PERSONALIZED FACE RECOGNITION AND TASK MANAGEMENT SYSTEM

Mini Project Report submitted by

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UNDER THE GUIDANCE OF

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In partial fulfillment of the requirements for the

INTERNET OF THINGS - 2IAM601

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AY 2023 - 2024

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CERTIFICATE

Certified that the mini project work entitled

"Personalized Face Recognition and Task Management System"

is a bonafide work carried out by as a component of

Internet Of Things (21AM601)

Akshatha
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in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree in Artificial intelligence and Machine Learning Engineering

prescribed by Visvesvaraya Technological University, Belgaum

during the year 2023-2024.

It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library.

The mini project report has been approved as it satisfies the academic requirements in respect of the mini project work prescribed for the Bachelor of Engineering Degree.

11/05/24.
Signature of Guide

Signature of HOD

Evaluation

Name of the Examiners	**Signature with Date**
1. Sneha Shetty R.	11/05/24.
2. Rakshitha	9/5/24

ACKNOWLEDGMENT

We believe that our mini project will be complete only after we thank the people who have contributed to make this mini project successful.

First and foremost, our sincere thanks to our beloved principal, **Dr. Niranjan N. Chiplunkar** for giving us an opportunity to carry out our mini project work at our college and providing us with all the needed facilities.

We acknowledge the support and valuable inputs given by, **Dr. Sharada U Shenoy** the Head of the Department, Artificial Intelligence and Machine Learning Engineering, NMAMIT, Nitte.

We express our deep sense of gratitude and indebtedness to our guide **Ms. Sneha Shetty R**, Assistant Professor, Artificial Intelligence and Machine Learning Engineering, for her inspiring guidance, constant encouragement, support and suggestions for improvement during the course for our mini project.

We also thank all those who have supported us throughout the entire duration on of our mini project. Finally, we thank the staff members of the Department of Artificial Intelligence and Machine Learning Engineering and all our friends for their honest opinions and suggestions throughout the course of our mini project.

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ABSTRACT

This project presents an innovative IoT-based face recognition system leveraging the ESP32-CAM module, Edge Impulse for model creation, Arduino Uno for device integration, and Superbase for database connectivity. The system aims to detect and recognize faces, associating each recognized face with a corresponding to-do list stored in a backend database.

The process begins with the ESP32-CAM capturing image data, which is then fed into Edge Impulse for model training. The trained model is capable of detecting faces and providing percentages for various predefined labels. This model is deployed onto the ESP32-CAM, enabling it to recognize faces in real-time.

Upon face recognition, the Arduino Uno, acting as a bridge between the ESP32-CAM and the database, retrieves the highest percentage label associated with the recognized face. This label is then sent to Superbase via HTTP request, triggering a lookup in the database for the corresponding to-do list.

Finally, the to-do list for the recognized individual is fetched from the database and displayed on the Arduino Uno's serial monitor, providing actionable information based on the identified individual.

This integrated system demonstrates the potential of IoT technologies in creating personalized and context-aware applications, merging image processing, machine learning, microcontroller programming, and cloud database connectivity to deliver a seamless and efficient solution for face recognition and task management.

The ESP32-CAM module's low power consumption enables deployment in diverse environments like homes, offices, and public spaces. Edge Impulse's platform streamlines the development of efficient machine learning models, enhancing real-world performance. Leveraging Arduino Uno's versatility, the system can expand to include features like automated task reminders or smart home control, showcasing IoT's potential to streamline processes and enhance daily interactions.

CHAPTER 1
INTRODUCTION

1.1 General

The project responds to the escalating need for intelligent surveillance and personalized services in various settings, ranging from residential to commercial environments. With security concerns becoming more prevalent, there's a growing demand for advanced systems that not only detect and recognize individuals but also provide contextual information to facilitate informed decision-making. By leveraging the capabilities of ESP32-CAM, Edge Impulse, Arduino Uno, and Superbase, this system not only fulfills the basic requirements of face recognition but also offers a seamless integration with backend databases to retrieve personalized data associated with recognized individuals. Moreover, by employing machine learning at the edge through Edge Impulse, the system ensures efficient processing and minimizes latency, making it suitable for real-time applications where timely responses are crucial.

Furthermore, the project underscores the potential of IoT technologies to revolutionize everyday interactions and optimize workflows. As IoT devices become increasingly ubiquitous, there's a pressing need to develop solutions that can intelligently analyze and respond to data generated by these devices. By harnessing the power of ESP32-CAM and Arduino Uno, coupled with advanced machine learning algorithms from Edge Impulse, this system exemplifies how IoT devices can be transformed into intelligent endpoints capable of interpreting complex data and taking autonomous actions. This not only enhances efficiency but also opens up possibilities for innovative applications such as personalized recommendations, adaptive environments, and proactive assistance, ultimately redefining the way we interact with technology in our daily lives.

1.2 Aim of Present Study

The primary objective of this project is to develop and implement an IoT-based Face Recognition System capable of accurately detecting and recognizing faces in real-time. The system aims to integrate hardware components such as the ESP32-CAM module and Arduino Uno with machine learning techniques facilitated by Edge Impulse to achieve robust face recognition capabilities. Additionally, the project seeks to establish seamless connectivity with a backend database using Superbase, enabling the retrieval of personalized data associated with recognized individuals. The overarching goal is to demonstrate the practical application of IoT technologies in enhancing security, efficiency, and user experience through intelligent and context-aware systems.

1.3 Objectives

1. **Face Detection and Recognition:** Develop a robust system using ESP32-CAM for real-time face detection and recognition, ensuring accuracy and efficiency in capturing and processing image data.
2. **Machine Learning Model Deployment:** Utilize Edge Impulse to train and deploy machine learning models capable of accurately identifying and classifying faces within captured images, minimizing false positives and optimizing detection performance.
3. **Integration with Arduino Uno:** Integrate Arduino Uno to establish communication between ESP32-CAM and Superbase backend database, enabling seamless retrieval of personalized data associated with recognized individuals.
4. **Efficient Data Transmission:** Implement efficient data transmission protocols to ensure low latency and reliable connectivity between IoT devices and the cloud-based backend, facilitating timely retrieval and display of relevant information.
5. **Exploration of Enhancements:** Explore opportunities for further enhancements and extensions, such as incorporating automated task reminders, smart home control, or integration with other IoT devices, to maximize the system's utility and versatility.

CHAPTER 2
LITERATURE REVIEW

The integration of face recognition technology with IoT systems, particularly using platforms like ESP32-CAM, represents a significant advancement in intelligent and connected devices. Studies have demonstrated the feasibility of deploying face recognition functionality locally on ESP32-CAM, minimizing reliance on cloud processing and reducing latency. However, challenges such as privacy concerns and environmental robustness persist, underscoring the need for further research and development. Nonetheless, the growing literature highlights the transformative potential of IoT-enabled face recognition systems for applications in security, automation, and personalized services.

1. **Design of an IOT System based on Face Recognition Technology using ESP32-CAM:** The proposed design of an IoT system utilizing face recognition technology, specifically with the ESP32-CAM hardware, adds to the existing literature on security and efficiency in networked systems. (Ref: Mahmoud, Ines, Saidi, Imen, & Bouzazi, Chadi. (2022, July 10). Design of an IOT System based on Face Recognition Technology using ESP32-CAM. International Journal of Computer Network and Information Security.)

2. **Face Recognition based Attendance System using ESP 32 CAM :** The introduction of face recognition-based attendance systems, signifies a shift from traditional methods like RFID and biometrics. Leveraging technologies like ESP32 CAM, IR modules, and FTDI modules, these systems aim to automate attendance recording while mitigating issues like contamination and proxy attendance. Research by Deshpande and Ravishankar (year) highlights the efficacy of Viola-Jones, PCA, and ANN fusion for accurate face detection and recognition, underscoring the importance of robust algorithms in such systems. (Ref: Medhavath, S., Modium, M., Pasula, P., Begari, D., & Chilupuri, A. (2023). Face Recognition Based Attendance System Using ESP32 CAM. International Journal of Engineering Applied Sciences and Technology, 7(12), 132-136.)

1. **Image Processing on ESP32 Microcontrollers based on Mobilenet Convolutional Neural Network :** The integration of machine learning, particularly neural networks,

into IoT devices addresses significant challenges such as power supply organization and efficient data processing. Neural networks, like MobileNet, offer solutions tailored for devices with limited resources, enhancing responsiveness and energy management. This integration enables predictive functionalities, optimizing device usage and improving user experience within smart buildings (Ref: Omelchenko, M., & Hotsyanivskyy, V. (2022). Image processing on ESP32 microcontrollers based on MobileNet convolutional neural network. Journal Name, 8.)

2. **Camera Image Processing on ESP32 Microcontroller with Help of Convolutional Neural Network :** The study investigates the potential of ESP32 microcontrollers for image classification tasks using convolutional neural networks (CNNs). It emphasizes the prevalence of ultra-low power embedded devices like ESP32 in IoT, highlighting their suitability for integrating artificial intelligence. The paper discusses the challenges of processing images on microcontrollers and demonstrates the feasibility of deploying CNNs, particularly MobileNet architecture, on ESP32, validating its capacity for simultaneous camera operation and neural network computation. (Ref : Sineglazov, V., & Khotsyanovsky, V. (2022). Image Classification on ESP32 Microcontrollers Based on Convolutional Neural Network. Journal of Automation and Computer-Integrated Technologies, 2(72).)

3. **Performance evaluation of ESP32 Camera Face Recognition :** The article explores the performance of ESP32 Camera Face Recognition for various projects, focusing on its potential for image recognition and face recognition tasks. It highlights the use of ESP32 cameras in smart door locks and other applications, emphasizing its affordability and accessibility. The study also discusses the development of image recognition technology, including the use of Raspberry Pi and M5StickC boards for artificial intelligence applications. Additionally, it addresses the weaknesses of ESP32-Cam and proposes solutions, such as using Arduino Uno as a microcontroller and enhancing wireless communication with the UFL Antenna feature. The paper provides a comprehensive analysis of the ESP32-CAM components and its performance metrics for different projects. (Ref: Adi, P. D. P., & Yuyu, W. (2022). ESP32 Camera Face Recognition for Various Projects. *Iota*, 2(1), 512.)

CHAPTER 3
METHODOLOGY

3.1. Methodology

1. Data Collection and Labeling:

- Collect a dataset of facial images using the ESP32 Cam's camera.
- Label the images with the corresponding person's identity or label using Edge Impulse.

2. Model Training with Edge Impulse:

- Upload the labeled dataset to Edge Impulse platform.
- Train custom machine learning model using the Mobilenet architecture provided by Edge Impulse.
- Optimize the model for deployment on resource-constrained devices like ESP32.

3. Deployment on ESP32 Cam:

- Deploy the trained model onto the ESP32 Cam using Edge Impulse's integration with AI Thiner.
- Write Arduino code to interface with the ESP32 Cam and execute the deployed model for face detection and recognition.

4. Integration with Arduino Uno:

- Connect the ESP32 Cam with an Arduino Uno for additional processing capabilities and interfacing with peripherals.
- Modify the Arduino code to receive output from the ESP32 Cam's model, extract the highest confidence label, and send an HTTP request to Superbase.

5. Database Integration with Superbase:

- Set up a database in Superbase to store the to-do lists corresponding to each recognized face label.

- Configure Superbase to handle HTTP requests from the Arduino Uno and update the database accordingly.

6. Display To-Do List:

- Retrieve the to-do list associated with the recognized face label from the Superbase database.
- Display the to-do list on the serial monitor of the Arduino Uno for the corresponding person.

7. Testing and Evaluation:

- Test the system with different faces to ensure accurate detection and retrieval of to-do lists.
- Evaluate the performance of the system in terms of recognition accuracy, response time, and overall usability.

8. Optimization and Fine-Tuning:

- Fine-tune the model and Arduino code based on testing results to improve accuracy and efficiency.
- Optimize the system for real-world deployment by addressing any performance bottlenecks or reliability issues.

3.2. Technologies Used

1. Edge Impulse Platform:

- **Data Collection and Preprocessing**: Edge Impulse simplifies data collection and preprocessing by offering a user-friendly interface for uploading raw sensor data and annotating it with relevant labels.
- **Model Training and Optimization:** Edge Impulse provides pre-built machine learning models optimized for edge deployment, allowing for customizable training with automated evaluation and tuning capabilities.

- **Deployment and Inference:** Once trained, Edge Impulse facilitates seamless deployment to edge devices like the ESP32 Cam by converting the model into a format suitable for efficient real-time inference.
- **Monitoring and Iterative Improvement:** Throughout development, Edge Impulse offers monitoring tools and key metrics to assess model performance, enabling continuous optimization and adaptation to evolving requirements.

2. **Deployment**:

- Converted the trained model into a format compatible with microcontrollers.
- Deployed the model on the Edge Impulse platform for efficient execution on resource-constrained devices.

3. **Arduino IDE Integration**:

- Integrated the deployed model into the Arduino IDE for embedded systems development.
- Developed Arduino-compatible C/C++ code to interface with the ESP32 Cam hardware.
- Configured the ESP32 Cam to capture and process images using the deployed face recognition model.

4. **Superbase Integration**:

- Employed Superbase as the backend database for storing to-do list information.
- Leveraged Superbase'stion between the ESP32 Cam and Superbase using HTTP requests over Wi-Fi.
- Leveraged Superbase's APIs for seamless interaction with the database.

5. **ESP32 Cam Setup**:

- Configured the ESP32 Cam to establish Wi-Fi connectivity and load the Arduino code.
- Implemented operations fpersonalized to-do lists from Superbase based on recognizedrieved and displayed personalized to-do lists from Superbase based on recognized identities.

CHAPTER 4

RESULTS

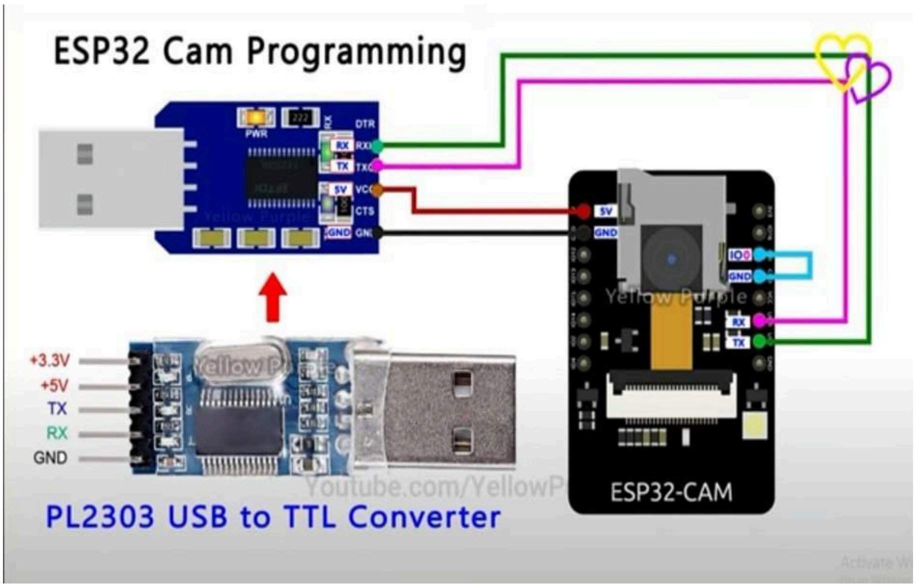

Figure 4.1. Connections

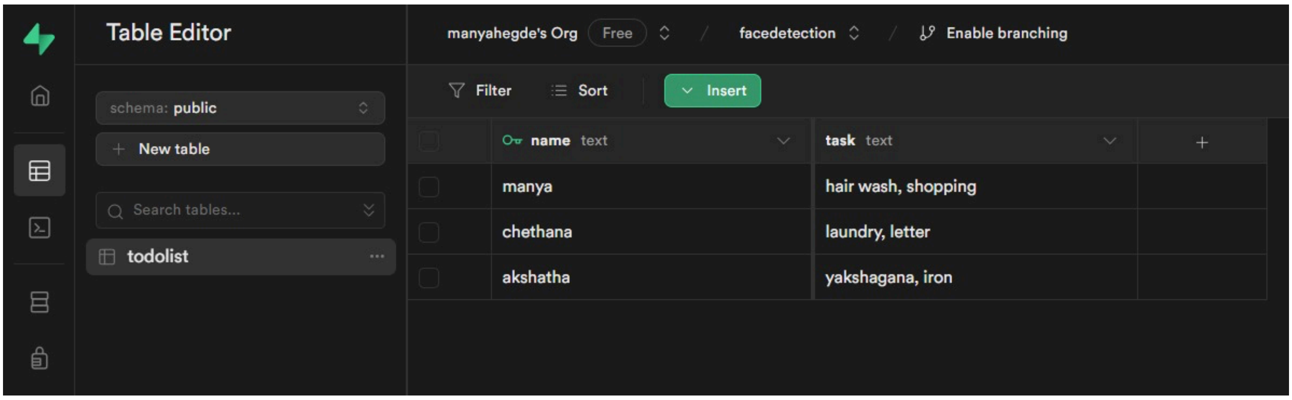

Figure 4.2. Supabase

Model testing results

ACCURACY

83.33%

	AKSHATHA	CHETHANA	MANYA	UNCERTAIN
AKSHATHA	75%	25%	0%	0%
CHETHANA	0%	100%	0%	0%
MANYA	0%	0%	75%	25%
F1 SCORE	0.86	0.92	0.86	

Figure 4.3. Edge Impulse Result

```
Connecting to vivo Y73
..
WiFi connected
IP address:
192.168.249.170
Predictions (DSP: 7 ms., Classification: 1160 ms., Anomaly: 0 ms.):
HTTP Response code: 200
{"rows":[{"name":"manya","task":"hair wash, shopping"}],"message":"done"}
Predictions (DSP: 8 ms., Classification: 1160 ms., Anomaly: 0 ms.):
HTTP Response code: 200
{"rows":[{"name":"akshatha","task":"yakshagana, iron"}],"message":"done"}
Predictions (DSP: 8 ms., Classification: 1161 ms., Anomaly: 0 ms.):
HTTP Response code: 200
{"rows":[{"name":"manya","task":"hair wash, shopping"}],"message":"done"}
Predictions (DSP: 8 ms., Classification: 1162 ms., Anomaly: 0 ms.):
HTTP Response code: 200
{"rows":[{"name":"akshatha","task":"yakshagana, iron"}],"message":"done"}
Predictions (DSP: 8 ms., Classification: 1162 ms., Anomaly: 0 ms.):
HTTP Response code: 200
{"rows":[{"name":"akshatha","task":"yakshagana, iron"}],"message":"done"}
Predictions (DSP: 8 ms., Classification: 1161 ms., Anomaly: 0 ms.):
HTTP Response code: 200
{"rows":[{"name":"manya","task":"hair wash, shopping"}],"message":"done"}
```

Figure 4.4 Arduino IDE

CHAPTER 5
CONCLUSIONS

In conclusion, the implementation of a face recognition system using Superbase, we have developed a practical and scalable face recognition system with diverse applications in smart home automation, access control, and personalizedhe integration of these technologies, we have successfully developed a system capable of recognizing faces in real-time and providing corresponding personalized information retrieved from a backend database.

The project began with data collection and preprocessing using the Edge Impulse platform, where raw sensor data was annotated and used to train a MobileNet model optimized for edge deployment. This model was then deployed onto the ESP32 Cam microcontroller, allowing for efficient real-time inference of facial recognition tasks.

Integration with Superbase provided seamless communication with a backend database, enabling the retrieval of personalized information such as to-do lists associated with recognized individuals. HTTP requests facilitated this interaction, allowing the ESP32 Cam to retrieve and display relevant information based on the recognized identity.

Throughout the development process, several challenges were addressed and overcome, including optimizing model performance for edge deployment, configuring Wi-Fi connectivity on the ESP32 Cam, and ensuring secure communication with the Superbase database.

Moving forward, further enhancements could be made to improve the system's accuracy and efficiency, such as fine-tuning the face recognition model, implementing additional security measures, and expanding the functionality to support more personalized interactions beyond to-do lists.

Overall, this project demonstrates the potential of integrating edge computing, machine learning, and cloud-based services to create intelligent and personalized IoT solutions. By leveraging the capabilities of the ESP32 Cam, Edge Impulse, and Superbase, we have developed a practical and scalable face recognition system with diverse applications in smart home automation, access control, and personalized user experiences.

CHAPTER 6

SCOPE FOR FUTURE WORK

1. **Enhanced Model Accuracy**: Continuously refining and fine-tuning the face recognition model to improve accuracy and robustness in diverse real-world scenarios. This could involve collecting additional labeled data, experimenting with different network architectures, and exploring advanced techniques such as transfer learning.

4. **Multi-Factor Authentication**: Implementing multi-factor authentication (MFA) techniques to enhance security and reliability. This could involve combining facial recognition with other biometric modalities such as voice recognition or fingerprint scanning to create a more robust authentication mechanism.

5. **Dynamic Personalization**: Expanding the system's capabilities to provide more dynamic and context-aware personalized interactions beyond simple to-do lists. This could involve integrating natural language processing (NLP) algorithms to understand and respond to user queries.

6. **Real-Time Feedback**: Incorporating real-time feedback mechanisms to provide users with immediate responses and updates. This could involve integrating audio or visual cues to indicate successful recognition or failure, as well as implementing feedback loops to continuously adapt and improve the system's performance over time.

7. **Scalability and Deployment**: Scaling the system to support larger deployments and diverse use cases. This could involve developing automated provisioning and deployment tools, as well as optimizing communication protocols and data transfer mechanisms to support distributed architectures and edge-to-cloud integration.

8. **Edge Computing Optimization**: Further optimizing the system for edge computing environments to reduce latency, power consumption, and resource usage. This could involve exploring techniques such as model quantization, pruning, and compression to minimize the footprint of the deployed model while maintaining high performance.

9. **Privacy and Ethical Considerations**: Addressing privacy and ethical concerns related to facial recognition technology, such as data privacy, consent management, and algorithmic bias. This could involve implementing privacy-preserving techniques such as federated learning or differential privacy.

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