Currency Recognition System for Visually Impaired using a Novel CNN-LSTM based Hybrid Approach

Karandeep Singh[1], Shashank Gupta[2], Manini Chawla[3], Gowhar Rashid[4], Ujjwal Anand[5], Rachna Jain[6], Aman Agarwal[7]

[1,2,3,4,5]Bharati Vidyapeeth's College of Engineering, New Delhi, India

[6]Bhagwan Parsuram Institute of Technology, New Delhi, India

[7]Chandigarh University, Punjab, India

karandeep041998@gmail.com[1], shashankgupta3891@gmail.com[2], maninichawla@gmail.com[3],gowhar687@gmail.com[4], ujjwalanand555@gmail.com[5],rachnajain@bpitindia.com[6], aman.agar85@gmail.com[7]

Abstract- One of the main problems faced by visually impaired people is dealing with monetarytransactions, due to their inability to recognize the value of currency notes because of the identicaldimensions and it's feel. We introduce in this paper, a camera phone-based money recognition system that executes real-time processing for every detected frame as the camera advances towardsthe note using CNN-LSTM algorithm and then generates a corresponding audio message telling about the value of the currency note. To make the system reliable in real-life scenarios, we have created a Currency recognition system (CRS) built on Convolutional neural network (CNN) and Long short-term memory (LSTM). The hybrid CNN-LSTM algorithm obtains results as fast and robust as possible.

Keywords: Currency Recognition, CNN, LSTM, Currency Recognition System (CRS), Indian Currency Detection, CNN-LSTM Hybrid

1. Introduction

According to the latest stats of the World Health Organization (WHO) around 286 million peoplein the world are visually impaired and about 62 million people are from India. Therefore, to resolvethis issue faced by visually challenged people, we propose a visually impaired mobile phone- based money scanner that conducts real-time operation for every recorded frame recorded as the photographic equipment travels towards the note, and then generates a corresponding audio message telling about the value of the currency note to the person. To resolve the issue faced by visually challenged people while detecting the value of the currency, we proposed a mobile phone-based currency reader that conducts real-time processing for each recorded frame as the camera travels towards the note, and then generates a corresponding audio message telling about the valueof the currency note to the person. This is done with help of a CNN-LSTM based Hybrid Approach. CNNs are used to model problems involving spatial inputs such as images. For picture-related activities such as computer vision, picture identification, and object detection, CNNs have provenuseful. Convolution is the initial level to generate characteristics of a picture. By learning visual characteristics from tiny input data squares, convolution maintains pixel relationships. Two intakes are required for the mathematical procedure to proceed, one of which is an image matrix and the other of which is a filter or kernel. LSTMs are used to model and predict sequences. LSTMs are extensively used in natural language processing tasks like machine translation, sentence classification, and production. The addition of a gating mechanism is a significant advantage of using LSTM over a standard RNN. This gating mechanism consists of an input gate, an output gate, and a forget gate. It is used to regulate the transmission of information between neural networks.

In this paper we described how CNN and LSTM technology can be used as a currency recognitionsystem for visually impaired people. So, we introduced a camera phone based model, through which people can recognize a currency note with the camera of their phone. We studied almost 30research papers in which we covered various techniques and the challenges which earlier authors faced, and we tried to overcome that and develop a robust and sustainable solution. We prepared a model using CNN-LSTM hybrid approach which includes convolutional, pooling and LSTM layers. We used technologies like cloud model deployment, crash detection system and enhancedthe camera scanning functionalities which works well even in low light and we used TTS (Text toSpeech) technology which helps us convert text to an audio message. After combining all these technologies we prepared a software solution which is robust, sustainable, compatible and works effectively in real life environment showing an accuracy of 92.55%.

1.1 Problem Statement

Owing to the issue faced by visually challenged people while recognizing the value of currency notes because of the resemblance of the feel and size of different notes, oneof the main challenges encountered by visually disabled persons is when performing money transactions.
There are 3 main challenges in existing current currency recognition systems (CRS) which are listed below:

- Detecting currency value from partially captured images and under different lighting conditions.
- Lack of fast and accurate methods for robust and quick currency recognition.
- Problem from frequent crashes in current applications because heavy machinelearning and deep learning processes are running in mobile devices.

These flaws in the existing systems motivates us to work upon this problem statement. To make the system reliable in real-life scenarios, we have created a Currency recognition system (CRS) on thebasis o Convolutional neural network (CNN) and Long short-term memory (LSTM). The hybrid CNN-LSTM algorithm obtains results as fast and robust as possible.

A Currency Recognition System (CRS) must possess three functionalities:
Image preprocessing (Elimination of background details)
Feature Extraction
Classification on basis of underlying algorithm
The primary objectives of this research project are as follows:

- To design a model which can recognize currency notes with limited training sets.
- To minimize the computational time of the proposed Currency Recognition System (CRS).
- To optimize the accuracy of the existing Currency Recognition System (CRS).

To deal with the research challenges and achieve these objectives, we are proposing a novel CNN-LSTM based hybrid approach for Currency Recognition system (CRS) in this research.

2. Background Study

The authors, [1] have incorporated a currency recognition system (CRS) in which it used Oriented FAST and rotated BRIEF (ORB) algorithm. ORB makes use of FAST detector and visual descriptor BRIEF (Binary Robust Independent Elementary Features). Itcomes up with a swift as well as an effective substitute to Local Scale-Invariant Features (SIFT).Inthe beginning, some preprocessing actions are carried out on the provided currency paper image. Thereafter,

the ROI is extricated out of the surroundings. For feature recognition and illustration of the image that has been provided , the ORB Algorithm has been used .And then, for matching binary descriptors procured from the extraction phase of the feature, Hamming Distance has beenused.

The authors, [2] have proposed a framework focused on basic utilities of image processing. The basic methods used throughout their proposed system involve segmentation of the image foreground, enhancement of the histogram, detection of the region of interest (ROI) and thus eventually comparing the template on the basis of cross-correlation between both the image procured and the dataset.The research outcomes indicates that the methodology recognizes Egyptian capital with a precision of 89%.

The authors, [3] have presented a Currency Recognition System on the basis of Oriented FAST and rotated YoloV3 algorithm. They preprocessed and converted the RGB image into the grayscale image. After pre-processing, a Sobel algorithm was applied for extraction of the inner as well as the outer edges of the image. Clustering was done using the YOLO V3 algorithm in which it forms the clustering of features one by one and after that shows the result of the currency value.

The authors, [4] have presented a framework for fake currencydetection.Using a real-time image captured from a web camera, this framework can identify Indiancurrency notes. The key goal of the system is image processing technology and thus using it to inspect authentic currency notes.By extracting the characteristics of notes, this software system can recognise the fake currency.The rate of success of this software system can be calculated in terms of precision and pace. MATLAB, image processing, edge Detection, CNN and Surf are themain technologies used.

The Author [5] in their Journal Computers in Industry by Springer they have suggested a novel work method for identification of Indian currency notes by following a modular approach. This suggested work collects unique and distinct characteristics of Indian banknotes, such as RBI seal, central numeral, identification mark and colour band for the visually challengedand uses specialized algorithms to detect each particular feature. The suggested mobile-based Indian currency detection model uses image processing for feature extraction and a simple CNN for currency detection using the provided feature inputs data. The Core Technologies used in thissystem may be Mobile Application, Edge Detection, CNN.

The Author [6] in their Journal International conference on Computer science, Communication. and security by Springer proposed a structure for the visually challengedand foreign visitors of India who many times find it difficult to recognize various types of banknotes. This proposed paper uses deep learning techniques and a detection model which is trained with a dataset. In this paper, the author chooses faster RCNN which helps train models andidentifies Indian banknotes quite well, which helps visually challenged people, foreigners and old people. The Tools and Technology used in this module is Python Programming Languages, TensorFlow, Image Processing

The Author [7] "CrashSafe: have studied the UI and its effect on people's experience. An unsatisfactory user interface often leads to a large number of user complaints. Systems with such faults put the dependability of software at risk. Due to the app's poor response,users give it a low rating. Users could have various expectations regarding the latency of the UI (e.g., the amount of time between when a user begins an operation and when the UI is updated) invarious tasks. The Google website recommends that UI response time should be less than 200ms.Users detest waiting longer than expected.The authors as per this paper, discuss their experiences developing user interfaces for database access to a corporate venture data system for field personnel while working on an industrial project.Size of the screen and screen resolutions vary significantly across devices, as do aspect ratios and the complexity of mobile operations.

The author [8] over 6 million intents against over 800 apps in this article and discovered that around 10% of Android components evaluated crashed as a result of intents. Separately, discovered 1414 open surfaces in 100 Android apps, the majority (1013) of which were triggered by intents. Application crashes are the most common issue (62 percent of all) encountered by users, with the majority of them prompting users to remove the programme. Additionally, we examined 15,000 Google Play apps and discovered that around 16% (337 out of 15,000) were leaking information through mobile application crashes.

The author [9] "TCM: test case mutation to improve crash detection in Android. discussed the significance of GUI testing of mobile applications andproposed Test Case Mutation (TCM). It is a technique for mutating existing test cases in order to generate more diverse test cases. These altered test cases discover crashes that were not identifiedbefore by standard test cases. TCM is distinct from the more commonly-familiar Mutation Testing(MT) technique, which involves inserting mutations into the source code of an Application Under Test (AUT) in order to determine the quality of test cases. However in TCM, we augment alreadypresent test cases with latest ones in order to improve the count of crashes identified.

The author [10] ―Currency Recognition Using of Image Processing to determine if the banknote is fake or not. The frameworkis built using the Python programming language. The steps in this procedure, which use appropriatemethods, include character extraction, grayscale conversion, segmentation, comparison, edge detection, and so on. This technique evaluates even more characteristics than previous suggested methods in order to extract features. Currency differences are as well shown alongside the result. Counterfeit money, Image Processing, Python programming language, grayscale conversion, edge detection, and segmentation are some of the technologies used in this article.

The author [11] in this paper use the cam scanner, with the aid of a scanner or a camera, the author digitises textual material in this document. It's also possible to use a portable scanner toprocess information right away. The gathered data and digitised material is sent to OCR, which extracts textual data from a file, which may be a snapshot, a scanned document, or a video clip. The transformation took place only after a machine has obtained the whole collection of files Formore study, the OCR uses grayscale versions of the files. Character recognition is achieved basedon the strength of the areas in the picture. The lighter areas are considered the backdrop, while thedarker areas are considered the text.The alphanumeric values are then identified and categorised using this information. Image de- skewing, de-speckling, binarization, line reduction, layout analysis, line and phrase identification, script recognition, character segmentation or separation, scaling, and aspect ratio normalisation are some of the OCR preprocessing techniques.Charactersare identified using attribute recognition and pattern detection algorithms. The characteristics of numeric or alphabets are independently told to identify these characters in text through feature detection. To increase the system's performance, complicated formats must be treated, proofreading and simple mistakes must be corrected, and the text must be stored for future use. For the visually disabled person, the voice synthesiser transforms the final material into audio output. This machine artificially generated human voice.

The author [12] uses the ORB Algorithm is used in this paper to propose a mobile-based currency recognition method for vision impared people. To remove the noise, this approach used image processing operations. The related part Algorithm is then used to remove ROI. For obtaining the binary descriptors for storage in the database, the ORB is used. Finally, using the hamming distance method, adapt the findings to the domain descriptors. In terms of processing time and precision, the proposed method outperforms the CRSFVI system, according to the evaluation findings. In coming time, we will work to incorporate more types of banknotes from various countries and develop the process by using other similar strategies so as to increase precision and achieve 100% accuracy

The author Vincent [13] in this paper demonstrates how a stacked sparse denoising autoencoder that was trained using numerous synthetic examples and which thenserved as a filter was used to train the image lightening up and denoising functions, which were subsequently used to clean essential shade and corrupted images. According to the findings, deeplearning methods are best suited to these kind of activities for natural reduced illumination imagesof various degradation. The suggested LLNet architecture outperforms existing image increase methods like CLAHE ,histogram equalisation, , hybrid methods and gamma correction like addingHE first and then using a state-of-the-noise reduction like BM3D.While some of these approachesachieve best in amazing cases, our system has been able to adjust as well as carry out number of (illuminating & buzz) scenarios. Also powerful methods of learning mark signals and loud soundmechanisms from shade pictures with out manual processing are deep autoencoders.

The author [14] have worked on an algorithm for banknote recognition in bionic eyeglasses for the visually impaired. Using thefollowing methods, preprocessing and feature detection of the banknotes has been done: binary conversion, tactile mark detection, pattern detection, morphological pre-classification. For classification, the following features have been selected- portrait, shape, colour, tactile mark classification and decision. The features extracted for tactile are mark classification the features are- number of objects, Axis ratio, extent, far away from centre, far away and major Axis ratio. The algorithms have successfully been trail through a mobile phone.

The author 15] have inventeda system for currency recognition using image processing. Since it is impossible to recognize all the currencies of the world, the creation of such a system was necessary. Convolution Neural Network(CNN) for object recognition and classification has been used along with TensorFlow Object Detection API which is an open-source schema built on TensorFlow. A model has been generated using a data set that has been split into 80% training and 20% testing. Then CNN has been used to increase the accuracy. For training the dataset faster R-CNN model is used. Its threesections are Convolution Layer, Region Proposal Network and Classes and Bounding Boxes prediction. In Convolution Layer training of filter and computation is done to form a feature mapand the faster R-CNN is applied to arrange the features.

The author [16] suggests to use latest techniques to automated speech accolade on the basis of active learning. Active learning requires effective use of particulars that would otherwise be transcribed at a high cost. Furthermore, active learning comes with the ability to modify to non stationary events through a response procedure built into the training algorithm. Active learning is also a test algorithm which selects training datato improve the accuracy of the word. In comparison to random sampling, our investigations have shown the use of active learning reduces by more than 60% the amount of labelled information required for the provided word precision, while also improving word accuracy.

The author [17] suggested that(ASR) Automatic Speech Recognition is considered as a tool for at most completing translations from colloquial speech to written wordings, and thus being quite inconvenient. Anyway, thanks to significant advancements in computer science technology & information processing methodology, ASR has become more reliable and manageable, and the amount of applications has grown significantly. A microphone will be used in lieu of a keyboard and mouse in many functions in the near future due to improved natural speech recognition (ASR) technology.a. It seems that clinicians who work with people who have oral communication disorders should be involved in this growth so that their clients can get the most out of this advanced hi-tech technology.

The authors [18] has said that this paper includes using a real-time picture obtained from a web camera, this machine can recognizeIndian currency notes. The system's main goal is to use image processing technology to verify thecurrency notes are valid. By extracting the

features of notes, this software system can detect fake currency. This software system's performance rate can be calculated in terms of accuracy and time. MATLAB, image processing, edge detection, CNN, and Surf are some of the maintechnologies used.

The authors [19] suggested that this paper they look at thedifficulties that a visually impaired person faces and the solutions that have been proposed to address this issue in recent years. They've also identified a few effective techniques, such as ANN(Artificial Neural Network), and others. They also learned how to identify fake currency using image processing in [10] Madhuri R. Raut, Prof. Dr Krishna. K. Warkhade's article in the International Open Access Journal. First, the image is acquired, and then pre-processing is appliedto the image. The picture is then transformed from RGB to HSV. The picture is then segmented and morphological operations are performed on it. Finally, the image's features are extracted.

The authors [20] showed that, due to advances in printing technology, the issue of counterfeit currency has grown in recent years. They looked at a variety of fake currency identification methods and algorithms to see what features areavailable in a currency note that can be used to determine its authenticity.

The authors, [21]in his journal on Reducing the size of the app updates has discussedhow the app network traffic can be reduced using DELTA++. He explained how Google built Google Smart Application Update utilising the Delta Encoding Method for this purpose at first, but that it wasn't the best approach. One reason for this is that it only functioned on the Android Application Package (APK) level, whereas DELTA++ may be used on Blackberry, iOS, and othermobile operating systems. Then came DELTA++, a technique for compressing Android application updates using the DELTA (Delta Encoding for Less Traffic for Applications) algorithm. The rsync algorithm, a sort of delta encoding, has been used to reduce network utilisation.So when any update has to be done, the whole version does not get downloaded ratheronly a part of the version that has got fixed needs to be downloaded.

This saves a lot on the network traffic which thereby decreases the load on the cellular infrastructure

The authors [22] in their paper have worked on the concept of DELTA++. They have also discussed the drawbacks of Google Smart Application andhow DELTA ++ overcomes its disadvantages.DELTA++ is a file transfer mechanism that transfersthe difference between two files rather than the whole file. It takes as input two files, one old andone fresh, and calculates the difference between them. This distinction is referred to as a "patch."This patch, which is sent, represents the difference between the two files. To construct patches, two tools were developed: UNIX bsdiff and bspatch.These Four steps comprise the application updation process: patch creation, transmission and deployment to the device, and lastly, setup of the upgraded version.Unlike Google Smart Application Update, DELTA++ decompresses the APK before unpacking its individual modules. According to their findings, DELTA++ cansignificantly reduce the size of application updates by 77 percent on average, compared to a 55 percent drop with Google Smart Application Update.

The authors [23] have developed a money note recognizer that recognises multiple shades of Malaysian banknotes and responds to them by transmitting different sounds for different notes. The aim of this endeavor is to create an attractive, simple, adaptable, and moderately priced device for the visually impaired. The shading sensor foridentifying the different shades is a Programmable shading light to recurrence converter (TCS230). The ATMega328P-PU microcontroller is used to sift through the contributions (TCS230). To create the ATMega328P-PU, a model of the Arduino board was developed, as well as an Arduino-independent circuit. The yield sound example is made by using the microcontroller's defer capability. The various banknotes were interpreted by evaluating the yield of various shading lightfrequencies and dissecting them. By and large, this approach was increasingly beneficial.

The authors [24] have also suggested a method for locating false banknotes that relies on profound learning for visibly disabled persons and visible light images captured by cell phone cameras. CNN is used to identify counterfeit banknotes in the US dollar, euro, krw, and jordan. To increase precision, the nearby ROI is focused on the centre of the banknotes territory and investigated using the class enactment planning method (CAM). There is no need to pre-orderthe banknote group or side. Numerous CNN struc+tures, such as AlexNet, ResNet18, and GoogleNet, were used, and they outperformed previous strategies.

The authors [25] have done a study on different crashes specific to android , what caused them and what could be a possible solution to solve different types of crashes. They chose a data where they manually selected the android specific bugs and divided into various categories like App State &UI, Compatibility, Memory etc. Crash causes are largely caused by inability to manage uncommon or exceptional circumstances, inabilityto upgrade programmes rapidly when platform issues arise, and failing to manage unfavourable circumstances, according to empirical investigations.

Hence this study proves that along with addressing to unusual occurrences and bad conditions while the app creation is on, programmers must periodically upgrade applications to accommodatesystem changes.

The authors [26] incorporated a currency recognition system (CRS) usingOriented FAST and rotated BRIEF (ORB) algorithm. The ORB is based on the FAST detector andvisual descriptor BRIEF (Binary Robust Independent Elementary Features). It aims to provide a fast and efficient alternative to Local Scale-Invariant Features (SIFT). Initially, somepreprocessing operations are performed on a given currency paper image. Then, important ROI isextracted from the background. The ORB Algorithm is used for a feature detection and descriptionof the input image. Finally, Hamming Distance is used for matching binary descriptors obtained from the feature extraction stage.

The authors [27] proposed a system based on simple image processing utilities. The basic techniques utilized in their proposed system include image foreground segmentation, histogram enhancement, region of interest (ROI) extraction and finally template matching based on the cross-correlation between the captured image and the dataset. The experimental results demonstrate that the proposed method recognized Egyptian currency with anaccuracy of 89%. Further in [3], presented a Currency Recognition System basedon Oriented FAST and rotated YoloV3 algorithm. They pre-processed and converted the RGB image into the grayscale image. After pre-processing, a Sobel algorithm was applied for extractionof the inner as well as the outer edges of the image. Clustering was done using the YOLO V3 algorithm in which it forms the clustering of features one by one and after that shows the result ofthe currency value.

The authors, [28] in International Journal of Research in Computer and Communication Technology proposed textureclassification for fake Indian currency detection. Automatic Fake Currency Recognition System (AFCRS) is developed to identify a fake currency. This system can be implemented on android phones as well, which makes it easier for a common man.

The authors, [29] in his Journal Computers in Industry by Springer proposes a work novel technique for recognition of Indian currency banknotes by adopting a modular approach. This proposed work extracts unique and distinct features of Indian currency notes such as RBI seal, central numeral, identification mark and colour band for the visually impaired and employs algorithms optimized for the detection of each specific feature. The mobile-based Indian currency detection model is the proposed model which will be using image processing for feature extraction and a basic CNN (convolutional neural network) for identification of currency with the given feature inputs. The Core Technologies used in this system may be Mobile Application, Edge Detection, CNN.

The authors, in the International Conference on Machine Learning and Cybernetics proposed different algorithms thatcan be used to identify monetary value of a currency note for

visually impaired people. The mainchallenge was to find an algorithm which is accurate as well as fast for analysing the monetary value of currency notes. They have focused on 3 algorithms SIFT, SURF and ORB which are available in the OpenCV library of Python. Also, They found that ORB is faster than the other twoalgorithms to find the monetary value of currency notes.

3. Proposed Work

This research paper has developed an effective way to predict currency note value where we implement a combination of two deep learning techniques CNN and LSTM which is working as a Hybrid approach named as CNN-LSTM. If we use it is the right procedure. Both techniques have their own advantages in this model and help us in predicting with more accuracy.

Fig 1: Background removal from Image

The main characteristics of convolutional layers include their capability of reducing the size by using convolution filter method on RBG 3D matrix data input of images, removal of the blank spaces and the extraction of the practical and the effective knowledge. Whereas, LSTM can be used for effectively identifying the long-term and the short-term dependencies.

The main motive of this proposed model is to present a combination of the benefits of CNN and LSTM deep learning techniques for achieving the desired results. Mainly, this proposed model is named as CNN-LSTM which consists of two major components.

The first major component includes pooling and convolutional layers which further consists of complex mathematical operations for developing features on the input data. Furthermore, the second component makes use of the LSTM and dense layer's generated features. Finally, the core of the proposed model i.e., LSTM, pooling and convolutional layers are described briefly.

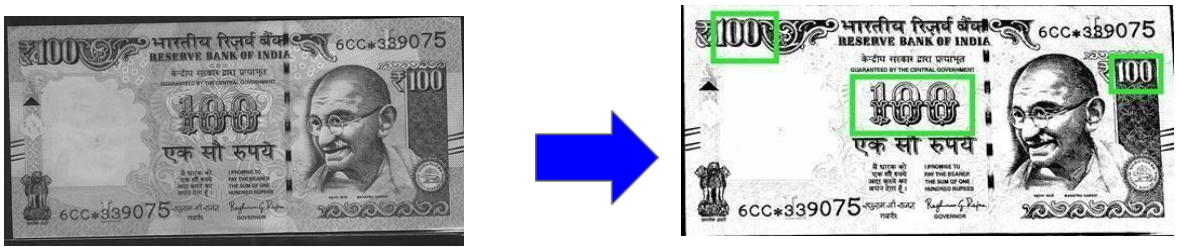

Fig 2: Image Segmentation

3.1 Convolutional Neural Network

Convolutional neural network (CNN) is a neural network having a deep structure and expertise in resolvingand dealing with issues related to images [31].

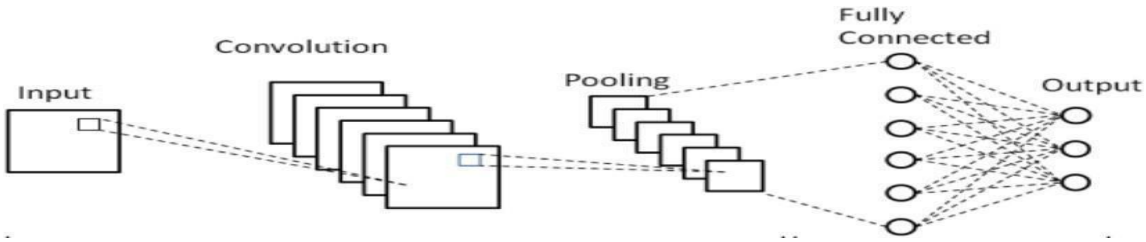

Fig 3: CNN Model

3.2 About Convolutional and Pooling Layers

Convolutional and pooling layers are mainly drafted for pre-evaluating of data. These layers are responsiblefor filtering out the data that has been inserted and withdrawing the beneficial and the important informationwhich has to be further put in a completely linked network layer of CNN.

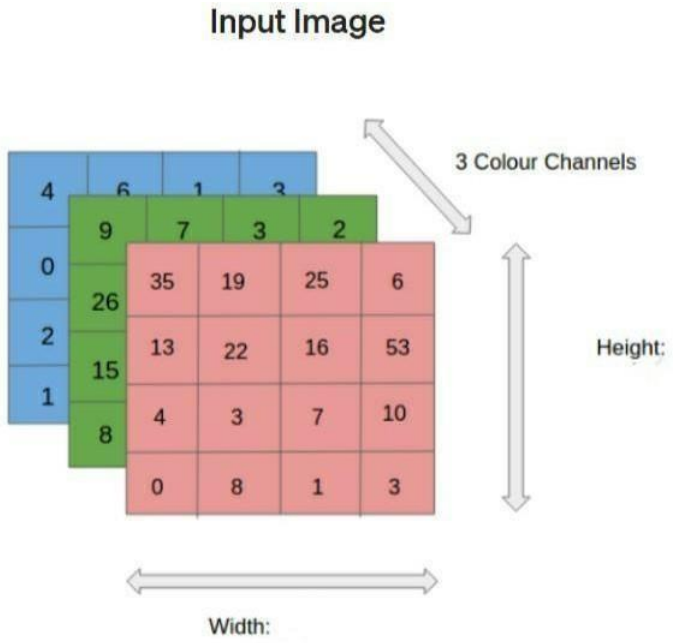

Fig 4: Input Image in RGB format

Moreover, the main function of convolutional layers is to assist the application of convolution operations between the unprocessed input data and the production of new features values by the convolution kernels. In addition, it is important to consider the input dataset must be in a structured form of a matrix as this technique only allows the extraction of features only from image datasets. Furthermore, the convolution kernel can also be referred to as a small window (in comparison to the huge input matrix) that consists of the coefficient values in a matrix form.

The kernel then puts in convolution operation on every other sub-region by sliding all over the input matrixsuch that the particular window intersects the input data matrix.
Therefore, a convolved matrix is derived as an output of all these operations. This convolved matrix also represents a specific feature value which is stated by the dimensions of the filter applied and the coefficientvalues. Furthermore, the generation of multiple convolved features can be done by application of various convolution kernels on the input dataset. Moreover, these multiple convolved features are more helpful as compared to the original feature of the input data which in turn improves the model's overall performance.

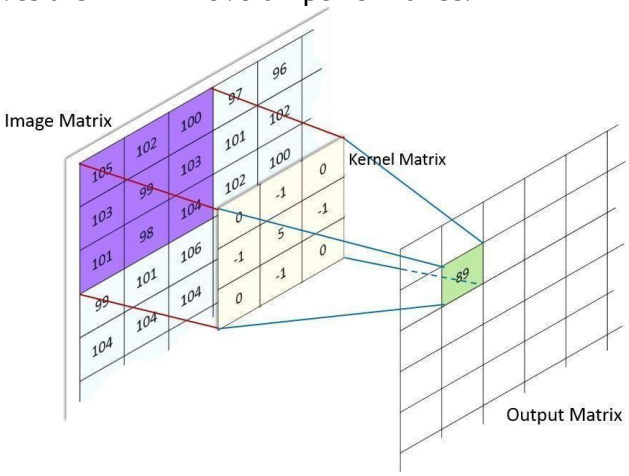

Fig 5: Convolution Operation

3.3 LSTM Layers

One of the major advantages of using LSTM over the standard RNN is the additional gating mechanism. This gating mechanism consists of the input gate, output gate and the forget gate for controlling the information transmission between the neural networks. This structure further enables the LSTM to manageand create an administered flow of information by helping to decide whether information has to be "remember" or "forget", hence resulting in the learning of long term dependencies. The architecture of the LSTM unit can be described by the state diagram in Fig. 6.

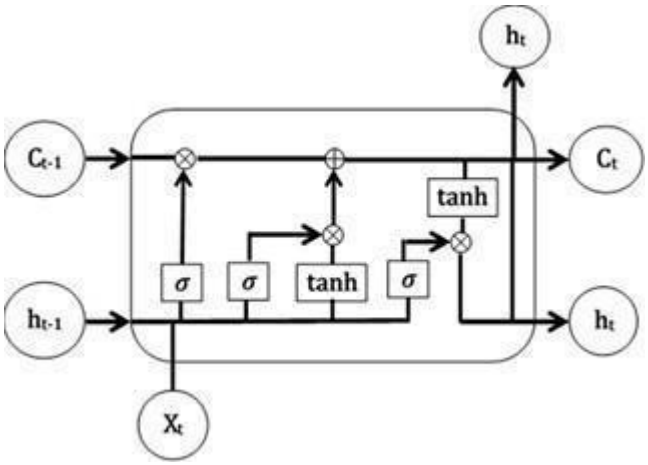

Fig 6: Architecture of LSTM Model

The forget gate contains a sigmoid layer that gets hold of the last hidden state (ht−1) and current input (xt) to generate an output in range of 0 and 1. Basically, this layer determines what data is to be retained or deleted. Here zero value indicates that we have to forget the previous values and one indicates to keep the previous values. The output for forget gate is as given in eq. 1

$$ft = b*f + \sigma*W*[ht-1, xt] \quad \ldots 1$$

After that, the forget gateway uses combinedly tanh and sigmoid functions to determine which data will be entered into the cell state. Both of these functions get ht - 1 and xt as input. The sigmoid output determineswhether or not the existing data is useful, and the tanh function controls the system by subtracting the figures in range of -1 and +1. Then finally, both results are multiplied as given in eq. 2 and 3

$$it = (bi+ Wi*[ht-1, xt])*\sigma \quad \ldots 2$$

$$Ct = \tanh(bc + WC*[ht-1, xt]) \quad \ldots 3$$

This data then gets replaced with the output from the forget gate and input gate in the cell state. It's done with a clear repetition of the current state of the cell and the removal of the forget gate. In the case of ft is 0, zero will also be the outcome of the product, thus implying a complete decrease in the previous value. Else, if ft is 1. Then, it's retained. After that, the cell state is updated by pointwise addition. As given in eq. 4

$$Ct = (it \times Ct) +(ft \times Ct-1) \quad \ldots 4$$

The output gate determines the final output is the final stage. This result also serves as a concealed state later on, ht.It takes ht−1 and xt as the input and the status of current cell state Ct is forwarded with the help of tanh function in this gate. After that, both sigmoid and tanh outputs are multiplied to find out whatinformation would be stored inside the hidden layer. As given in eq. 5

$$St = \sigma(Wo*[ht-1, xt] + bo)\ ht = \tanh(Ct) \times St \quad \ldots 5$$

3.4 CNN-LSTM Model

We utilized versions of the proposed model in our implementation. The CNN–LSTM model contains convolutional layers that are succeeded by a pooling layer, an output layer and LSTM layer of one neuron.CNN-LSTM outline is given below in the Fig 7.

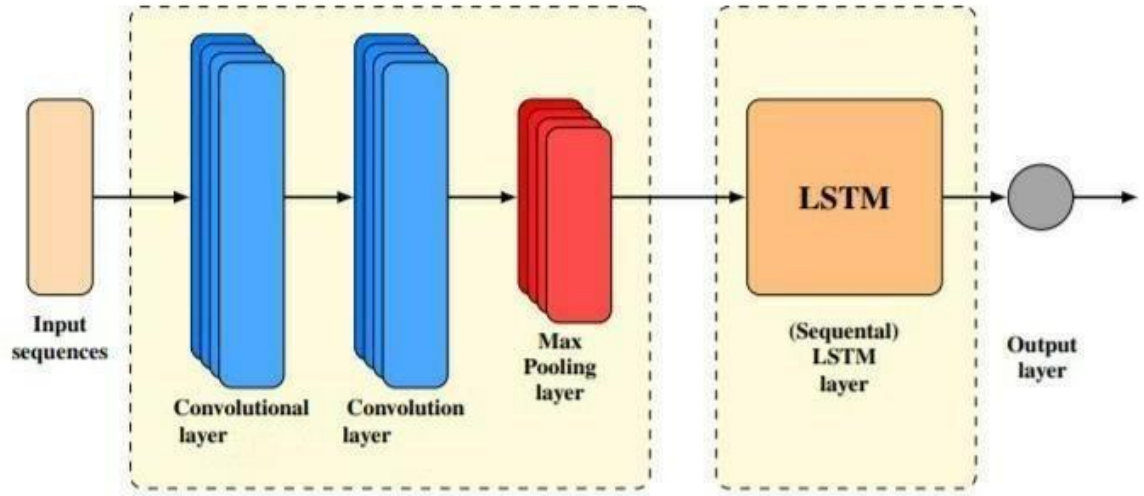

Fig 7: CNN-LSTM Model

3.5 Cloud Model Deployment

Our previous system was based on the model that was directly deployed in an android mobile app which made it slower in terms of speed and heavy in terms of size and gave problems like frequent app crashing.We couldn't even get to know when the crash occurred because apps usually crash without giving any warning or error messages. And error messages are something which gives developers a way to fix it.

Now, In the current system, We will implement a model on the cloud which will help us to reduce the appsize, make our app fast, and most importantly we can update our model in production without updating theapp on the playstore. Current model is going to be implemented in Google MLOps Cloud service which will be having the following benefits-

- Straightforward management of infrastructure
- Better scalability
- Price is less
- Always available

3.6 Crash Detection System

Our Previous system was based on mobile computation which wasn't giving up to the mark performance asit was processing everything on a mobile. The problem being that mobile phones have only a limited memory and processing power, no matter how good the smartphone is. Hence, to improve on this ,we willimplement a crash detection system which will help in getting errors sources and stack tracing of applications at the time of crash in mobile applications. It will also give us data about a particular device which has been getting frequent crashes so that we can analyse it and improve the software easily.

We'll also use Google Crashlytics, a lightweight, real-time crash reporter that will help us track, prioritise,and resolve stability issues that are affecting the app's quality. It also helps you save time troubleshooting by automatically grouping crashes and highlighting the events that led up to them.

3.7 Enhanced Camera Scanning Functionality

Our Previous system was based on default native scanner api available on android development platform which was not compatible with all types of lighting conditions. Now, We will be testing different third partypackages available on android platform that can be made by an individual or a community. Its implementation in our current system will help us achieve better results.

Image alignment and stitching techniques will be adapted with other image processing methods to stitch together closely captured images of portions of a page. Then the images will be passed into an image stitching pipeline which will extract and match the features in the images, perform bundle adjustment and warp the images together.

3.8 Converting the text result to corresponding audio message

TTS (Text-To-Speech) allows an Android smartphone to "speak" text in a variety of languages. A numberof languages are supported by the Android platform's TTS engine. Although the engine has all Android devices supporting TTS, certain equipments possess finite space and may lack language-specific resource files .The TTS API permits an application to request that language files are available from the platform andto start downloading and installing, When a user wishes to install the resources. The TTS engine keeps trackof all the entries that need to be synthesized in a global queue. Every TextToSpeech instance may check which expressions disrupt the present one and are just queued by managing their own queue. The initial proposal for a speech might stop everything that was being synthesized currently: the queue would be smoothed out, the latest utterance would be torn into the queue and put it on the front of the line and the text message would be transformed to its matching audio message.

4. Result

We have successfully completed our goal to create and depict a system which can be utilized to identify currency for a visually impaired user. We have translated the system to a smart phone technology, performing around strain like restricted computing capacity and memory, we bestow an application for recognizing currency bills using computer visual system and techniques, that can run on a affordable smartphone. while still attain great accuracy and little stated time.

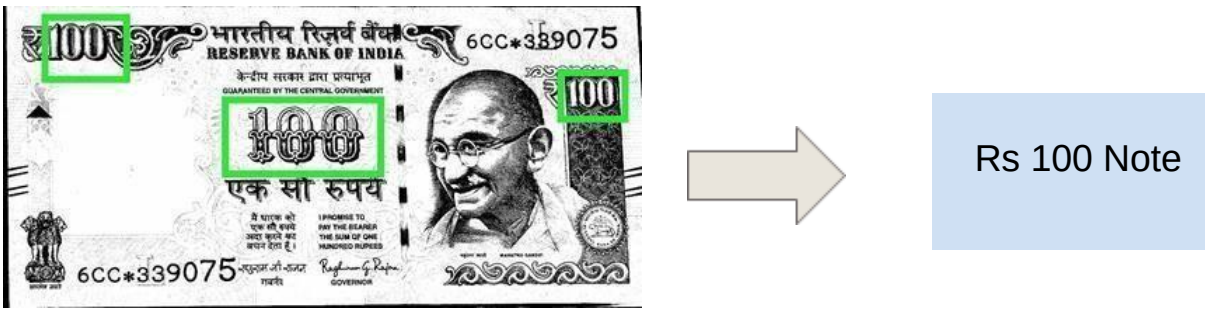

Fig 8: Image Recognition

The enforcement of the proposed system has been estimated using the advanced dataset of 300 images. In the assessment, the authors try out a database of 300 indian banknotes, which includes 5 kinds of banknotes(2000,500,200,100,50,10).

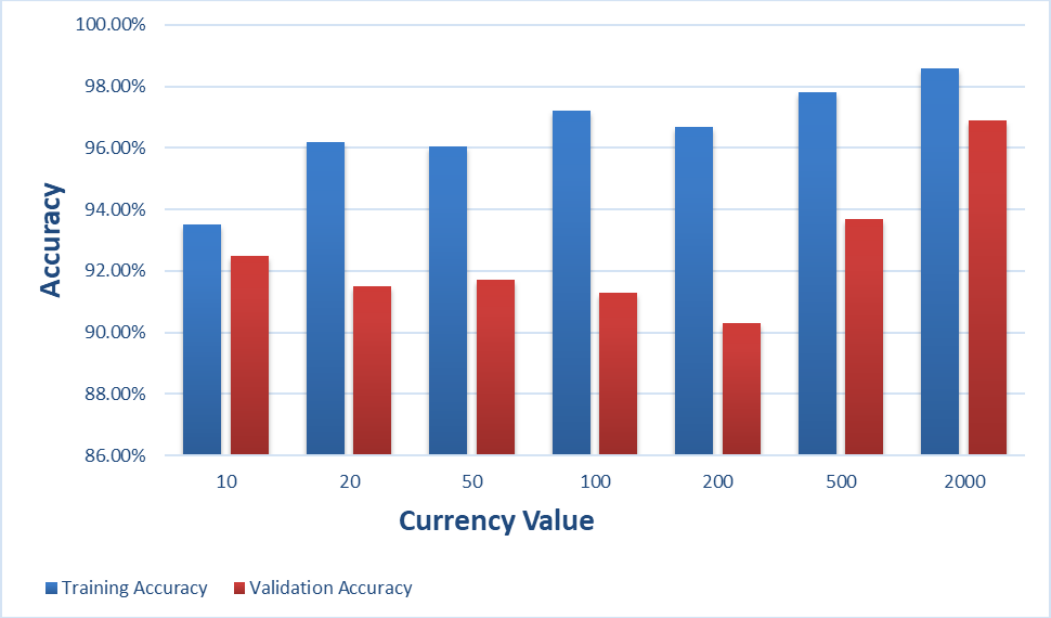

Fig 9: Accuracy Curve for CNN-LSTM

TABLE 1) Accuracy of the Proposed System

Currency Value	Training Accuracy	Validation Accuracy
10	**93.5%**	**92.5%**
20	**96.2%**	**91.5%**
50	**96.05%**	**91.7%**
100	**97.2%**	**91.3%**
200	**96.67%**	**90.3%**
500	**97.8%**	**93.7%**
2000	**98.6%**	**96.9%**

In order to recognize the denomination of the currency we compare the extracted features with the availabledatasets**.** The recognized text are recorded in the form of script files. Then we make use of the text to speechconverter to load these files and display the audio output of text information. Visually impaired or Blind users can adjust the generated audio accordingly based

on their preferences which includes speech rate, volume and language. The earlier model used to show a little spike in the accuracy of that proposed system,but our model is used to show 92.55% of an accuracy.

5. Conclusion

Currency recognition system (CRS) built on hybrid of Long short-term memory (LSTM) and Convolutional neural network (CNN) obtained highly accurate results and with very less computational time. Adding cloud deployment and crashlyitcs functionalities further made the system more robust irrespective of the camera quality and lighting conditions. The innovative outcome have shown the success of hybrid CNN- LSTM algorithm in general for Indian banknote currency recognition, while our algorithm is tested in a better challenging dataset with the images taken in contrasting circumstances. As a result, the results indicates the accuracy and speed of the CNN-LSTM technique, which can be applied in real-world scenarios to assist visually impaired people with monetary transactions.

References

[1]. Shah, A., Vora, K., & Mehta, J. (2015). A review paper on currency recognition system. *InternationalJournal of Computer Applications*, *115*(20).

[2]. Suresh, I. A., & Narwade, P. P. (2016). Indian currency recognition and verification using image processing. *International Research Journal of Engineering and Technology (IRJET)*, *3*(6), 87-91.

[3]. Rajebhosale, S., Gujarathi, D., Nikam, S., Gogte, P., & Bahiram, N. (2017). Currency Recognition System Using Image Processing. *International Research Journal of Engineering and Technology (IRJET)*,*4*(3).

[4]. Darade, S. R., & Gidveer, G. R. (2016, December). Automatic recognition of fake Indian currency note. In *2016 international conference on Electrical Power and Energy Systems (ICEPES)* (pp. 290-294). IEEE.

[5]. Sawant, K., & More, C. (2016). Currency Recognition Using Image Processing and Minimum Distance Classifier Technique. *International Journal of Advanced Engineering Research and Science*, *3*(9), 236826.

[6]. Kang, Yu, et al. "Experience report: Detecting poor-responsive ui in android applications." 2016 IEEE27th international symposium on software reliability engineering (ISSRE). IEEE, 2016.

[7]. Holzinger, Andreas, Peter Treitler, and Wolfgang Slany. "Making apps usable on multiple different mobile platforms: On interoperability for business application development on smartphones." International Conference on Availability, Reliability, and Security. Springer, Berlin, Heidelberg, 2012.

[8]. Khan, Wilayat, et al. "CrashSafe: a formal model for proving crash-safety of Android applications." Human-centric Computing and Information Sciences 8.1 (2018): 1-24.

[9]. Koroglu, Yavuz, and Alper Sen. "TCM: test case mutation to improve crash detection in Android." International Conference on Fundamental Approaches to Software Engineering. Springer, Cham, 2018.

[10]. Chinmay Bhurke, Meghana Sirdeshmukh, Prof. Mrs. M.S.Kanitkar, ―Currency Recognition Using Image Processing‖ International Journal of Innovative Research in Computer and Communication Engineering, Vol. 3, Issue 5, May 2015

[11]. R. Szeliski, “Image alignment and stitching: A tutorial,” Found. Trends. Comput. Graph. Vis., vol. 2,pp. 1–104, Jan. 2006.

[12]. Joshi, AV Kumar, T. Prabhu Madhan, and S. Raj Mohan. "Automated electronic pen aiding visuallyimpaired in reading, visualizing and understanding textual contents." In 2011

IEEE International Conference On Electro/Information Technology, pp. 1-6. IEEE, 2011.
[13]. Kumar, P., Kumar, R., & Gupta, M. (2021). Deep Learning Based Analysis of Ophthalmology: A Systematic Review. *EAI Endorsed Transactions on Pervasive Health and Technology*, *7*(29).
[14]. Singh, S., Tiwari, A., Shukla, S., Pateriya, S., & Student, I. M. S. (2010). Currency recognitionsystem using image processing.
[15]. Solymár, Z., Stubendek, A., Radványi, M., & Karacs, K. (2011, August). Banknote recognition for visually impaired. In 2011 20th European Conference on Circuit Theory and Design (ECCTD) (pp. 841-844). IEEE.
[16]. Giuseppe Riccardi, Dilek Hakkani-Tür "Active Learning: Theory and Applications to Automatic Speech Recognition" IEEE TRANSACTIONS ON SPEECH AND AUDIO PROCESSING, VOL. 13, NO.4, JULY 2005
[17]. Gupta, M., Thakur, N., Bansal, D., Chaudhary, G., Davaasambuu, B., & Hua, Q. (2022). CNN-LSTM hybrid real-time IoT-based cognitive approaches for ISLR with WebRTC: auditory impaired assistive technology. *Journal of healthcare engineering*, *2022*.
[18]. Zahid Ahmed, Sabina Yasmin, Md Nahidul Islam, Raihan Uddin Ahmed "Image ProcessingBased Feature Extraction of Indian Banknotes".
[19]. Zhang,Q.,Yan,W.Q.,kankanhalli,M Overview of Currency Recognition using Deep LearningJ.Banking Financ Technol .3(1),59-69(2019)
[20]. Thakur, M., & Kaur, A. (2014). Various fake currency detection techniques. International Journal for Technological Research in Engineering, 1(11), 1309-1313.
[21]. Rajai, Hari H., and Sachin Bojewar. "REDUCING SIZE OF UPDATES IN ANDROID APPLICATIONS." (2015).
[22]. Samteladze, Nikolai, and Ken Christensen. "DELTA++: Reducing the Size of Android Application Updates." *IEEE internet computing* 18.2 (2013): 50-57.
[23]. Jha, Ajay Kumar, Sunghee Lee, and Woo Jin Lee. "Characterizing Android-specific crash bugs." *2019IEEE/ACM 6th International Conference on Mobile Software Engineering and Systems (MOBILESoft)*. IEEE, 2019.
[24]. Pham, T. D., Park, C., Nguyen, D. T., Batchuluun, G., & Park, K. R. (2020). Deep Learning-Based Fake-Banknote Detection for the Visually Impaired People Using Visible-Light Images Captured by Smartphone Cameras. IEEE Access, 8, 63144-63161.
[25]. g Mohamed, A., Ishak, M. I., & Buniyamin, N. (2012, May). Development of a malaysian currency note recognizer for the vision impaired. In 2012 Spring Congress on Engineering and Technology (pp. 1- 4). IEEE.
[26]. Yousry, A., Taha, M., & Selim, M. M. (2018). Currency Recognition System for Blind people using ORB Algorithm. Int. Arab. J. e Technol., 5(1), 34-40.
[27]. Semary, N. A., Fadl, S. M., Essa, M. S., & Gad, A. F. (2015, December). Currency recognition system for visually impaired: Egyptian banknote as a study case. In 2015 5th International Conference on Information & Communication Technology and Accessibility (ICTA) (pp. 1-6). IEEE
[28]. P. Gayathri, P .Soniya, V. YaminiPriya, G. Srinivas, V. Ravindra, TEXTURE CLASSIFICATION FOR FAKE INDIAN CURRENCY DETECTION, International Journal of Research in Computer and Communication Technology
[29]. Guo, T., Dong, J., Li, H., & Gao, Y. (2017). Simple convolutional neural network on imageclassification. In 2017 IEEE 2nd international conference on Big Data Analysis (ICBDA) (pp. 721–724). Beijing.
[30]. Rahman, M. M., Poon, B., Amin, M. A., & Yan, H. (2014, July). Recognizing Bangladeshi currency for visually impaired. In International Conference on Machine Learning and Cybernetics (pp. 129-135). Springer, Berlin, Heidelberg.
[31]. Kaur, R., Kumar, R., & Gupta, M. (2022). Predicting risk of obesity and meal planning to

reduce the obese in adulthood using artificial intelligence. *Endocrine*, *78*(3), 458-469.