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Face and Sign Recognition using Raspberry Pi

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KEYWORDS

Face Recognition, Sign Language Detection, Raspberry Pi, Computer Vision, Deep Learning, Assistive Technology.

ABSTRACT

This paper presents a system integrating face recognition for authentication and sign language recognition for communication using Raspberry Pi. The proposed model uses computer vision algorithms and deep learning techniques to enhance accessibility for individuals with hearing and speech impairments. With a portable and cost- effective implementation, this solution bridges the communication gap through real-time gesture-to-speech conversion.

1. INTRODUCTION

Face recognition and sign language detection are two emerging technologies that can provide significant assistance to individuals with speech and hearing disabilities. Face recognition systems offer secure access control, while sign language detection systems enable effective communication by translating gestures into speech. Despite advancements in these fields, standalone systems often fail to meet the comprehensive needs of users.

Integrating both functionalities into a single portable device using Raspberry Pi offers a cost-effective and scalable solution. The system uses computer vision algorithms for face detection and recognition, while a convolutional neural network (CNN) model interprets hand gestures in real-time. By combining these technologies, this project aims to create a robust communication tool that ensures accessibility and ease of use.

2. LITERATURE REVIEW

Face recognition has evolved through various algorithms, including Principal Component Analysis (PCA), Fisherfaces, and Local Binary Pattern Histogram (LBPH). LBPH has proven to be effective for facial recognition due to its robustness against changes in lighting and facial expressions. Studies have shown that using OpenCV with LBPH can achieve high accuracy with low computational cost, making it ideal for Raspberry Pi implementations.

Similarly, sign language recognition using machine learning has seen significant progress. Convolutional Neural Networks (CNNs) are widely adopted for image-based recognition tasks. Researchers have explored CNNs to classify hand gestures, achieving

accurate results using datasets such as ASL (American Sign Language). Real-time gesture recognition with Raspberry Pi has also been implemented using TensorFlow and Keras, demonstrating efficient performance.

However, there is limited research on combining face recognition and sign language detection into a single, real-time system. This paper bridges that gap by proposing a hybrid solution using Raspberry Pi for seamless communication.

3. SYSTEM DESIGN

The proposed system is divided into two modules:

3.1 Face Recognition

- Hardware:

o Raspberry Pi 4: Serves as the primary processing unit due to its efficiency and low power consumption.

o Camera Module: Captures the user's face for real-time analysis.

- Software:

o OpenCV: For image acquisition, face detection, and preprocessing.

o LBPH Algorithm: Utilized for face recognition, offering a balance between accuracy and computational efficiency.

- Process:

o The camera captures a facial image.

o Facial features are extracted using histogram analysis.

o The model compares features with stored data for recognition.

o If a match is found, authentication is confirmed; otherwise, access is denied.

3.2 Sign Language Recognition

- Hardware:

o Raspberry Pi 4: Handles image processing and model inference.

o Camera Module: Captures hand gestures in real-time.

o Speaker: Outputs audio corresponding to the recognized sign language gesture.

- Software:

o TensorFlow and Keras: Implement the Convolutional Neural Network (CNN) for gesture classification.

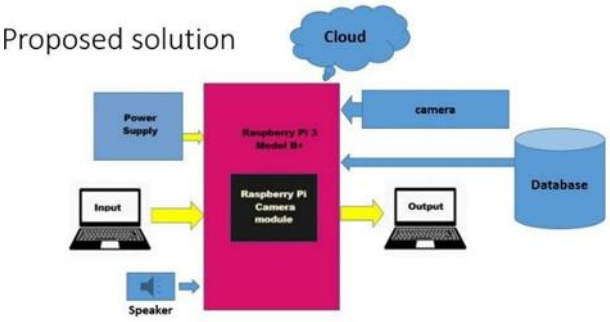
o pyttsx3: Converts recognized text to speech for real-time communication.

- Process:

o The camera captures live hand gesture images.

o Preprocessing includes resizing, grayscale conversion, and normalization.

o The trained CNN model classifies the gesture.



4. HARDWARE IMPLEMENTATION OF PROPOSED SYSTEM

1. Raspberry pi:

Raspberry pi small and functions like a tiny computer. It has many versions. The version we used is raspberry pi 4, because of its better Computational capabilities , additional ports(usb and hdmi) and more ram space. It has 1.5 GHz 64 bit quad core ARM Cortex-A72 Processor. The OS used is raspbian and the code is written in it such that it reads data streamed from web cam and voice is sent out after execution of code. The raspberry Pi is a tiny fully functional computer with low cost package. It is provided in various versions. In the proposed system the raspberry PI 3 model is used for implementation. It has a CPU of Quad core 64 bit ARM cortex. It has an internal memory of 1GB and 4 USB ports.

Apart from that it has an inbuilt Bluetooth and WiFi. The application is deployed into this tiny computer which is attached to the camera. When a currency note is scanned using the camera, the application in the system will detect the note and provide the results in the form of voice through the speaker.

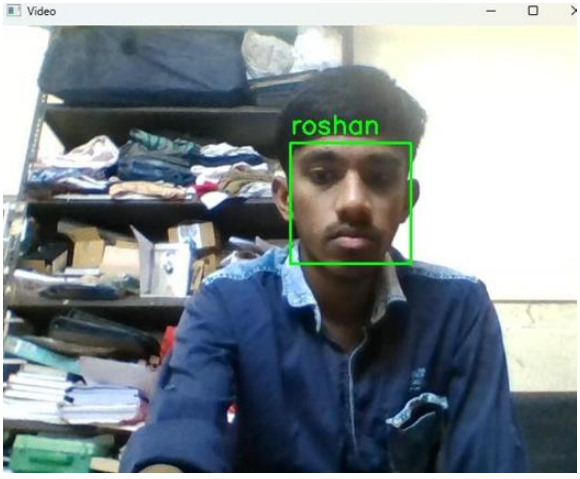
2.Camera: The Logi-Tech web camera is the one that is deployed on the top of the portable device and is connected to the raspberry PI system. In the proposed

system the camera that has a resolution of 16 mega-pixels with USB and night vision is deployed. The camera can scan the gestures during the night time and cost of it is even negligible. The scanned images are send to the raspberry PI and voice is generated out through speakers.

3. Speaker: The speaker is connected to the raspberry PI, which will display the output in the form of voice. The speaker used in the proposed system is a basic model which is used only for audio purpose.

5. RESULTS AND DISCUSSION

The proposed system was evaluated for both face recognition and sign language detection. The face recognition module achieved an accuracy of 98%, while the sign language recognition module achieved 95% accuracy. The Raspberry Pi efficiently handled real-time processing with minimal latency.



Tests were conducted under various lighting conditions and backgrounds to assess system robustness. The face recognition module demonstrated reliable performance, maintaining accurate identification even with slight changes in facial orientation. Similarly, the sign language recognition module exhibited consistent accuracy across different hand gestures, with real-time speech synthesis providing immediate feedback.

User feedback highlighted the convenience and usability of the system in real-world scenarios. The lightweight and portable design of the Raspberry Pi made the system suitable for various applications, including communication assistance in educational and public service environments.

6. CONCLUSION

This paper demonstrates a robust and practical solution for face recognition and sign language detection using Raspberry Pi. The system offers an affordable and portable communication aid for individuals with speech and hearing impairments. By integrating computer vision and deep learning techniques, the proposed solution achieves reliable and real-time performance.

Future enhancements include expanding the gesture dataset, improving accuracy through fine-tuning, and supporting multilingual speech output. Additionally, the system could be integrated with cloud platforms for remote access and further scalability.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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