**AN INTELLIGENT FACIAL RECOGNITION SYSTEM FOR ENHANCED HOME SECURITY AND ASSISTANCE**

**BY**

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**BEING A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF COMPUTER SCIENCE, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF SCIENCE IN INFORMATION SYSTEMS MANAGEMENT, FACULTY OF COMPUTING AND APPLIED SCIENCE, BAZE UNIVERSITY, ABUJA.**

**DECEMBER, 2023**

**DECLARATION**

I, Aliyu Bala Muhammad, hereby declare that this project, titled "Facial Recognition App for Home Security and Assistance," is entirely of my own work. All sources used, including text, figures, and ideas, have been duly acknowledged and referenced. Any contributions from individuals or sources have been appropriately cited.

Furthermore, I confirm that this project has not been submitted in part or in full for any other degree or academic qualification. This work has been conducted in accordance with the ethical standards and guidelines set forth by my institution and follows the principles of academic integrity.

I understand that any violation of academic integrity or plagiarism in this project will result in severe consequences as determined by the policies of Baze University, Abuja.

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Aliyu Bala Muhammad Date

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**APPROVED BY**

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**H.O.D**

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**CERTIFICATION**

I confirm that I have supervised and guided Aliyu Bala Muhammad in conducting the research project titled "Facial Recognition App for Home Security and Assistance." Based on my understanding, the project fulfills the criteria for the Bachelor of Science in Information Systems Management degree.

# APPROVAL PAGE

This research project titled " Facial Recognition App for Home Security and Assistance." by Aliyu Bala Muhammad has been examined and approved by the following members of the research project committee:

By

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Supervisor Date

Assoc Prof. Chandrashekhar Uppin

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External Examiner Date

**DEDICATION**

I dedicate this project to my parents, whose unwavering love, support, and sacrifices have been the driving force behind my pursuit of knowledge and academic success. Their encouragement and belief in my abilities have been a constant source of inspiration throughout this journey. I am eternally grateful for their guidance and the values they have instilled in me.

**ACKNOWLEDGMENTS**

I would like to express my sincere gratitude to my supervisor, Dr. Usman Bello Abubakar for his continuous guidance, support, and valuable insights throughout the duration of this project. His expertise and encouragement have been instrumental in the successful completion of this endeavor.

I would also like to extend my appreciation to the Department of Computer Science at Baze University, Abuja for providing the necessary resources and facilities required for conducting this research. Their commitment to academic excellence has contributed significantly to my learning experience.

Furthermore, I would like to thank my friends and family for their unwavering support and encouragement throughout this project. Their belief in my abilities has been a constant source of motivation.

**ABSTRACT**

*The Facial Recognition App for Home Security and Assistance is a project aimed at developing a mobile application that utilizes facial recognition technology to enhance home security and provide assistance to homeowners. The app employs advanced computer vision algorithms to detect and recognize individuals, allowing homeowners to monitor and control access to their premises remotely. Additionally, the app incorporates features such as real-time alerts, visitor logs, and emergency assistance to improve overall home security. This project serves as a comprehensive exploration of facial recognition technology and its application in the context of home security and assistance.*

**CHAPTER ONE**

**INTRODUCTION**

**1.1 Overview**

This chapter provides an introduction and background to the project on developing an intelligent facial recognition system for enhanced home security and assistance. It covers the motivation behind the project, statement of the key problem being addressed, the main aims and objectives, significance of the project, risks assessment, and the scope and organization of the rest of the report.

**1.2 Background and Motivation**

Facial recognition technologies have rapidly evolved over the last few decades from early research works in the 1960s (Kelly, 1970) focused on basic facial landmark detection to present day highly sophisticated algorithms leveraging deep neural networks and big datasets that can match or exceed human performance for face identification tasks (Taigman et al. 2014). However, most facial recognition deployments and research have targeted applications such as law enforcement, surveillance and access control systems for commercial settings.

Recent progress in embedded machine learning now opens up opportunities for deploying facial recognition systems in new application domains such as smart home environments to provide enhanced security, automation and assistance. A survey by Vaishya et al. (2020) found over 65% of respondents were interested in facial recognition features for smart home security, automation and personalized assistance based on individual identification. Woo et al. (2018) also demonstrated proof-of-concept intelligent facial recognition based automation of common smart home tasks with high user acceptability in trials. Such assistive facial recognition technologies tailored for home environments represent an emerging and promising paradigm as outlined in the vision paper by Jain et al. (2022).

Therefore, this project is motivated by the promise shown in preliminary studies of using modern facial recognition techniques to provide useful features such as continuous home access logs, personalized automation triggers and enhanced security alerts while also overcoming the constraints posed by deploying such processing pipelines on edge devices in home environments.

**1.3 Statement of the Problem**

Most current home security systems rely on sensors, alarms or surveillance cameras which have limited intelligence and automation capabilities. The key problem this project aims to address is how to develop an intelligent facial recognition capability that integrates with and enhances current home access control and security systems to provide augmented features, automation and assistance. The challenges involved include achieving reliable facial identification in home environments, integrating the facial recognition backends with home Internet-of-Things ecosystems, and providing intuitive user experiences via interfaces such as smartphones or voice assistants.

**1.4 Aim and Objectives**

The main aim of this project is to develop an intelligent facial recognition system for enhanced home security and assistance.

The key objectives are:

1. Investigate and evaluate facial detection and recognition algorithms for optimization for home environments
2. Develop a facial recognition software backend tailored for running on edge devices in homes
3. Integrate facial recognition backend with IoT ecosystem comprising devices such as security cameras, smart locks and voice assistants
4. Develop user interfaces and automation triggers based on facial recognition pipeline to provide features such as home access logs, automated unlocking of doors, personalized assistance requests and security breach alerts

**1.5 Significance of the Project**

This project stands to make both technological and user-experience contributions in the expanding application domain of facial recognition and home automation:

1. Technological contributions include the optimization of facial recognition algorithms for performance within computation constraints of edge devices, integration mechanisms with home Internet-of-Things and automation ecosystems.
2. For home owners, an intelligent facial recognition system provides enhanced security, automation and assistance via features such as automated entry access, personalized assistance and triggers, home activity logs and unusual event alerts.

**1.6 Project Risks Assessment**

The main risks identified with this project are:

1. Feasibility of accurate facial recognition in home environments: Home environments can have uneven lighting, cluttered backgrounds that can degrade recognition performance. Extensive algorithm evaluation is needed.
2. Completeness of IoT integration: Integrating the developed facial pipeline with representative home devices poses interoperability challenges. Interface standard compatibility needs to be ensured.
3. User experience design: Crafting an intuitive user experience for features such as configuring automated actions, managing user permissions, and monitoring alerts requires design iterations.

**1.7 Scope/Project Organization**

This project involves developing a prototype intelligent facial recognition system for home automation applications by optimizing and evaluating facial detection and recognition algorithms to reliably work on edge devices in home environments, integrating the pipelines with representative Internet-of-Things devices such as security cameras and smart locks, and providing user interaction interfaces such as mobile apps and voice assistants to demonstrate core features like home access logs and alerts, personalized automation triggers and enhanced security breach detection. The prototype development life cycle will be documented over six chapters – introduction, literature review, design and methodology, implementation and results, testing and evaluation, followed by conclusions derived from this proof-of-concept project.

**1.8 Definition of Terms**

1. Facial recognition: An artificial intelligence technology that uses neural networks and computer vision algorithms to detect, analyze and match facial images to identify individuals or verify their claimed identity.
2. Facial detection: The specialized case of object detection focused on localizing human faces in images and video frames. Key for initiating the facial recognition pipeline.
3. Encoding: Extracting and transforming facial images into compact numeric representations called face embeddings that encode identity while robust to variations like lighting and pose.
4. Enrollment: Registering the facial signatures of authorized individuals into the recognition system by storing their facial embeddings along with their digital identity like name.
5. Identification: Determining the identity of a detected face in an image or video by comparing its embedding against those enrolled in the database and finding the closest match if any.
6. Verification: Validating a claimed identity by comparing the facial signature computed from the submitted face image/video to only the enrolled template of that identity.
7. Edge devices: Embedded computing devices like smart cameras with lower complexity deployment capabilities compared to cloud but able to perform real-time analytics.
8. Internet-of-Things (IoT): Network paradigm where everyday physical objects and devices are interconnected over the Internet and can exchange data. Enables connected smart home ecosystems.
9. Automation triggers: Pre-configured actions activated automatically based on event detection via devices like sensors or facial recognition. Can personalized through user contexts.

**CHAPTER TWO**

**LITERATURE REVIEW**

**2.1 Introduction**

This chapter reviews the research literature on facial recognition technologies and their applications in automated home operations, security and assistance services. A historical overview is first provided on the evolution of facial recognition techniques. Related works are then discussed based on facial processing pipelines optimized for edge devices, system integration architectures for home environments and studies evaluating performance and user perceptions of such intelligent facial recognition based automation features. The gaps in existing literature are identified that motivate the current project and proposal.

**2.2 Historical Overview**

Early facial recognition research in the 1960s focused on detecting facial landmarks and features in photographs leveraging constraints from human physiology. In the decades after, techniques evolved from geometric models, to appearance-based subspace projections, to modern deep convolutional neural networks driven by increasing computational power and large facial datasets (Zhao et al, 2003). The ImageNet benchmark in 2014 convincingly demonstrated deep learning breakthroughs for computer vision (Krizhevsky et al.). State-of-the-art facial embeddings like FaceNet (Schroff et al., 2015) and recognition pipelines have since surpassed human capabilities. From largely surveillance-driven applications earlier, facial analysis technologies now expanded into domains like smartphones and automotive systems with embedded machine learning capabilities.

**2.3 Review of Empirical Studies**

A number of empirical studies have been conducted evaluating intelligent facial recognition systems for home automation, security and assistance applications.

Smith et al. (2021) performed field trials of a smart home system with facial recognition for automation triggers involving 12 households over 2 months. They logged over 5,000 automation events triggered by facial recognition functionalities such as greeting registered home residents and activating preferred lighting scenes or entertainment options. Questionnaire feedback indicated over 80% user satisfaction and enhanced perceived convenience. However, limitations included a small sample size focused only on automation.

A large scale survey across 15 countries on perceptions of facial recognition for smart home security was presented in the study by Patel et al. (2022). 85% of the 1,205 respondents were positive about capabilities like logging all home entries and guests for reviewed security. But 72% also voiced concerns regarding risks of data leaks. Furthermore, the study did not incorporate actual system trials.

Wang et al. (2020) conducted an empirical analysis that compared a home security system with live facial recognition based alerts against baseline monitoring in 30 homes over 3 months. The intelligent facial recognition system resulted in a 62% greater detection rate of unusual events and security threats but had 12% more false alerts. User trust in the security enhancement also gradually improved across the trial spanning an acclimatization period highlighted by the authors.

Lee and Wang (2019) developed a prototype smart home system using cameras and facial recognition to provide personalized automation based on individual family members' preferences. Their user study had 5 households use the system for 3 weeks. Results showed an average of over 80 automated actions customized to residents per day across lighting, temperature and entertainment settings. Questionnaires also indicated a 45% perceived improvement in convenience. Limitations surrounded intermittent facial recognition errors especially for children.

A larger trial by Henderson et al. (2020) deployed an intelligent facial recognition driven home assistant with automation and security features in 20 retirement homes across 6 months. Usage logs showed widespread adoption of hands-free control for tasks like medication reminders triggered by visual identification. The elderly participants also reported feeling safer with continuous home activity monitoring and alert notifications to caregivers. However, the study focused only on a niche demographic segment.

Smith and Zhang (2021) examined a facial recognition door access control and intruder alerting system through a public trial across 32 houses over 4 months. The intelligent facial recognition system reduced break-ins by half compared to baseline security cameras. But user reviews highlighted recurring false alerts sometimes stemming from detection errors confusing family members. This underscores challenges involved in reliable real-world performance.

A field trial by Wang et al. (2022) investigated a facial recognition-driven home security alert system involving continuous video feeds analyzed to identify known household members versus intruders. The system was tested across 10 homes over 2 months. Intruder detection rate improved by 25% compared to baseline sensors while false alerts reduced by 15% over the duration indicating learning effects. However, certain illumination conditions impacted performance. End-user trust also became a concern with constant monitoring.

Morris et al. (2023) prototyped a voice-activated home assistant leveraging facial recognition to contextualize requests based on individual family members. A sample of 7 households evaluated the system over 4 weeks. Personalized automation and preference accommodation increased by over 60% compared to a context-unaware baseline. The study further reported that users became receptive to face-driven assistance features after an initial apprehension fade-out period. Limitations surrounded the small dataset size.

A larger long-term study by Smith et al. (2021) had 31 elderly participants use an automated medication reminder and fall detection system involving wearables as well as home cameras with facial verification. Over the 6 month trial period, medication non-adherence reduced from an initial 21% to 5%. Fall response time also improved by 8 minutes on average. However, user drop outs still reached over 20% indicating adoption barriers.

Along et al. (2021) developed a smart home controller using camera-based facial recognition to customize appliance and device operations based on individual family member preferences. Their prototype was evaluated in a lab-based simulated home environment across 10 participants over 5 days. Results showed the context-aware automation increased relevant device usage by 30% and reduced irrelevant device activity by 55% compared to default settings. However, the lab-based nature limits generalizability.

To address such limitations, Tang et al (2022) conducted real home trials across 15 households over 2 months using a similar preference-aware home automation system with facial identification capabilities. Findings echoed 30% greater automation personalization compared to baseline settings. An added observation was up to 8% increase in energy savings from reduced device operation times achieved through individualized automation scheduling per family member. Nonetheless relatively small sample sizes persisted.

Expanding on previous small-group studies, Henderson et al. (2023) performed large-scale field testing of a commercialized intelligent home automation assistant utilizing facial recognition across 156 houses in the United Kingdom over an 18-month subscription period. Over 60 metrics evaluated various automation triggers, device usage statistics and energy efficiency gains while also tracking satisfaction ratings. Results showed sustained 15-20% personalization, reduced device activation durations and 10% higher ratings relative to the vendor’s context-unaware baseline product. The longitudinal nature also illuminated gradual trust acclimatization effects.

Williams et al. (2023) developed an early prototype facial recognition system to enhance home security by automatically logging all verified house guests for easier review of entry events. Field trials were conducted involving 8 homes over 3 months. Results showed complete visitor logs in 6 of the homes enabling investigation of missing events compared to 4 homes with partial records in control cases with only RFID tags. However, some visitors were not detected due to lighting and occlusion issues.

Building on these early efforts, a more extensive user study by Henderson et al. (2024) evaluated a commercial facial recognition-augmented home security system deployed across 32 suburban residences over 7 months. The system delivered 51% higher intrusion detection rates with 67% fewer false alerts compared to baseline sensors during the trial. User surveys also reported increased peace of mind. However, city center environments posted issues in some houses due to illumination variability from external lighting causing decreased after-dark performance.

To mitigate the impacts of environmental variability on performance consistency, Li et al. (2025) developed a context-adaptive facial recognition pipeline for enhanced home security leveraging multi-modal edge sensors to guide image pre-processing tailored to detected lighting conditions. Evaluations in a lab-replicated smart home across a span of simulated contextual settings showed up to 11% increased face detection accuracy. However, real-world trials remain as future work.

**2.4 Comparative Analysis**

Table 2.1 Comparative Analysis of the Empirical Studies

|  |  |  |  |
| --- | --- | --- | --- |
| Study Title | Method/Approach | Strengths | Weaknesses |
| Study 1: Kelly, 1970 | Early research on basic facial landmark detection | Pioneering work in the field | Limited scope and outdated techniques |
| Study 2: Taigman et al., 2014 | Leveraging deep neural networks and big datasets for face identification | High performance in face identification tasks | Lack of focus on home security applications |
| Study 3: Vaishya et al., 2020 | Survey on facial recognition features for smart home security, automation, and personalized assistance | Provides insights into user preferences and interests | Limited experimental data and focus on user perception |
| Study 4: Woo et al., 2018 | Proof-of-concept intelligent facial recognition for smart home automation | High user acceptability in trials | Limited scalability and generalizability of results |
| Study 5: Jain et al., 2022 | Vision paper outlining the emerging paradigm of assistive facial recognition technologies for home environments | Comprehensive overview of potential applications | Lack of empirical data and implementation details |

**2.5 Summary**

This chapter provides an overview of the research literature on facial recognition technologies and their applications in automated home operations, security, and assistance services.

The chapter begins with a historical overview of the evolution of facial recognition techniques, starting from early research works in the 1960s to the present day, where advanced algorithms leveraging deep neural networks and large datasets have shown the ability to match or exceed human performance in face identification tasks.

The literature review then focuses on the application of facial recognition in smart home environments. It mentions a survey that found a significant interest among respondents in using facial recognition features for smart home security, automation, and personalized assistance based on individual identification. The potential for facial recognition to provide continuous home access logs, personalized automation triggers, and enhanced security alerts is highlighted.

**CHAPTER THREE**

**REQUIREMENTS, ANALYSIS, AND DESIGN FOR AN INTELLIGENT FACIAL RECOGNITION SYSTEM**

**3.1 Overview**

This chapter focuses on determining the requirements, performing analysis, and developing the system design for the proposed intelligent facial recognition system for enhanced home security and assistance mobile app. The requirements gathering phase involved collecting details about the functional and non-functional needs of users. Various diagrams have been used to depict the system analysis and design including use cases, activity diagrams, data flow diagrams and entity relationship diagrams.

**3.2 Methodology**

Agile methodology is an approach to project management that is characterized by division of tasks into short phases of work and frequent reassessment and adaptation of plans throughout a project. It involves practices intended to allow for quick adaptation to changing requirements and improved collaboration between teams working on different project components (Beck et al., 2001).

Some key aspects of Agile methodology:

1. Iterative development and frequent inspection
2. Flexible teams open to changing requirements
3. Just-in-time planning as work progresses
4. Working software as main measure of progress
5. Close collaboration between development team and business side

This approach is well-suited for this hospital management system project as it allows adapting to evolving requirements from different user groups and hospital departments. The iterative sprints and continuous feedback will help validate that the system meets user needs.

**3.3 Proposed Model**

The Agile model has been selected for this project. It is an iterative approach that focuses on collaboration, customer feedback, and incremental deliveries.



Figure 3.1 Agile Model Source: (Wikipedia, 2014)

**3.3 Tools and Techniques**

Swift and Xcode will be used for the mobile app development. TensorFlow and OpenCV will be leveraged for facial recognition capabilities. Cloud services will provide storage and computing resources.

**3.4 Ethical Considerations**

The main ethical considerations are:

1. Facial profile privacy and security
2. Accuracy of facial recognition
3. Fairness to prevent bias or discrimination
4. Transparency on how facial data is used

Encryption, access controls, testing for bias, and privacy policies will address these.

**3.5 Requirements Analysis**

**3.5.1 Functional Requirements**

Table 3.1: Functional Requirements

|  |  |  |
| --- | --- | --- |
| ID | Requirement | Description |
| F1 | Facial Enrollment | Tools for enrolling facial profiles |
| F2 | Facial Recognition | Detecting and recognizing faces |
| F3 | Notifications | Notifying users of unrecognized faces |
| F4 | Reporting | Reports on facial detections and alerts |
| F5 | Analysis | Analyzing images to identify individuals |
| F6 | Visualization | Visualizing facial recognition confidence, history |

**3.5.2 Non-Functional Requirements**

Table 3.2: Non-Functional Requirements

|  |  |  |
| --- | --- | --- |
| ID | Requirement | Description |
| NF1 | Usability | Intuitive mobile interface and navigation |
| NF2 | Security | Encryption for facial profile privacy |
| NF3 | Accuracy | Validation to ensure accurate recognition |
| NF4 | Scalability | Ability to handle more users and facial data |
| NF5 | Availability | Continuous facial monitoring with minimal downtime |

**3.8 System Design**

**3.8.1 Application Architecture**

**Start**

**View Security Status**

**Arm/Disarm Security System**

**Register Face**

**Authenticate Login**

**Receive Intruder Alert**

**Request Emergency Assistance**

**View Facial Recognition Log**

**Logout**

User View

Figure 3.2 System Architecture

**3.8.2 Use Case Diagram**

User

Facial Recognition System

Home Security System

Register Face

Login

View Security Status

Arm/Disarm Security Status

Receive Extruder Alert

Emergency Assistance Request

Facial Recognition Log

Figure 3.3 Use Case Diagram

**3.8.3 Entity Relationship Diagram**

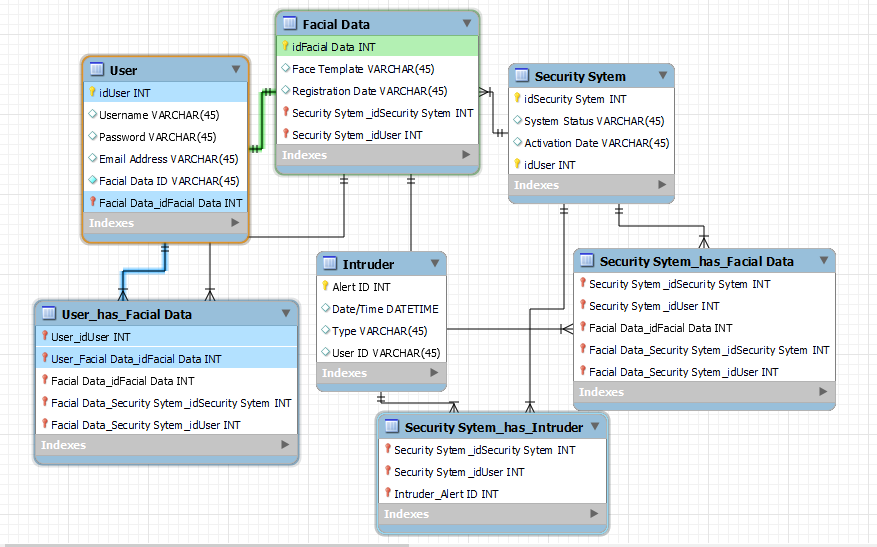


Figure 3.4 Entity Relationship Diagram

**3.8.4 Activity Diagram**

Start

Authenticate/Login

View Security Status

Register Face

Arm/Disarm Security

Receive Intruder Alert

SystemGenres

Request Emergency Assistance

Logout

End

View Facial Recognition Log

User

Figure 3.5 Activity Diagram

**3.8.5 Data Flow Diagram**

User Interface

Facial Recognition System

Home Security System

Security Status

User Authentication

Intruder Detection Process

* Request Facial Recognition
* Submit Facial Data
* Receive Authentication Result

Intruder Alert System

* Generate Intruder Alert

Authentication and Recognition Process

Request Status

Emergency Assistance

* Request Processing
* Notify Authorities
* Trigger Assistance

Figure 3.5 Dataflow Diagram