CURRENCY CLASSIFICATION FOR VISUALLY IMPAIRED

A MINI PROJECT REPORT

submitted By

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in partial fullfilment of the requirements for the award of the degree

of

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Declaration

I undersigned hereby declare that the project report titled **”Currency Classification for Visually Impaired”** submitted for partial fulfillment of the requirements for the award of degree of Master of Computer Applications of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Asst.Professor Sreerekha V K. This submission represents my ideas in my words and where ideas or words of others have been included. I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity as directed in the ethics policy of the college and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the Institute and/or University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title.

Place : Trivandrum **Roshin James**

Date : 06/12/2023

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CERTIFICATE

This is to certify that the report entitled **Currency Classification for Visually Impaired** submitted by **Roshin James** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Master of Computer Applications is a bonafide record of the project work carried out by him under my guidance and supervision. This report in any form has not been submitted to any University or Institute for any purpose.

Guide   Coordinator

Head of the Dept

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Abstract

Currency Classification for Visually Impaired is a machine learning project which aims to provide a solution to assist individuals with visual impairments in recognizing and differentiating Indian currency notes. This project leverages computer vision and machine learning techniques to create an accessible system enabling users to identify various denominations of Indian currency accurately. The user-friendly interface developed here facilitates easy navigation and interaction with the help of voice feedback. Features such as training the model, detecting currency notes, checking model availability, displaying confusion matrices and adjusting text sizes contribute to enhancing the system's usability.This project aims to empower individuals with visual impairments by providing a reliable and accessible tool for independently managing currency notes, fostering financial independence and inclusivity.

Contents

List of Figures

List of Tables

Chapter 1

Introduction

In today's technologically driven world, accessibility and inclusivity are paramount. However, for individuals with visual impairments, everyday tasks like identifying currency notes can pose significant challenges. To address this issue and foster financial independence for the visually impaired community, the "Currency Classification for Visually Impaired" project emerges as a pioneering solution.This project harnesses the power of cutting-edge technologies such as computer vision and machine learning to create an innovative system capable of accurately identifying various denominations of Indian currency notes. Its primary objective is to provide a user-friendly and accessible platform enabling individuals with visual impairments to confidently differentiate between different rupee denominations. The system's core functionality revolves around training a specialized model on an extensive dataset containing images of Indian currency notes. Once trained, the system employs this knowledge to swiftly identify and announce the denomination of the currency notes through auditory feedback upon capturing an image. Designed with accessibility in mind, the user interface facilitates easy interaction, featuring intuitive functionalities such as model training, currency detection, availability checks, and adjustable text sizes. These features ensure a seamless experience, catering to the diverse needs of individuals with visual impairments. By focusing on empowering individuals with tools for independent financial management, this project aims to contribute to their autonomy and integration into societal systems, fostering an environment of inclusivity and equal opportunities.

Chapter 2

Problem Defnition and Motivation

Individuals with visual impairments often face challenges in independently identifying different denominations of Indian currency notes. This limitation can lead to dependency on others for financial transactions and hinder their ability to manage their finances autonomously. The lack of accessible tools or systems tailored to address this specific need poses a significant barrier to financial independence for the visually impaired community.

2.1 Existing System

The major motivation behind choosing the project was the drawbacks of the existing system. The major drawbacks of the existing system are mentioned below,

- Accuracy and Processing Time: Many existing systems lack the necessary accuracy and may require significant processing time to identify currency denomination. There is a need for a system that can provide high accuracy with minimal processing time.

- Insufficient Accessibility Features: Lack of integrated accessibility features such as clear auditory feedback, or compatibility with assistive devices might limit the software's usability for visually impaired users.

- The current system only accommodates individuals who are fully blind, while those with partial blindness aren't receiving adequate consideration..

- In case of existing voice assistant system(e.g.,Microsoft Cortana), To use the voice assistant, users are required to have an account(Microsoft account). This dependency may limit the accessibility of System for users who do not have or prefer not to use a such type of account.

- Technological Limitations: Some systems may rely on outdated technology or algorithms that are not efficient enough to deal with the sophisticated counterfeiting methods used today. For example, convolutional neural networks (CNNs) have been identified as playing a vital role in improving the accuracy of currency recognition, but there is still room for improvement in the overall training and detection process1

- Existing System collects and processes user data to provide personalized responses and improve its functionality. This data collection may raise privacy concerns for some users, and the extent of control over data collection and usage may be limited.

2.2 Proposed System

The proposed 'Currency Classification for Visually Impaired' system introduces a revolutionary solution tailored to address the unique needs of individuals with visual impairments. This innovative system presents a multitude of advantages aimed at elevating accessibility and precision in currency identification. Powered by a robust deep learning model trained on diverse datasets, the system ensures accurate recognition of various rupee denominations, granting users the ability to independently manage their finances. Its user interface, specifically designed for accessibility, integrates features such as voice-guided navigation, clear auditory feedback, and compatibility with assistive devices, ensuring intuitive and effortless usage for individuals with visual impairments. Notably, the system's offline functionality ensures seamless operation even in areas with limited network access. Moreover, its steadfast commitment to user privacy and data security stands out—it operates without requiring a user account and abstains from collecting any personal data, thus reinforcing privacy protection and fostering user trust and reliability.

Chapter 3

Literature Review

3.1 Deep Learning

Deep learning stands as the backbone of the system's currency classification capabilities, particularly in addressing the unique needs of visually impaired individuals. The utilization of deep learning methodologies, with their intricate neural network architectures, forms the bedrock of the system's ability to discern and classify Indian rupee denominations. The depth and complexity of these neural networks enable the system to unravel intricate patterns and features inherent in currency notes, contributing significantly to the precision and accuracy of identification. By harnessing the power of deep learning, the system undergoes continuous learning and refinement, adapting to varying visual cues across different currency denominations. This enables the system to deliver robust auditory feedback, empowering users with visual impairments to confidently manage their financial transactions independently.

3.2 FastAI Framework and Vision Learner

The FastAI framework, integrated within the project codebase, serves as a powerful tool for training machine learning models. Particularly, the vision learner component of FastAI facilitates the creation and training of models for image classification tasks. The system incorporates this framework to train and fine-tune deep learning models, enhancing the accuracy and reliability of currency classification for visually impaired users.

3.3 Transfer Learning

Transfer learning is a pivotal technique within the realm of machine learning, and it holds significant importance in the context of the proposed currency classification system for visually impaired users. This technique involves leveraging knowledge from pre-trained models and applying it to a new task—currency classification in this instance. By harnessing the principles of transfer learning, the system benefits from the prior learning of complex features and patterns present in images, allowing for more efficient and accurate training of models. This approach not only expedites the model training process but also enhances the system's ability to discern and classify Indian rupee denominations, ensuring improved accessibility and precision for users with visual impairments.

3.4 Currency Recognition through Computer Vision

In the realm of assistive technologies for visually impaired individuals, currency recognition via image analysis stands as a pivotal area. It involves the development of systems capable of interpreting currency denominations through image processing techniques, enabling individuals to discern and manage finances without direct physical contact with currency notes. The proposed system leverages image analysis to accurately detect and classify Indian rupee denominations, empowering users with visual impairments to identify currency through auditory feedback.

3.5 Accessibility Features and Auditory Feedback Integration

The integration of auditory feedback mechanisms, akin to those found in gesture recognition and voice assistant systems, plays a pivotal role in the proposed currency classification system for visually impaired individuals. Similar to the principles guiding voice assistants, the project prioritizes accessibility features to create a user-friendly interface. This includes implementing voice-guided navigation and clear auditory feedback ensuring ease of interaction and comprehension for users with visual impairments. By leveraging these technologies, the system enables individuals to independently discern and manage currency denominations through auditory cues, promoting autonomy and accessibility in financial transactions.

Chapter 4

Requirement Analysis

4.1 Purpose

The "Currency Classification for Visually Impaired" project aims to assist visually impaired individuals in identifying different currency denominations using a computer-based system. It eliminates the need for physical interaction with a device by utilizing image processing and machine learning techniques.

4.2 Overall Description

This proposed system facilitates currency identification by analyzing captured images of banknotes. It employs a trained model to recognize various denominations. The system also incorporates an audio feedback mechanism to convey the identified currency to the user.

4.2.1 Product Functions

The project's main functions include:

- Capturing Images of Currency.
- Currency Denomination Identification.
- Audio Feedback for Identified Denomination.
- Audio Feedback to Guide the User Across the Interface.

- Text Size Adjustment.
- Checking Model Availability.
- Model Training.
- Audio assisted User Manual

4.2.2 Hardware Requirements

- Processor : Intel Core i3 or above
- Storage : 512 GB Hard Disk space
- Memory : 4 GB RAM
- Web Camera
- Speakers

4.2.3 Software Requirements

- Operating System : Windows
- Language : Python
- IDLE used:
  - Visual Studio Code
  - Python IDLE (3.10 64-bit)
- Libraries used:
  - FastAI
  - Tkinter
  - Pygame
  - OpenCV
  - PIL
  - Matplotlib

4.3 Functional Requirements

The functional requirements includes all the activities or processes that should be achieved by the proposed system. It includes

- **Image Data Processing using OpenCV:**
  - **Purpose:** OpenCV (Open Source Computer Vision Library) is utilized to process images captured from the webcam. It enables tasks such as capturing, resizing, and enhancing the quality of currency images before feeding them into the classification model.
  - **Functions:**
    - Image capturing from the webcam in real-time.
    - Preprocessing tasks like resizing, enhancing contrast, and converting to the required format for model input.
    - Handling image transformations and manipulations as needed for classification.
- **Model Training and Prediction using Fastai:**
  - **Purpose:** Fastai, a deep learning library, is employed for training and predicting currency denominations based on the images processed through OpenCV. It involves model creation, training, and making predictions on new images.
  - **Functions:**
    - Loading the pre-trained or custom-built currency classification model.
    - Training the model using labeled currency images to recognize different denominations.
    - Utilizing the trained model for predicting the denomination of new currency images.
- **Audio Playback using Pygame:**
  - **Purpose:** Pygame, a multimedia library, facilitates the playback of audio files associated with identified currency denominations. It plays specific audio cues or spoken feedback to communicate the recognized denominations to the user.

- **Functions:**
  - Playing predefined audio files corresponding to different currency denominations.
  - Triggering audio playback based on the prediction results obtained from the classification model.
  - Managing audio cues or spoken outputs to assist visually impaired users in recognizing currencies.

- **User Interface Design using Tkinter:**
  - **Purpose:** Tkinter, a GUI toolkit, is used to create an interactive and accessible user interface for the system. It provides the visual elements and controls necessary for users to interact with the system's functionalities.
  - **Functions:**
    - Designing and implementing a user-friendly interface for the application.
    - Creating buttons, labels, and interactive components to trigger system functions.
    - Integrating the audio playback, image processing, and model prediction functionalities within the graphical interface.

4.4 Non Functional Requirements

4.4.1 Performance Requirements

- **Accuracy :** Ensuring accurate identification of currency denominations is paramount to the system's functionality and user-friendliness.
- **Speed :** The system must exhibit efficient processing to swiftly analyze and convey currency information to the user.
- **Cost-Efficiency :** Implementing the system should be affordable without compromising its usability and effectiveness.
- **Time Efficiency :** The system should significantly reduce the time required for currency identification compared to traditional methods, enhancing user convenience.

- **User-Friendly Interface :** The system interface should be intuitively designed and accessible to facilitate a positive user experience for visually impaired individuals.

4.4.2 Quality Requirements

- **Scalability :** The system should seamlessly accommodate different currency denominations and adapt to potential future enhancements without compromising its core functionality.
- **Maintainability :** The system should include mechanisms for regular backups, system logs, and straightforward maintenance procedures to mitigate potential failures and ensure smooth operation.
- **Reliability :** Minimizing system downtime is crucial. The system should have a high mean time between failures and efficient recovery protocols in case of any breakdown.
- **Availability :** The necessary hardware and software components required to build and run the system should be easily accessible and readily available in the market.
- **Functionality Across Environments :** The system should exhibit high functionality and adaptability across varying environments to ensure its usability for visually impaired users in diverse settings.

Chapter 5

Design And Implementation

The purpose of design phase is to plan a solution of the problem specified by the analysis phase. This phase is the first step in moving from the problem domain to solution domain.

5.1 Design

The proposed system is structured around two primary modules: one focused on direct interaction with captured currency images utilizing Fastai and OpenCV, and the other leveraging audio outputs as voice assistance. The system harnesses CNN models implemented through Fastai for currency classification based on images processed through OpenCV's real-time computer vision capabilities.

5.1.1 System Design

The system architecture comprises two pivotal modules essential for aiding visually impaired individuals in currency identification. The first module, the Currency Denomination Classification Module, operates in real time using Fastai and OpenCV. This component processes live currency images captured via a webcam, employing Fastai's convolutional neural network (CNN) models and OpenCV's image preprocessing. Upon successful identification of a currency note, the system generates an audio output, announcing its denomination to the user. Complementing this, the User Interface Audio Feedback module enhances accessibility by providing auditory cues during cursor interactions with interface elements. When the cursor navigates buttons or elements, corresponding audio cues are played, ensuring comprehensive guidance. Additionally, the system audibly announces the denomination value upon successful currency classification, fostering a user-friendly and inclusive experience reliant on auditory cues for information dissemination.

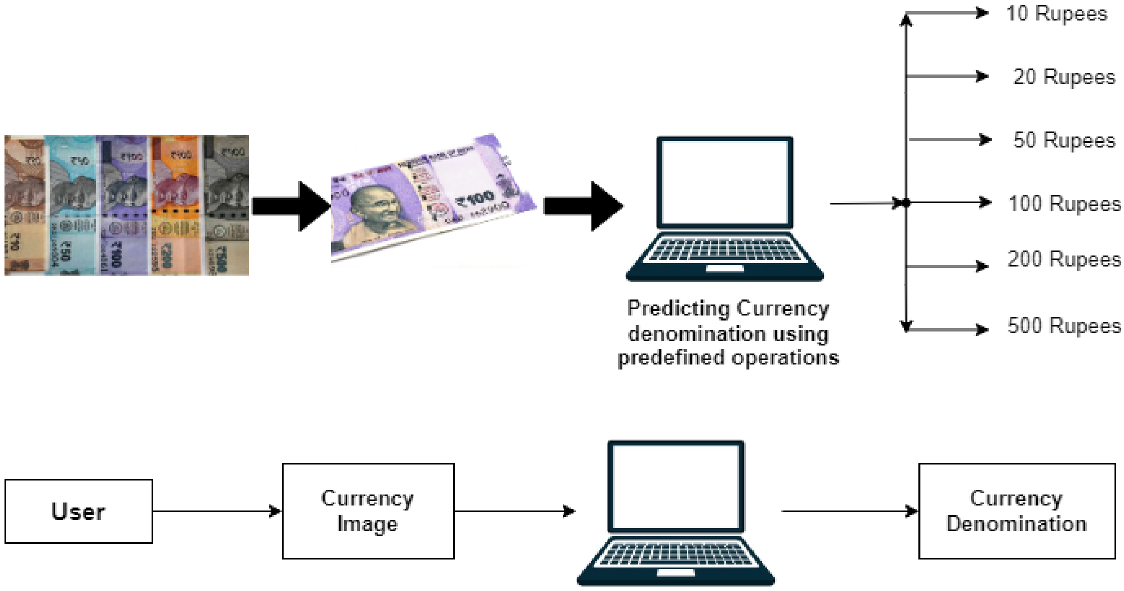

Figure 5.1: Architecture Diagram of Proposed System

5.1.2 Methodology

The project methodology comprises two core components vital for enabling seamless currency identification and interaction for visually impaired users. The first component, the Currency Denomination Identification Process, involves real-time capture of currency images through a webcam. These images undergo rigorous processing using Fastai's CNN models and OpenCV, enabling precise identification and classification of various currency denominations. Upon successful classification, the system triggers an audio output, announcing the identified denomination, crucially aiding users with visual impairments. Additionally, the User Interface and Audio Interaction facet enriches the user experience by incorporating audio feedback during interface interactions. As the cursor navigates interface elements or buttons, corresponding audio cues are activated, providing intuitive guidance to visually impaired users. This dual approach of auditory interface cues and denomination announcements ensures an inclusive and user-friendly interaction paradigm for individuals reliant on auditory cues for information and navigation.

5.2 Implementation

5.2.1 Dataset

The dataset available from the Indian Currency Note Images Dataset 2020 encompasses a comprehensive collection of Indian currency notes valid in 2020. This dataset amalgamates images gathered from Google's image repository and photographs captured via a Redmi Note 5 Pro device. Comprising a total of 3428 images, meticulously curated for model training, the dataset is structured into two primary directories: Train and Validation. These directories further categorize the data into seven specific subfolders representing various currency denominations—10, 20, 50, 100, 200, 500, and Background. Notably, this dataset deliberately excludes images of the banned 1000 Rupees and 500 Rupees notes, aligning with current legal tender. Furthermore, to ensure data accuracy and relevance, images of the banned 2000 Rupees notes were meticulously removed from the dataset before subsequent processing. This curation ensures that the dataset exclusively focuses on valid and legal currency denominations, providing a robust foundation for model training and validation within the realm of currency classification tasks.

Figure 5.2: Dataset Image Examples

5.2.2 Training and Validation

In this project, the training and classification phases were empowered by the fastai library, a powerful framework built on top of PyTorch. Leveraging fastai's capabilities, we utilized a pretrained ResNet 34 model, a popular convolutional neural network architecture renowned for its efficiency in image classification tasks. The flexibility and ease of use offered by fastai enabled us to fine-tune this pretrained model over 9 epochs, further enhancing its ability to discern intricate features within Indian currency notes.The library's high-level abstractions simplified the training process, allowing us to swiftly adapt the model to our specific currency classification task. With fastai, the fine-tuning of the model after initially freezing it for 3 epochs was seamless, resulting in the exceptional accuracy of 97 percentage. Additionally, during the classification stage, fastai's functionalities facilitated precise predictions, with 298 out of 300 classifications accurately identified.This underscores fastai's effectiveness in streamlining complex deep learning tasks, offering a robust platform for training and deploying accurate machine learning models.

epoch	train_loss	valid_loss	error_rate	accuracy	time
0	2.791857	2.316141	0.761905	0.238095	02:03
1	2.560488	1.450993	0.523810	0.476190	02:05
2	1.961284	0.714913	0.285714	0.714286	02:17

```
Better model found at epoch 0 with valid_loss value: 2.316141128540039.
Better model found at epoch 1 with valid_loss value: 1.4509930610656738.
Better model found at epoch 2 with valid_loss value: 0.7149134278297424.
```

epoch	train_loss	valid_loss	error_rate	accuracy	time
0	0.739201	0.603834	0.214286	0.785714	02:59
1	0.515674	0.456163	0.190476	0.809524	03:07
2	0.409850	0.339175	0.119048	0.880952	03:07
3	0.323581	0.263609	0.071429	0.928571	03:08
4	0.267966	0.208517	0.047619	0.952381	02:59
5	0.219488	0.161106	0.023810	0.976190	03:05
6	0.182787	0.156312	0.023810	0.976190	03:05
7	0.157523	0.161525	0.047619	0.952381	03:01
8	0.130798	0.149971	0.023810	0.976190	02:42

```
Better model found at epoch 0 with valid_loss value: 0.6038337349891663.
Better model found at epoch 1 with valid_loss value: 0.456162691116333.
Better model found at epoch 2 with valid_loss value: 0.339175283908844.
Better model found at epoch 3 with valid_loss value: 0.2636088728904724.
Better model found at epoch 4 with valid_loss value: 0.20851746201515198.
Better model found at epoch 5 with valid_loss value: 0.16110587120056152.
Better model found at epoch 6 with valid_loss value: 0.15631230175495148.
Better model found at epoch 8 with valid_loss value: 0.14997069537639618.
```

Figure 5.3: Training details

- **ResNet 34 :**

  ResNet-34, a convolutional neural network architecture belonging to the ResNet family, stands out for its 34-layer structure that incorporates residual blocks and skip connections. Introduced to tackle the challenges of training deep networks, ResNet-34's architecture comprises an initial convolutional layer, multiple residual blocks, and final fully connected layers. Its innovation lies in skip connections, enabling the network to learn residual functions and mitigate the vanishing gradient problem, allowing for deeper networks without degradation. This design fosters improved performance, generalization, and adaptability across various computer vision tasks like image classification, object detection, and semantic segmentation. ResNet-34's versatility extends to transfer learning, where pre-trained models can be fine-tuned for specific tasks, solidifying its status as a pivotal architecture in deep learning, influencing subsequent designs and advancing the capabilities of neural networks.

5.2.3 Classification

The detection process commences by activating the webcam using OpenCV. This enables the system to continuously capture video frames in real-time. These frames are then processed and analyzed for currency detection. To ensure accuracy in classification, specific time criteria are set to capture a frame of the currency note, optimizing the image for subsequent analysis. The captured frame undergoes a series of preprocessing steps, such as resizing, normalization, or other enhancements, to prepare it for classification. Leveraging a pre-trained machine learning model, particularly a Fastai-based model, the system employs advanced computer vision techniques. This model has been trained on a diverse dataset containing various currency denominations. Using sophisticated algorithms and deep learning methods, the model analyzes the captured image to predict and classify the denomination of the currency note. This process relies on the model's ability to identify specific patterns, features, or visual cues unique to different currency denominations. The integration of machine learning, computer vision, and predefined classifiers ensures accurate and reliable currency denomination identification in real-time, aiding visually impaired individuals in recognizing and distinguishing different currencies effectively.

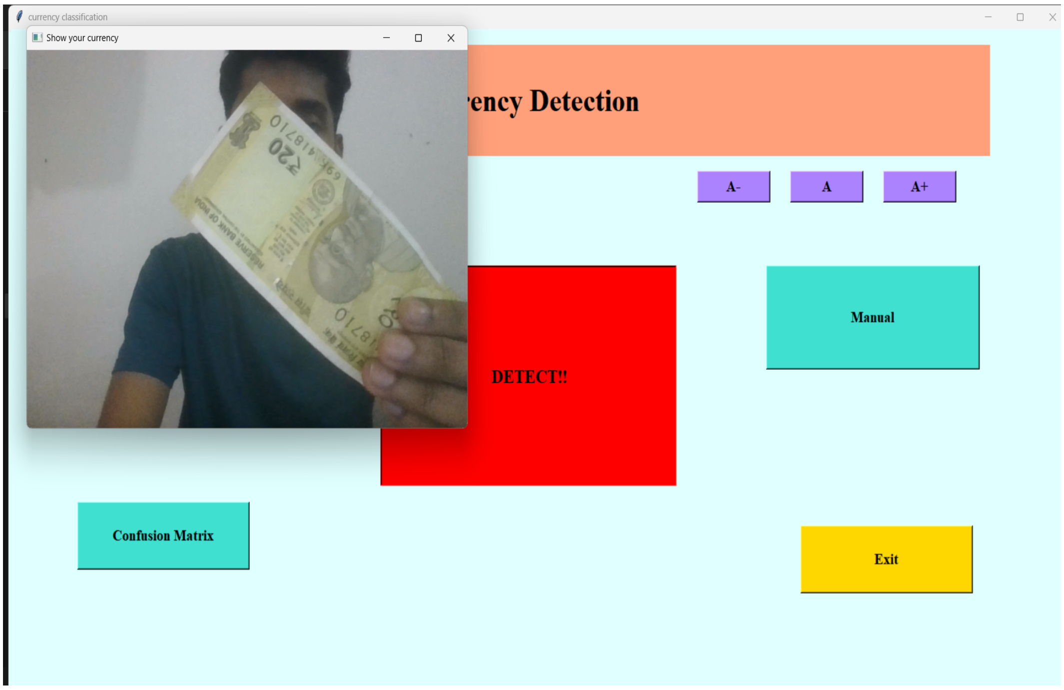

Figure 5.4: Detection of Currency(20 Rupees)

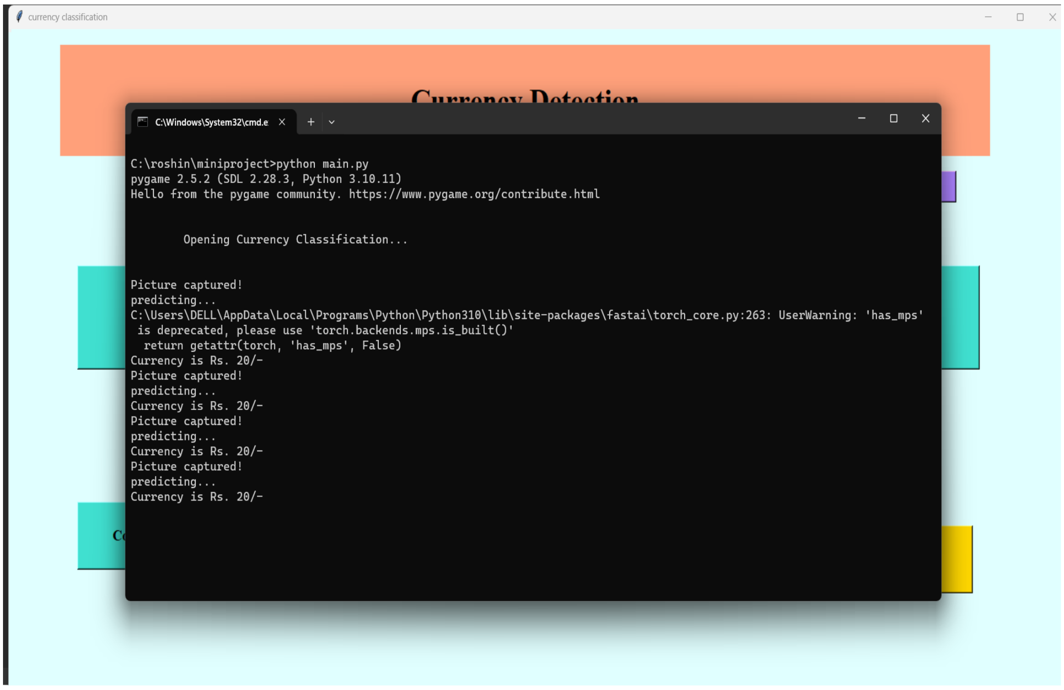

Figure 5.5: Detection of Currency(20 Rupees)-Prediction Result

Chapter 6

Coding

Algorithm 1 Algorithm for Training the Model :

Start

Obtain the dataset for the model. The overall result and quality of the model is heavily dependent on the quality of the dataset that is used to train the system.

Determining and identifying the classes to predict.

Define the ResNet 34 pretrained model.

Train the ResNet 34 model for 3 freeze epochs.

Fine-Tune the ResNet 34 model for 9 epochs.

Evaluate the Trained model by using the validation data to make predictions.

Analyze the confusion matrix to see the accuracy of the trained model.

Stop

Algorithm 2 Algorithm for Real Time Application :

Start

Initialize video stream and capture a frame after 5 seconds.

Pass the obtained frame to the Trained ResNet 34 model to make classification.

Makes the prediction and classification.

An audio output will be given notifying the predicted class.

Stop

Chapter 7

Testing and Implementation

System testing is the process in which the system undergoes experimental testing so as to check that the system does not fail i.e., to check whether the required system is running according to specification and user expectation. System testing also tests to find discrepancies between the system and its original objective, current specification and systems documentation. Hence most useful and practical approach is with the understanding that testing is the process of executing a program with the explicit intention of finding errors that is making the program fail. Testing Is considered to be the least creative phase of the whole cycle of system design. In the real sense it is the phase, which helps to bring out the creativity of the other phases make it shine.

7.1 Testing and various types of testing used.

Once a software is developed, the major activity is to test whether the actual results match with the experimental results. This process is called testing. It's used to make sure that the developed system is defect free. The main aim of testing is to find the errors and missing operations by executing the program. It also ensure that all of the objectivs of the project are met by the developer. The objective of testing is not only to evaluate the bugs in the created software but also finding the ways to improve the efficiency, usability and accuracy of it. It aims to measure the functionality, specification and performance of a software program. Tests are performed on the created software and their results are compared with the expected documentation. When there are too much errors occurred, debugging is performed. And the result after debugging is tested again to make sure that the software is error free. The major testing processes applied to this project are unit testing, integration testing and system testing.

In unit testing, our aim is to test all individual units of the software. It makes sure that all of the units of the software works as it intended. In integration testing, the combined individual units are tested to check whether it met the intended function or not. It helps us to find out the faults that may arise when the units are combined. In system testing the entire software is tested to make sure that it satisfies all of the requirements. The tables shown below describes the testing process occurred during the development of this project. This defines the various steps took to create the project error free.

7.1.1 Unit Testing

Unit testing is a fundamental practice in software development that involves testing individual units or components of a software application in isolation. The goal is to validate that each unit functions as expected by examining its behavior against predefined test cases

Text Cases and Result :

Sl No	Procedures	Expected result	Actual result	Pass or Fail
1	create the user interface	Recieve input from webcam	Same as expected	Pass
2	Pre processing	Convert input to required features	same as expected	Pass
3	Training and testing of the trained model	Create the model and store in a PKL file	PKL file generated	Pass
4	Prediction and Classification	Predict the results accurately	same as expected	Pass

Table 7.1: Unit test cases and results

7.1.2 Integration Testing

Also known as integration and testing, is a step in software testing in which individual modules are combined and tested as a single block.Integration testing is conducted to evaluate its possibilities with specified functional requirements.

Text Cases and Result :

Sl No	Procedures	Expected result	Actual result	Pass or Fail
1	Connect the trained model with the interface	The user interface is loaded and ready to make prediction	Same as expected	Pass

Table 7.2: Integration cases and result

7.1.3 System Testing

System testing is the process in which the system undergoes experimental testing so as to check that the system does not fail.

Text Cases and Result :

Sl No	Procedures	Expected result	Actual result	Pass or Fail
1	Execute program without any crash	Python packages executed successfully, hence the entire program worked without any crash	Same as expected	Pass

Table 7.3: System test cases and results

Chapter 8

Results and Discussion

The project aimed to enable visually impaired individuals to recognize currency denominations through computer vision. The assessment and testing of this system were performed in varying environmental conditions and distances between the user and the webcam. The model underwent rigorous testing under different lighting scenarios, including bright and dim light settings, and varying distances from the webcam to ensure robustness in currency recognition.

8.1 Advantages and Limitations

8.1.1 Advantages

- **Enhanced Accessibility :** The system provides an accessible means for visually impaired individuals to identify currency denominations through audio guidance, promoting independence in financial transactions..
- **Stability and Reliability :** Demonstrates stability even in diverse environmental conditions, reducing dependency on external factors.
- **Cost-Efficient :** Eliminates the necessity for additional hardware devices to detect currency, reducing hardware costs.
- **Real-Time Currency Recognition :** Instantaneous recognition of currency when placed before the camera streamlines the identification process, enabling quick and efficient transactions.

- **User-Friendly Interface :** Incorporation of an intuitive interface with audio prompts simplifies interaction, ensuring ease of use for individuals with visual impairments.

- **Deep Learning Implementation :** Leveraging fastai with a fine-tuned pre-trained ResNet34 model resulted in a robust system achieving a high accuracy rate of 97 percentage. This accuracy fosters trust and reliability in currency denomination identification.

8.1.2 Limitations

- **Limited Currency Support :** The system may have constraints in recognizing currencies beyond the scope of the trained dataset, restricting its use to specific currencies or denominations.

- **Dependency on Camera Quality :** Accuracy might be affected by the quality of the camera used for currency detection, leading to potential inaccuracies in identification under poor camera conditions.

- **Voice Command Sensitivity :** Users need to understand and articulate voice commands accurately for the system to interpret them correctly. Misinterpretation due to pronunciation variations could hinder functionality.

Chapter 9

Conclusions and Future Scope

The currency classification system for visually impaired individuals demonstrates the potential of computer vision in addressing accessibility challenges. By leveraging deep learning methodologies, particularly fastai's fine-tuned ResNet34 model, the system accurately identifies currency denominations through audio output. The model achieves a commendable accuracy rate of 97 percentage, indicating its reliability in assisting visually impaired users during financial transactions. The project significantly enhances the independence and ease of access for users with visual impairments, streamlining currency recognition through a user-friendly interface.

Expanding the currency support involves enriching the dataset with a broader spectrum of currencies and denominations, facilitating a more comprehensive recognition system adaptable to diverse global currencies. This expansion ensures the inclusivity of different currency designs, promoting usability across varied financial contexts worldwide. Improving real-time performance signifies refining the system's speed and accuracy in identifying currencies, exploring advanced inference techniques to enhance responsiveness, especially in challenging lighting conditions. This optimization aims to elevate the system's reliability and speed in recognizing currencies, ensuring seamless user experiences across different environments. Enhancing user interaction through tactile feedback or intuitive voice prompts aims to improve the overall user experience. By incorporating additional sensory cues or clearer verbal instructions, the system becomes more user-friendly and accessible, catering to the needs and preferences of visually impaired users.

Adapting the system for mobile platforms or developing dedicated mobile applications broadens accessibility beyond desktops. This extension to mobile devices empowers users in various situations, offering currency recognition on-the-go and supporting mobile-centric lifestyles.

Integrating with existing assistive technologies fosters a comprehensive ecosystem for visually impaired users, enabling seamless financial management and daily transactions. Collaboration with other assistive tools enhances the system's utility and streamlines its integration into users' routines. Continued model refinement involves periodic updates and adjustments to accommodate evolving currency designs, ensuring consistent high accuracy rates. This ongoing process ensures the system remains updated and aligned with the latest currency iterations, maintaining its reliability and relevance. Exploring AI applications in broader financial accessibility involves leveraging AI beyond currency recognition. This exploration spans voice-controlled banking, expense tracking applications, and other financial tools tailored for visually impaired individuals, fostering greater financial independence and inclusivity. Each aspect signifies a pivotal direction for the project's growth, focusing on inclusivity, usability, and continuous advancements to further empower visually impaired individuals in their daily financial interactions.

By addressing these potential avenues, the currency classification system can evolve into a more versatile and inclusive tool, contributing to the financial autonomy and quality of life for visually impaired individuals.

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