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Design Of Currency Note Identification System For Visually Impaired

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Abstract:
This paper introduces an assistive technology solution aimed at aiding visually impaired individuals in identifying currency notes, utilizing the ESP32 CAM microcontroller and TensorFlow image classification model. Upon activation, the ESP32 CAM captures an image of the currency note, which is transmitted to a cloud server hosting the TensorFlow model via an API. The model processes the image and returns classification results indicating the denomination of the currency note. To enhance accessibility, feedback is provided through a piezo buzzer and vibration motor, with the number of beeps and vibrations corresponding to the identified denomination, enabling users to accurately discern the value of the currency note. Seamlessly integrating hardware and software components, the system is user-friendly and accessible for visually impaired individuals, offering real-time processing and accurate classification for currency note identification tasks

***Background**:*
We introduce a new method that uses hardware and software to help people who are visually impaired recognise different types of currencies. Our approach provides a simple and effective method for identifying currency by utilising the features of the ESP-32 CAM microcontroller, the TensorFlow picture classification model, and feedback methods like piezo buzzers and coin vibration motors.

***Materials and Methods**:*
At its heart, the assistive technology system relies on the TensorFlow image classification model, which reliably identifies scanned banknotes. In order to learn and identify unique characteristics and patterns linked with various monetary denominations, the model makes use of a deep learning technique.

***Results**:*
This paper provides an overview of our assistive technology system, including its design, implementation, and evaluation. It emphasises how this system could improve the lives of visually impaired individuals and makes a contribution to the field of assistive technology.

***Conclusion:** In conclusion, we have presented a novel assistive technology system designed to aid visually impaired individuals in currency note identification. Leveraging the OV2640 camera module for image capture, the ESP32 CAM microcontroller for processing and communication, and cloud-based TensorFlow image classification for currency recognition, our system offers a practical and effective solution to a pressing challenge faced by the visually impaired community. By providing real-time feedback through a piezo buzzer and vibration motor, our system enhances accessibility and promotes independence for users, empowering them to engage confidently in financial transactions and daily activities involving currency notes. Through extensive testing and evaluation, we have demonstrated the reliability and effectiveness of our system in accurately identifying currency denominations across various environments and lighting conditions. Moving forward, we envision further refinements and enhancements to our system, including optimizations for speed and accuracy, expansion to support additional currency types, and integration with other assistive technologies for enhanced functionality. Ultimately, our research contributes to the advancement of assistive technology solutions and underscores the importance of leveraging technology to improve the quality of life for individuals with visual impairments.*

***Key Word**: Assistive technology, visually impaired, ESP32 CAM, TensorFlow, Image classification, Currency notes identification.*

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I. Introduction

Visually impaired individuals face numerous challenges in their daily lives, including the identification of currency notes, which is crucial for independent financial transactions and economic participation. Traditional methods of currency identification often rely on assistance from others or specialized devices, limiting the autonomy and privacy of visually impaired individuals. In recent years, advances in technology have paved the way for innovative solutions aimed at addressing these challenges. In this paper, we present a novel assistive technology system designed to assist visually impaired individuals in identifying currency notes using a combination of hardware and software components. Leveraging the capabilities of the ESP-32 CAM microcontroller, TensorFlow image classification model, and feedback mechanisms such as piezo buzzers and coin vibration motors, our system offers a practical and user-friendly solution for currency identification. The integration of machine learning algorithms and IoT (Internet of Things) technologies enables real-time processing of currency images and provides immediate feedback to the user, enhancing accessibility and promoting independence. This paper outlines the design, implementation, and evaluation of our assistive technology system, highlighting its potential impact on the lives of visually impaired individuals and its contribution to the field of assistive technology.

II. Literature Survey

Currency recognition systems for the blind and visually impaired have garnered significant attention in recent years due to their crucial role in facilitating daily financial transactions. Dunai Dunai et al. [1] developed a portable system using Raspberry Pi technology and computer vision algorithms to enable blind individuals to independently detect and recognize Euro banknotes, achieving an impressive accuracy of 84% for banknote detection and 97.5% for banknote value recognition. Similarly, Andika and Kustija [2] proposed a device utilizing sensors and microcontroller technology to detect both the colour and nominal value of currency, aiming to enhance the independence of visually impaired individuals in financial transactions. [3] Pokala and Teja (2020) addressed the challenge of Indian currency recognition for visually impaired individuals by proposing a handheld device capable of segregating different denominations. Their approach involved comparing features of currency images with reference images, extracting the numeric part of the currency, and matching it to recognize the denomination. This system successfully recognized Indian currency denominations such as 50,100,500,2000,20, and 10 rupee notes, contributing to improved accessibility for visually impaired users. Joshi et al. [4] introduced a YOLO-v3 based system for real-time detection and recognition of banknotes, achieving high accuracy rates of 95.71% for detection and 100% for recognition. Finally, Ijaz et al. [5] conducted a comprehensive survey of currency identification systems, providing an overview of current literature and techniques, with a focus on developing effective systems for blind and visually impaired individuals. These studies collectively highlight the ongoing efforts to develop accurate and reliable currency recognition systems, ultimately aiming to enhance the financial independence and security of individuals with visual impairments.

III. Block Diagram

The block diagram illustrates the architecture and components of the assistive technology system for currency note identification.

1.Camera (OV2640):

The OV2640 camera module serves as the primary image capture device, providing high-resolution images of currency notes to the system. It captures images in various lighting conditions and environments, ensuring accurate identification.

2.ESP32 CAM Microcontroller:

The ESP32 CAM microcontroller acts as the central processing unit of the system, responsible for image processing, communication with external devices, and control logic implementation. It interfaces with the OV2640 camera module for image capture and communicates with the cloud server for image classification.

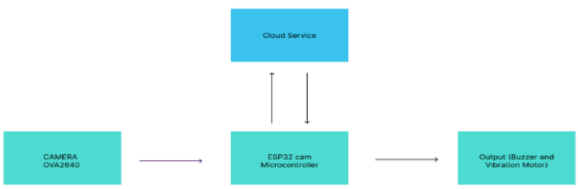

Figure 1: Block Diagram of System

3. Cloud Server:

The cloud server hosts the TensorFlow image classification model and serves as a computational resource for processing currency note images. It receives image data from the ESP32 CAM microcontroller via Wi-Fi and returns classification results to facilitate currency identification.

4.Output (Buzzer and Vibration Motor):

The output block consists of a piezo buzzer and a vibration motor, which provide feedback to the user based on the classification results obtained from the cloud server. The buzzer emits audible signals, while the vibration motor generates tactile sensations, enabling visually impaired individuals to identify currency notes effectively.

This block diagram outlines the functional components and interactions of the assistive technology system, highlighting the integration of hardware (camera, microcontroller, output devices) and software (cloud server, image classification model) elements to enable currency note identification for visually impaired individuals.

IV. Methodology

ESP32 CAM

Figure 2: ESP32 CAM

The ESP32 CAM is a versatile microcontroller board based on the ESP32 system-on-chip (SoC) with integrated Wi-Fi and Bluetooth capabilities, along with a camera module. It combines the power of a microcontroller with the ability to capture images, making it suitable for various applications such as IoT projects, surveillance systems, and image processing tasks. The ESP32 CAM board typically features GPIO pins for interfacing with external components, including sensors, actuators, and communication modules.

Piezo Buzzer

A piezo buzzer is an electronic component that generates sound when an electrical signal is applied to it. It consists of a piezoelectric ceramic disc mounted between two conductive plates. When a voltage is applied across the plates, the piezoelectric material contracts or expands, producing vibrations that create audible sound waves. Piezo buzzers are commonly used in electronic devices for generating alert signals, notifications, and tones due to their compact size, low power consumption, and simplicity of operation.

Vibration Motor

A coin vibration motor, also known as a pager motor or vibration disc motor, is a small and lightweight electromagnetic motor designed to produce vibrations when powered. It typically consists of a coil of wire wound around a core, mounted on a disc-shaped mass. When current flows through the coil, it creates a magnetic field that interacts with the permanent magnet in the motor, causing the coil to move back and forth. This movement of the coil induces vibrations in the motor's mass, resulting in a tactile sensation. Coin vibration motors are commonly used in mobile phones, wearable devices, and haptic feedback systems to provide tactile alerts, notifications, and feedback to users.

Tensor Flow Image Classification Model:

The TensorFlow image classification model serves as the core component of the assistive technology system, responsible for accurately identifying currency notes from captured images. The model employs a deep learning approach to learn and recognize distinct features and patterns associated with different currency denominations.

1.Model Training:

Figure 3: Dataset

The TensorFlow model is trained using a dataset comprising a diverse collection of currency note images representing various denominations. These images are labelled with corresponding class labels, allowing the model to learn to distinguish between different currencies through supervised learning techniques.

2.Feature Extraction:

During the training process, the model learns to extract relevant features from input images using convolutional neural network (CNN) layers. These convolutional layers apply filters to the input images, capturing hierarchical features such as edges, textures, and shapes that are characteristic of currency notes.

3.Classification:

Once the features are extracted, the model passes them through fully connected layers, which learn to map the extracted features to specific currency classes. The final output layer of the model consists of softmax activation functions, which compute the probability distribution over all possible currency classes.

Figure 4: Image Class Prediction

4.Inference:

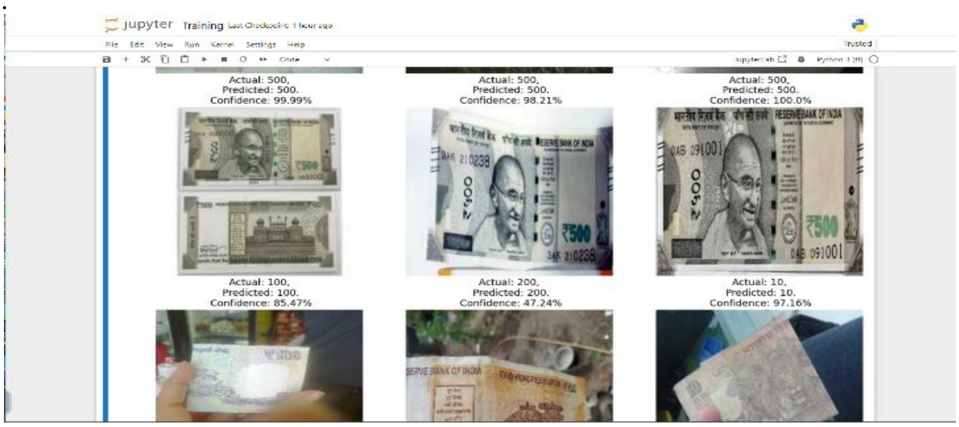

Figure 5: Image Classification

During inference, the trained model is deployed to classify new, unseen currency note images. The input image is pre - processed to ensure consistency in size, resolution, and colour channels. The pre - processed image is then fed into the trained model, which computes the probability scores for each currency class.

5.Post-processing:

The model's output probabilities are interpreted to determine the predicted currency denomination. The class label with the highest probability score is selected as the predicted class. The classification result is then returned to the ESP32 CAM microcontroller for further processing and feedback generation.

6.Deployment:

Upon satisfactory evaluation, the trained TensorFlow model is deployed to the cloud server, where it awaits incoming image data from the ESP32 CAM microcontroller. The model processes incoming images in real-time, providing fast and accurate currency identification for visually impaired users.

API:

The API facilitates communication between the ESP32 CAM microcontroller and the cloud server hosting the TensorFlow image classification model. When the microcontroller captures an image of the currency note, it sends an HTTP POST request to the designated endpoint of the API on the cloud server. The POST request includes the image data as the payload, which is encoded and transmitted securely over the network. Upon receiving the POST request, the API extracts the image data and forwards it to the TensorFlow model for classification. The model processes the image data and returns the classification result to the API. The API then formulates an HTTP response containing the classification result and sends it back to the microcontroller. This interaction enables real-time communication between the microcontroller and the cloud server, facilitating currency identification for visually impaired users.

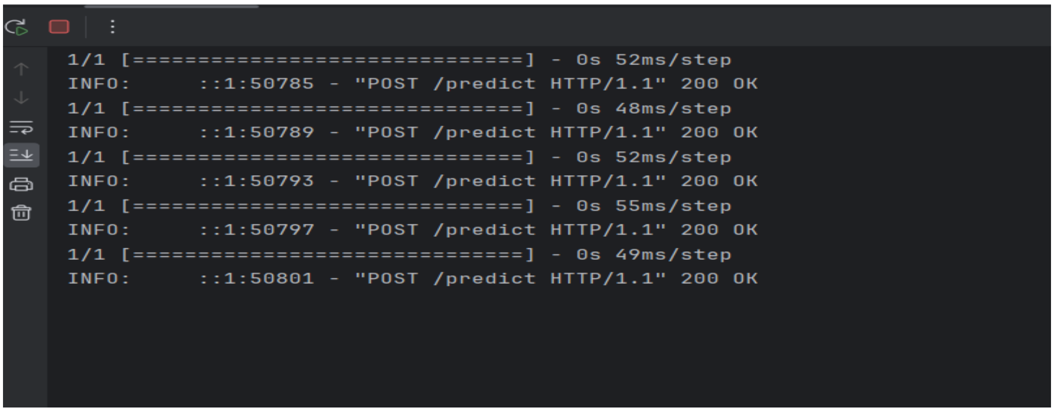

Fig -6: API Response

Upon activation, the ESP32 CAM microcontroller captures an image of the currency note using the OV2640 camera module. The captured image is then transmitted to the cloud server for classification using the TensorFlow image classification model. Once the classification result is obtained, the microcontroller interprets the result to determine the identified currency denomination class. Each currency class is associated with a specific number of beeps for the piezo buzzer and vibrations for the vibration motor. The microcontroller then activates the piezo buzzer to emit the predetermined number of beeps corresponding to the identified class, providing auditory feedback to the user. Simultaneously, it triggers the vibration motor to generate the specified number of vibrations, offering tactile feedback. This combined auditory and tactile feedback allows visually impaired users to accurately identify the denomination of the currency note without relying on visual cues. By integrating camera capture, classification, and feedback mechanisms, the system enhances accessibility and promotes independence for visually impaired individuals in currency identification tasks.

V. Advantages

The proposed assistive technology system offers several advantages for visually impaired individuals. Firstly, it provides an efficient and accurate method for currency note identification, allowing users to independently and confidently discern the denomination of various currency notes. Secondly, the system enhances accessibility by incorporating feedback mechanisms such as the piezo buzzer and vibration motor, which are easily distinguishable and understandable for users with visual impairments. Additionally, the integration of hardware components, such as the ESP32 CAM microcontroller, and cloud-based machine learning models enables real-time processing and classification of currency notes, contributing to the system's effectiveness and reliability. Moreover, the user-friendly design and intuitive interface of the system promote ease of use and enhance the overall user experience, ultimately fostering greater independence and autonomy for visually impaired individuals in their daily lives.

VI. Applications

The application of the proposed assistive technology system extends to various contexts where visually impaired individuals interact with currency notes on a regular basis. One primary application is in daily financial transactions, where users can confidently identify and differentiate between different denominations of currency notes, enabling them to make accurate payments and manage their finances independently. Additionally, the system can be utilized in banking and retail environments, allowing visually impaired individuals to access ATM machines, conduct transactions at cashier counters, and verify currency received in change. Furthermore, the technology can be integrated into educational settings, empowering visually impaired students to participate fully in activities involving currency, such as budgeting exercises and financial literacy programs. Moreover, the system has potential applications in international contexts, facilitating currency identification for travellers with visual impairments navigating unfamiliar currencies. Overall, the versatility and practicality of the assistive technology system make it applicable across various scenarios, empowering visually impaired individuals to engage more effectively in daily tasks and activities involving currency notes.