ATM System based PIN and Fingerprint Biometric authentication in Rwanda

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***Abstract*— ATMs are a vital component of the financial infrastructure in Rwanda, enabling users to conveniently access their funds and perform a wide range of transactions. However, traditional authentication methods such as PINs and passwords are vulnerable to security threats such as theft, fraud, and shoulder surfing attacks. Using Biometric authentication along with the existing authentication offers a more secure and user-friendly alternative, as it uses all properties of the MFA (Multi-Factor Authentication) to identify users. This paper presents a study on the implementation of a biometric authentication system for ATMs in Rwanda, based on the use of PIN and fingerprint recognition technology.**

***Keywords— ATM, Biometric, Access control, PIN, MFA, FAR, FRR, EER.***

# Introduction

Automated Teller Machines (ATMs) have become an integral part of banking services, providing customers with access to their accounts 24/7. However, traditional authentication methods like Personal Identification Number (PIN) have proven vulnerable to theft and fraud. Biometric authentication methods, such as fingerprint recognition, have been proposed as a solution to enhance ATM security. This research project focuses on implementing an ATM system based on PIN and fingerprint biometric authentication in Rwanda. The study aims to evaluate the feasibility, security, and usability of this system in the context of Rwanda's financial landscape. The research aims to investigate the following inquiries. 1. How can we eradicate the weakness observed in the prevalent ATM card system? 2. In what way can financial institutions avert card skimming assaults at ATMs? 3. How can Biometric authentication along with the existing authentication offer a more secure way to enhance the effectiveness of prevailing ATM frameworks? After introducing the topic, we proceeded to define terms and explored the issue of ATM fraud. summarized prior research in Section 2 and outlined the approach to address research inquiries in Section 3.

## *A. Definition of Terms*

**Automated Teller Machine (ATM)**: a device that enables users to perform banking transactions and cash withdrawals [1].

**PIN (Personal Identification Number)**:is a numeric password used to authenticate identity in electronic transactions [2].

**OTP (One-Time Password):** is a temporary password used for authentication, typically sent via SMS or generated by an app [3].

**Card skimming** is a method of stealing credit/debit card information by using a device to read card details [4].

**RFID** stands for radio frequency identification, a technology that uses radio waves to identify and track objects [5].

**GSM** (Global System for Mobile Communications) is a standard for digital cellular networks used for mobile communication [6].

## *B. Problem Statement*

The significant expansion of automated teller machine (ATM) card utilization within African banking systems including Rwanda has led to an elevated incidence of fraudulent activity involving the unauthorized acquisition of card data, also known as card skimming. For example, Deloitte carried out a survey which revealed that banks in East African countries including Rwanda experienced a total financial loss of $245 million due to cyber fraud [7]. This has drawn our attention towards acquiring knowledge on how to address the difficulties encountered by bank clients in Rwanda who are susceptible to being deceived while using Automated Teller Machines (ATMs).

According to the study, PIN authentication methods for ATMs have been found vulnerable to fraud and theft, making it crucial to improve ATM security. One way is through the implementation of a PIN and fingerprint biometric authentication system in Rwanda. Skimming is the most common type of ATM fraud, where criminals use a skimming device to read and record a user's card information, including the card number, expiration date, and security code, to make unauthorized purchases or create counterfeit cards. Criminals may also sell stolen information on the dark web.

## *C. Assumptions*

The study assumes that the use of biometric authentication in ATMs will be well-received by users in Rwanda, and that they will be willing and able to use the technology effectively. It also assumes that the PIN and fingerprint recognition technology used in the biometric authentication system will be reliable and accurate, with a low rate of false positives and false negatives. Additionally, the study assumes that the implementation of biometric authentication in ATMs will be financially feasible for financial institutions in Rwanda, and that the benefits of increased security and usability will outweigh the costs of implementation and maintenance.

# IMPORTANCE AND PRIOR WORK

The World Bank estimates that the cost of fraud in developing countries has increased from $50 Million to $80 Million every year [8]. The risk of credit card fraud could be reduced by the use of Biometric authentication. The fingerprints are unique from one person to another as they cannot be replicated, or stolen unlike traditional PINs or passwords [9].The Significant concerns for the Banks institutions and Customers are the existence of the Fraud in Banking sector. The use of Biometric authentication in ATMs will enhance security and reduce fraud. The Biometric-based authentication in ATM method is found to be more secure compared to other forms of the authentication [10]. Biometric authentication is a secure and reliable method of authentication that ensures that only authorized individuals can access their accounts [11].

The general public in Rwanda will benefit from safer and more practical financial services, which will reduce the prevalence of ATM fraud. Financial institutions and regulators in Rwanda will have a better understanding of the technological requirements, potential security issues, and user behavior associated with the use of biometric authentication in ATMs. Overall, the study has important implications for improving the security and usability of existing ATM systems and can have an impact on other places with similar financial systems that want to improve ATM security.

Related studies suggest that biometric authentication, such as fingerprint and face recognition, combined with one-time passwords (OTPs), can enhance the security, ease, and overall experience of ATM transactions while guarding against fraud. For example, the Fingershield ATM system [12] offers insightful information on how biometric identification is implemented and its impact on ATM security. Another study [13] highlights the necessity of safe authentication procedures in ATM systems due to the rise in ATM fraud, identifying possible risks to ATM security and the weaknesses of authentication techniques like PIN. Additionally, studies [14] and [15] propose alternatives to the current ATM card and PIN authentication mechanism, combining the usage of OTPs generated at random and communicated over IoT services. This research project aims to determine the benefits and drawbacks of adopting PIN and fingerprint biometric authentication in Rwandan ATM systems.

# METHODOLOGY

1. *Literature review of biometric authentication systems and their application in financial systems*

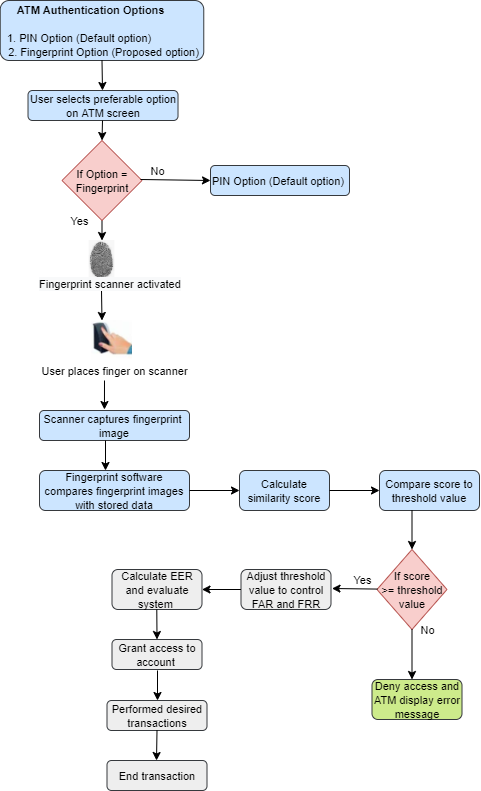
The literature review involved searching and analyzing peer-reviewed articles, academic journals, conference proceedings, and government reports on biometric authentication systems and their application in financial systems. The primary sources of data were electronic databases like CMU Digital Library [16], IEEE Xplore, and Google Scholar. The research utilized keywords like "biometric authentication," "ATM security," "financial systems," "MFA," "fingerprint recognition," and "PIN authentication" to filter the search results.

1. *Empirical evaluation of the proposed biometric authentication system through user testing*

The empirical evaluation will involve conducting user testing of the proposed biometric authentication system with ATM users in Rwanda. The user testing will use a mixed-methods approach that combines qualitative and quantitative data collection techniques [17][18]. The research will recruit a diverse sample of ATM users from different age groups, genders, and educational backgrounds. The research will also use surveys, interviews, and usability metrics like the System Usability Scale (SUS) and the Single Ease Question (SEQ) to collect data.

1. *Analysis of system performance*

The proposed biometric authentication system will be tested in a controlled laboratory environment to evaluate its technical performance. Performance metrics such as False Acceptance Rate (FAR), False Rejection Rate (FRR), and Equal Error Rate (EER) will be used to evaluate accuracy and reliability [19]. The system's response time, throughput, and scalability will also be analyzed, and various usage scenarios will be simulated. The performance of the biometric authentication system will be compared with existing methods such as PIN and password authentication. A graphical representation of the proposed ATM biometric authentication system is also provided.

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*Figure1: Flowchart diagram for ATM biometric authentication*

1. *Assessment of the feasibility of implementing biometric authentication technology in Rwanda*

The research aims to determine if it's possible to implement biometric authentication technology in Rwanda. It will analyze the cultural, social, and legal contexts through qualitative data collection, including interviews with stakeholders. The study will look at legal and ethical issues and assess public perception and infrastructure supporting the technology.

# CONCLUSION

Financial institutions in Rwanda should consider implementing biometric authentication in their ATM systems to enhance security and convenience for their customers. Biometric authentication has the potential to improve the safety of financial transactions and minimize the risk of fraud, thus making financial services more secure and practical for the society in Rwanda. To move this project forward, the next step would involve conducting a further feasibility study and developing a prototype of the biometric authentication system for ATMs in Rwanda. The prototype would enable testing and validation of the proposed system, while the feasibility study would evaluate the technical, financial, and social aspects of the system, including the cost of implementation and maintenance, as well as the legal and ethical implications of using biometric data in financial institutions in Rwanda.

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