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ORIGINAL ARTICLE

RFID-Based Medical Health Card and Emergency Alert System

Diksha Gautam Nikam[1*], Anushree Gitesh Sanvatsarkar[1], Sakshi Sachin Zombade[1]

1 Electronics and Telecommunication, PES's Modern College of Engineering, Pune, Maharastra, India.

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*** Corresponding author.**
dikshanikamd7@gmail.com

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Abstract

This paper presents an RFID-based Medical Health Card and Emergency Alert System designed to improve patient identification and emergency response. The system uses a dual-mode identification approach combining RFID cards for normal conditions and fingerprint recognition for emergency situations where the card is unavailable. A Raspberry Pi acts as the central controller, interfacing with an RFID reader and fingerprint sensor to retrieve patient data from a cloud-based database. A web interface is used to display patient details, and a GSM module is integrated to send emergency alerts with patient information and hospital location to registered contacts. The proposed system enhances accessibility, security, and reliability of medical data retrieval during critical situations.

Keywords: RFID, Healthcare System, Fingerprint, Recognition, Raspberry Pi, Emergency Alert System, IoT, Cloud, Database, GSM Module

Introduction

The rapid advancement of embedded systems and Internet of Things (IoT) technologies has significantly improved healthcare services. However, one major challenge in emergency healthcare is the unavailability of patient medical history at the time of treatment. In situations such as road accidents or unconscious conditions, patients are often unable to communicate critical medical information such as allergies, chronic diseases, or ongoing treatments.

RFID-based medical health card systems have been introduced to address this issue by enabling quick access to patient data using a unique identification card. Although these systems are fast and convenient, they have a major limitation: they depend entirely on the availability of the RFID card. If the card is lost or not present during emergencies, patient identification becomes difficult.

To overcome this limitation, this paper proposes a dual mode identification system that combines RFID technology with fingerprint recognition. RFID is used for fast and efficient identification in normal conditions, while fingerprint recognition ensures reliable identification in emergency situations where the card is unavailable. The system is implemented using Raspberry Pi as the central controller, along with cloud-based data storage and an emergency alert mechanism.

The proposed system aims to improve accessibility, reliability, and security of patient data retrieval, making it highly useful for hospitals, emergency services, and accident response systems.

System Architecture

The proposed system consists of both hardware and software components integrated to ensure efficient patient identification and data retrieval.

The hardware components include a Raspberry Pi 4B as the central controller, an MFRC522 RFID reader for scanning medical cards, and a fingerprint sensor for biometric identification. These components are connected to the Raspberry Pi using SPI and serial communication protocols.

On the software side, a cloud-based database (AWS) is used to store patient information such as name, medical history, allergies, and emergency contacts. A web-based interface is developed to display patient data in real time.

During operation, the RFID reader scans the card to retrieve a unique ID, while the fingerprint sensor is used for identification in emergency conditions. The Raspberry Pi processes the input and fetches corresponding data from the database. Additionally, a GSM module is integrated to send emergency alerts to registered contacts.

Methodology

The proposed system follows a dual-mode identification approach to ensure reliable patient data retrieval in both normal and emergency conditions.

In Case 1 (Normal Condition), the patient scans the RFID medical card using the RFID reader. The system retrieves a unique identification number and directly fetches the corresponding patient data from the cloud database. This method is fast and efficient for regular hospital use.

In Case 2 (Emergency Condition), when the RFID card is unavailable, the fingerprint sensor is used. The system scans the patient's fingerprint and matches it with stored templates in the database. Once a match is found, the patient's data is retrieved. Additionally, an emergency alert message is sent to registered contacts with patient details and hospital location.

This dual-mode approach ensures both speed and reliability, making the system suitable for real-world healthcare applications.

Implementation

The proposed system is implemented using Raspberry Pi 4B as the central processing unit. The hardware setup includes an MFRC522 RFID reader for scanning medical cards and a fingerprint sensor for biometric identification. These components are interfaced with the Raspberry Pi using SPI and serial communication protocols.

The system is connected to a cloud-based database (AWS) where patient records are securely stored. A web application is developed using Flask to provide a user-friendly interface for displaying patient information such as name, medical history, allergies, and emergency contacts.

For fingerprint recognition, machine learning models are used. Model A is a custom CNN-based model, while Model B uses a MobileNetV2-based Siamese architecture for improved accuracy and feature matching.

Additionally, a GSM module is integrated to send emergency alert messages. When triggered, the system sends an SMS to the registered emergency contact with patient details and hospital location.

Two different models were implemented for fingerprint recognition. Model A is a custom Convolutional Neural Network (CNN) designed from scratch, while Model B is based on a pretrained MobileNetV2 architecture combined with a Siamese network for feature comparison. The pretrained model in Model B enables better feature extraction and improves recognition performance.

Results and Discussion

The performance of the system was evaluated using two models: Model A (custom CNN) and Model B (MobileNetV2-based Siamese model).

Model A showed acceptable performance but had difficulty distinguishing between similar fingerprint patterns, leading to higher misclassification. This is because the model was trained from scratch and required a large amount of data for effective feature learning.

Model B demonstrated significantly improved performance due to the use of a pretrained MobileNetV2 backbone. The pretrained model, trained on large-scale datasets, provides strong feature extraction capabilities, allowing better differentiation between fingerprint patterns. The Siamese architecture further enhances accuracy by comparing feature embeddings instead of direct classification.

Due to its higher accuracy, better generalization, and improved feature extraction, Model B was selected for deployment in the proposed system.

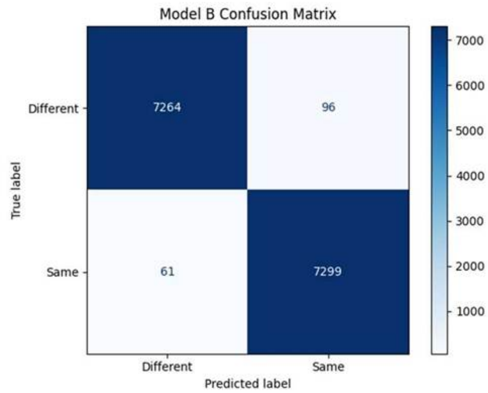

Fig. 1: Confusion matrix of Model A showing perfect classification of same and different fingerprint pairs

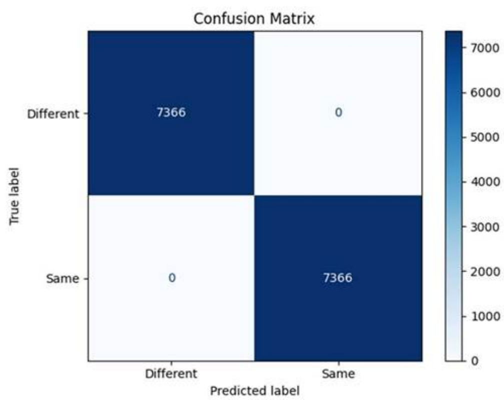

Fig. 2: Confusion matrix of Model B showing minor misclassification, indicating realistic performance under practical conditions

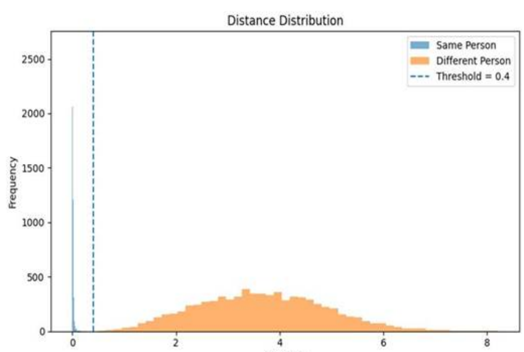

Fig. 3: Distance distribution of Model A showing clear separation between same and different fingerprint pairs

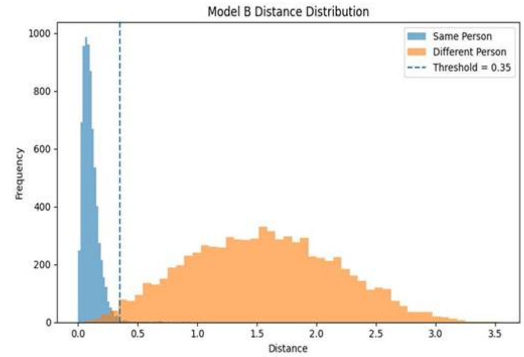

Fig. 4: Distance distribution of Model B showing slight overlap, representing real-world variation

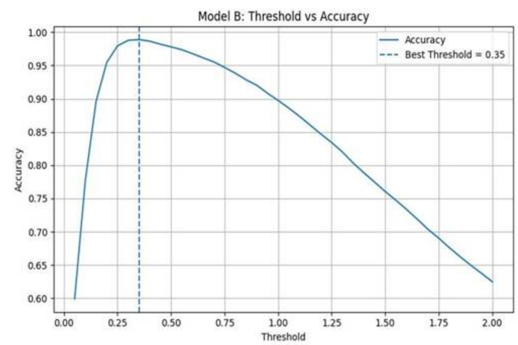

Fig. 5: Threshold vs accuracy curve for Model B indicating optimal threshold selection

Table 1: Comparison of Model A & Model B

Parameter	Model A (Custom CNN)	Model B (MobileNetV 2 + Siamese)
Accuracy	~100%	~98.9%
Architecture	From scratch	Pretrained (Transfer Learning)
Feature Extraction	Limited	Strong
Generalization	Low	High
Overfitting Risk	High	Low
Real-world Performance	Limited	Reliable
Final Selection	Not Selected	Selected

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