, recall and roc curves", In Proceedings of the 23rd international conference on Machine learning, pages **233**–**240**, **2006**.

[9] B. Sun and J. Li, "The recognition of new and old banknotes based on svm", In 2008 Second International Symposium on Intelligent Information Technology Application, volume **2**, pages **95**–**98**, **2008**.

[10] Z. Solym´ar, A. Stubendek, M. Radv´anyi, and K. Karacs, "Banknote recognition for visually impaired", In 2011 20th European Conference on Circuit Theory and Design (ECCTD), pages **841**–**844**, **2011**.

[11] Miha Vuk and Tomaz Curk, "Roc curve, lift chart and calibration plot" Metodoloski zvezki, 3(1**):89**, **2006**.

[12] Rohini M., Arsha P., "Detection of Microaneurysm using Machine Learning Techniques," International Journal of Scientific Research in Network Security and Communication, Vol.**7**, Issue.**3**, pp.**1-6, 2019**.

[13] Smita D. Raut, S. A. Thorat, "Deep Learning Techniques: A Review", International Journal of Scientific Research in Computer Science and Engineering, Vol.**8**, Issue.1, pp.**105-109**, **2020**.

[14] Oluwabunmi Ayankemi ONI , "A Framework for Verifying the Authenticity of Banknote on the Automated Teller Machine (ATM) Using Possibilistic C-Means Algorithm", International Journal of Scientific Research in Computer Science and Engineering, Vol.**6**, Issue.**2**, pp.**57-63**, **2018**.


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