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AN INTELLIGENT SYSTEM FOR PAKISTANI CURRENCY RECOGNITION AND FAKE CURRENCY DETECTION FOR VISUALLY IMPAIRED

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Abstract
Blind or visually impaired people face many difficulties in their daily life such as recognizing objects, reading text, and especially in their daily monetary transactions. Currency recognition is a big problem that are faced by blind people. So, we want to design a system that is specially designed for blind people to assist them in recognizing the amount of currency and also for the detection of fake currency. For this purpose, we are using the latest technology like Artificial Intelligence to design currency recognition system. There is only one system that is designed for Pakistani Currency recognition but this system is only designed to recognize the amount of currency not for the detection of fake Pakistani Currency, so we propose to design a system that is specially designed for the recognition of the amount of currency and also for the detection of fake Pakistani currency. The currency recognition system helps blind people in the easy payment and also from this system blind can also recognize fake banknotes easily. For Pakistani Currency recognition system, first, we use KNN to develop our system but we didn't get good results to detect fake Pakistani currency and also to recognize the amount of currency. When we use KNN to develop our system, the accuracy of our system is 84% which is not suitable for our system. So, to improve the accuracy of the system we used the CNN algorithm for the development of a currency recognition system. The accuracy of our system using the CNN algorithm to recognize the amount of currency is 99.10% which is very good. And the accuracy of our system to detect fake Pakistani currency is 93.2%. Our system is very helpful for blind people in their daily transactions.

INTRODUCTION

Visually impaired people are those who are facing vision impairment or loss. So many people are blind by birth. According to a survey, that is conducted by a World Health Organization there are at least 2.2 billion blind or visually impaired persons in the world. Many difficulties are faced by blind people on daily basis especially in monetary transactions.

Monetary transactions are very important task of our daily life. Society's economy highly depends on their currency in terms of dealing with other societies. Currency recognition is the major issue especially for blind people as they face so many issues in daily transaction like incorrect recognition or fake currency detection so we require an efficient and precise mechanism to assist blind people. There are currency sorting machines available in banks for recognizing currency. It is precise and highly efficient but these machines are not portable, so this is not easy for individuals/blind to use them in their daily lives [1].

Counterfeit currency poses serious threats and is very common these days. Therefore, this issue is quite challenging for blind people to secure themselves from fake currency. There are so many systems available in the market that are designed for different countries for the detection of fake currency and also for the recognition of the amount of currency. Hence, we need to develop such system because they are not designed for the recognition of Pakistani currency. Keeping all things in mind we developed a system that is extremely useful for all people especially visually impaired people to recognize the amount of currency and also to detect fake Pakistani currency.

Before the development of advanced technologies people could detect counterfeit currency through various techniques like UV technology but now counterfeit currency looks so real that it became very difficult for us and impossible for the visually impaired or blind to detect counterfeit currency. So, this UV technology is not enough to help visually impaired people for the recognition of counterfeit currency. Therefore, for the development of our system, we used the latest technologies (artificial intelligence and deep learning) to make our system useful for visually impaired people to make their life easier. With the help of the latest technologies like artificial intelligence, we will make a system that is extremely beneficial to the visually challenged population in their daily task. When we combine two or more algorithms to design the system results are more accurate and efficient. Artificial intelligence is an emerging technology in the development of any society. That's why we use Artificial Intelligence technology to help visually impaired persons so that they can live normal and independent lives like everyone else. There is a system available in the market for the recognition of Pakistani currency but the limitation of this system is this system only recognize the amount of currency not detect fake Pakistani currency. Therefore, we have developed such type of system that will perform both functions to recognize the amount of currency as well as to detect fake Pakistani currency. We used k-Nearest Neighbors (KNN) and Convolutional neural network (CNN) which are algorithms of deep learning. To develop this system, we design a dataset of Pakistani Currency in which all the images of Pakistani currencies are stored that are raw images. First, we apply the k-Nearest Neighbors (KNN) algorithm to develop our system. As we know k-Nearest Neighbors (KNN) algorithm is a very simple technique for prediction. KNN keeps the training dataset stored and only learns from it when producing real-time predictions. So, we use KNN algorithm to develop our system to make our system accurate and faster. We got good results with KNN but we want to make our system more accurate. For this purpose, we used the Convolutional neural network (CNN) algorithm of deep learning. The convolutional neural network (CNN) algorithm is an algorithm that is used for feature extraction and classification. Of all the algorithms of deep learning, CNN is the best algorithm for image recognition and also getting the best results. CNN produced high accuracy results for our system. This research aims to:

- Help blind people in currency recognition.
- Build a currency recognition system consisting of two parts that are recognition of the amount of currency and detection of fake Pakistani Currency in the form of audio.
- Provide a system that is user-friendly, therefore blind people can easily use our system easily.
- Capture only the image of currency, then system will notify blind people about the amount of currency and also alert them about fake currency in the form of audio.

2. Literature Review

Now, we are going to review the relevant research papers that are based on latest technologies for the assistance of blind people to make their life easier:

The authors have proposed a currency recognition system that is specially designed for the recognition of Egyptian banknotes. In their proposed system they used image processing techniques such as histogram enhancement, region of interest extraction, and template matching. The cross-correlation between the captured image and their data sets is used for template matching. For Android application, they used OpenCV library. In this system, they used MATLAB for offline captured images and

the android application is used for live video capture [2].

The authors aim to build a system that is specially designed for Pakistani currency. This system is designed to assist blind people in the recognition of Pakistani currency. Their system is based on a Convolutional Neural Network (CNN) and Support Vector Machine (SVM). Their proposed system is designed to recognize different Pakistani currencies like 10,20,50,1000,5000. The accuracy of this system is 96.85%. This proposed system is effectively helpful for blind people to recognize Pakistani currency [3].

A recognition system was introduced that is specially designed to recognize fake currency in the Indian economy. An interface that has been proposed that consists of four main parts image acquisition, image processing, segmentation, and feature extraction. The accuracy of this system is about 90%[4][5][6][7][8].

Deep learning based fake currency note detection system is presented. Their focus is the detection of fake Indian currency. In their proposed system, they used deep neural network called transfer learning using Alex net. Then they tested their proposed network with a database of 100 images per currency [9].

The author proposed a currency recognition system for the recognition of Ethiopian currency. Their methodology is first they take images of Ethiopian currency using camera or scanner. Then they used image pre-processing technique to extract features and also to improve the quality of old paper currency images using Gaussian filter. They used four different feature sets for the classification of banknotes. These sets are dominant color of the image, distribution of dominant color, hue value of the image and SURF (Speeded Up Robust Feature) of banknotes. This proposed system is good with the accuracy of 96.13% [10].

The authors have discussed the currency recognition system to recognize the currency of the various countries. This idea is especially good for people who are traveling from one country to another. They used LBP (local binary pattern) to extract texture features. As so many countries have the same color and size of currency so this is hard to recognize currency country for this purpose, they used the Markov chain concept. In the last step, classification is done based on extracted features to recognize multiple country currencies [11].

The author introduces a system for the recognition of Indian currency. They capture the image and then apply binarization to convert RGB to greyscale. Then apply Edge detection to find boundaries and also for image segmentation and data extraction. Then they compare captured image with the original image that is stored in the database to show the result [12].

[13].

The authors present a currency recognition system for the recognition of the origin of currency and also for the denomination of currency. They proposed their system for these countries Australian Dollars, Canadian dollars, Chinese Renminbi, American Dollars, Danish Krone, Euro, Hong Kong Dollar, Indian Rupee, Indonesian Rupiah, Kuwaiti Dinar, Mexican Peso, Norwegian Kroner, New Zealand Dollar, Philippine Peso, Japanese Yen, Russian Rubbles, Saudi Riyal, Singapore Dollar, Swiss Franc, UAE Dirhams. They used template matching and a K means clustering algorithm to identify the origin of the currency. The accuracy rate of the system is 93.3% which is very good [14].

The authors present the currency recognition system using a mobile phone and also, they compare color SIFT with the Grey SIFT algorithm. This system is developed for Jordanian currency. They used 10 kinds of Jordanian banknotes and compare these with a dataset of 400 images. Color SIFT also takes less time than Grey SIFT. This system gives good results in terms of Coin banknotes [15].

Authors designed a currency recognition system to assist blind people. They used image processing, ORB algorithm, Brute force matcher, Raspberry PI to design their system. [16][17]. Oriented FAST and rotated BRIEF (ORB) algorithm is used to design an app in which users take pictures of Egyptian banknotes that may be worn, blurred, or folded. They applied hamming distance technique for matching the captured currency image with the dataset. The accuracy of their system is 96% which is very good [18, 19].

The author introduces electronic glasses for the assistance of blind people. In this paper, they used DEEP Learning, CNN, and OCR for the development of their system. They designed

wearable glasses which is used to recognize real-world objects for helping blind people as they face so many challenges regarding this. They used a dataset of 500 images which are used to train their system. The accuracy of their system is 95% for face detection and 90% for currency recognition [20].

Currency recognition system for Sri Lankan banknotes was developed in the Sinhala language to assist Sri Lankan visually impaired people. Their system is divided into three modules speech recognition currency recognition and text to speech conversion. For the training dataset, they used 9000 images and for the validation dataset, they used 3000 images. All images are in jpg format. Their accuracy rate for the validation dataset is 46.7% and for the training dataset accuracy of the system is 95.54% [21].

A system has been developed that uses SIFT algorithm. Their system contains two phases: In the first phase, they take pictures of unknown currency then apply preprocessing techniques to remove noise from the captured image. For the development of their system, they use a stick-on camera is mounted which capture the image of currency they apply all discussed steps on it. Their accuracy rate is very good, which is 93.71% in processing speed of 0.73 second [22].

The author proposed a smart currency detection system that is a mobile based for visually impaired people in India. The system tells the user the amount of currency in the form of vibration which means that if the system doesn't vibrate its mean currency is invalid less than 100. They used MATLAB for the implementation of their system. This system is very helpful for visually impaired people [23].

Fake currency is so similar to original ones that anyone gets cheated easily. To detect fake currency, authors used a deep neural network that detects deep features of currency to detect fake currency. This survey for the development of this system is very helpful for the detection of fake Indian and Bangladeshi currency [24] [25].

Table 1 represents the literature summary. Based on our findings, we have designed a system that is specially designed for Pakistani currency recognition to assist blind people to recognize currency amount and also detect fake currency from original ones.

Table 1: Literature Summary

Reference	Approach	Currency	Accuracy
[2]	Image processing technique and MATLAB Machine	Egyptian	89%
[3]	Convolutional Neural Network and Support Vector Machine	Pakistani	96.85%
[9]	Image processing technique and Minimum distance classifier	Indian	90%
[18]	Oriented FAST and rotated BRIEF (ORB) algorithm	Egyptian	96%
[12]	Deep learning, Image processing, YOLO Algorithm	Indian	78%
[10]	Image processing technique and Gaussian filter	Ethiopian	90.42%

3. Methodology

We now introduce the specific methods used in this research to meet the requirements for currency recognition, and describe the details of each step.

Our system alerts blind people with fake Pakistani currency in the form of an audio message. For this purpose, we are using different security features of Pakistani Currency like security thread, picture of Quaid-e-Azam in sherwani on the left side of currency, watermark, RBI microprint, etc. We used CNN and KNN with sklearn. Our aim of research is Pakistani currency recognition. Figure 1 represents the flowchart of our system, depicting the compete process for recognition and for fake Pakistani currency detection.

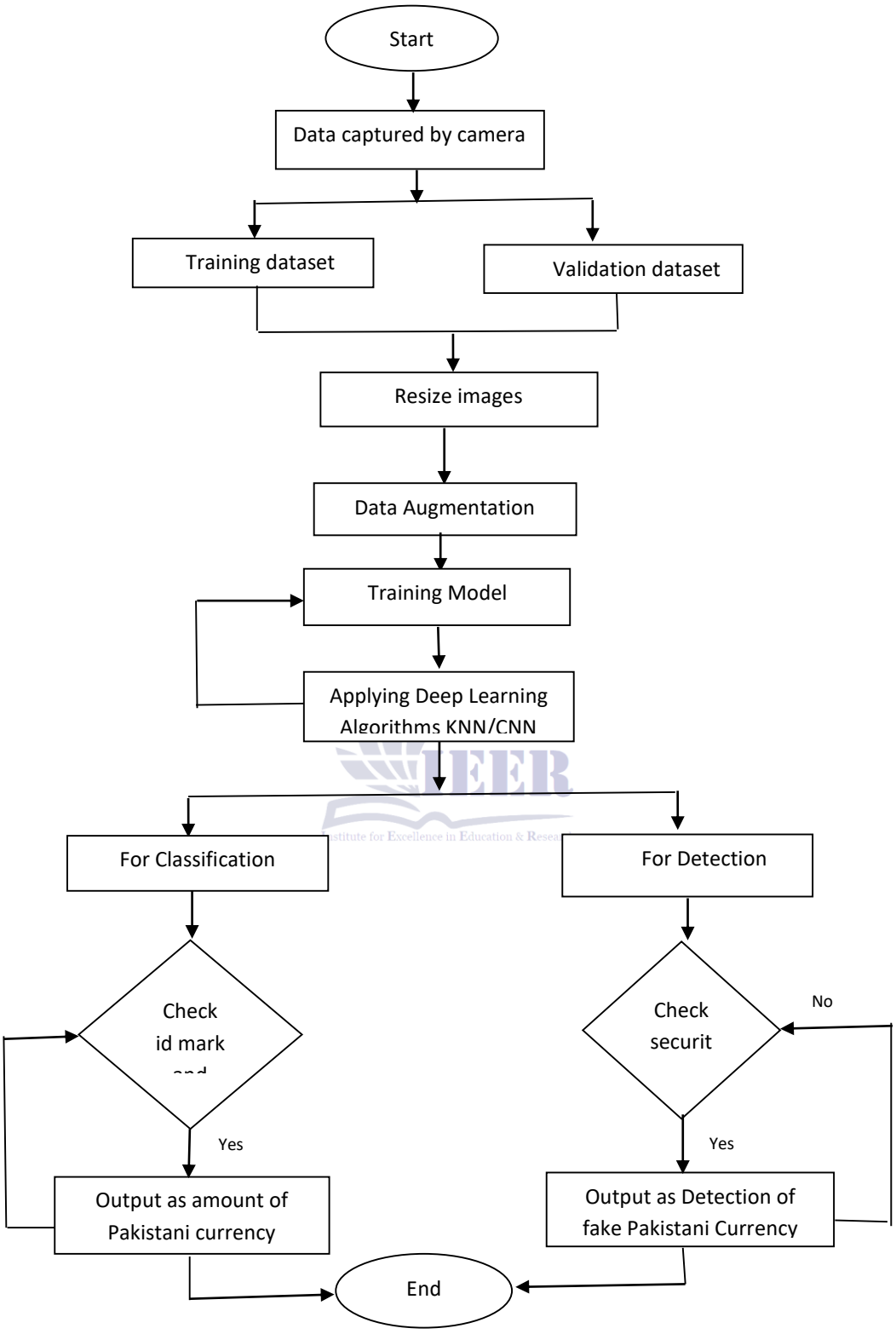


Figure 1: Flowchart for currency recognition and for fake currency detection

3.1 Image Acquisition

In image acquisition, first, we take images of five Pakistani Currencies which are 10, 100, 500, 1000, 5000. We take clear pictures of Pakistani Currency in a different environment with our phone OPPO A5 2020. We captured images of

Pakistani currencies from both sides taking pictures of currency images from the front side and back side. This is how we make our dataset.

3.2 Splitting our dataset then resize images

In this step, we split our dataset into a validation dataset and into a training dataset. We split our data into the training dataset 80% and into the validation dataset 20%. As we know, we take different images of Pakistani currency that have different pixel values so to make our system reliable we resize all images of Pakistani Currency into 200 x 200 pixels.

3.3 Data Augmentation

Then we apply data augmentation to our dataset. Data Augmentation is a technique through which we increase the size of our dataset. Data augmentation performs rotation, and scaling and also move the picture to different angles to improve the size of the dataset. As we take 250 images of five Pakistani Currencies by applying data augmentation size of the dataset increased from 450 to 500.

3.4 Train Model using Deep Learning algorithm

In this step, we trained our model using deep learning algorithms which are KNN and CNN. As we know deep learning algorithms are widely used in the detection system. So, we used KNN and CNN in our system that is designed for Pakistani currency recognition and fake Pakistani currency detection.

3.5 Classification and Detection

At last, our system shows the result about the amount of currency and also alert about fake Pakistani currency. Our system shows results in the form of audio because this system is specially designed for the assistance of blind people to get them to save from fraud people.

Figure 2 shows the training framework of our system first step is important step that is currency dataset and in next step we apply addition, scaling and rotation on dataset that is known as data augmentation. Then we apply 2 models of deep learning which is KNN and CNN to train our model.

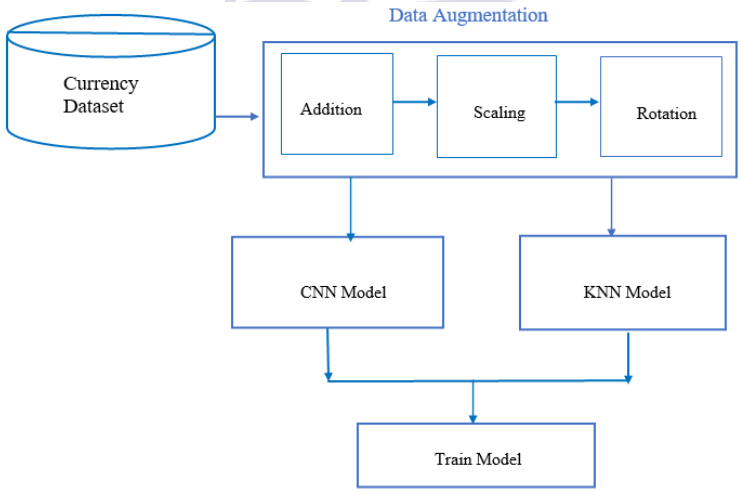


Figure 2: Training framework of our system

Figure 3 shows the framework of classification and detection. As shown, in the working process of system we need a camera to capture image of Pakistani currency. Then we extract required features of currency image. At last, we perform algorithms of deep earning model which are KNN and CNN to classify the Pakistani currency in NOTE 10, NOTE 100, NOTE 500, NOTE 1000 and NOTE 5000. And also, to detect fake Pakistani Currency from original one. Collection of data of currency images to make dataset is most important part of our system for

currency recognition. To meet the requirements, first we filtered data of datasets then apply training on datasets. We apply data augmentation to increase the amount of data. Then we apply KNN and CNN model for currency classification and fake currency detection.

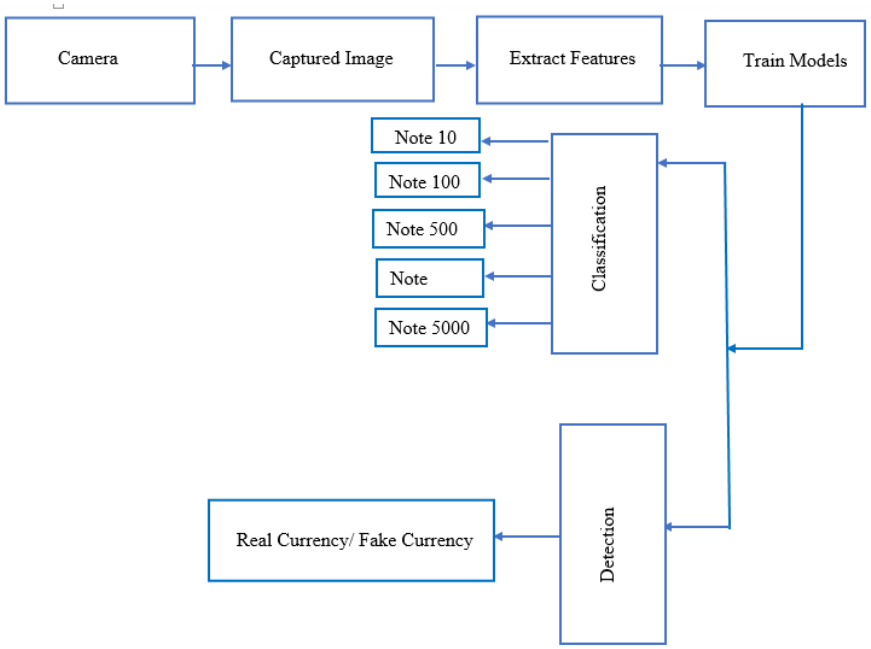


Figure 3: Classification and Detection Framework

3.6 Data Collection

In order to increase the accuracy of research results, we eventually decided to use real currency as our source of data. The monetary denominations for currency recognition are 10, 100, 500, 1000 and 5000. Each denomination's money will have a front and back side. First, we take pictures of each side of these five denominations. We must ensure that the currency is level and that it should be completely visible in the image. Simultaneously, we rotated the currency in all the directions like left, right, forward, and backward which improves the dataset quality. We must also verify that there is enough brightness around the camera while taking pictures of different Pakistani Currencies as we want to get all the features of currency more properly. We organized these images into five folders. After obtaining the images of currency, we must edit all the images of currency and ensure that the currency is complete and accurate in each photo, with no portions omitted from the frame. In this scenario, we take 25 images of each currency, for a total of 250 images as a dataset. The resolution of these images after being filtered and renewed in size. is 200 × 200 pixels as shown in Figure 4.

Figure 4: The five folders of the currency images

3.7 Partitioning of Data

When the number of samples in the datasets grows rapidly and is varied, partitioning the

data into a training dataset and validation dataset is the best option. We split the data ratio of 80% training dataset and 20% of validation dataset.

3.8 Data Augmentation on Dataset

In a nutshell, data augmentation is a preprocessing strategy that allows us to produce numerous image variants while avoiding overfitting and improving the quality of model. This is the library of TensorFlow.

As we know that after collecting the data of currency images, we categorized all the collected data into five groups. We acquired a total of 250 authentic raw currency images for recognition. However, such amount of data is not sufficient to perform deep learning training.

We initially created a surface area, which is the area of currency images as a percentage of overall screen. We perform random cropping to adjust the balance and modify the currency positioning when the percentage of data is bigger than original size. When the input data percentage is less than the actual one, we expand the actual image at randomized extent.

While capturing the images of different currencies, we moved the angle of currency images at various positions but this range is not sufficient for currency recognition. So, we use data augmentation in terms of enhancing the currency's position data to increase the currency's ability to check the currency image from various angles. We chose to apply random rotation on the real image from this we get different angles of currency images.

After applying data augmentation on dataset, we obtained 19 resized currency images from raw images. As we take 250 raw images of different Pakistani currencies as our input but when we apply data augmentation, we will get 19 more resized images of different Pakistani currencies. Through data augmentation technique we get 4750 images that considerably improving the performance and accuracy of our system (Figure 5). After data augmentation, the performance and accuracy of our system improves greatly as data augmentation increase the size, positioning and angle of the currency and also increase the color of currency.

As we know that when we are capturing images of different currencies there are various environment around it. Therefore, all captured images of currencies have different saturation of colors due to various lightening condition. So, for this we convert all captured images into grey scale after checking all the pixels of images on OpenCV. Then convert all the pixels into NumPy array then we saved NumPy in a file named as x. pickle and y. pickle. As we know pickle is a library that is used to save the variables of python in the file which we can re-read.

3.9 Applying Deep Learning Algorithm

After applying data augmentation, we apply different algorithm of deep learning on augmented dataset to recognize amount of currency and also to detect fake Pakistani Currency. For this purpose, we used K-Nearest Neighbor (KNN) Algorithm and Convolutional Neural Network (CNN) Algorithm. These algorithms are very effective to detect objects that's why we used CNN and KNN for Currency recognition. First, we apply KNN algorithm on augmented dataset but the result of KNN is not so good then we applied CNN algorithm to get better result.

3.9.1 K-Nearest Neighbor (KNN) Algorithm

K-Nearest Neighbor (KNN) is one of the best algorithms of deep learning model because KNN algorithm is very easy to use and very easy to understand. There are so many developers are using KNN algorithm to develop various application to make their application more feasible. When KNN algorithm is in training phase it used the entire dataset for prediction.

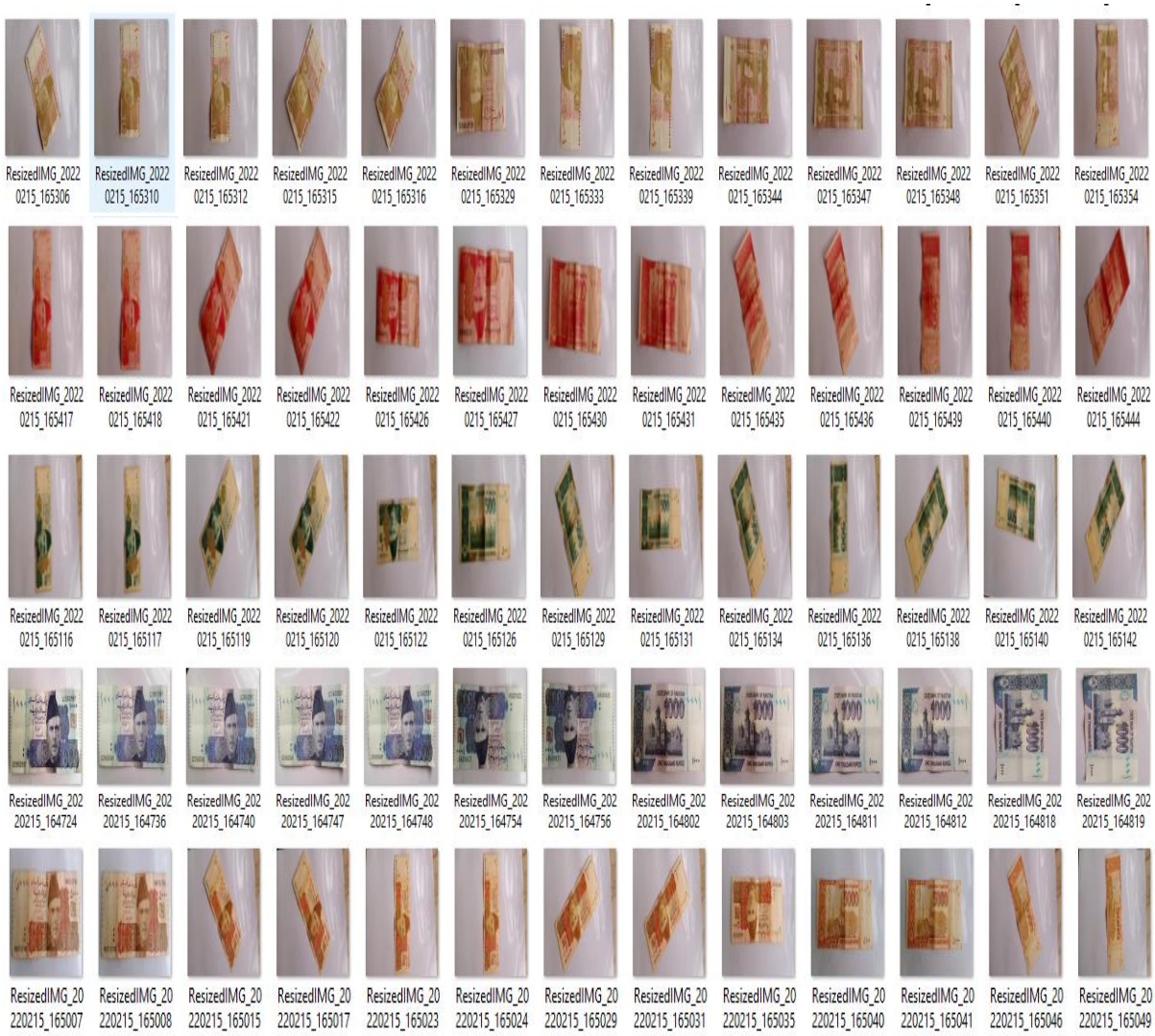


Figure 5: Images after Data augmentation

3.9.2 Build our Currency Recognition System Using KNN

To develop our system using KNN first we import essential libraries that are required to detect fake currency and to recognize amount of currency. We import python important packages of scikit-learn library. These are the important libraries of python that are used for classification, Labeling, splitting dataset into training dataset and testing dataset, and to show the classification report.

These libraries are used for image processing function like rotating, scaling and resizing etc. glob module is used to search a file or folder of specific pattern. Cv2 module is used to import OpenCV which is used to analyze image or video for face detection or for object detection.

NumPy is the python library which is used to work with arrays.

Then we did process on images. First, we give the path of folder where all the data is placed. From which they get data by itself and resize the data into fixed width and height of 32 x 32 pixels. Then append the list of images. We resize images because we take pictures of almost same size but for processing, we set image size by resizing them. Then we convert array of images which we get from OpenCV and convert array of images into NumPy array. Then we extract label and data of images and then get the size of image and reshape it.

We divide our dataset into training and testing dataset using train_test_split through this we understand our algorithm in best way and also through this we should avoid overfitting. We

perform train_test_split function on the data of 75% train and 25% test. We set random state as 42 because we want the same data every time when we run the program. If we don't keep random state as 42 then we get different test set every time when we run the code.

We used two parameters for model creation. n_neighbor is set to 3 which means that when we classify a given input point, we take 3 nearest neighborhood points. And n_jobs is set to -1 indicates that all the processors are used for classification to speed up the processing of system. Then we apply fit to process the model. At last, system shows the classification report of currency. We didn't get good results by applying KNN algorithm so to get better result we applied CNN algorithm which will discuss in next section.

3.9.3 Convolutional Neural Network (CNN) Algorithm

CNN is the most popular algorithm of deep learning. CNN is highly recommended to extract features of input image. CNN consist of two parts which are feature extraction and classification. In feature extraction we used several convolutional layers and also include max-pooling and activation function. There is usually fully connected layer in classification. CNN is very useful algorithm because it detects all the important features of object without the involvement of human. That's why we used CNN algorithm to make our system performance better. After applying augmentation on data, we get dataset of wide variety of currency images. Then we apply CNN algorithm to train our model.

3.10 Build our Currency Recognition System Using CNN

For this purpose, first we import different libraries of python that are necessary to run CNN model. We used tensor flow to run sequential model of CNN and to apply different layers and functions (max-pooling and Activation) on model for currency recognition. We also used Tensor Board to show the results and output of model in the form of graph and structure. Then, we applied sequential model of convolutional neural network. We used two layers of convolutional neural network. In Keras, sequential model is the best model where we make model layer by layer.

We used two layers of convolutional network which is used to deal with input images that are 2 dimensional because we use Conv2D. We apply 256 filter in both layers and the kernel size of 3 mean we take filter matrix of 3 x3. Kernel size is basically width and height of 2D convolutional window. We set input shape as 1 which shows that images are in greyscale. Then we apply activation function relu which is Rectified Linear Activation that is used well in neural networks. Then we applying MaxPooling2D on convolutional layer that makes data more unique. MaxPooloing2D extract the largest or unique element from feature map as shown in Figure 6.s

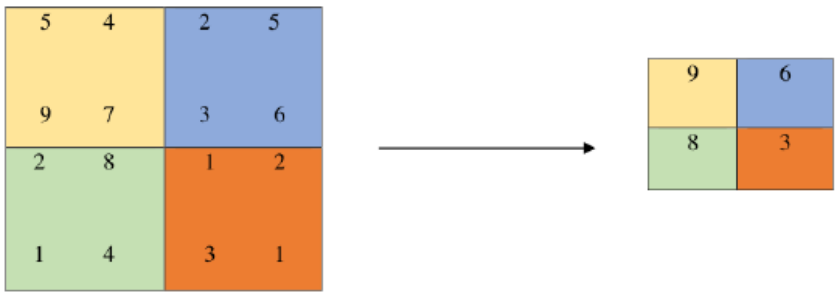


Figure 6: Maxpooling Example

Then we apply 2nd layer of convolutional neural network then we apply again max-pooling to make our data more squeeze and unique. We add flatten layer to make a connection between Convolutional and dense layer. We take 5 Pakistani currency for our system so we use 5

dense layers for output of our model. And we use sigmoid as activation layer because this is more effective for binary classification. Then we compile our model, for this we take three parameters optimizer, loss and metrics.

We use "sparse_categorical_crossentropy" for our loss function. Mostly we use this loss function for classification because this is the best choice for loss function. If loss function score is lower than this shows our system performance is better. We used adam as our optimizer. Adam is best optimizer to employ. We used accuracy as metrics. When we train the model, we see the accuracy value on the validation set to make thing easier to understand.

Then we used Tensor Board to see the workflow of our model and also to see the accuracy of our system in the form of graph.

E used Fit function to train our model. In fit function, x is a training data and y is the target data. Validation_split = 0.3 means, we use 30% data for validation and we apply 10 epochs to get better results and after every epoch we show the result by using tensor board. Then we saved data of our model. The results that are gained by using CNN model for Pakistani currency recognition system is very good.

4. Experimental Results

We used many android smartphones to test our system. We also show the results of our system on the Tensor board using python in the form of a graph. Every phone has a different image quality and features. We use different environmental conditions like illumination, rotation, etc., to show our results and the results are excellent. We used OpenCV libraries to build our proposed system that runs on the android platform. We used OpenCV libraries because OpenCV libraries are very useful for getting effective results.

4.1 Results by applying KNN

First, we show the result of the system using the KNN algorithm. Below is the figure that shows the result of our system using the KNN algorithm. As we see in Figure 7, that the precision for Note 10, Note 100, Note 1000, Note 500, and Note 5000 is 86%, 80%, 100%, 100%, and 54% respectively.

As we know precision is referred to as a number of correct positive predictions. When we see the total accuracy of our currency recognition and fake currency detection is 84% which is not up to the mark. So, to increase the accuracy of our system and make the system useful for the blind we used another model of deep learning which is CNN.

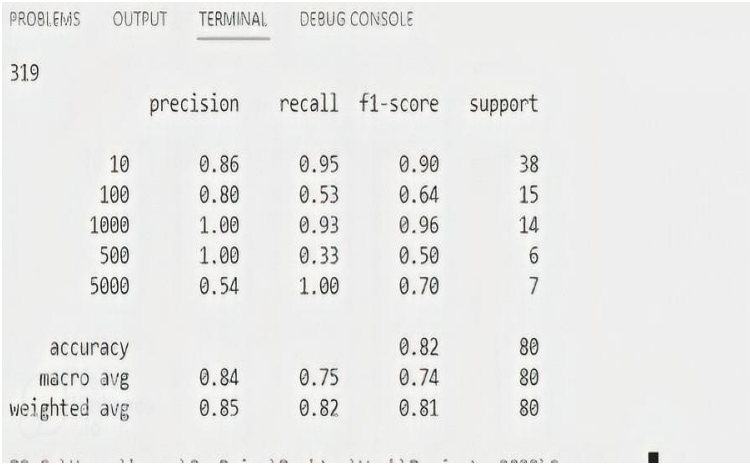


Figure 7: KNN Model Results

4.2 Results by applying CNN

First, we apply the KNN algorithm to develop our currency recognition and fake currency detection system but we didn't get good results so we apply another model of Deep Learning which is CNN. As we discussed earlier how we implement the CNN algorithm now we show the results of our currency recognition and fake Pakistani currency detection system using CNN. Figure 8 shows starting accuracy of our system as we apply 10 epochs to increase the accuracy of our system. As shown in the below figure, Accuracy in epochs 1, 2, 3, and 4 is 36, 51%,

65%, and 76% respectively. And loss value for our system is at epoch 1, 2, 3, and 4 is 1.5359, 1.2492, 1.0665, and 0.8160 respectively. The loss value for our system is further reduced in the next epochs.

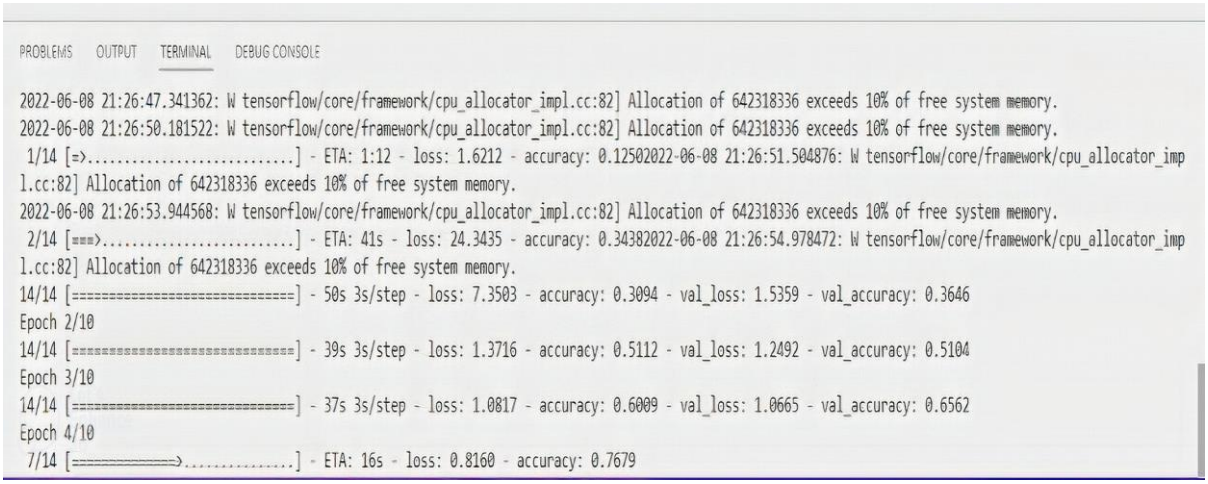


Figure 8: Initial CNN Model results

In the Figure 9, discuss in detail the accuracy and loss value by applying more epochs. As we see from below figure accuracy at epoch 5, 6, 7, 8, 9 and 10 is 72%, 81%, 90%, 98%, 98% and 98% respectively. And loss value for our currency recognition system at epoch 5, 6, 7, 8, 9, 10 is 0.8384, 0.5823, 0.4573, 0.6025, 0.6071, 0.6505 respectively. So, we achieve the accuracy of our system is very good and also loss value is very low. So, this system is very useful for the assistance of the blind in recognizing the amount of currency and also to detect fake Pakistani Currency.

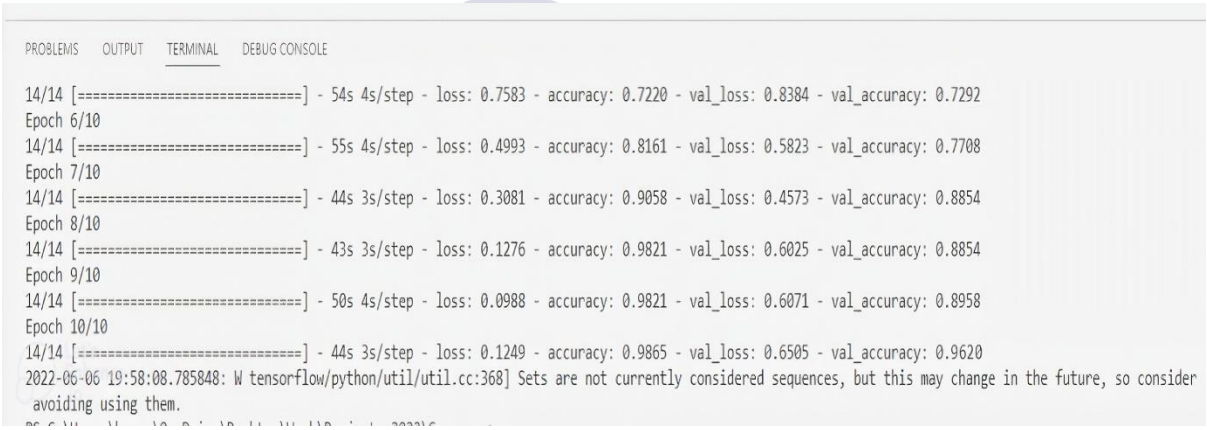
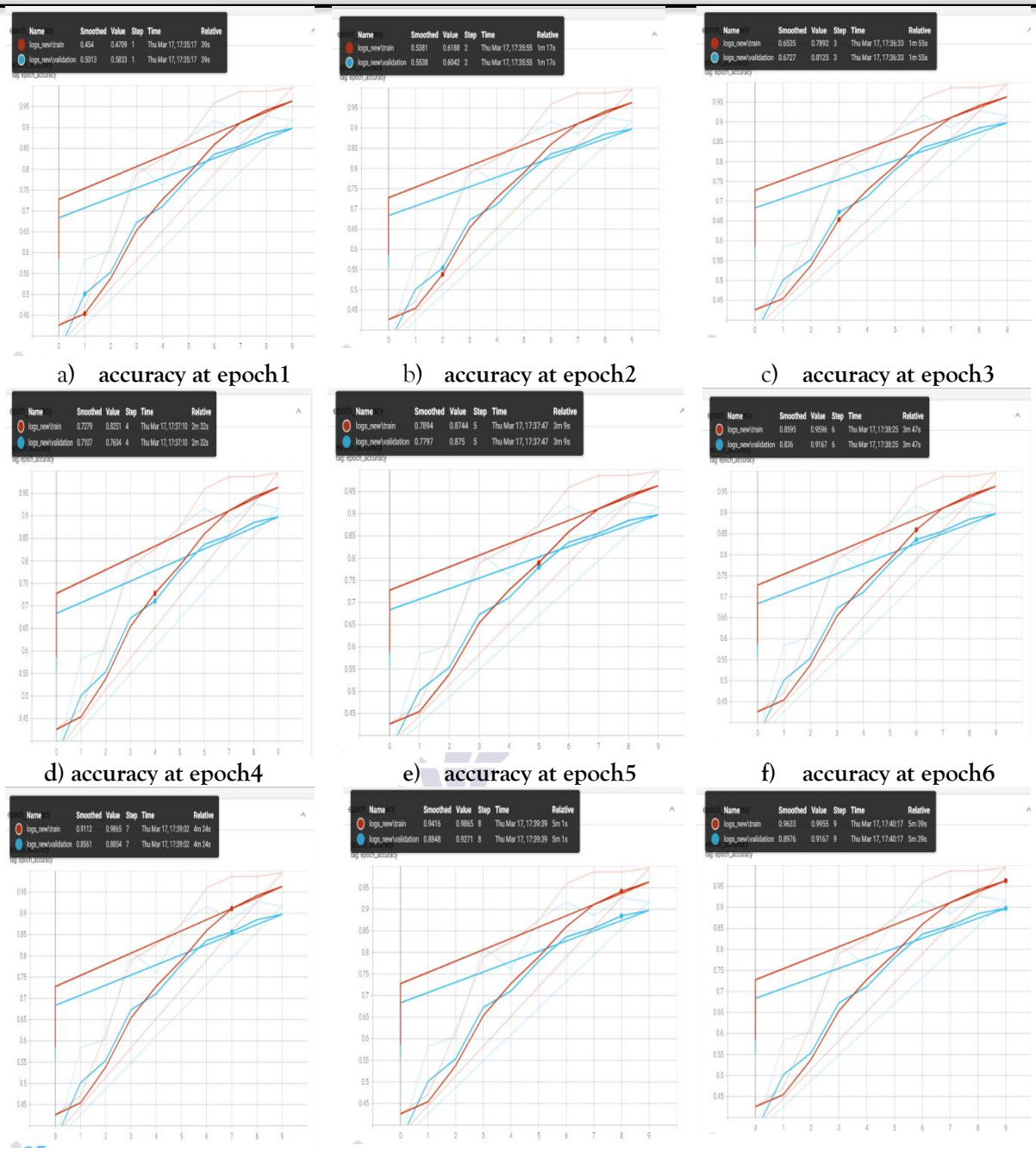


Figure 9: CNN Model Results after increasing epochs

Figure 10 shows the accuracy for training dataset at different epochs. These results are summarized in Table 2.



a) accuracy at epoch1 b) accuracy at epoch2 c) accuracy at epoch3

d) accuracy at epoch4 e) accuracy at epoch5 f) accuracy at epoch6

g) accuracy at epoch7 h) accuracy at epoch8 i) accuracy at epoch9

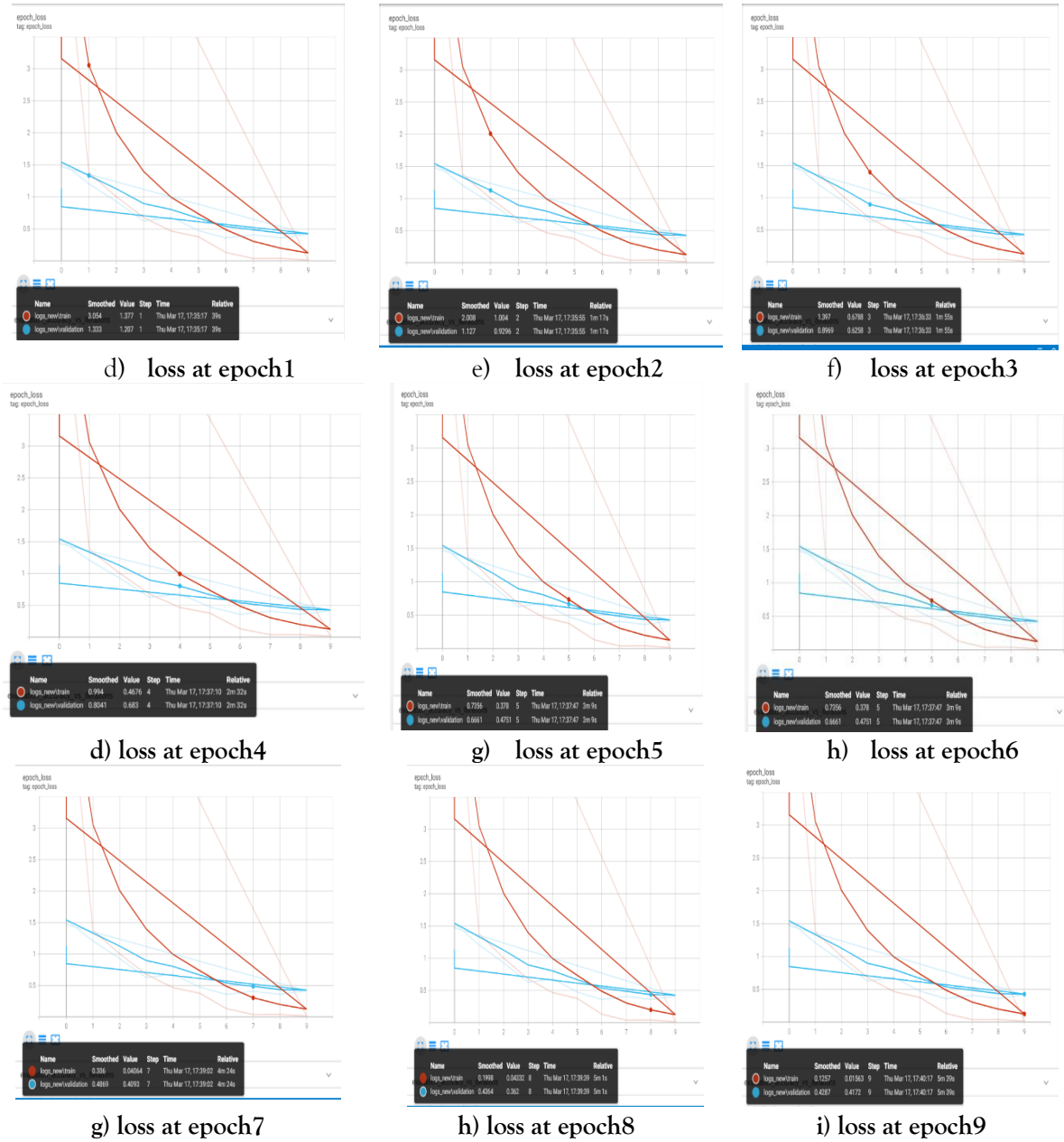
Figure 10: Accuracy at different epochs

Table 2: Training and Validation Accuracy at Different Epochs

Epoch	Training Accuracy	Validation Accuracy
1	47%	58%
2	61%	60%
3	78%	81%
4	82%	76%
5	87%	87%
6	87%	87%
7	98%	88%
8	98%	92%

9	99%	91%

Now we discuss in detail about the loss value of our system at every epoch. Figure 11 shows the epoch loss for training dataset for 9 epochs. These results are summarized in Table 3.



d) loss at epoch1 e) loss at epoch2 f) loss at epoch3

d) loss at epoch4 g) loss at epoch5 h) loss at epoch6

g) loss at epoch7 h) loss at epoch8 i) loss at epoch9

Figure 11: Loss at different epochs

Table 3s: Training and Validation Loss at Different Epochs

Epoch	Training Loss	Validation Loss
1	1.377	1.207
2	1.004	0.9296
3	0.6788	0.6258
4	0.4676	0.683
5	0.378	0.4751
6	0.1338	0.36

7	0.0406	0.4093
8	0.0433	0.362
9	0.0156	0.4172

As shown in the above figure epoch loss value is 0.01 which is very low that show our system works ideally for currency recognition and also to detect fake Pakistani currency for the assistance of blind people. Now we show results of our system on android phone. We discuss in detail about the working of our system on mobile phone. Our system is very user-friendly. Further we will show all the results of captured currency image on android phone. In Figure 12, we show the result of NOTE 10. After that the user will get output whether the note is real or fake after a control button is clicked. It also counts the total value of the currency notes.

Figure 12: Mobile view for NOTE 10

4.2.1 Overall Accuracy of our System

We show the overall accuracy of the system in Table 4 and Table 5. It is obtained in terms of sum of all the accuracy of all categories of Pakistani currency that we take for experiment and divide total accuracy with total classes of currency.

Overall accuracy = sum of all currency's accuracy / total classes of currency Equation1

Table 4: Overall accuracy for classification

Categories	Accuracy
NOTE 10	98.7%
NOTE 100	99.2%
NOTE 500	96.6%
NOTE 1000	100%
NOTE 5000	99.2%
Overall accuracy	99.10%

Table 5: Overall accuracy for Identification

Categories	Accuracy
NOTE 10	95.6%
NOTE 100	93.8%
NOTE 500	98.1%
NOTE 1000	93.5%
NOTE 5000	97.3%
Overall accuracy	93.2%

We have discussed in detail about all the result of our system at every epoch and also show result in the form of graph. We also show the mobile view of our system. We explain in detail how our system will assist blind people in their daily monetary transactions. As table 3 shows the overall accuracy of our system that is 99.10% with respect to classification of amount of currency.

Conclusion

The main purpose of this research is to assist blind people in their daily monetary transactions. We would like to help blind people in recognizing the amount of currency and also detect fake Pakistani currency. There are so many systems that are already available in markets but these are not developed for Pakistani currency. Counterfeit currencies are so common nowadays that everyone gets victimized by fraudsters easily. So, this is so hard for blind people to detect fake Pakistani Currency. For this purpose, we used artificial intelligence and a deep learning model. We used different algorithms of the Deep Learning model like KNN and CNN. We also used python for the coding of our system. We used a Tensor board to represent the results of our system deeply. We take five denominations (10, 100, 500, 1000, and 5000) of Pakistani currencies to design our system. We apply data augmentation on images to increase the size of the dataset and also to improve the quality of images. We used the CNN algorithm and the results of our system are 99.10% with respect to recognizing the amount of currency and 93.2% regarding detection of fake Pakistani currency. We also designed an android app that is very user-friendly and works well to recognize the amount of currency and also to detect fake Pakistani Currency.

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