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VisioFace: An Android App Utilizing Deep Learning for Facial Recognition to Aid the Visually Impaired

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Abstract: Over the years, assistive technologies aimed at helping individuals with visual impairments have undergone significant advancements. These advancements encompass various tools such as screen-reading software, magnification programs, and daisy book readers, offering a wide range of devices to support visually impaired individuals in their daily activities. Despite the proven usefulness of these devices, their widespread adoption has been hindered by certain limitations, including high costs, societal stigma associated with public usage, and a lack of sustained support. However, in the present era, smartphones have become an integral part of our modern lives, featuring advanced camera technology and an array of mobile applications. The continuous enhancements in computer vision and machine learning, particularly on mobile devices, have created an ideal platform for the development of a mobile application solution. Although there are existing similar solutions, they also possess certain drawbacks. Introducing Vision Assist, a mobile application that offers an intuitive user experience by leveraging AI-Driven face recognition. With Vision Assist, users can effortlessly scan their surroundings and receive verbal feedback about the person present by simply tapping anywhere on the screen. This innovative solution capitalizes on the power of AI-Driven and smartphone technology, enabling visually impaired individuals to navigate their environment with ease and confidence.

Keywords: *facial recognition, visual impairment, Android application, Deep learning, Convolutional Neural Networks (CNNs).*

1. Introduction

Visual impairment poses significant challenges for individuals in their daily lives, especially when it comes to recognizing[1], [2] people around them. Facial recognition technology has shown promise in addressing this issue by providing a means for individuals with visual impairments to identify people through their facial features. This paper presents the development of an Android application that leverages deep learning techniques for facial recognition to assist visually impaired users[3], [4]. The objective of this paper is to harness the advancements in AI-Driven and smartphone technology, particularly processing power and camera technology in recognitions of faces via the camera and then the recognition system will identify them and pass the information to the text to speech module, in conjunction with progress in AI & machine learning and computer vision. The goal is to develop a mobile application solution for vision assist that assists visually impaired individuals in their day-to-day activities. The increasing prevalence of smartphones, numerous solutions have emerged to address everyday challenges. Among these are smartphone applications designed specifically for the visually impaired, employing different approaches. Some focus on emergency services, while others recognize essential items like currencies. For instance, applications such as 'eyeNote' and 'LookTel' can identify currencies [5]and audibly communicate the information to the user. Meanwhile, projects like 'BlindSighted' provide haptic feedback to notify users when they are in close proximity to objects. In this project, the approach involves audibly communicating recognized objects to users through the mobile application [6]

The subsequent discussion of this paper will provide concise analyses, design, and implementation of the face recognition & object detection system aimed at assisting the visually impaired.

According to the World Health Organization [6] individuals with visual impairments encompass those suffering from low vision or blindness [6]. These individuals encounter numerous challenges in their daily lives[7].

Throughout history, various conventional technologies, devices and methods have been developed to overcome these difficulties. These range from traditional tools like walking sticks and reading glasses to Braille, a touch-based reading and writing system, as well as more recent assistive devices. Assistive devices, including specialized screen-reading software, magnification programs, and daisy book readers, enhance the understanding of the visually impaired individuals' surroundings[7] .However, despite their proven usefulness, the wide-ranging adoption of these devices has faced obstacles due to factors like cost and negative sensitivities surrounding vision loss.

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Globally, the WHO reports that at least 2.2 billion people suffer from visual impairment or blindness, with over 1 billion having visual impairments that could have been prevented or addressed.

In recent decades, smartphones and tablets have gained popularity and become essential in mainstream society. These devices have integrated a significant number of built-in accessibility tools, maximizing accessibility for users with diverse needs [8] In contrast to traditional assistive devices, smartphones have achieved broad acceptance, thanks to their extensive adoption, affordability, and the ability to remain inconspicuous, thus avoiding negative perceptions from others. Additionally, smartphone operating systems provide developer platforms that enable the creation of third-party assistive and accessibility applications. Considering the ubiquity of smartphones, with approximately more than 3.5 billion devices worldwide, the majority running iOS or Android, it is logical to develop applications, particularly those focused on accessibility, for these platforms. Leveraging this ubiquity allows for faster accessibility provision to those in need.

Moreover, the advancement of smartphone camera technology and computer vision algorithms has been rapid. These developments offer a promising opportunity to simulate vision more effectively for individuals with visual impairments, surpassing the limitations of traditional methods while maintaining affordability and minimizing societal perceptions. By harnessing the power of readily available face and object recognition technologies, such as AI-driven algorithms, smartphone cameras, computer vision algorithms, and a voice assistant, it becomes possible to develop a face and object recognition application. This application can accurately label surrounding objects, recognize faces, and audibly communicate the recognized labels to the user.

2. Literature Review

Considerable research has been conducted in the realm of visual impairments, resulting in a range of available solutions for this condition. These solutions encompass traditional remedies like eyeglasses, as well as more recent advancements in assistive technologies. Similarly, extensive research has been undertaken in the fields of artificial intelligence and computer vision, leading to significant progress in these disciplines. This progress includes the development of sophisticated algorithms, the availability of large labelled face [1], [4], [9] & object datasets [10], and the increasing computational capabilities of modern devices. We will delve into the existing research conducted in both fields, with a focus on the emergence and evolution of assistive devices. Additionally, we will explore relevant theories, tools, and utilities employed in these fields. Furthermore, we will examine instances where the domains of artificial intelligence and computer vision intersect, specifically exploring how these technologies have been implemented to aid individuals with visual impairments**.**

2.1 Assistive Technologies

Advancements in Assistive Technologies for Visual Impairments. Throughout history, visual impairments have been documented in various religious texts, literature, and inventions aimed at addressing these challenges. Assistive technologies have played a crucial role in improving the lives of visually impaired individuals, offering increased autonomy, safety, and social interaction opportunities. Traditional assistive devices, including specialized software, magnification tools, and book readers, have enabled visually impaired individuals to engage in daily activities such as reading, cooking, and traveling, thereby enhancing their quality of life and self-esteem[8],[11]. However, despite the numerous benefits, traditional assistive devices often face high abandonment rates due to factors like cost, lack of technical support, and the associated stigma.[6]. Affordability issues restrict access to a wide range of potential users, while the specialized nature of these devices limits the ability of users and their social networks to troubleshoot technical problems. Stigma is another significant challenge, as the use of specialized assistive devices can draw attention and potentially lead to feelings of alienation or exclusion. Studies have shown that individuals with disabilities are more likely to abandon their devices if they perceive them as divergent from the norm or if they face societal stigmas.

To address these issues, integrating assistive functionalities into mainstream devices following universal design principles has emerged as a promising solution. Mobile technology, such as smartphones and tablets, has revolutionized connectivity and information access, making it an ideal platform for inclusive assistive technologies. These devices incorporate built-in accessibility features that allow visually impaired individuals to customize settings like color, contrast, and size, while also providing speech output software for reading text aloud.[6]

Moreover, voice-controlled digital assistants, like Siri, Alexa, and Cortana, offer further assistance by reading text and performing various tasks. These advancements have significantly increased the potential for IT-based assistive technologies to enhance the quality of life and independence of individuals with visual impairments. Research has shown that smartphones and tablets, particularly those running Apple iOS, are widely used by visually impaired individuals. While there may be initial challenges in learning to use Android-based devices, most users quickly adapt and benefit from their assistive functionalities. A survey conducted among smartphone and tablet users indicated that the majority preferred Apple iOS, further highlighting its popularity among visually impaired individuals.[12]

Transitioning from traditional assistive devices to mobile technology has brought significant progress in addressing the limitations of traditional solutions. However, there is still room for improvement. For example, the Android operating system faces some setbacks, and current mobile devices primarily focus on conveying information displayed on the screen rather than providing detailed information about the users' surroundings. Nonetheless, advancements in haptic feedback, text-to-speech, and gesture recognition systems offer exciting opportunities to expand accessibility for visually impaired individuals, enabling them to interact with their environment more effectively.

In a study referenced as [6], a survey was conducted among 259 smartphone and tablet users to investigate their usage of free and paid applications, including those designed for the visually impaired and low-vision community. The findings revealed that 95.4% of the participants used smartphones, 40.5% used tablets, and 37.1% utilized both devices. It was also observed that the majority of users (79.9%) were Apple iOS users, while only 7% used Android. Considering the prevalence of Android users in Nigeria, this further justifies the primary development of the application on the Android platform.

2.2 Computer Vision

Biological sciences and engineering perspectives on computer vision (CV) can be distinguished. The biological approach to CV relies on using computational models to replicate human visual systems. The engineering perspective, on the other hand, aspires to create autonomous systems that can carry out a variety of activities that are comparable to, and perhaps even above, the capacities of the human visual system. It is clear that these two goals are connected and rely on one another. [13]. A branch of artificial intelligence (AI), computer vision, was developed in the 1960s. During this time, computer scientists worked to develop software that could mimic human vision. [13].

Computer vision was first developed in the 1960s under the direction of a small team at MIT. They wanted to create a platform that could automatically do background/foreground segmentation and extract different items from photographs taken in the real world. Unfortunately, the group undervalued the difficulties involved in carrying out such a task, which led to the project's failure. [14]. Computer Vision (CV) is still a problem even after more than 50 years. But over the years, a number of strategies have been investigated in an effort to find a solution. The focus in the 1970s was on creating algorithms that could extract data from digital images, like contours, lines, and shapes. The focus of computer vision research shifted to statistics and mathematics in the 1980s and 1990s. Academics and researchers started fusing mathematical algorithms with computer vision approaches. The application of edge detection methods in image processing serves as an explanation of this integration. With the introduction of Deep Learning in the 2000s, Computer Vision had a revolutionary epoch. The media, academics, and researchers in the computer science community began to discuss CV again as a result of this discovery. [13]

Multi-layered neural networks are used in deep learning, a subset of machine learning, to extract more complex features from input data. It is a cutting-edge strategy that has greatly aided developments in a number of fields, including computer vision. Recurrent Neural Networks (RNN) and Deep Convolutional Neural Networks (CNN) are two prominent examples of deep learning methods. The field of computer vision is well known for being difficult. In this field, very few research issues have been satisfactorily addressed and solved. [15]. While there have been tremendous improvements in some computer vision issues, others remain quite difficult. For instance, computers show extraordinary skill in precisely reconstructing a scene's three-dimensional shapes from photos taken from multiple angles. Even at the level of a two-year-old toddler, they have trouble naming and identifying all the items and animals that are shown in a photograph. The time frame for obtaining this level of performance is still up for debate among researchers. This begs the question of why recognition tasks are intrinsically challenging. [16].

The processes of investigating a situation and identifying one or more objects contained therein are known as recognition and detection. The most difficult visual tasks we can give a machine to complete are recognition and detection [16]. In order to identify the items in a scene, object detection includes using an object identification algorithm on an original image. Real-time object detection algorithms are those that execute this analysis on video data made up of numerous images or frames per second and carry out the detection in real-time. Due to the increased processing power needed, the capacity to analyses several photos per second for object recognition emphasizes the importance of having effective algorithms and computing hardware. [15].

The real world is made up of a large variety of jumbled items and faces that all obscure one another and appear under various lighting, viewpoint, expression, and other conditions. Another challenge for computer vision systems is that they currently fall short in compared to the human visual system because a human can recognize objects despite all kinds of differences [13]. Furthermore, there is a sizable amount of intrinsic unpredictability inside object classes. Let's have a look at the class of canines to validate. Due to the wide variety of shapes and appearances, such as the variances between different breeds, identifying dogs becomes an interesting endeavor. As a result, it becomes extremely rare to try to conduct a thorough search and match against a database of cases. [16]. Over the course of several decades, tremendous progress has been accomplished despite these obstacles. This evolution includes a number of things, such the creation of effective algorithms and the accessibility of more potent computational tools. These developments have opened the door for creative uses in several fields, including robotic assembly, driverless vehicles, facial recognition, and many more.

3. Related Works

Converging developments in computer vision, assistive technology, and mobile technology have created new opportunities for enabling people with visual impairments in their daily lives. This section seeks to give a quick rundown of several of these strategies, emphasizing their advantages and disadvantages.

As previously mentioned, applications like 'eyeNote' and 'LookTel' excel in recognizing currencies and audibly communicating them to the user [17]. While this solution enables visually impaired individuals to conduct transactions confidently, it is limited in scope, focusing solely on this particular scenario.

Satrio et al (2022) [18] built a smart mirror based on the Raspberry Pi, its primary purpose was to detect faces and record physical characteristics, which will then be shown on an Android application. The Haar Cascade approach and the Local Binary Pattern method are contrasted for face detection and recognition was used. The test findings demonstrate that both approaches have advantages in terms of speed of identification depending on the number of users, with Local Binary Pattern superior for three or more users and Haar Cascade superior for two or less users in a single iteration process.

Furthermore, our study highlights the transition from conventional assistive technologies to mobile assistive technologies, complemented by the advancements in Computer Vision. Through the investigation of these resources, it becomes apparent where the current solutions display limitations. This understanding facilitates the identification of areas that can be improved to enhance the existing solutions.

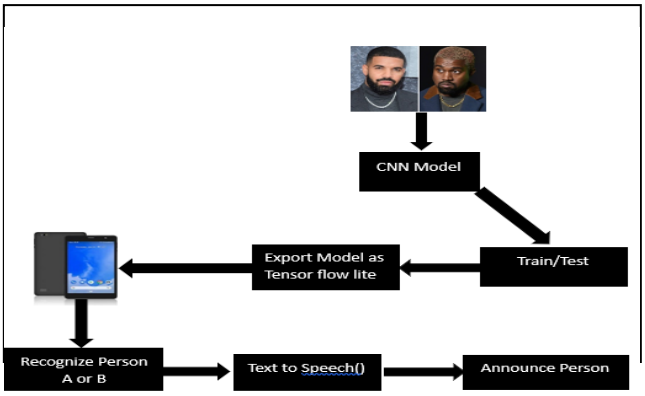


Fig. 1. shows the proposed model for creating the CNN model for person classification.

In our study, we utilize an Android tablet that facilitates face scanning by family members or friends through the device's camera. The recognition system is employed to identify the individuals, and the extracted information is then passed to the text-to-speech module. This module is responsible for audibly pronouncing the names of the recognized individuals.

Once the model is developed, we will pass it to the android application as a TensorFlow lite[19] file, which would be used by the application for real time classification.[20]

Deep learning Facial Recognition model was built using python, Convolution neural network and was trained on five person images.

We used Haar Cascade classifier that is built into Open CV to detect face, this classifier is designed specifically for detecting frontal faces in visual input.

We then used open CV to access the camera of the device and then the image is then passed to our facial recognition model to match the person face with one in had already in the data store.

Android Text-to-Speech (TTS): The Text-to-Speech module is implemented to transform the labeled face and object information of the detected object into spoken feedback. The study utilizes the built-in Text-to-Speech library provided by Android Studio, which offers support for 25 different languages. The text-to-speech process is illustrated in Fig. 2. below.

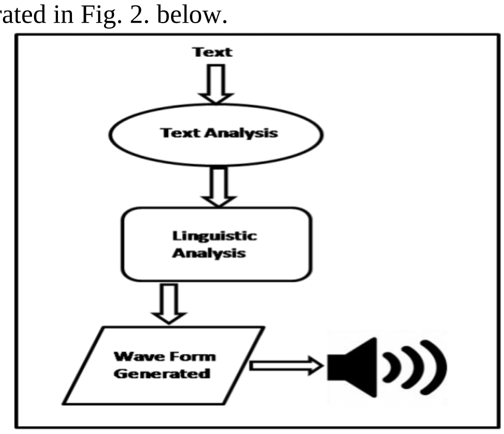


Fig. 2. Process of Text-to-Speech

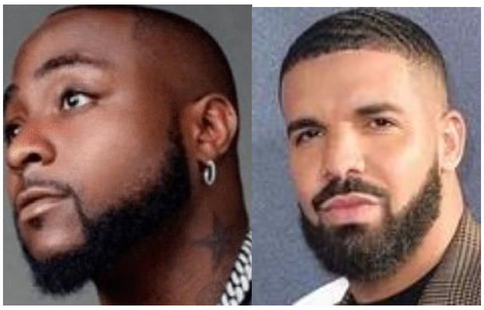
The android tablet would use the front or back camera to capture the person's face and the in real time classify the person into the most appropriate class (person's name).

3.1 Dataset

for the training we used 50 Davido images and Drake images downloaded from the internet, from google.

Table 1. Content of our prepared dataset

S/N	Name	Amount
0	Davido	50
1	Drake	50



(0) (1)

Fig. 3. shows the two classes

3.2 Data Pre-Processing

Resizing the images to 221 *221 to meet the input requirement of our CNN model. The photos must be normalized using the model criteria specified.

Training the model

We used a batch size of 64, and ran the testing on 50 epochs using a learning rate of 0.001.

3.3 Technological Support

3.3.1 Tool and Utilities

In this section, we will provide a concise overview of the two primary tools and libraries that will be implemented throughout the duration of this project.

3.3.2 TensorFlow Lite

TensorFlow Lite is a specialized version of the TensorFlow framework tailored for mobile and embedded devices. It offers the ability to deploy machine learning models on platforms with limited resources, including smartphones, IoT devices, and microcontrollers. TensorFlow Lite excels in providing efficient execution of neural networks by optimizing model size and minimizing computational demands.

Key features of TensorFlow Lite include:

- Model Optimization: TensorFlow Lite uses various techniques to optimize models for deployment on mobile and embedded devices. This includes quantization, which reduces the precision of model weights and activations, resulting in smaller model sizes and faster inference.
- Efficient Execution: TensorFlow Lite leverages hardware acceleration, such as GPU, DSP, or Neural Processing Unit (NPU), to speed up model inference on devices. It also supports hardware-specific optimizations for specific platforms.
- Flexibility: TensorFlow Lite supports a wide range of neural network architectures, including convolutional neural networks (CNNs), recurrent neural networks (RNNs), and transformers. It provides tools and APIs to convert TensorFlow models into a format compatible with TensorFlow Lite.
- On-Device Inference: With TensorFlow Lite, machine learning models can be run locally on the device without requiring a constant internet connection. This enables real-time and privacy-preserving inference, making it ideal for applications with low-latency requirements and sensitive data.
- Developer-Friendly: TensorFlow Lite offers developer-friendly tools, including the TensorFlow Lite Converter for model conversion, and the TensorFlow Lite Interpreter for model inference. It supports popular programming languages such as Python, C++, Java, and Swift, making it accessible to a wide range of developers.

TensorFlow is a widely used platform for machine learning (ML) tasks. It is an end-to-end open-source software developed by Google, offering a comprehensive ecosystem of tools, libraries, and resources. This enables developers and researchers to easily build and deploy ML applications [19] TensorFlow provides a user-friendly interface for expressing ML algorithms and executable code for models, making it highly accessible. Additionally, models developed in TensorFlow can be seamlessly ported across various systems, from mobile phones to distributed servers, with minimal modifications [19].

Google designed TensorFlow to be compatible with diverse systems, including mobile devices. This addresses the challenge of data transmission between devices and data centers, particularly in scenarios where computations can be performed directly on the device. TensorFlow Mobile was specifically developed to facilitate the creation of interactive applications without the latency associated with network-based computations. Given that ML tasks are computationally intensive, model optimization techniques are employed to enhance performance. TensorFlow Mobile has relatively low hardware requirements in terms of Random-Access Memory (RAM) size and CPU speed [19].

TensorFlow Lite, on the other hand, represents an evolution of TensorFlow Mobile, specifically tailored for deployment on mobile and embedded devices. With the growing trend of integrating ML into mobile applications and the continuous improvement of mobile devices, users have higher performance expectations. TensorFlow Lite addresses these demands by providing further optimizations for lightweight mobile usage [19].

3.3.3 Android Text-to-Speech

Android Text-to-Speech (TTS) is a built-in feature of the Android operating system that allows text to be converted into spoken words. It enables applications to provide audio feedback to users, enhancing accessibility and usability.

Key features and capabilities of Android Text-to-Speech include.

- Speech Synthesis: Android TTS engine uses natural language processing techniques to convert written text into spoken words. It supports multiple languages and dialects, enabling a wide range of users to benefit from the feature.
- Customization Options: Android TTS provides various customization options to control the speech output. This includes the ability to choose different voices, adjust speech rate (speed), and modify pitch (intonation) to suit individual preferences.
- Accessibility Support: Android TTS plays a vital role in making Android devices accessible to individuals with visual impairments. It enables screen readers and other accessibility features to read aloud text on the screen, providing a spoken representation of the content.
- Integration with Applications: Android TTS is designed to be integrated seamlessly into Android applications. Developers can utilize the TextToSpeech API to incorporate text-to-speech functionality into their apps, allowing text content to be spoken to users.
- Text Markup Support: Android TTS supports various text markup formats, such as SSML (Speech Synthesis Markup Language), which provides additional control over the speech output. SSML allows developers to specify aspects like pronunciation, emphasis, and pauses within the text.
- Multitasking and Interruptibility: Android TTS can handle multitasking scenarios, allowing multiple applications to utilize speech synthesis simultaneously. It also supports interruptibility, which means it can pause and resume speech output when other audio events occur, such as phone calls or media playback.

Android Text to Speech (TTS) is a feature that converts text into speech, allowing for immediate playback or the creation of sound files (TextToSpeech Android Developers, 2020). It is a powerful and straightforward capability that supports a wide range of languages. Android TTS has found effective implementation in various applications, including educational apps for children and pronunciation learning tools. Integrating TextToSpeech enhances the user's interaction with the mobile application.

Android TTS has been available since Android version 1.6. Along with its core functionality, it also offers additional features such as the ability to adjust the speed and pitch of the speech playback, providing further customization options for developers and users alike.

4. Experimental results

We used an input shape of [221, 221, 3], We utilize ADAM as a loss function, set the batch size to 32, and the learning rate to 0.001. We made the decision to apply a cross-entropy loss function to all the models. We split the dataset from Section 3.1 into two groups: training (70%) and validation (30%). The first group is used for training, while the second is used for testing the outcome of the procedure.

4.1 Results of training and testing

From the result seen we can deduct, that using the above parameters and fine tuning the model we can get better results.

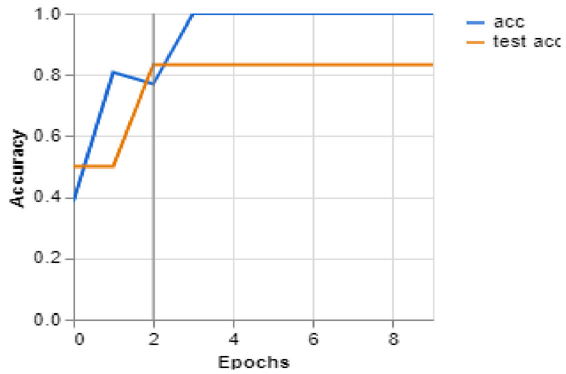


Fig. 4. shows the classification accuracy using 16 batch size

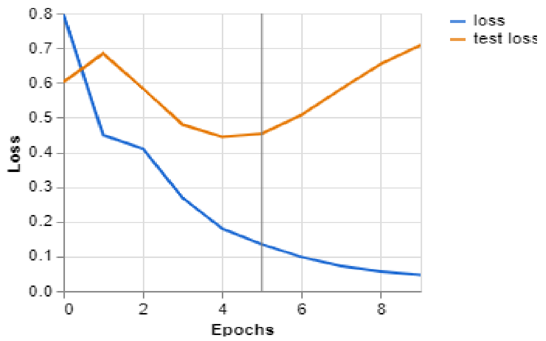


Fig. 5. shows the loss using 16 batch size

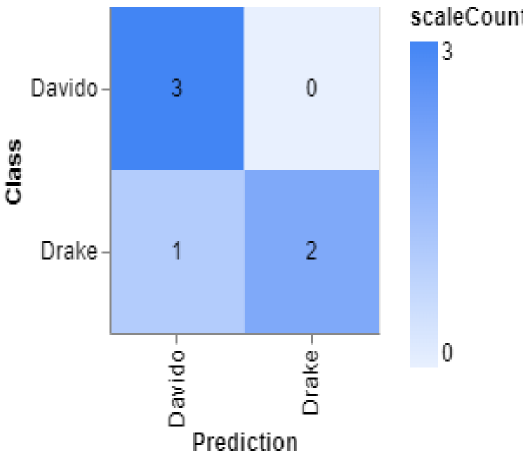


Fig. 6. confusion matrix using 16 batch size

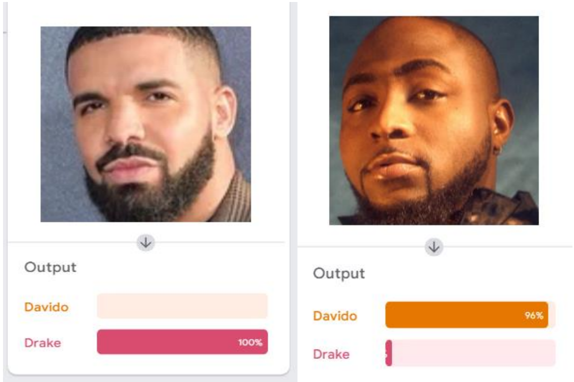


Fig. 7. Testing the model

5. Results

Table 2: the accuracy of the trained model.

Model	Accuracy
Custom CNN	88%

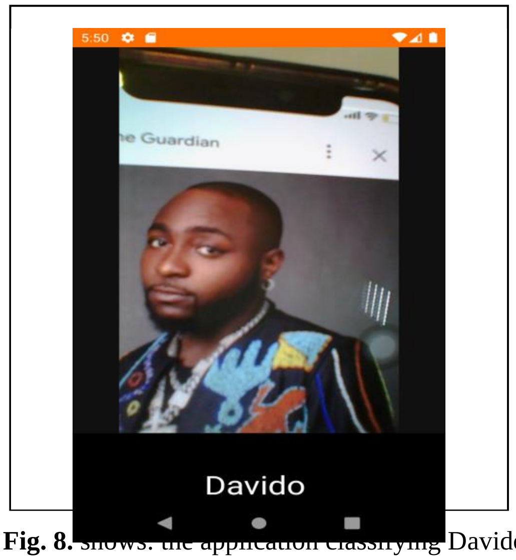


Fig. 8. shows: the application classifying Davido

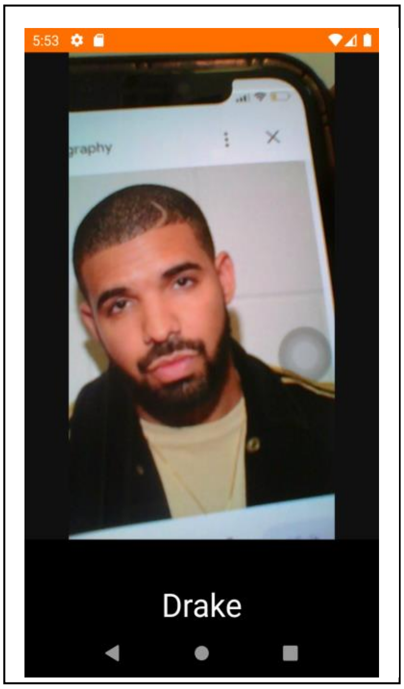


Fig. 9. shows the application classifying Drake

6. Conclusion

In recent times, wearable devices have successfully integrated compact and lightweight cameras and microphones. This enables the utilization of popular recognition methods for both audio and video. Particularly, modern face recognition technology has proven to be highly effective. Incorporating AI models into applications plays a vital role in simplifying our lives. In this regard, we have demonstrated the practicality of employing a CNN model, which can be trained and deployed on an Android device. This model enables live classification of individuals and utilizes text-to-speech functionality to audibly notify visually impaired users. Through our training process, we achieved an impressive accuracy rate of 88%. This showcases the significant potential of AI in developing assistive technologies for individuals with visual impairments.

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