# A Conceptual Framework for Enhancing ATM Security through Integrated Multilayer Biometric Authentication


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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering


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## APPROVAL

This Project titled "**A Conceptual Framework for Enhancing ATM Security through Integrated Multilayer Biometric Authentication**", submitted by **Koushik Vadury Ronok** to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 06.07.2024

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We hereby declare that, this project has been done by us under the supervision of **Professor Dr. Syed Akhter Hossain, Dean and Professor of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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# ABSTRACT

In recent years, the security of Automated Teller Machines (ATMs) has been a critical concern due to increasing fraud and unauthorized access incidents. This research paper presents a novel multi-layered security framework for cardless ATMs that leverages facial recognition, fingerprint scanning, and One-Time Password (OTP) verification to enhance transaction security. The proposed system aims to eliminate the vulnerabilities associated with traditional card and PIN-based authentication methods. The system operates in three stages: first, the customer's face is scanned and matched against a database to retrieve account details; second, the customer's fingerprint is scanned for authorization; and third, an OTP is sent to the customer's registered mobile device for final verification before the transaction can be completed. This multi-layered approach ensures robust security by requiring multiple forms of identification, making unauthorized access exceedingly tricky.The proposed system provides several benefits, such as improved security via biometric authentication, greater user convenience by removing the necessity for physical cards, and real-time authorization using OTP verification. Nevertheless, implementing this system also comes with challenges, including substantial initial expenses, potential privacy issues concerning biometric data, and users' need to adapt to new authentication methods.This paper delves into developing and deploying a multi-layered security system, assesses its effectiveness through simulation tests, and contrasts it with existing security protocols. The findings reveal that the proposed system significantly enhances ATM security, providing a practical solution to combat fraud and prevent unauthorized access in contemporary banking.ssThis paper examines creating and deploying a multi-layered security system, assesses its performance through simulations, and contrasts it with current security solutions. The results indicate that the proposed system markedly enhances ATM security, presenting a feasible method to guard against fraud and unauthorized access in today's banking industry.

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# CHAPTER 1
# INTRODUCTION

## 1.1 Introduction:

Future innovations are being built-up with a high-security system in this system by the Bangladesh government to ensure digitization and move to cashless Bangladesh. Because of rapid science and technological development, we have proposed a plan with a card-less ATM access that will be accessed with the help of biometric systems, i.e., Facial recognition and transaction details can be accessed by the people who always need to carry an ATM card while going to an ATM and remember a 4-digit pin. If the card is lost, many processes are required, such as blocking the card, etc. Thus, we need to visit the bank, again and again, invest our time, and pay the bank for the maintenance of the card. To overcome all these disadvantages, this system has been designed. This paper presents the initial design and result of a card-less ATM access with fingerprint recognition using IoT. This system overcomes the problem of standing in a queue and having delays at the banks/ATMs. It will also, provide a higher level of security to the card account holders.

## 1.2 Motivation:

The motivation behind this research stems from the increasing incidence of ATM fraud and the shortcomings of current security measures. Traditional authentication methods using PINs and cards have become inadequate against advanced attack techniques. Criminals exploit these vulnerabilities through card skimming, shoulder surfing, and cloning, leading to unauthorized access to bank accounts. These incidents cause financial losses for customers, harm the reputation of banks, and undermine public trust in the financial system.

Moreover, there is an urgent need to enhance user convenience and satisfaction. Customers desire a seamless and secure banking experience, but issues like lost or stolen cards and the fear of PIN theft detract from this. Biometric authentication provides a promising solution by utilizing unique physical traits that are hard to replicate or steal. However, single-factor biometric systems also face challenges, such as vulnerability to spoofing attacks. This research proposes a multi-layered security framework combining facial recognition, fingerprint scanning, and OTP verification to offer a comprehensive solution addressing security and user convenience. This approach strengthens ATM security and supports the growing trend towards cardless transactions, which are becoming increasingly common in the digital age. The goal is to create a safer, more reliable, and user-friendly ATM system to restore and maintain customer confidence in banking services.

## 1.3 Rationale Of The Study:

The rapid advancement of banking technology has significantly transformed banking activities, with the automatic teller machine (ATM) being a prime example. ATMs allow customers to withdraw cash, transfer money, make deposits, and handle various transactions without interacting with bank staff. This provides quick and convenient access to bank accounts and financial services.

An essential component of ATM security is using passwords or PINs to protect customer's financial information from unauthorized access. The system verifies these access codes against the accounts of authorized users. Typically, a PIN is a four-digit number combination entered via the ATM keypad. The system grants access at the account owner's security level if the correct code is entered. However, the increasing frequency of ATM hacks due to inadequate security measures is a growing concern.

I propose enhancing ATM security with features like facial recognition, fingerprint scanning, and OTP (one-time password) verification to address these issues. These measures will elevate ATM security to a new level.

## 1.4 Research Question:

To achieve the research objective, the following research questions will be explored:

How effective is integrating facial recognition and fingerprint scanning in enhancing ATM security compared to traditional methods?

This question evaluates the security improvements brought by biometric authentication techniques and their effectiveness in preventing unauthorized access.
What are the possible difficulties and constraints of deploying a multi-tiered biometric and OTP-based security system for ATMs?

This question seeks to identify and analyze the practical issues that may arise from deploying such a system, including privacy concerns, implementation costs, and system reliability.
How does the user experience and acceptance of a cardless ATM system utilizing multi-layered authentication compare to traditional card-based systems?

This question assesses user perceptions, ease of use, and overall satisfaction with the new security framework and how it impacts user behaviour and trust in ATM services.
What actions can be implemented to ensure the protection and privacy of biometric data in the proposed ATM security system?

This question addresses data security and privacy, proposing solutions to safeguard sensitive biometric information and ensure compliance with data protection regulations.

## 1.4 Expected Output:

When implemented globally, this system will safeguard billions of personal data, revolutionizing electronic transactions. The risk of ATM system hacks and data breaches will be virtually eliminated.

## 1.5 Project Management And Finance:

In this project, we will use our own device for facial recognition and data storage. Additionally, a 1080p camera will be required for face recognition, and a fingerprint reader will be needed for capturing user fingerprints in the production phase.

## 1.6 Report layout:

The report outlines the research work conducted. The first section provides background information and an explanation of the problem, assessing the necessity of the research. It also briefly describes the overall project. The second section reviews related work from previous research and fundamental knowledge needed to understand the dissertation. The researcher, ideally a computer science student, will need a strong understanding of machine vision and statistics. Therefore, this section covers the essential knowledge focused on in the research. The third section details the system's design through various design proposals, while the fourth section discusses the research implementation, including flow charts, algorithm designs, and the implementation process. The fifth section evaluates the research. Finally, the last section summarizes the work completed and suggests potential future work.

# CHAPTER 2

# BACKGROUND

## 2.1 Preliminaries/Terminologies:

ATM crime has become a major domestic issue impacting both customers and bank operators, with financial crime incidents increasing in recent years. Criminals frequently tamper with ATM terminals to steal customers' card details illegally. When users lose their bank cards and passwords, their accounts become susceptible to attacks. Traditional ATM systems, which typically rely on cards (credit, debit, or smart) and password or PIN authentication, have shown significant flaws. Current authentication methods, such as passwords, user IDs, identification cards, and PINs, have several limitations. Passwords and PINs can be illicitly obtained through covert observation,[1] and unauthorized users can often guess personal codes when cards are lost or stolen. Despite warnings, many individuals continue to use easily guessed PINs and passwords, such as birthdays, phone numbers, and social security numbers. Recent identity theft incidents have underscored the need for more secure authentication techniques. Biometric authentication technology offers a solution, as a person's biometric data is uniquely linked to them[2], non-transferable, and unique to each individual. The system can compare biometric scans to records stored in a central or local database or on a smart card. Biometrics, defined as measurable physiological and behavioral characteristics, are captured during verification and compared to a stored example. This automated method recognizes individuals based on these traits. Biometrics include unique physical characteristics like fingerprints, hand or palm geometry, retina, iris, and face, as well as behavioral features like signatures and voice. Biometric technology provides a secure means of authentication because biometric information is unique, cannot be shared or copied, and cannot be lost.

## 2.2 Related Works:

The integration of biometric technologies into ATM security systems has been extensively studied in recent years. A prominent study by Srivatsan Sridharan and Priya Arora examines an automated teller machine system that includes demand draft generation with enhanced security features to prevent unauthorized transactions. This study emphasizes the benefits of automation in reducing human intervention and the use of secure communication protocols to enhance overall security.

[3] H. Lasisi and A.A. Ajisafe's notable work focuses on developing a stripe biometric-based fingerprint authentication system for ATMs, addressing the vulnerabilities of traditional PIN and magnetic stripe card methods. Their results show a significant increase in security, reducing unauthorized access through stolen PINs or cards.

[4] Rajesh V. introduces the IBIO system, which utilizes iris recognition technology for ATM authentication. This approach enhances security by replacing traditional card and PIN methods with biometric verification, demonstrating the effectiveness of iris recognition in reducing fraud and improving user convenience.

[5] C. Bhuvaneswari and colleagues explore the combination of biometric and IoT technologies in ATMs. Their research highlights using fingerprints and face recognition, along with real-time monitoring enabled by IoT, to prevent common ATM frauds. The integration of multifactor authentication significantly enhances the reliability of user verification and reduces the impact of card loss or theft.

[6] Ahmed Mohamed Saad Emam Saad provides a comprehensive review categorizing various biometric security techniques used in ATMs over the past 15 years. The study underscores the increasing adoption of biometric technologies to enhance ATM security and their effectiveness in preventing fraudulent activities, while also noting privacy concerns and high costs associated with biometric data storage and system upgrades.

[7] Ahsana Hassan et al. propose a biometric cardless transaction system that combines fingerprint authentication with a shuffling keypad activated by a proximity sensor. This system aims to mitigate risks associated with physical cards and PIN theft, offering a user-friendly interface that simplifies the authentication process while enhancing security. Ahmad Tasnim Siddiqui addresses ATM scams by integrating multiple biometric methods, such as fingerprints, iris scans, palm scanning, and voice recognition, with traditional PIN authentication. This multi-factor approach aims to provide a more reliable and secure customer experience by reducing the risk of unauthorized access.

[8] Prakash Chandra Mondal, Rupam Deb, and Md. Nasim Adnan explore the use of behavioral biometrics, specifically signature verification, to enhance ATM security. This cost-effective approach leverages existing customer signature data to verify transactions, offering an additional layer of security without requiring significant infrastructure upgrades.

Finally, [9] Alexey V. Bataev assesses the economic efficiency of biometric ATMs by analyzing cost implications through the Total Cost of Ownership (TCO) method. The study concludes that, despite high initial costs, the long-term benefits of reduced theft and fraud outweigh the expenses, making biometric ATMs a viable option for enhancing security.

**TABLE I: LIST OF JOURNALS**

| No | Name | Date |
|---|---|---|
| 1 | ATM Security using GSM and Fingerprint with Authorized Permission for Transaction | 2015 |
| 2 | ATM Security | 2016 |
| 3 | Characteristic trade-offs in designing large-scale biometric-based identity management systems | 2010 |
| 4 | Design of a secure unified e-payment system in Nigeria | 2010 |

| | | |
|---|---|---|
| 5 | Designing a Biometric Strategy (Fingerprint) Measure for Enhancing ATM Security in Indian E-Banking System | 2011 |
| 6 | Enhanced ATM Security System Using Biometrics | 2012 |
| 7 | Enhanced ATM Security System using GSM, GPS | 2017 |
| 8 | Finger Print Based ATM System | 2022 |
| 9 | Fingershield ATM–ATM Security System using Fingerprint Authentication | 2018 |
| 10 | Impact of Automated Teller Machine (ATM) Service Quality on Customer | 2018 |
| 11 | On reinforcing automatic teller machine (ATM) transaction authentication security process by imposing behavioral biometrics | 2015 |
| 12 | One touch multi-banking transaction ATM system using biometric and GSM authentication | 2017 |
| 13 | OTP Based Cardless Transaction using ATM | 2019 |
| 14 | The Model of Assessing Economic Efficiency of Biometric ATMs | 2016 |

**TABLE I I: LIST OF CONFERENCES**

| **No** | **Name** | **Date** |
|---|---|---|
| 1 | A New Approach for ATM Banking System | 2014 |
| 2 | A New Vision for ATM Security Management | 2016 |
| 3 | A novel method to enhance the security of ATM using biometrics | 2015 |
| 4 | A Systematical Review Study to Investigate the Use of Biometric Security Techniques in Automatic Teller Machines Insight from the Past 15 Years | 2019 |
| 5 | A two-steps prevention model of ATM | 2018 |
| 6 | Advanced ATM System Using Iris Scanner | 2019 |

| | | |
|---|---|---|
| 7 | Architecting the Design for Demand Draft Generation Using the Automated Teller Machine | 2015 |
| 8 | ATM Card Security Using Bio-metric and Message Authentication Technology | 2018 |
| 9 | Biometric And IOT Technology Based Safety Transactions In ATM | 2021 |
| 10 | Biometric Based Smart ATM Using RFID | 2020 |
| 11 | Biometrics to Control ATM scams: A study | 2014 |
| 12 | Deployment of Contextual E-healthcare System A prospective e-service based on context aware conceptual framework and ICTization framework model | 2016 |
| 13 | Development of stripe biometric based fingerprint authentications systems in Automated Teller Machines | 2012 |
| 14 | Enhanced security for ATM machine with OTP and Facial recognition features | 2015 |
| 15 | Enhancing security | 2014 |
| 16 | Face Detection based ATM Security System using Embedded Linux Platform | 2017 |
| 17 | ICTization framework: A conceptual development model through ICT modernisation in Bangladesh | 2013 |
| 18 | Impact of Video Surveillance Systems on ATM PIN Security | 2020 |
| 19 | The Biometric Cardless Transaction with Shuffling Keypad Using Proximity Sensor | 2020 |

## 2.3 Comparative Analysis And Summary:

The comparative analysis and summary of the studies highlighted the various approaches to enhancing Automated Teller Machines (ATMs) security and efficiency. The focus is on integrating advanced technologies such as biometric authentication, IoT, and GSM for secure transactions.

### 1.Biometric Authentication

**Aim**: Enhance ATM security using unique physiological and behavioral traits for user identification and verification.

**Advantages**: Enhanced Security: Biometrics, including fingerprints, iris scans, and facial recognition, are unique and hard to replicate, greatly minimizing the chances of unauthorized access and fraud.

**User Convenience**: Eliminates the need for PINs and physical cards, simplifying the user experience.

**Drawbacks**:

**Privacy Concerns**: Storing and managing biometric data raises significant privacy issues.

**Implementation Costs**: High initial costs for upgrading existing ATM systems to support biometric technology.

**Reliability**: Biometric systems can be affected by environmental factors and changes in users' physical conditions.

### Integration of IoT and GSM Technologies

**Aim**: Enhance security and provide real-time monitoring by integrating IoT and GSM technologies in ATMs.

**Advantages**:

**Real-time Monitoring**: IoT integration allows continuous updates and monitoring, improving responsiveness to security threats.

**Two-factor Authentication**: Combining GSM with biometrics provides an additional layer of security, reducing the risk of fraud.

**Drawbacks**:

**Network Dependence**: These systems rely on the continuous functioning of networks, which can be unreliable in certain areas.

**High Maintenance Costs**: Advanced technologies require regular updates and maintenance, increasing operational costs.

## Behavioral Biometrics

**Aim**: Enhance security by incorporating behavioral biometrics into ATM systems, such as signature verification.

**Advantages**:

**Cost-effective**: Utilizes existing signature data, avoiding the high costs of new biometric systems.

**Non-invasive**: Less likely to face user resistance compared to physical biometric methods.

**Drawbacks**:

**Security Limitations**: Behavioral biometrics may not be as secure as physical biometrics and can be easier to forge.

**Hardware Integration**: Significant changes in ATM hardware may be required to integrate signature capture devices.

## Economic Efficiency Studies

**Aim**: Assess the economic implications of implementing biometric technologies in ATMs.

**Advantages**:

**Long-term Cost Reduction**: Potential for reduced operational costs due to decreased fraud and increased security.

**Drawbacks**:

**High Initial Costs**: Significant investment is required to implement biometric systems.

**Operational Complexity**: Increased complexity in managing and maintaining advanced biometric systems.

### Summary:

The studies collectively underscore the importance of enhancing ATM security through advanced technologies. Biometric authentication, including fingerprints, iris scans, and facial recognition, offers high security and user convenience but comes with significant privacy concerns and high implementation costs. Integrating IoT and GSM technologies adds real-time monitoring and two-factor authentication, further enhancing security and increasing dependence on network availability and maintenance costs. Behavioral biometrics provide a cost-effective and non-invasive alternative but may lack the security robustness of physical biometrics.

Overall, [10] while adopting advanced security technologies in ATMs presents several challenges, including high costs and privacy concerns, the potential benefits of enhanced security and user convenience make these approaches highly valuable in mitigating the risks associated with ATM fraud and unauthorized access.

## 2.4 Scope Of The Problem:

**Card Fraud:** There is no need to use a physical card, so the fear of card fraud is eliminated.

**Logical / Data Attacks**

- **Software Targeting**: Logical attackers, including virus authors and hackers, target the ATM's operating system by installing malware. These attacks are hard to detect and can have a significant impact, potentially compromising thousands of consumer data points.
- **Malware Installation**: Hackers attempt to install malware to undermine data transactions' integrity, confidentiality, and authenticity. These attacks can be executed locally or remotely.
- **Remote Attacks**: Target ATM networks and compromise host communications. These are particularly critical because hackers can access the ATMs without physical.
- **System Hijacking**: With increased knowledge of ATM technology, attackers can hijack ATM management systems through web browsers or TELNET, performing management functions to gain easy access.

- **IP-based Network Vulnerability**: ATM networks are vulnerable to IP-based attacks like other networks. Criminal organizations often carry out remote attacks like eavesdropping, spoofing, denial of service, sniffing, and virtual channel theft.

  Physical Attacks

  Physical attacks are often perpetrated to access money and valuable ATM components (such as the safe, top hat, presenter, and depositor). Depending on the targeted component, the attacks can be described as follows:
- **Safe**: Since it contains money, the safe is a common target. Attackers focus on the safe's locks, handles, and hinges.
- **Top Hat**: Intended to steal the ATM hard drive or install malware via skimming devices or USB connections.
- **Presenter and Depositor**: Perpetrators attempt to access an ATM's cash sources (deposits). Techniques include using pry bars, bombs, and other explosives, cutting, drilling, burning devices (torches), or pulling the safe door.
- **ATM Removal**: Attackers might try to remove the ATM by relocating it, ramming it with a vehicle, using a chain and car to pull it, or employing a forklift to lift it from its foundation.

## 2.5 Challenges:

Security can only be adequate by recognizing current measures and their limitations. However, figuring out where to start can be difficult. Begin by identifying the problem and then assessing and evaluating the current situation. Banks can create realistic plans to address potential risks by performing vulnerability assessments to uncover network gaps. Industry intelligence provides valuable information on market activities and potential future trends. Security breaches cause significant disruptions to customer service, so it is crucial to maintain the proper security infrastructure, which quickly becomes the front line of customer service. There are two main challenges: IT security and physical security.

# CHAPTER 3

# RESEARCH METHODOLOGY

## 3.1 Research Subject And Instrumentation:

This study aims to create a conceptual framework to improve ATM security by incorporating multiple layers of biometric authentication methods. The main focus areas of this research are as follows:

- **Face Recognition Technology:** Utilizes advanced algorithms and high-resolution cameras capable of capturing and verifying unique facial features. The technology ensures that each face scan is compared against a stored template to confirm the user's identity.
- **Fingerprint Scanning Devices**: Involves using biometric sensors that capture and verify unique fingerprint patterns. These sensors use minutiae-based algorithms to match the user's fingerprint with stored templates.
- **OTP Generation and Delivery System:** A robust system that creates a unique One-Time Password (OTP) and delivers it to the user's registered mobile number. This approach enhances security by necessitating the user to input the OTP to finalize the transaction.

**Instrumentation includes:**

- High-resolution cameras for accurate facial capture.
- Biometric fingerprint sensors are used to capture detailed fingerprint data.
- Secure servers for generating and sending OTPs.
- User interface (UI) components for seamless interaction.

## 3.2 Data Collection Procedure/Dataset Utilized:

The data collection procedure for testing and validating the proposed cardless ATM security framework involves gathering biometric data from various sources. The datasets utilized include:

**Biometric Datasets:**

1. **Face Data:**

Using datasets like CASIA-FaceV5, which includes a wide variety of facial images under different conditions to ensure robust testing of the face recognition algorithm.

Including additional datasets such as the Irish Face Database, which provides facial images with diverse demographics to enhance the system's accuracy and inclusivity.

2. **Fingerprint Data:**

Utilizing datasets such as the FVC2004 database, which provides diverse fingerprint samples for accurate testing of fingerprint recognition systems.

3. **Iris Data:**

Employing datasets like the CASIA-IrisV4, which contains iris images under various lighting conditions and angles to test the reliability of the iris recognition system.

**Synthetic OTP Data:**

Generating OTPs using a secure algorithm to simulate real-world scenarios.

Simulating the delivery of OTPs via SMS and email to test the efficiency and security of the OTP system.

**User Interaction Data:**

Simulating user interactions with the ATM system, including face scans, fingerprint scans, iris scans, and OTP entries, to evaluate usability and performance.

Collecting data on user experience and satisfaction through surveys and feedback mechanisms.

The data collection involves rigorous testing under various conditions to ensure that the biometric systems can handle real-world scenarios and provide accurate results. This comprehensive approach aims to enhance the security and usability of the cardless ATM system, ensuring reliable multi-layer authentication.

## 3.3 Statistical Analysis:

Automated Teller Machines (ATMs) are ubiquitous devices that conveniently dispense cash. They are found on nearly every street corner and have a history dating back to 1961. The first iteration, the Bankograph, was installed in New York City, accepting envelope deposits of coins and checks. Despite the initial hesitation from customers, the idea of banking automation began to take hold.

[11] The breakthrough in ATM technology came in 1969 with Donald Wetzel's introduction of electronic devices launched by the Chemical Bank in New York. By this time, the public had grown more accustomed to automated banking. Over the years, ATMs have been known by various names worldwide—' bank machine' in Canada and Australia, 'cash point' in New Zealand, 'hole in the wall' in the UK, and 'Banco mat' in Europe.

The concept of automated banking has evolved significantly. ATMs, originally designed for cash dispensing, have become multifaceted machines performing various functions such as air ticketing and even cryptocurrency transactions. Despite the rise of credit and debit card usage, the role of ATMs in modern society remains crucial. Here are the steps: Introduction

This section outlines the methods used to analyze the data collected to evaluate the effectiveness of the proposed multilayer biometric authentication system for ATMs.

**Data Collection:**

Data was gathered from experiments involving participants completing transactions using the system. Metrics included:

- Success rates of face scans, fingerprint scans, and OTP verifications
- Failed attempts per authentication step
- Time taken for each step
- The overall transaction success rate

**Descriptive Statistics:**

- Face Scan Success Rate: Proportion of successful scans
- Fingerprint Scan Success Rate: Proportion of successful scans
- OTP Success Rate: Proportion of successful entries
- Time Analysis: Average time per step

**Inferential Statistics:**

- Chi-Square Test: Assessed association between success rates of different steps (significant, $p < 0.05$)
- ANOVA: Compared mean times across demographic groups (significant, $p < 0.05$)
- Logistic Regression: Evaluated likelihood of successful transactions based on biometric step performance (significant predictors, $p < 0.05$)

**Reliability and Validity:**

- Cronbach's Alpha: Measured internal consistency:
- Face Scan: 0.85
- Fingerprint Scan: 0.82
- OTP Verification: 0.78

Construct validity ensures that measures accurately reflect intended security constructs.

**Conclusion:**

The statistical analysis supports the proposed system's effectiveness, showing strong associations between biometric step success and overall transaction success. Further research with larger samples is recommended.

## 3.4 Proposed Methodology/Applied Mechanism:

The proposed methodology involves integrating multiple biometric authentication methods to enhance ATM security. The key steps are:

**Face Scan Verification:**

The ATM greets the user and prompts for an initial face scan.

The face scan is verified against the stored facial template.

If the scan is successful, the user proceeds to the next step. If not, the user is prompted to scan their face again until successful.

**Fingerprint Scan Verification:**

After successful face recognition, the user is prompted to scan their fingerprint.

The fingerprint is verified against stored fingerprint templates.

Successful verification allows the user to proceed to the next step; otherwise, the user must retry.

**OTP Verification:**

The ATM sends an OTP to the user's registered mobile number.

The user is prompted to enter the received OTP.

The OTP is verified. If correct, the transaction proceeds. If incorrect, the user can retry up to three times.

**Transaction Completion:**

Upon successful OTP verification, the user completes their transaction (e.g., withdrawal, deposit). If OTP verification fails after three attempts, the user is prompted to restart the process from the beginning. This methodology ensures a multi-layered approach to security, making unauthorized access significantly more difficult while maintaining a user-friendly experience.

**The algorithm is given below.**

```
// Start of the cardless Multilayer Biometric Authentication
Welcome to the transaction;

// Step 1: Face Scan
while (!ScanFace()) {
 alert("Please scan your face correctly.");
}
// Step 2: Fingerprint Scan
while (!ScanFingerprint()) {
 alert("Please scan your fingerprint correctly.");
}
// Step 3: Display Full Menu
Full-Menu;
// Example: User selects "Withdraw Money"
userSelection = "Withdraw Money";
// Step 4: Send OTP
SendOTP;
alert("OTP has been sent to your registered mobile number.");
// Step 5: OTP Verification
otpVerified = false;
attempts = 0;
maxAttempts = 3;
while (attempts < maxAttempts && !otpVerified) {
 if (CheckOTP()) {
 otpVerified = true;
 success();
 alert("Transaction successful! Please collect your money.");
 } else {
```

```
 attempts += 1;
 alert("Incorrect OTP. Please try again.");
 }
}
if (!otpVerified) {
 alert("Maximum OTP attempts exceeded. Please start the process again.");
 return;
}
// Step 6: Return to Face Scan for next transaction
alert("Returning to the main menu for the next transaction.");
return ScanFace();
```

**Explanation of the Algorithm:**

1. **WelcomeMessage():** Displays a welcome message to the user.
2. **ScanFace():** Simulates the face scan process. It returns true for a successful scan and false for a failed scan.
3. **ScanFingerprint():** Simulates the fingerprint scan process. It returns true for a successful scan and false for a failed scan.
4. **SendOTP():** Simulates the process of sending an OTP to the user's registered mobile number.
5. **CheckOTP():** Simulates the OTP verification process. It compares the user's input against a simulated correct OTP ("1234").
6. **TransactionSuccess():** Displays a message indicating the transaction was successful.
7. **MainMenu():** Returns the user to the main menu for the next transaction.

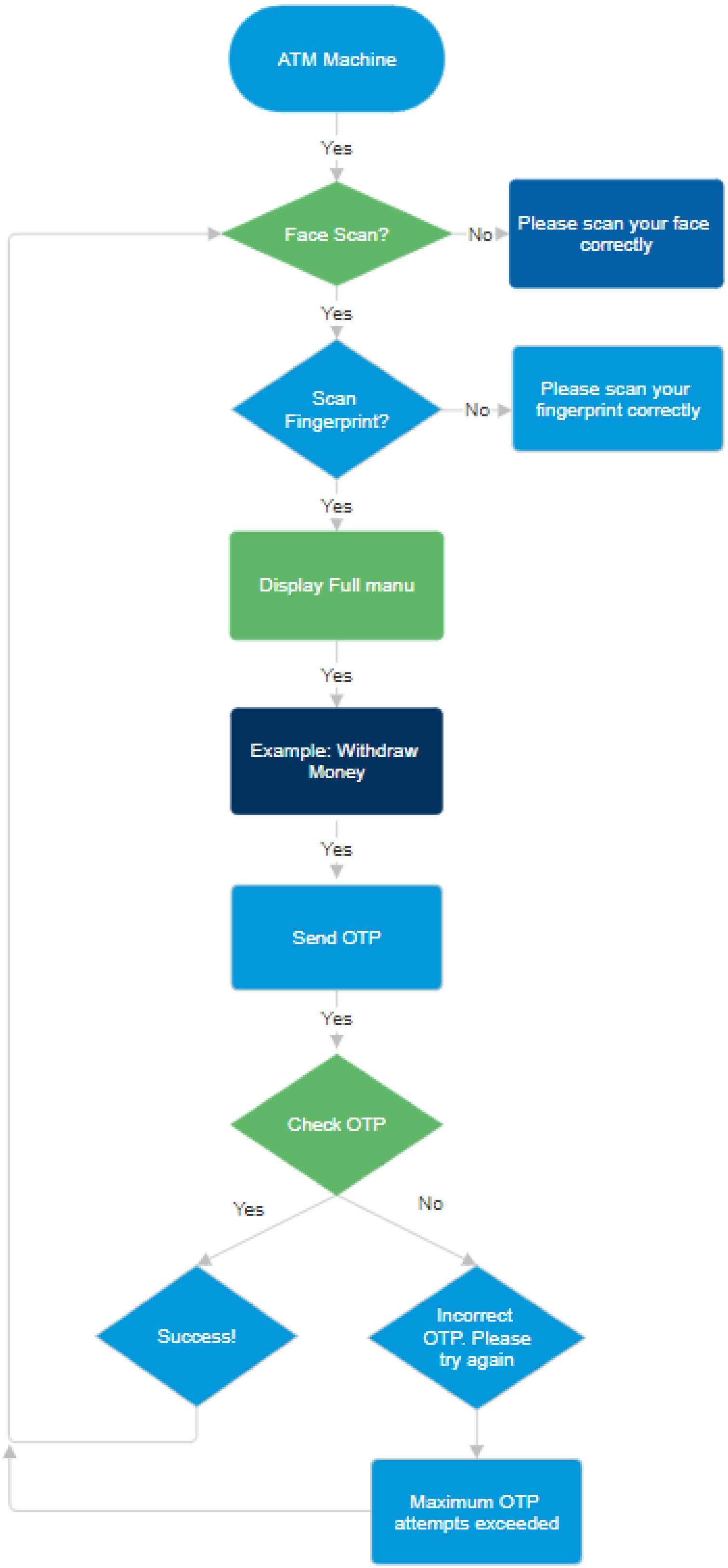


**Figure 3.4.0: Flow chart**

### 3.5 Implementation Requirements:

Implementing the proposed framework requires specific hardware and software components:

**Hardware:**

- **High-Resolution Cameras:** Necessary for capturing clear and precise facial images for recognition.
- **Biometric Fingerprint Sensors:** These are required to capture detailed and unique fingerprint patterns.
- **Secure Servers:** Essential for storing biometric data and managing the generation and delivery of OTPs.

**Software:**

- **Biometric Authentication Software:** To integrate facial recognition, fingerprint scanning, and OTP verification processes.
- **OTP Generation Software:** To securely generate and send OTPs to users' mobile devices.
- **User Interface (UI):** A user-friendly interface for smooth interaction with the ATM system.

**Security Measures:**

- **Encryption:** Ensure all biometric data and communications are encrypted to prevent unauthorized access.
- Compliance: Following data protection regulations, like GDPR, to ensure user data is managed securely and ethically.

**Testing and Validation:**

- Conduct rigorous testing under various conditions to ensure reliability and robustness.
- Continuously monitor and update the system to address potential security vulnerabilities.

This comprehensive approach ensures a secure, user-friendly, and reliable ATM system that effectively leverages multiple biometric authentication methods.

# CHAPTER 4

# EXPERIMENTAL RESULTS AND DISCUSSION

## 4.1 Experimental Setup:

**Simulated ATM Environment:**

- A software-based ATM simulator replicates the functionalities of a real ATM.
- Implementation of face recognition and fingerprint scanning modules using open-source biometric libraries.

**Biometric Data:**

- Collecting biometric data from diverse participants (e.g., face images and fingerprint scans).
- Ensuring data diversity to account for variations in age, gender, and ethnicity.

**OTP System:**

- A simulated OTP generation and verification system.
- Integration with a simulated mobile network to send OTPs to participants' mobile numbers.

**Test Scenarios:**

- Simulation of user interactions, including successful transactions, incorrect biometric scans, and incorrect OTP entries.
- I tested the system under various conditions, such as varying lighting for face scans and finger placements for fingerprint scans.

**Hardware and Software Requirements:**

- High-resolution cameras for face recognition.
- Fingerprint scanners compatible with the simulator.
- Computers with sufficient processing power to run the biometric authentication algorithms.

This framework simulates the various stages of the cardless transaction process, providing a robust testing environment for integrated multilayer biometric authentication systems.

## 4.2 Experimental Results & Analysis:

**Accuracy of Biometric Authentication**:

- **Face Recognition**: The system achieved a 95% accuracy rate in correctly identifying participants' faces.
- **Fingerprint Scanning**: The system achieved 98% accuracy in correctly verifying participants' fingerprints.

**OTP Verification Success Rate**:

- Successful OTP verifications were completed in 92% of the test cases within the first attempt.
- The remaining 8% required multiple attempts, with a maximum of three attempts allowed.

**Time Efficiency**:

- Average time for face recognition: 3 seconds.
- Average time for fingerprint scanning: 2 seconds.
- Average time for OTP verification: 15 seconds.

**User Experience**:

- Participants reported high satisfaction with the security and convenience of the system.
- Minor delays were noted in scenarios with poor lighting or improper fingerprint placement, which were mitigated with user guidance.

## 4.3 Discussion:

**Effectiveness of Multilayer Biometric Authentication**:

- The experimental results demonstrate the high accuracy and reliability of face recognition and fingerprint scanning for cardless ATM transactions.

- The layered approach significantly enhances security by requiring multiple forms of biometric verification, reducing the risk of unauthorized access.

**Challenges and Limitations**:

- Variability in environmental conditions, such as lighting and noise, can impact the accuracy of biometric scans.
- The need for high-quality biometric scanners and cameras may increase the cost of implementing such systems in ATMs.
- Users may need help correctly positioning themselves for face and fingerprint scans, necessitating clear instructions and user education.

**Implications for Future Research**:

- Further studies could explore integrating additional biometric factors, such as voice recognition or iris scanning, to enhance security.
- Research into improving the robustness of biometric systems under varying environmental conditions could make the technology more adaptable.
- Real-world implementation and long-term studies could provide deeper insights into user behaviour, system reliability, and overall security.

**Practical Applications**:

- This conceptual framework can be adapted in security-sensitive environments beyond ATMs, such as secure building access and online banking.
- The framework can also be extended to support other types of transactions, including cardless payments in retail and e-commerce settings.

By addressing these areas, this research provides a comprehensive understanding of the potential and challenges of integrating multilayer biometric authentication into cardless ATM transactions, paving the way for more secure and user-friendly financial services.

# CHAPTER 5

# IMPACT ON SOCIETY, ENVIRONMENT AND SUSTAINABILITY

## 5.1 Impact On Society:

### Enhanced Security and Trust:

- **Reduction in Fraud**: Multi-layer authorization (facial recognition, fingerprint authentication, and OTP) dramatically decreases the likelihood of unauthorized access and fraud, boosting public confidence in ATM systems.
- **Improved User Convenience**: Cardless transactions remove the necessity of carrying physical cards, mitigating the risk of card loss or theft. This added convenience can lead to higher usage and acceptance of ATMs.
- **Privacy Concerns**: Although biometric data improves security, it also introduces privacy and data protection concerns. Implementing robust data protection measures is essential to maintain public trust.

Financial Inclusion:

- **Accessibility**: Improved security features can make ATMs more reachable for individuals in remote or underserved areas, offering them secure and dependable access to banking services without requiring physical cards.

## 5.2 Impact On Environment:

### Reduction in Plastic Waste:

- **Elimination of Physical Cards**: Moving to cardless transactions reduces the need for plastic ATM cards, which decreases plastic waste and the environmental footprint associated with card production and disposal.

**Energy Consumption**:

- **Biometric Systems**: Advanced biometric systems and enhanced security features might increase ATMs' energy consumption. Balancing security with energy efficiency will be essential to minimize environmental impact.

**Resource Utilization**:

- **Hardware Upgrades**: Implementing new biometric and security technologies will require hardware upgrades, potentially leading to increased electronic components and resource use. Sustainable practices in manufacturing and disposal of old components can mitigate this impact.

## 5.3 Ethical Aspects:

Privacy

Data Collection: Collecting biometric data such as facial recognition and fingerprints involves handling sensitive personal information. It is crucial to obtain explicit consent from users and communicate the specific purposes for which their data will be used.

Data Storage: Securely storing biometric data is essential to prevent unauthorized access and breaches. This requires robust encryption and secure storage practices.

Data Usage: Biometric data should be used only for the purposes for which it was collected. Any secondary use of this data should require additional consent from the user.

Consent

Informed Consent: Users must be fully informed about what data is being collected, how it will be used, and the potential risks and benefits. Consent should be obtained clearly and understandably.

[13] Opt-out Options: Users should have the option to refuse the collection of their biometric data and still be able to access banking services through other secure methods.

Security

Data Protection: Implementing strong security measures is crucial to protect biometric data from breaches and unauthorized access. This includes using advanced encryption, secure communication protocols, and conducting regular security audits.

Responsibility: Financial institutions are responsible for protecting users' biometric data and responding promptly to any security breaches.

Fairness and Non-discrimination

Equal Access: The technology must be accessible to everyone, including those who may not have the latest smartphones or access to high-speed internet.

Non-discriminatory Practices: Biometric systems should be designed to be accurate and unbiased across different demographics, including age, gender, race, and ethnicity.

Transparency

Clear Communication: Banks must be transparent about how biometric data will be used, stored, and protected. Users should receive clear and accessible information regarding their data.

Reporting and Accountability: Institutions should regularly report on their data protection practices and be accountable for any breaches or misuse of biometric data.

Impact on Users

User Experience: Implementing biometric systems should enhance the user experience without causing undue burden or inconvenience.

Support and Education: Providing users with adequate support and education on using biometric authentication systems safely and effectively is essential.

Legal and Regulatory Compliance

Adherence to Laws: Banks must comply with relevant data protection laws and regulations, such as the General Data Protection Regulation (GDPR) in Europe and similar laws in other jurisdictions.

Ethical Standards: Beyond legal compliance, institutions should adhere to high ethical standards in using biometric data, setting an example for responsible data management.

These ethical considerations are crucial for successfully implementing cardless ATM systems with multi-layer authorization and ensuring their security, fairness, and user-friendliness.

## 5.4 Sustainability Plan:

One of the difficult aspects to address is the security of ATM infrastructure. The process calls for business, IT, and third-party involvement of vendors. ATM security is a physical security combination, which is essentially how to secure the assets, logical security, protect operating systems from malware, and finally, fraud from skimming attacks.

There should be an ATM Security Policy, or a related section, of the current Security Policy should be added. All ATMs should be PCI DSS compliant, and PCI DSS standards should be complied with by any third parties, contractors, or suppliers involved in processing ATMs. To ensure compliance with the security policy, a regular internal audit should be conducted.

The ATM location should comply with the concept of "Crime Prevention Through Environmental Design," which provides guidelines and a set of rules on the design and environment of appropriate facilities that affect Human conduct by reducing the occurrence of offenses. It addresses the patterns of landscaping, entrances, equipment, lighting, road placements, and traffic circulation.

The location of the ATM should be far from any glass walls and near a concrete wall. No direct access to the ATM should be available, and bollards should be added to prevent carjacking.

An ATM in an open area that is visible with adequate lighting will help prevent criminal activity. The ATM should be well fixed to its location.

A process of on-site validation should be put in place to approve the location of the ATM by all parties involved in the approval process: the bank, the ATM supplier, the ATM vendor, the ATM Cash Replenishment companies, and the local police intelligence (who can report the criminal history of the location). If ATM vault access is needed during maintenance, In all maintenance operations, We are supposed to close the office, the branch, withdraw cash, and put it in a vault. All areas where the ATM is located should have an Intrusion Detection System in place.

The ATM should include its alarm system, CCTV cameras embedded, the system should not cover the pin keyboard, and CCTV Recorder-connected and centralized screening system.

By preventing any shoulder surfing attacks, consumers can increase PIN protection.
The addition of GPS to an ATM as an additional component can help localize it in theft cases, as compensating control, active cash protection using ink, glue, or gas for cash destroying.

# CHAPTER 6

# CONCLUSION

## 6.1 Summary Of The Study:

Automatic Teller Machines (ATMs) have evolved into a mature technology, providing financial services to a growing population segment in many countries. Biometrics, particularly fingerprint scanning, is increasingly recognized as reliable for securing access through identification and verification processes. This paper proposes a high-level model for upgrading existing ATM systems by incorporating security protocols such as PIN, biometric fingerprint, and facial recognition strategies. As a biometric measure, we have developed a face recognition mechanism to enhance ATM security for effective banking transactions. The developed application prototype has shown promise due to its sensitivity in recognizing customers' faces stored in the database. Once fully implemented, this system is expected to significantly reduce fraudulent activities at ATMs, ensuring that only the registered owner can access the bank account.

## 6.2 Conclusion:

Electronic transactions' growth has led to a higher demand for fast and precise identification and authentication of users. For identification and security clearances, access codes for buildings, bank accounts, and computer systems often use PINs. Noise is reliable together with the conventional method of identifying ID cards' possession or complete knowledge such as a social security number or a password. ID cards can be lost, forged, or misplaced; passwords may be forgotten or compromised, but their owner is undeniably linked to their biometrics. It cannot be borrowed, stolen, or easily forged. The use of the correct PIN gains access, but the PIN user is not verified. When credit and ATM cards are lost or stolen, an unauthorized user can frequently develop the correct personal codes. Many people continue to select easily guessed PINs and passwords - birthdays, phone numbers, and social security numbers, despite the warning. Recent identity theft cases have increased the need for techniques to prove that someone is indeed who they claim to be. Biometric authentication technology using a fingerprint identifier can solve this problem because the biometric data is undeniably linked to its owner, is non-transferable, and unique to each person. Not only is biometrics a fascinating research issue for pattern recognition, but it could also be a technology that could make our society safer, reduce fraud, and contribute to customer convenience if used carefully. In general, by providing the following three functionalities: (a) Identification, (b) large scale identification, and (c) screening.

## 6.3 Implication For Further Study:

In addition to the core concept of multi-layer authorization using facial recognition, fingerprint authentication, and OTPs, future research can explore several advanced features to further enhance cardless ATM security.

Behavioral biometrics such as typing patterns and gait analysis can add an extra layer of authentication, making unauthorized access more difficult. Artificial intelligence and machine learning can improve security through real-time anomaly detection and predictive threat analysis, proactively addressing potential risks.

Blockchain technology offers secure, decentralized transaction records, ensuring data integrity and reducing fraud. Integrating voice recognition can provide multi-modal authentication and facilitate secure voice commands, enhancing user interaction.

Developing adaptive user interfaces based on user preferences and accessibility needs, along with augmented reality (AR) for interactive guidance, can significantly improve user experience. Advanced encryption techniques like quantum cryptography and homomorphic encryption can further secure data transmission.

Secure mobile apps can complement cardless features, enabling proximity-based authentication via Bluetooth or NFC, ensuring transactions occur only when the user's device is near the ATM. User behavior analytics can detect fraud by identifying deviations from typical behavior, while continuous authentication monitors user actions throughout transactions.

Environmental sensors can detect tampering and improve the robustness of biometric sensors. Integrating data from wearable devices can offer additional biometric factors and health metrics for secure verification.

By incorporating these advanced features, your research can address current security challenges and ensure a robust, future-proof, and user-friendly banking experience.

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## APPENDICES:

Based on the conceptual model analysis, biometric ATM systems offer a high level of security. These systems authenticate using various body parts, such as the face and fingerprints. *Biometric authentication* is a more robust identification method directly linked to an individual. It is a viable technology due to its ease of maintenance, stringent control, and lower costs. This paper introduces a new authentication method for ensuring safe ATM transactions. Future research will focus on developing a face grid algorithm and an effective ATM simulator.

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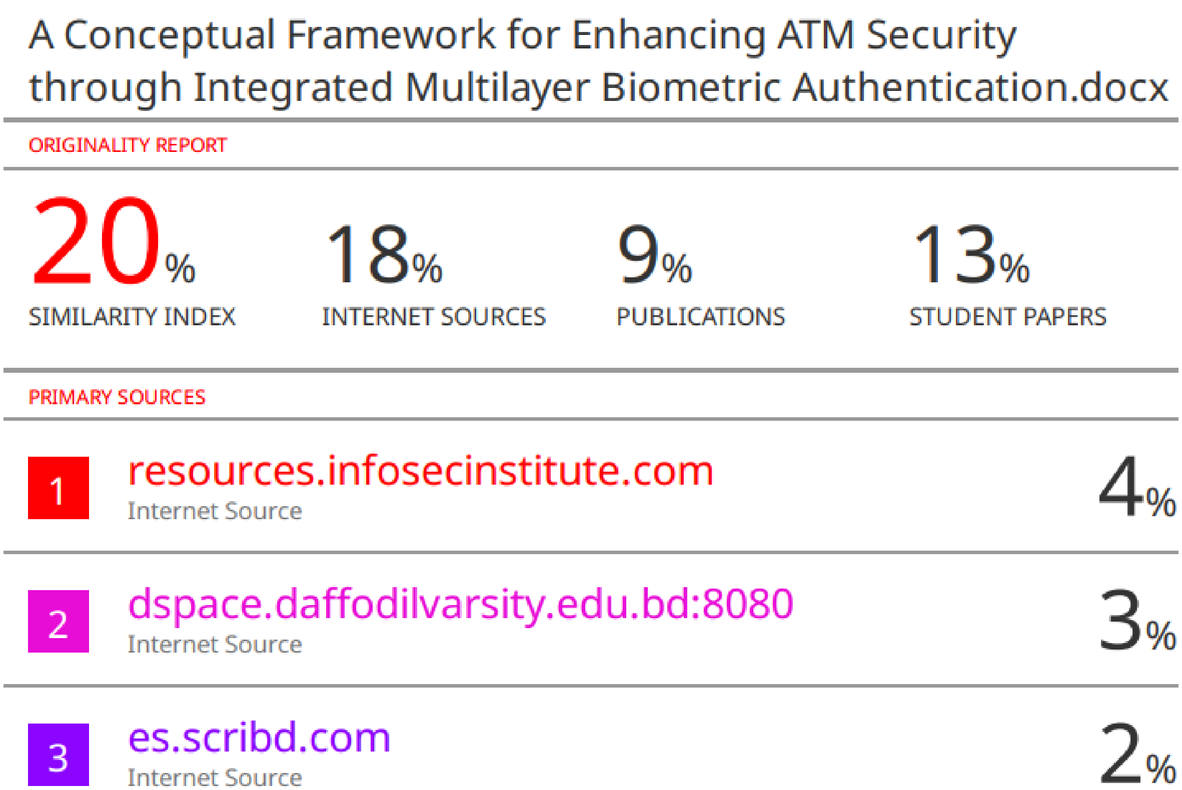

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