AJEMA GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 3, Issue 4, 2025 ISSN (E): 2993-2637

Designing an Arduino-Based Smart Fingerprint Authentication Mechatronic Model

Ergashev Odiljon Alijon o‘g‘li
Intern teacher of the department "Automation of machine building production" of the Andijan State Technical Institute
ergashevodiljon944@gmail.com

Inomjonov Umar Inomjon o‘g‘li
Andijan State Technical Institute, "Automation of Machine Building Production" Department, "Mechatronics and Robotics" 4th year student
bookmedia75@gmail.com

Abstract: This article explores the development of an Arduino-based smart fingerprint authentication mechatronic model for secure access control. The study highlights the integration of biometric technology with mechatronic modules to enhance security and automation. The proposed system utilizes fingerprint recognition, microcontrollers, and IoT-based connectivity to ensure efficient and reliable authentication. Experimental results demonstrate that the system significantly improves access control efficiency, reduces unauthorized access risks, and enhances operational reliability. The findings emphasize the high potential of mechatronic and biometric technologies in various security applications, suggesting future adaptability in different sectors, including smart homes, industrial security, and financial institutions.

Keywords: Smart authentication, fingerprint recognition, mechatronics, Arduino, IoT security, biometric access control, automation, secure identification systems.

Introduction

Humanity has always considered security as a priority. The simple mechanical lock and key were one of the earliest forms of security. A key is a small metal object with grooves and cuts that correspond to the internal structure of a particular lock, which must be inserted into the lock and turned to lock or unlock it. However, people often lose their keys, and it is also difficult for other users to find the right key. In addition, keys do not have any protection - anyone except the user can easily access them. Therefore, in this research, a smart fingerprint authentication system based on Arduino was developed and proposed[1].

The history of locks is very ancient, and they began to develop when humanity's need for security and protection arose. The earliest known locks were found in Egypt, and were developed about 4,000 years ago. They were made of wood, and the internal mechanism was operated by cylindrical pins. Later civilizations such as Babylon and Assyria also used locks. Their locks were based on simple wood and metal mechanisms. It is clear that the lock is one of the most important things to humanity, if it were not for this, then the need for locks would not have been felt today, or perhaps the lock would not have been invented in the first place[2]. A key safe is

designed to store keys in a more organized and efficient place. Biometrics is the science of identifying a person based on physical, chemical, or behavioral characteristics. The importance of biometrics in modern society has been further strengthened by the need for large -scale personal identification systems. This system is based on accurate personal identification, recognizing the unique fingerprints of authorized individuals and providing access to them[3].

Scan their fingerprint. As a result, new fingerprint minutiae (small details and markings) are obtained and compared with the data in the database. If the fingerprint matches, the liquid crystal display (LCD) screen displays the message "Fingerprint Match". The microcontroller then instructs the relay and solenoid lock to open the cabinet door. If the fingerprint does not match, the LCD screen displays the message "Not Matching" and the cabinet door remains closed[4].

Thus, the proposed system provides better security, higher efficiency and, in most cases, user convenience, since it is built on the basis of a biometric system. Modern security systems play an important role in protecting users' personal data and preventing unauthorized access. Traditional mechanical and electronic locks (systems based on passwords, keys or RFID cards) are not reliable enough from a security point of view. There is a risk of losing keys, breaking passwords or copying RFID cards[5].

Therefore, the use of biometric authentication systems, especially those based on fingerprint scanners, is becoming a hot topic. However, many of these systems are expensive or complex to program and integrate, making them unsuitable for ordinary users or small businesses.

This thesis deals with the design of a relatively inexpensive, easy-to-use, and secure fingerprint authentication system based on the Arduino platform. This system is implemented as a mechatronic model and is planned to include automatic door opening and closing functions[6].

The problem is seen in the following aspects :

Security issue: Weakness of traditional authentication systems.

Convenience and cost: Expensive and complex biometric authentication systems are not suitable for small business and personal use.

Technical integration: The problem of efficiently controlling a fingerprint sensor and mechanical actuators (servo or solenoid) based on Arduino.

This project aims to make biometric security systems more efficient and reliable by designing a smart fingerprint authentication mechatronic model based on Arduino. Currently, traditional identification systems based on keys, passwords or RFID cards are not reliable enough from a security point of view. Because the key can be lost, the password can be broken or the RFID cards can be stolen. Therefore, biometric authentication systems - especially the method of identifying a person using a fingerprint scanner - allow to increase the level of security[7].

The main goal of the project is to develop a smart fingerprint authentication system based on the Arduino platform, create its software and hardware, and analyze its potential for real-world use.

Scientific and technical significance:

Exploring the relevance of biometric authentication:

Developing a cheap and reliable fingerprint identification method based on Arduino:

Integration with mechatronic systems:

Practical results:

Creating a cheap and reliable biometric security system:

Gain experience working with Arduino and fingerprint sensors:

Further expansion of the system and adaptation to smart devices:

Future prospects of the project:

Creating IoT- related biometric authentication systems to a cloud server and add remote management capabilities

Integration with facial recognition and other biometric identification methods

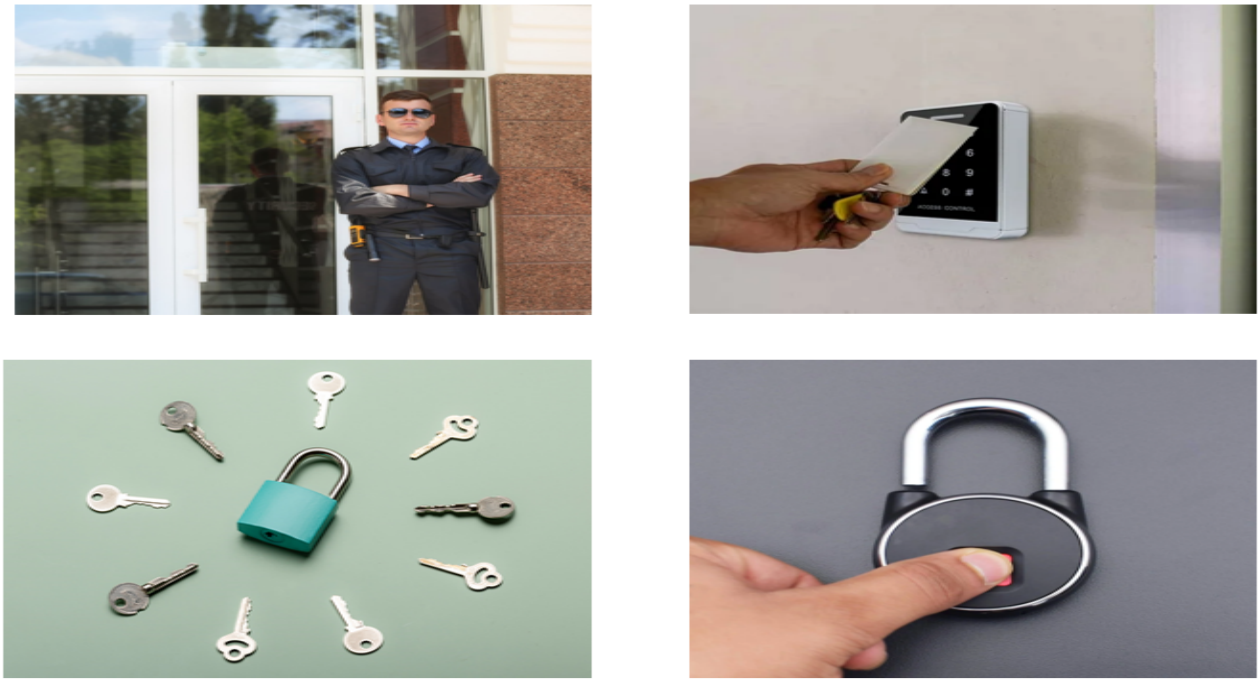

Figure 1. Security types for the input section.

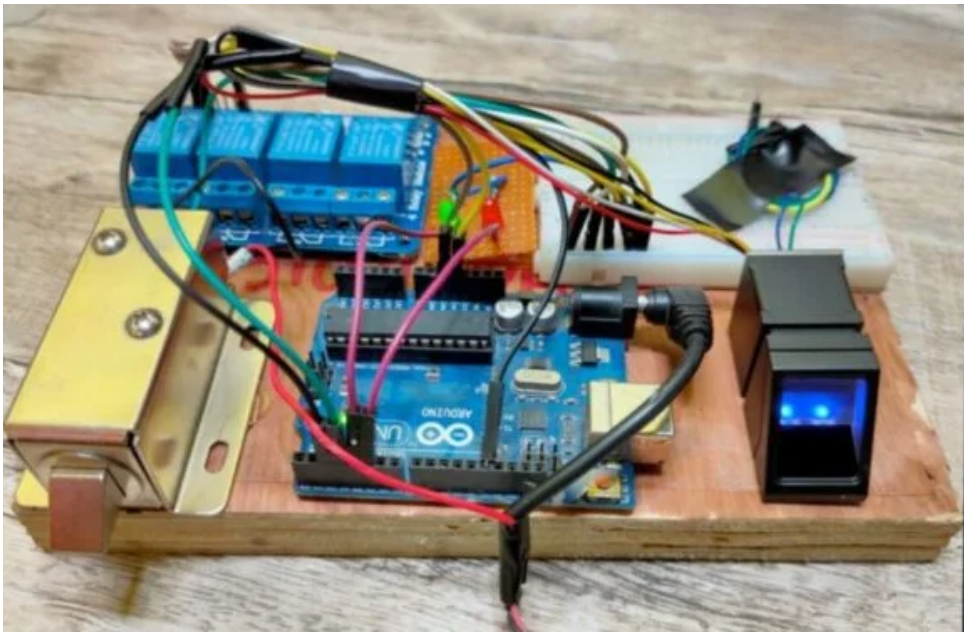

Figure 2. Arduino-based smart fingerprint authentication mechatronic model.

Ready-made projects for smart fingerprint authentication based on Arduino have been developed, and its work process is regulated by the control room, that is, by the Arduino board. The module requires several additional devices, one of which is a signal transmitter, which can be called a finger scanner. Its operation is to take information from the finger, convert it into a digital signal and send it to the Arduino. If the information sent matches, it allows access, if it does not match, the information is stored in the database, and the person is not allowed to enter. This method has become the main security system for the entrance to buildings and offices in the 21st century[8].

Fingerprint authentication is a biometric identification method that provides for the recognition of an individual based on the uniqueness and non-repetition of each person's fingerprint. The fingerprint authentication system was scientifically developed in the early 19th century, with the first fingerprint discovery in 1823 by the Czech scientist Jan Evangelist Purkyně, who created a system for classifying fingerprint types, and then in 1892 by the British scientist Sir Francis Galton, who scientifically proved that fingerprints are unique for each person, and it would not be wrong to say that we are currently using a perfect version[9].

The working principle is as follows. Initially, the Fingerprint Authentication Module works in the following steps. First, the user places his fingerprint on the scanner, and the scanner transmits this fingerprint in digital form to the Arduino microprocessor. The Arduino compares this information with the fingerprints in the previously stored database. Fixed ridge pattern on each fingertip. Biometric authentication is therefore one of the most advanced security features.

Serve as a unique form of identification for each person. The widespread use of fingerprint scanners in modern mobile phones and computers once again proves their popularity and reliability.

If the scanned fingerprint is present in the database and a match is detected, the LED (green) light will turn on and the buzzer will sound a confirmation signal, which you can see through the inscriptions on the LCD display, for example; “You can enter, White path, or Name-Surname” will be displayed and then the Arduino will control the servo motor or electromagnetic locks through the output signal and open the door or mechanical system.

If the scanned fingerprint is not available in the database and no match is detected, the LED (red) light will turn on and the buzzer will sound a warning signal. You can see the warning through the inscriptions on the LCD display, for example;

"Entry prohibited, Not possible" appears or "Name-Surname" does not appear and the door or mechanical system does not open. But it is necessary to provide constant power to this because the main part of this is the electrical part and if there is a problem in that part, the rest of the system will not work at all and we know that no one in the electrical industry can give a 100% accurate answer because there is a possibility of a breakdown in each country.

But electricity from natural sources can be a solution. If I use a solar panel in addition to this project, I will have created a much more perfect module. This, as the name suggests, will provide uninterrupted, trouble-free access to your home, office or any other institution with electricity stored in the battery if there is a power outage for a while. It is enough to have a maximum 12V power source[10].

Conclusion:

The design and implementation of the fingerprint-based door locking system is designed to be flexible and easily configurable. This door locking mechanism is cheaper and more economical than traditional locking systems available in the market.

Our fingerprint-based locking system has a high level of accuracy and quickly recognizes fingerprints. This provides seamless integration with users and further strengthens security. In our country, private and public organizations pay great attention to security issues. Many companies are interested in using such a locking mechanism, but the installation cost of existing systems on the market is very high. Due to these excessive costs, many small businesses cannot use such systems. Therefore, we planned to develop a convenient and affordable system for both large and small businesses, taking into account the installation costs.

This design can be further developed and improved by adding additional functions, for example, multiple locks can be added to the system. This way, instead of having to buy a separate lock for each door, it will be possible to control multiple doors through one system. A fingerprint storage

system can also be created without using a computer, but this requires more components than the ones we used.

Complete security, the entire mechanism must be placed inside the door panel or on the other side of the door. One of the main advantages of this system is its flexibility. At the same time, other types of security systems can be combined with this system. The system is highly secure, and since fingerprints are not duplicated, the sensor accurately identifies all traces.

However, the system also has some drawbacks. For example, it is complex and difficult to make hardware changes because it is a closed system. It also requires a constant power source, so uninterrupted power supply through batteries can sometimes be a problem.

References

1. Odiljon, E., Muhammaddiyor, O. va Ahmadali, U., 2024. Cnc moshinalarda sezish element va elektr diskning sinxron ishlatini loyihalash. *Fan, jamiyat va innovatsiyalar*, *1* (10), 30-35-betlar.
2. Odiljon, E. va Ahmadali, M., 2024. Akilli piyodalar kechasini loyihalash. *Fan, jamiyat va innovatsiyalar*, *1* (10), 66-69-betlar.
3. Odiljon, E., 2024. Sut maxsulotlari ishlab chiqarish zavodlarida ultrtovushli dizinfeksiyalash tizimini loyihalsh. *Fan, jamiyat va innovatsiyalar*, *1* (9), 24-28-betlar.
4. H. Hassan, R. A. Bakar, and A. T. F. Mokhtar, "Face recognition based on auto-switching magnetic door lock system using microcontroller," in 2012 International Conference on System Engineering and Technology (ICSET), IEEE, 2012.
5. Y. T. Park, P. Sthapit, and J.-Y. Pyun, "Smart digital door lock for the home automation," in TENCON 2009-2009 IEEE Region 10 Conference, IEEE, 2009.
6. Keriya, F.R.B., "Development of IoT–based locking system," B.S. dissestation, Dept. Faculty of Electrical and Electronic Engineering (UTHM), Johor, Malaysia 2019.
7. Z. Mumtaz, Z. Ilyas, A. Sohaib, S. Ullah, and H. A. Madni, "Design and implementation of user-friendly and low-cost multiple-application system for smart city using microcontrollers," arXiv preprint arXiv:2010.07016, 2020.
8. Y. Motwani, S. Seth, D. Dixit, A. Bagubali, and R. Rajesh, "Multifactor door locking systems: A review," Materials Today: Proceedings, 2021.
9. S. Goyal, P. Desai, and V. Swaminathan, "Multi-level security embedded with surveillance system," IEEE Sensors Journal, vol. 17, no.22, pp. 7497-7501, 2017.
10. S. Hossain, M. I. Ahmed, and M. N. Mostakim, "A prototype of automated vault locker solution for industrial application," in 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT), IEEE, pp. 1-7, 2019. E-ISSN : 2798 – 4664 160
11. A. M. A. Bakry, and D. R. Rajaa, "Smart phone-Arduino based of smart door lock/unlock using RC4 stream cipher implemented in smart home,"International Journal of Advanced Computer Technology, vol. 5, no. 5, pp. 14-18, 2016.
12. G. K. Verma, and P. Tripathi, "A digital security system with door lock system using RFID technology," International Journal of Computer Applications, vol. 5, no. 11, pp. 6-8, 2010.
13. N. Meenakshi, M. Monish, KJ. Dikshit, and S. Bharath, "Arduino based smart fingerprint authentication system," in 2019 1st International Conference on Innovations in Information and Communication Technology (ICIICT), IEEE, pp. 1-7, 2019.