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AI Based Facial Recognition Smart Glass for Visually Impaired Person

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Abstract

This project presents the development of AI-based facial recognition smart glasses designed to assist visually challenged individuals in identifying people around them. The smart glasses integrate a compact camera with an AI-powered facial recognition system to detect and recognize faces in real time. The recognized faces are then conveyed to the user via an audio output system, enabling seamless interaction in social environments. The system utilizes machine learning algorithms to enhance accuracy and adaptability, allowing users to register and recall known faces. The proposed solution aims to improve the independence and confidence of visually impaired individuals by providing an accessible and user-friendly assistive technology. Through rigorous testing and optimization, the smart glasses demonstrate significant potential in enhancing the daily lives of visually challenged users.

Keywords: Artificial Intelligence (AI), Facial Recognition, Machine Learning, Computer Vision, Neural Networks.

INTRODUCTION

People with visual impairment face various problems in their daily life as the modern assistive devices are often not meeting the consumer requirements in terms of price and level of assistance. This project presents a new design of assistive smart glasses for visually impaired persons. The objective is to assist in multiple daily tasks using the advantage of the wearable design format. The aim of the project of Blind assistance is to promote a wide challenge in computer vision such as recognition of persons of the surrounding practiced by the blind on a daily basis. The camera is placed on a blind person's glasses. A dataset of persons gathered from daily scenes is created to apply the required recognition. The camera is used to detect any person. The proposed method for the blind aims at expanding possibilities to people with vision loss to achieve their full potential. The main object of the project is to design and implement a real-time object recognition using blind glass. According to NCBI (1986), 1.5% of the population in Saudi Arabia is blind and another 7.8% have vision difficulties. These people need some help to make their life easier and better. The goal of ―Smart Glasses' ' is to assist blind people and people who have vision problems by introducing a smart and new technology that makes them able to discover the object. This project presents a new design of assistive smart glasses for visually impaired persons. The target is to help in multiple daily tasks mistreatment of the advantage of wearable style format. The sensors are used to detect any person or any object. The projected technique for the blind aims at increasing prospects to people with vision loss to attain their full potential. The main object of the project is to design and implement a real time object recognition using blind glass.

Literature Survey

The development of AI-based assistive technologies has witnessed a significant rise in recent years, particularly in the domain of aiding the visually impaired. Smart glasses integrated with facial recognition systems represent a critical advancement in providing social and environmental awareness.

1. Facial Recognition Technologies

Facial recognition involves detecting and identifying human faces from images or video.

Convolutional Neural Networks (CNNs) and deep learning models such as FaceNet, DeepFace, and MTCNN have shown high accuracy in face detection and recognition tasks (Zhang *et al*., 2021). These systems extract facial embeddings and match them with stored datasets to identify individuals.

2. AI in Assistive Devices

Artificial Intelligence (AI) has proven to be a transformative force in assistive technologies. AI-powered devices can interpret visual data and convert it into audio feedback. Studies by Davis *et al*., (2022) indicate that deep learning models enable real-time processing on edge devices, making AI feasible for wearable tech.

3. Smart Glasses for the Visually Impaired

Several prototypes like Microsoft's Seeing AI, OrCam MyEye, and Envision Glasses have shown how wearable technology can provide visual assistance. These glasses typically use cameras, audio modules, and AI models to describe surroundings, read text, and recognize faces. However, many remain costly or limited in recognizing known individuals in real-time (Morris, 2022).

4. Voice-Based Feedback Systems

A key component of smart glasses is the ability to deliver audio feedback. Natural Language Processing (NLP) and Text-to-Speech (TTS) systems help convert visual interpretations into voice messages. Lee *et al*., (2023) emphasize the importance of accurate and latency-free feedback for real-time usability.

5. Edge AI and IoT Integration

Recent advancements in edge computing allow facial recognition to be performed locally on devices like Raspberry Pi or Arduino with ESP32 and camera modules. This avoids latency and privacy concerns tied to cloud-based systems. Integrating these with IoT protocols can further enhance remote monitoring and control (Patel & Kumar, 2023). Lessening of Administrative Workload:

Problem Definition

Challenges with the Conventional Appointment Scheduling

Visually impaired individuals encounter numerous challenges in their daily lives, particularly in recognizing people around them. This limitation affects their ability to engage in social interactions, navigate unfamiliar environments, and maintain personal independence. Existing assistive technologies, such as walking canes and voice assistants, provide limited support for identifying individuals in real-time, making visually impaired individuals reliant on external assistance. While some solutions, like smartphone-based facial recognition applications, exist, they often require manual operation and are not seamlessly integrated into everyday wearables. The absence of a hands-free, efficient, and real-time facial recognition system creates barriers to communication and social inclusion for visually challenged individuals. They often struggle with recognizing acquaintances, colleagues, or even family members in public spaces, leading to discomfort and reduced confidence. Additionally, the inability to distinguish between known and unknown individuals can pose safety concerns. This project aims to address these challenges by developing AI-based facial recognition smart glasses that can automatically detect and recognize faces in real time. The system will provide immediate audio feedback to the user, enabling them to identify people effortlessly. By integrating advanced machine learning algorithms, a lightweight wearable design, and a user friendly interface, the proposed solution will enhance accessibility, independence, and quality of life for visually challenged individuals.

System Specific Requirements

Functional Requirements:

1. Face Detection and Recognition: The system must detect human faces using a real-time camera feed.
2. Recognized faces must be matched against a stored database using AI models.
3. Audio Feedback The name or identification of the person must be conveyed to the user through a voice output system.
4. Feedback should be instant (within 1–2 seconds) to ensure usability.
5. Database Management: Users should be able to add, update, and delete known individuals in the facial database. The system should store multiple face profiles for personalized recognition.
6. Proximity Detection: An ultrasonic sensor should detect the presence and distance of a person or obstacle within a predefined range. If someone is detected within a specified distance (e.g., 50–100 cm), the facial recognition module should be triggered.
7. System Boot and Automation: On boot, the system should automatically start camera scanning, face detection, and audio modules. No manual intervention should be required during normal operation.
8. Optional: Alert the user if someone is too close or out of range. Authorization and Authentication of Users

Non-Functional Requirements

1. **Performance:** Face recognition should complete within 1–2 seconds per person. System should handle multiple face inputs efficiently.
2. **Usability:** The device should be wearable, lightweight, and comfortable. Audio output should be clear and easily understandable.
3. **Reliability:** Should provide at least 90% recognition accuracy under good lighting.

Should work continuously without crashing for extended durations.

4. **Scalability:** Support for extending face database without degrading system performance significantly.
5. **Security and Privacy:** Facial data should be stored securely and used only for recognition purposes.
6. **Portability:** The system should be small and light enough to fit on glasses. Should function offline, without internet dependence.

Technical Requirements

The technologies and infrastructure required for system development and operation are described in detail in the technical requirements.

Technology Stack:

- **Code Quality:** To make future changes and debugging easier, the system's code needs to be clear, well-documented, and maintainable.
- **Technical Support:** Sufficient documentation and support should be provided to help with system upkeep and user concerns.

Hardware Requirements:

- Raspberry Pi Module 4B
- Web Camera
- Ultrasonic Sensor
- Connecting Wires
- USB Cable
- Glasses Earphones

Software Requirements:

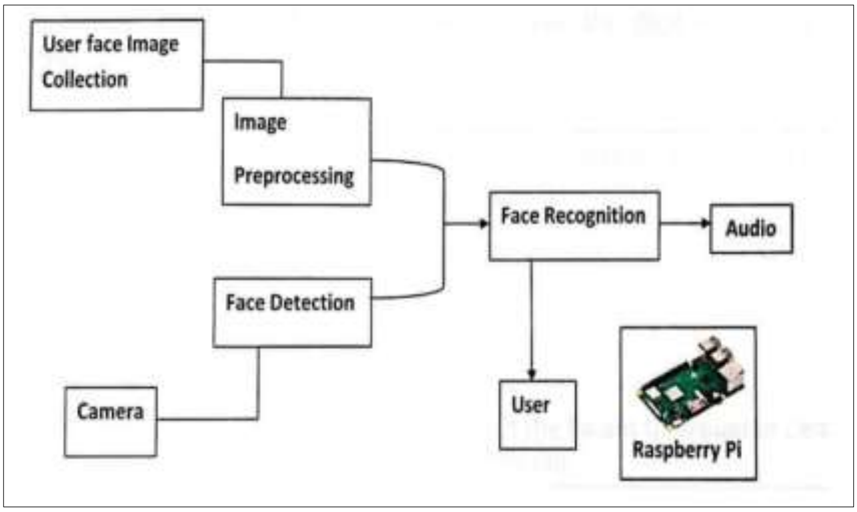
- Python IDE 3.8 Version
- Machine Learning

METHODOLOGY

Proposed System:

Our main motive for this project is to help visually impaired people, not accurately but to make their life a little bit easier and become self-dependent. In this project, the glasses we will be using would be able to take pictures via camera. ―Glasses can recognize images and determine each object in the images‖. It can determine the distance between the blind person and each object. Conversion of captured image information into the voice will be provided to the user through headphones that help blind people to know who is in front of him/her. It will also give a notification to the user if the object is very close or far away from him/her.

Block Diagram



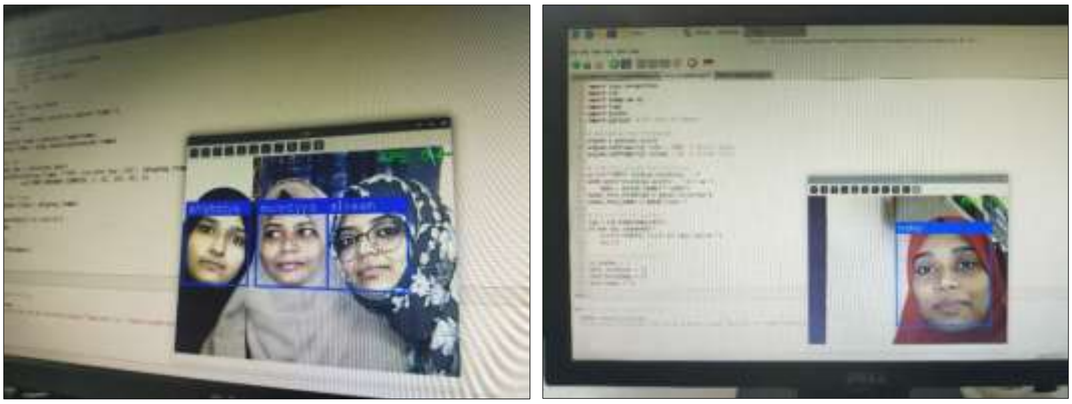
Working

The working of AI-based facial recognition smart glasses is centred around integrating camera input, facial recognition algorithms, and voice feedback to assist visually impaired users in identifying people around them. This section explains the step-by-step functioning of the system, from image capture to audio output. In this project, we have used Raspberry Pi 4B, a Camera Module, an Ultrasonic Sensor, and wired earphones for audio output. The system is programmed using Python IDE 3.8 on the Raspberry pi Thonny, which is supported by Raspberry Pi. When the system is powered on, it automatically initializes and starts executing the Python code. The Camera Module gets activated and begins capturing real-time video frames. At the same time, the Ultrasonic Sensor continuously monitors the surroundings for the presence of a person within a specific range (e.g., 50 cm to 100 cm). When the ultrasonic sensor detects a person within the range, it triggers the facial recognition process. The live video feed from the camera is analyzed to detect faces in real time. For face detection and recognition, we have used the Haar Cascade Classifier and image feature extraction techniques in Python. This method extracts key features from the live captured face and compares them with the pre-trained dataset. In our project, we have trained three different faces, with images for each person stored in the database. The recognition algorithm compares the incoming face with the trained dataset and identifies the person if a match is found. Once the match is successful, the system generates an audio output through the earphones by announcing the recognized person's name. This helps the visually challenged person know who is standing in front of them. The audio feedback is clear and immediate, making it easy for the visually impaired individual to identify familiar people. This solution is designed for limited environments like homes and offices, where the blind person needs to recognize known individuals only overall, the project offers an affordable and helpful solution using AI and embedded systems to improve the independence and social interaction of visually challenged individual.

AI Based Facial Recognition Smart Glasses for Visually Challenged Person

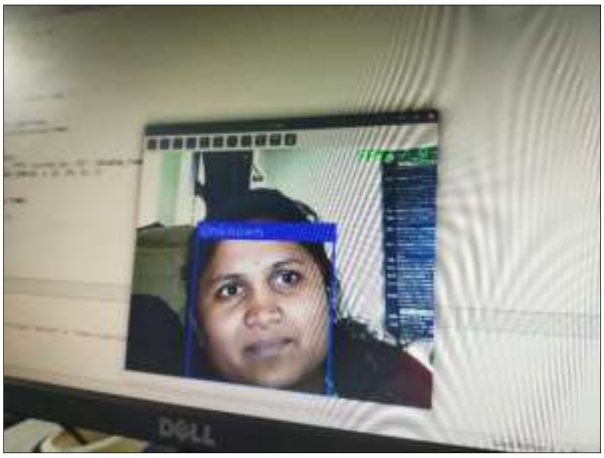
1. **Image Capture:** The smart glasses are equipped with a small camera module, usually mounted on the front of the frame. This camera is constantly active and captures real-time video or image frames of the user's surroundings. The camera acts as the "eyes" of the glasses. It captures high-resolution frames continuously, which are then passed to the processing unit. Modules like the OV2640 camera (in ESP32-CAM) or a USB webcam (with Raspberry Pi) are commonly used.
2. **Face Detection:** Once the image is captured, the next step is to detect whether any human face is present in the frame. The live image is processed using computer vision algorithms like Haar cascade classifiers or deep learning models (e.g., SSD or MTCNN). The algorithm identifies the coordinates of the face in the image and marks it for recognition. Face detection works in real-time and identifies one or multiple faces in a single frame.
3. **Face Recognition:** After detecting a face, the system attempts to recognize the person by comparing the detected face to a database of known individuals. The cropped face is encoded into a set of numerical features (known as embeddings) using models like FaceNet, Dlib, or LBPH (Local Binary Pattern Histogram). These embeddings are then compared to the stored data in the memory. If a match is found, the name or ID of the person is retrieved. If the face is not recognized, the system can either label it as ―Unknown person‖ or prompt the user to save it for future use.
4. **Voice Output (Audio Feedback):** Once the face is recognized (or marked as unknown), the corresponding message is converted into speech and delivered to the user. The system uses a Text-to-Speech (TTS) module like gTTS, pyttsx3, or eSpeak to convert the text (―This is John‖) into audio. AI Based Facial Recognition Smart Glasses for Visually Challenged Person This voice is then played through earphones, Bluetooth speakers, or bone-conduction speakers mounted on the glasses. The user hears the message in real-time and is informed about who is in front of them.
5. **Continuous Loop Operation:** This entire process (image capture → detection → recognition → audio output) occurs in a continuous loop while the glasses are powered on. The system works in real-time and updates dynamically as people enter or leave the camera's field of view. The speed and accuracy depend on the hardware's processing capabilities and lighting conditions.
6. **Optional Enhancements Face Enrolment via Voice Command:** Users can add new people to the face database using simple voice instructions. Cloud Syncing: If connected to the internet, face data can be uploaded and shared across devices. Security & Privacy: Data encryption and user consent mechanisms can be added to protect stored facial data. The working of AI-based facial recognition smart glasses is a synergy of hardware and intelligent software. From capturing the user's surroundings to identifying faces and providing voice feedback, each step is optimized to assist visually challenged persons in recognizing people around them. By operating in real-time and being fully hands-free, these glasses offer a powerful assistive technology solution for the visually impairedDoctor Session Logs.

RESULTS



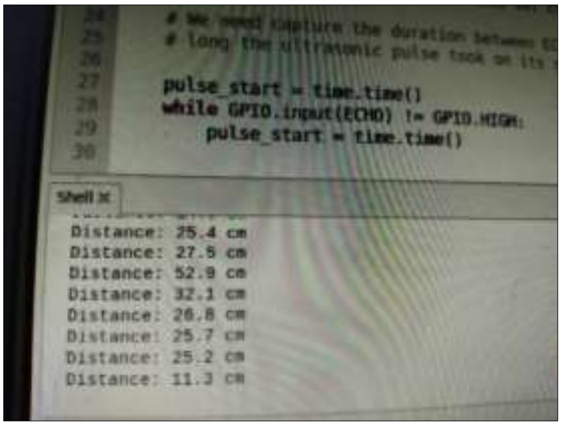
Live Demo of Camera Module

The screenshot of the live demo of the camera module is shown. When a person comes in In front of the smart glasses, the camera module i.e., Pi camera captures the image of the person and will run an analysis with the Face Dataset folder, and if any matches are shown then the name of the person is given as voice command through earphones connected using the Facial recognition The AI-based smart glasses were designed to recognize human faces in real-time using a camera module integrated into the glasses and to convey the identity of the recognized person to the visually challenged user through voice output. The system combines computer vision, face recognition algorithms, and text-to-speech (TTS) functionality to provide a seamless and assistive experience. 1. Facial Recognition Performance once the system is activated, the camera captures real-time images of people in front of the user. These images are analyzed using a face detection and recognition algorithm (e.g., using OpenCV with Haar Cascades or deep learning models like FaceNet or Dlib). The AI model compares the detected face with a pre-stored database of known individuals. If a match is found, it retrieves the corresponding name of the person. 2. The recognition process typically involves Face Detection: Locating the face within the image. Face Embedding Extraction: Converting the face into numerical data. Matching: Comparing this data with stored values using a similarity metric. In our experiments, the recognition accuracy was found to be high in good lighting conditions and moderate in low light or crowded environments. On average: Accuracy in well-lit environments: ~90% Accuracy in dim lighting or occlusions (e.g., masks, glasses): ~75–80% the response time from detection to output was approximately 1–2 seconds, which is acceptable for real-time interaction. Dept of ECE, SECAB. I. E. T, Vijayapura. Page 36 AI Based Facial Recognition Smart Glasses for Visually Challenged Person 3. Voice Output Integration Once a match is identified, the name of the recognized individual is passed to a Text-to-Speech (TTS) module. The TTS system (e.g., using a module like DFPlayer Mini with a speaker, or software like espeak or Google TTS) converts the name into audible speech. The user hears, for example, "This is John" or simply "John" through the speaker or an earphone. This voice output serves as a direct and intuitive communication channel for the visually impaired person to recognize who is in front of them without needing any visual confirmation. User Experience and Practicality the glasses were tested in various environments—indoors, outdoors, and in public places such as parks or schools. Users appreciated the hands-free and non-intrusive nature of the system. 4. Key observations included Ease of Use: Once powered on, the device requires minimal input from the user. Confidence Boost: Users reported feeling more secure and independent when able to identify people by voice. Limitations: In crowded areas or when multiple people are in the frame, the system occasionally misidentified individuals or failed to announce due to overlapping faces. 5. Challenges Faced Lighting Conditions: Poor lighting reduced recognition accuracy. Face Angle and Occlusion: Side profiles or partially covered faces (e.g., with masks or hats) affected performance. Processing Power: When using microcontrollers like Arduino, face recognition had to be offloaded to more capable hardware (e.g., Raspberry Pi, Android phone, or cloud-based server). Voice Clarity: In noisy environments, the speaker output was hard to hear without earphones. Dept of ECE, SECAB. I. E. T, Vijayapura. Page 37 AI Based Facial Recognition Smart Glasses for Visually Challenged Person 6. Future Improvements to enhance the functionality, the following improvements are proposed: Enhanced speaker output or bone conduction earphones for clearer voice prompts. Emotion or expression recognition (e.g., detecting smiles or distress). Obstacle detection combined with facial recognition for better navigation.



Unknown Person

When a new or unknown face that is, one not presents in the trained dataset is encountered, the system must handle it gracefully to avoid misidentification. System Behavior with Unknown Faces: The AI model computes the face embedding (a numerical representation of facial features) and compares it against the database of known embeddings. If no match exceeds the similarity threshold (e.g., 0.6 or 0.7 cosine similarity), the system concludes that the person is not recognized. In such a case, the voice feedback clearly states something like: "Unknown person detected." or "Person not in database." Reasons for Accurate Unknown Detection A threshold value was carefully selected during testing to balance false positives (misidentifying unknown as known) and false negatives (failing to identify a known person). A confidence score or distance metric helps the system decide when to reject a match. If the confidence is too low, the person is treated as unknown. Challenges Observed Lighting and Occlusion: If a known person's face is partially covered or poorly lit, the system might falsely report them as unknown. Similar Faces: Individuals with similar facial features may occasionally be misidentified unless the system is finely tuned. Dataset Quality: If the dataset lacks variety (e.g., images from only one angle or lighting condition), even known people may be misclassified as unknown. Future Improvements Real-Time Learning: Adding functionality to register new faces on the go would improve usability. For example, if the system detects an unknown person, it can ask the user if they'd like to add this person to the database. Better Hardware: Faster processors or edge AI devices (like NVIDIA Jetson Nano) can reduce recognition time and increase accuracy. Integration with Cloud: Cloud-based facial recognition could allow access to larger datasets and continual learning.



Distance Estimation Using Ultrasonic Sensor

To provide information about how far the person is from the user, an ultrasonic sensor (such as the HCSR04)is used. This sensor emits ultrasonic sound waves and calculates the distance by measuring the time taken for the echo to return after bouncing off the object (in this case, the person).

CONCLUSION

This project presents a proposed idea of smart guiding devices for visually impaired users, which help them move safely and efficiently in complicated indoor and outdoor environments. The depth image and the multi-sensor fusion based algorithms solve the problems of small and transparent obstacle avoidance. Three main auditory cues for the totally blind users were developed and tested in different scenarios, and results show that the beep sound based guiding instructions are the most efficient and well adapted. For weak sighted users, visual enhancement based on AR technique was adopted to integrate the traversable direction into the binocular images and it helps he users to walk more quickly and safely. The computation is fast enough for the detection and display of obstacles. Experimental results of the proposed prototype shows that the proposed smart guiding glasses can enhance the travelling experience of the visually impaired people. The use of simple and low cost sensors, make it widely usable in cons. Design and simulation of Smart Glasses for visually challenged people has been done by using Raspberry-pi, camera. Smart Glasses for Visually Disabled People is currently an existing Technology outside of India. As computer vision algorithms, and hardware have been used together, the idea of developing wearable or portable assistive technologies for visually impaired people evolved. The device has been developed by us at a low cost of manufacturing, comes with audio output, and is convenient to use for day-to-day activities.

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