Intelligent Machine Inspirational Project

Automated Key Management System

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Declaration

We declare that this project is our own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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Abstract

Conventional key managements systems are used to manage the keys in most of the institutions such as schools, offices and hospitals etc. Those manual systems are insecure and inefficient and need human interventions all the time. We have studied the process of manual key management and identified some features that can be used to extend the existing machine into an intelligent machine. The intelligence can be implemented mainly on ensuring the security of the system and recording the information. Throughout this project, we focused on minimize the human intervention in the process of management by automating the features of the existing machine.

As the approach to design, the Automated Key Management System was inspired by the Rotor Parking System. The system uses fingerprint, keypad input, hall effect sensor input and signal from the push buttons as the inputs and perform the processes such as checking whether the entered fingerprint is already available in the fingerprint sensor, detecting whether the key halls are already occupied or empty, rotating the correct chamber when the user authentication is valid, opening and closing the relevant chambers when the user needs to take the key and after keeping the key, preventing the manual rotation of key chambers, sending the information such as Fingerprint ID, Key hall number, Date, Time and performed action to the database and sending the records from the database to the webpage providing displaying the instructions to be followed, detecting the log events of existing users and show user details and log events, displaying the entered key hall number if the fingerprint is valid, displaying whether the keys are there or not in the chambers, enabling the user to take or keep the key if all the prerequisites are satisfied and indicating the state (occupied / empty) of the key hall using the LED bulbs as the outputs. The main functions of the system are issuing and returning the keys, while the people who are in-charge of managing keys in institutions with large number of buildings, the people who are authorized to access the keys of the different rooms/halls in a building and the owners of the institutions are considered as the users of the system.

For the design of the system we used the modules such as, Arduino UNO micro controller, AS608 Fingerprint module, A3144 hall effect sensors, Keypad 3x4, I2C expander module PCF8574T, push buttons, L298N Stepper motor drivers, Nema 17 Stepper motors, LCD display 16x2, I2C module PCF8574T, Node MCU, SG90 Servo motor and LEDs along with a database and a webpage to achieve the aims and objectives of the project.
The implementation of the intelligent features is done by using a numerous hardware and software technologies and algorithms. The system was evaluated by manually testing the system by operating with some test cases.

As a conclusion we were able to successfully complete the project with the complete design of the Automated Key Management system. As further developments we are planning to increase the number of keys can be stored in the system and to introduce the AKMS in various dimensions according to the user requirement. Also we are planning to increase the security of the system by introducing new security mechanism such as using biometrics and more secure physical structure to prevent accessing the other keys through one key chamber.

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1. Introduction

A machine is defined as an apparatus using mechanical power and having several parts, each with a definite function and together perform a particular task [[1]]. In early of civilization people have been used different types of machines to carryout various tasks. Ancient people used to invent machines inspired by the nature to perform their daily tasks. There are seven simple machines identified from the early stages of evolution of machines namely, (1)The Inclined Plane consisting a sloping surface and used to raise heavy bodies, (2) The Wedge which is an object that tapers to a thin edge used for splitting, lifting or tightening, (3)The Pulley which carries a wheel and a flexible rope used to transmit energy and motion, (4) The Screw consisting a circular inclined plane used either as a fastener or as a force and motion modifier, (5) The Lever which is a bar rests on a support called fulcrum allowing a small force to lift heavy objects, (6) The Wheel and (7) The Axle made up of circular frame that revolves on a shaft or rod used for raising weights [[2]]. Basically every machine has four main components, Input, Output, Process and Power.

The evolution of machine has started in 18th century with the industrial revolution. Since then process and power used to operate machines have been evolved over centuries. Power has evolved from man power, steam, electricity, electronics to algorithms. With the development of technology, people invented machines with very less human intervention. The most recent concern about the machines is powering machines with Artificial Intelligence (AI). The concept of AI is first introduced with the programmable machines. One of the principal inventors of the computer was the great British mathematician Alan Turing. It was he who first figured out, in highly abstract terms, how to design a programmable computing device, what we now call a universal Turing machine [[3]]. Over the decades, machines are developed to operate with their own intelligence.

In the context of Intelligent machines, our interest was drawn to develop an automated key management system as an improved version of conventional key management system. Here we have developed an apparatus to store keys securely and manage the access to the keys. The objectives of the project are as follows;

- To study the existing key management system and identifying the drawbacks.
- To study the evolution of machines.
- To identify the intelligent extensions for the existing system.
- To design and implement the automated key management system including the intelligent features.
- To evaluate the automated key management system.
- To write a project report.

2. Development of Key Management system

The most used existing method to manage keys in institutions is using a conventional key holder with the keys with the name tags and that is kept under the supervision of a security person. When someone needs to access some secured property, they come to the in-charge of the key holder and collect the key. This conventional method has many drawbacks and malfunctions in terms of security and efficiency. As all the keys are under the supervision of one person or a single group, they can use the keys to access the properties even though they are not authorized so that the frauds may happen. Also because the keys are just kept in a holder without any advanced security, thefts may occur. And the keys can be misplaced as some people may forget to return the keys after taking them. This existing system is not very efficient as it may take a lot of time to find the keys and to record the relevant information in the event of taking or handing over the keys. The human intervention in managing keys and recording the information is a crucial factor in the existing key management system.

Figure 1: Key Hanging board

Possible intelligent extensions.

The security of the keys can be ensured by introducing a fingerprint mechanism. The fingerprints of the authorized users can be stored in the system so that the system can check whether the person who is accessing the key is authorized or not. This intelligent feature minimizes the chance of occurrence of fraud and theft as the access of the keys are denied for the unauthorized users.

The human intervention in supervision and recording information can be replaced by a centralized system. When the keys are placed in a closed structure and only the necessary key is made accessible when an authorized person entered the particular ID or Key Number, there is no need of human involvement for managing the keys.

The recording of information when taking and handing over the keys can be automated by sending the fingerprint ID, Key Number, Date, Time and the action (Taken/ Kept) automatically to a database when a user is takin or handing over the keys. This makes the system more efficient as well as secure because no any time is wasted to record the information manually and no one can change the records updated in the database except the people who are authorized to access the database.

The extraction of information of the events of taking or keeping the keys has been made more efficient as the administrators do not need to search through the manual records instead they can filter the events based on a particular date, user or key from the database.

3. Automated Key Management System (AKMS)

It is evident that people have used different types of machines from the early civilization. Most of those machines were inspired by the nature. The machines such as wheel, axe, and lever can be considered as the simple machines invented by ancient human[4]. With the advancement of time, the human needs started to get complex and people needed more advanced machines. Because of that people tended to think and innovate machines which are capable of advanced tasks than simple machines. That leaded to the evolution of machines[5]. The Industrial revolution[6] took place in 18^{th} century had a great impact on evolution of machines. People started to innovate theories and mechanisms and started to discover the world scientifically therefore the machines were invented with more understanding of the mechanisms and physics behind it and with more advanced technologies. Starting from the mechanical machines now the machines are developed all the way to the machines compatible with human intelligence. The evolution of machines has paved the way for the birth of intelligent machines, revolutionizing the field of artificial intelligence[7].

The evolution of machines started with the invention of mechanical machines. Those machines were mechanical in nature, driven by simple mechanisms and physical forces[8]. The first calculator Pascaline [9], the weaving machine with flying shuttle [10] are some examples for the mechanical machines invented after the industrial revolution.

Then people needed machines enabled with some memory to do the processes according to the given instructions. Then people invented programmable machines to perform the given tasks according to pre defined set of rules. The invention of programmable machines, such as the Jacquard loom in the early 19th century, marked a significant advancement. These machines could follow instructions stored on punched cards, allowing for more complex operations[11]. EDSAC, ENIAC can be considers as the examples for the computers invented in this era. The vacuum tubes[12] and the punch cards[13] are the main technologies used in those machines.

Then comes the digital era inventing the digital computers using the Boolean logic [14]. The development of digital computers in the mid-20th century revolutionized the field of computing. Electronic components and binary logic allowed for faster processing and complex calculations[15]. Those computers were designed using the Von Neumann Architecture [16].

The journey towards intelligent machines [17] began with the advent of electronic digital computers in the mid-20th century. These early machines laid the foundation for machine intelligence by performing complex calculations and executing instructions using binary logic. However, it was in the 1950s and 1960s that the field of Artificial Intelligence (AI) emerged [18], aiming to create machines capable of intelligent behavior. The Turing machine concept by Alan Turing[19], Deep blue[20], ENIGMA [21] are early inventions of machines with AI.

Artificial Intelligence is a broad area with many technologies such as Machine Learning[22], Expert Systems[23], Deep Learning[24], Natural Language Processing[25], Image Recognition[26], Automation[27] and many more.

The first stage witnessed the development of expert systems in the 1970s and 1980s. These systems utilized rule-based reasoning and knowledge representation to solve specific problems within specialized domains. Examples of such systems include MYCIN[28], a medical diagnosis system, and DENDRAL[29], used for chemical analysis.

Machine learning emerged in the 1990s, allowing machines to learn patterns and make predictions from data. Supervised learning, unsupervised learning, and reinforcement learning became key approaches in developing intelligent machines. Examples include spam filters[30] that learn from labeled data, recommendation systems that analyze user preferences, and image recognition algorithms trained on vast datasets.

Deep learning, a subset of machine learning, gained prominence in the 2000s. Deep neural networks, inspired by the human brain's structure, demonstrated breakthroughs in image and speech recognition, natural language processing, and other AI tasks. Examples include image classification systems like ImageNet, speech recognition systems like Google's DeepSpeech[31], and language models like OpenAI's GPT[32].

Integrating AI with robotics [33] led to the creation of intelligent machines capable of physical interaction and manipulation. Industrial robots, self-driving cars, and autonomous drones exemplify the fusion of AI technologies and robotics for intelligent decision-making and real-time adaptation. For instance, self-driving cars use AI algorithms to perceive their surroundings and make informed driving decisions.

The evolution of machines has led to the birth of intelligent machines, transforming the field of artificial intelligence. From expert systems to deep learning and robotics, each stage has contributed to the development of machines capable of intelligent behavior. Insights such as machine learning and deep learning have been instrumental in their creation. The background required to build intelligent machines encompasses data availability, AI algorithms, hardware infrastructure, and software frameworks. As exemplified by AlphaGo[34], voice assistants, autonomous cars, and humanoid robots, these intelligent machines are revolutionizing various domains, promising a future where intelligent machines coexist with humans.

Many advanced technologies and mechanisms found in the way of evolution of the machines were used in the development of the AKMS.

4. Approach- AKMS

We have developed a key management system as a solution for the existing key management system. The developed system is named as AKMS, an acronym for Automated Key Management System.

There are large number of keys operating to protect various resources in the institutions such as schools, universities, banks and offices. But currently those keys are managed manually using methods such as hanging them on a board and keeping someone in-charge of all the keys. Different people who are in-charge will need to access different keys at different times. This conventional key management system can be lead to issues such as misplace of keys, exchange of keys and their labels and frauds occur due to unauthorized access. The aim of our project is to introduce a system to store and manage keys more efficiently with lesser human intervention.

The real-world inspiration;

The main inspiration for this system was the Rotor parking system used to park the vehicles efficiently by circulating pallets vertically in which the cars are taken up and down by a big chain [35].

The inputs, process and the outputs of the AKMS as follows;

Inputs:

- In /Out button signal
- Fingerprint
- Signal from hall effect sensor
- Number of the key chamber

Processes:

- Check whether the entered fingerprint is already available in the fingerprint sensor.
- Detect whether the key halls are already occupied or empty.
- Rotate the correct chamber when the user authentication is valid
- Open and close the relevant chambers when the user needs to take the key and after keeping the key.
- Send the information such as Fingerprint ID, Key hall number, Date, Time and performed action to the database.
- Send the records from the database to the webpage.

Outputs:

- Display the instructions to be followed.
- Detecting the log events of existing users and show user details and log events.
- Display the entered key hall number if the fingerprint is valid.
- Display whether the keys are there or not in the chambers.
- Preventing the manual rotation of key chambers.
- Enables the user to take or keep the key if all the prerequisites are satisfied.

- Indicating the state (occupied / empty) of the key hall using the LED bulbs.

Functions of the system:

Main Functions:

- Issuing the key

  Input the fingerprint of a person and the hall number of the required key then the system checks whether the person is authorized by checking the pre-stored fingerprint IDs and if there is a key available in the mentioned hall, the system allows the user to take the key and record the necessary data in the database and those data are made visible through the website.

- Returning the key

  Input the fingerprint of a person and the hall number then the system checks whether the person is authorized by checking the pre-stored fingerprint IDs and if the key hall is empty, the system allows the user to keep the key and record the necessary data in the database and those data are made visible through the website.

Sub Functions:

- Checking whether the entered fingerprint and the key hall numbers are valid.
- Checking whether the required key hall contains a key or already empty and indicating the state.
- Preventing the manual rotation of key chambers.
- Sending the fingerprint ID, Key hall number and the date and time along with the performed action to the database.
- Sending records from the database to the website.

Features of the system:

The apparatus consists of 12 chambers which can be used to store 12 key sets in each. Each chamber is given a unique number and users can access the keys by entering the chamber number through the keypad. The records of the chamber numbers along with the associated keys are maintained in the database.

Only the pre-authorized users can access the keys through the system.

The state of the chambers, whether occupied or empty is indicated.

Display all the instructions step by step to be followed by the users when taking and keeping the keys.

Recording actions performed along with the date, time, user and the key number are recorded in the database and the admins can access those records through the website.

Users of AKMS:

- The people who are in-charge of managing keys in institutions with large number of buildings.
- The people who are authorized to access the keys of the different rooms/halls in a building.
- The owners of the institutions.

5. Design of AKMS

Architecture of the AKMS- Input Output Diagram:

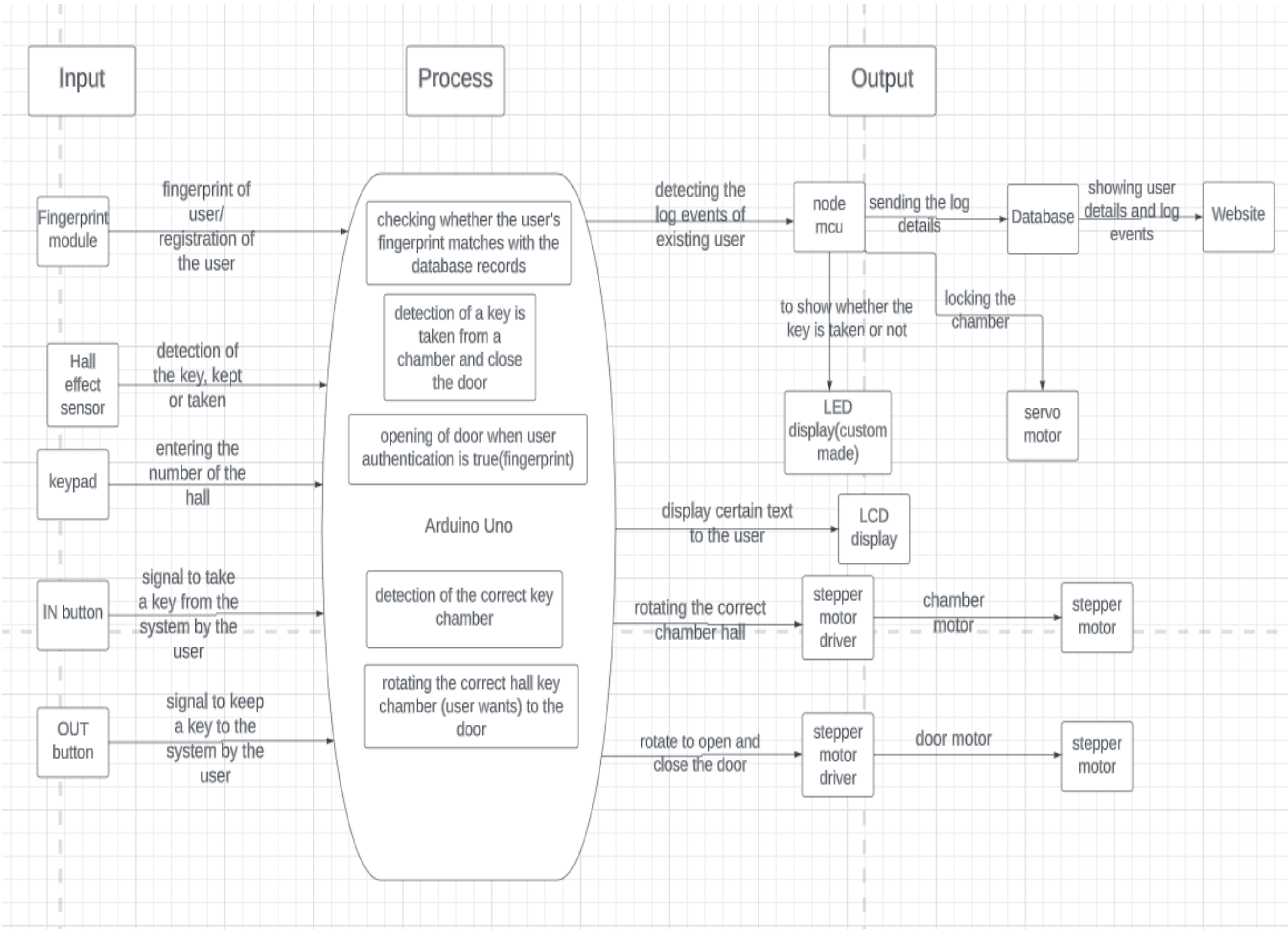

Figure 2: Input Output diagram of the AKMS

3D Design:

Figure 3: 3D design of the AKMS_ front view

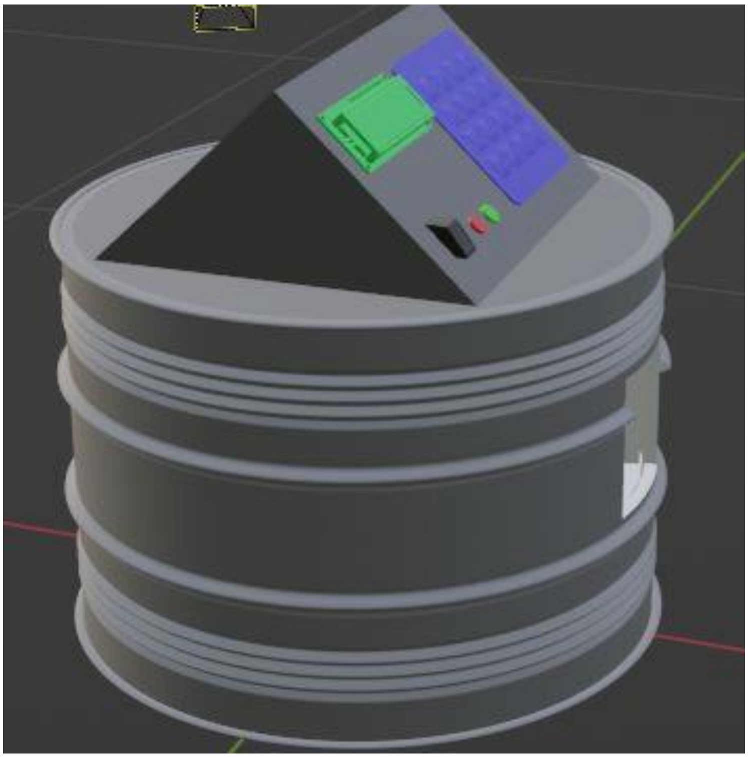

Figure 4: 3D design of the AKMS_ side view

Schematic Diagram:

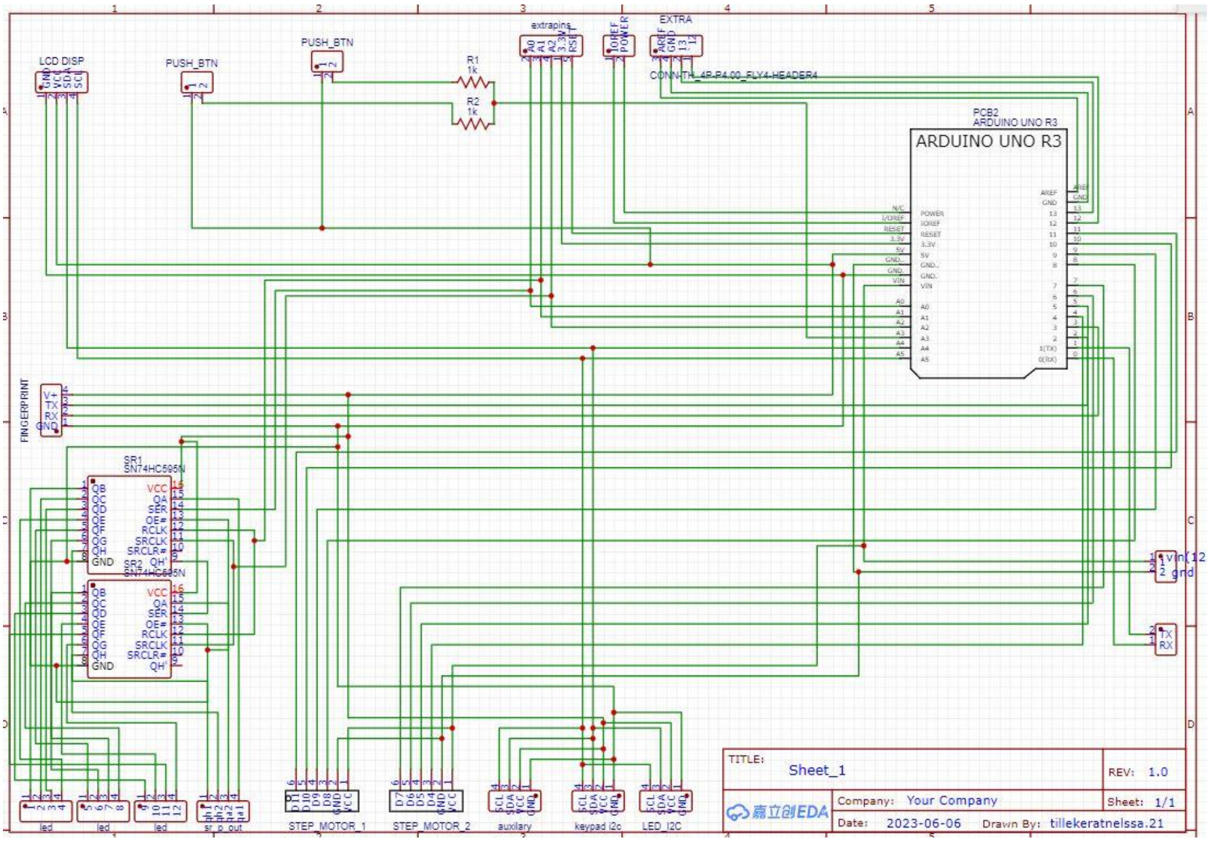

Figure 5: Schematic diagram of the circuit

PCB Design:

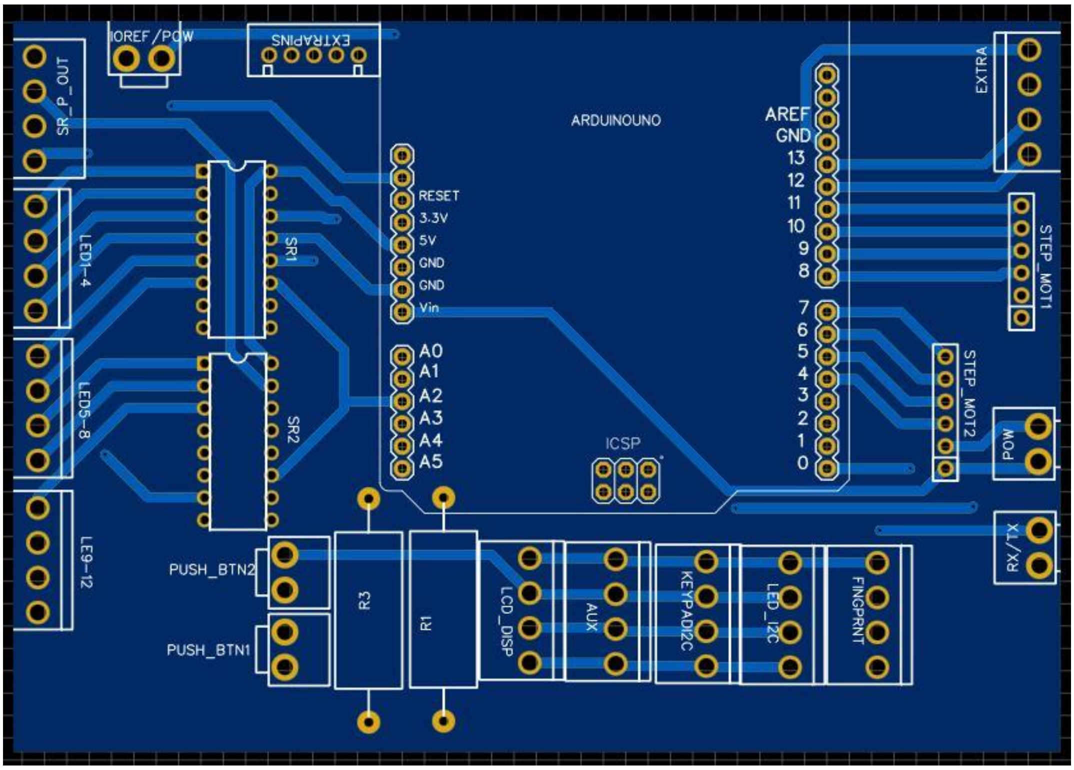

Figure 6: 2D view of PCB

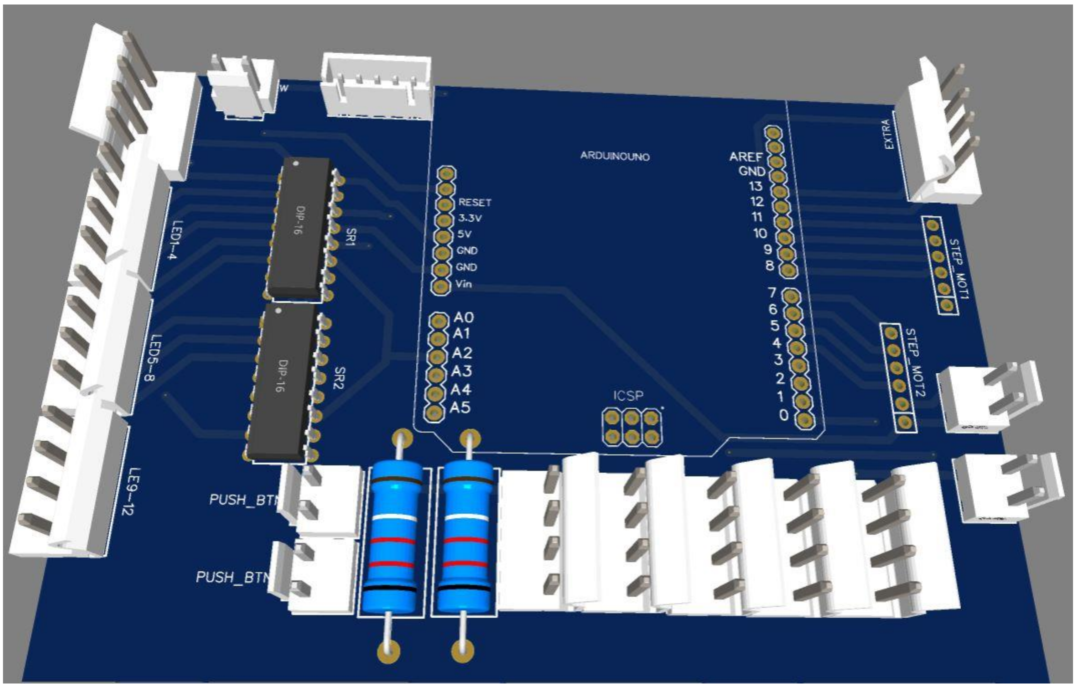

Figure 7:3D view of PCB

Modules Used:

Arduino Uno micro-controller:

Arduino-Uno is the main board and serves as the brain of the system. It stores the program code, provides the input/ output interfaces, provides the communication interfaces and provides the power supply management of the system. The finger print sensor, hall effect sensors, keypad, in/out buttons, node MCU, LCD display, stepper motor and the motor driver are connected to and operated by the Arduino-Uno. It reads the sensor data and user inputs through the input pins and communicates with the database and controls the motors and LEDs and enables the communication to transmit data through the input pins.

Intelligence features can be added to the Arduino Uno by programming the board to implement decision making based on pre-defined algorithms or conditions. Also different sensors can be integrated with the Arduino Uno to gather data and intelligent features can be added by analyzing and processing those sensor data. Due to limited computational power of the board complex intelligent tasks cannot be performed using this.

Specifications:

Micro-controller	ATmega328P (speed 16MHz)
Memory and Storage	32 KB flash memory, 2KB SRAM, 1KB EEPROM
Dimensions	68.6mm x 53.4mm
Operating Voltage	5V
Pins	14 digital I/O pins, 6 analog input pins, 6 PWM output pins.
Programming	Using Arduino IDE with C/C++

Table 1: Specifications of Arduino Uno

Push (IN) Button:

The role of this button is to run the code satisfies a particular ‘if’ condition in the main code. When a user presses this button, the system identifies that the user requires to keep a key. So the code related to that process is executed on the system.

Push (OUT) Button:

The role of this button is to run the code satisfies a particular ‘if’ condition in the main code. When a user presses this button, the system identifies that the user requires to take a key out. So the code related to that process is executed on the system.

LCD Display:

A 16x2 LCD is used to display all the instructions to be followed when taking or keeping the key. Also this displays the input by the keypad when the user enters the required key chamber to be accessed.

Specifications:

Operating Voltage	3.3V – 5V (DC)
Current	2mA @ 5VDC
Dimensions	80mm x 36mm
Back light	Blue with Black characters
Pins (LCD)	2 source pins (GND,VCC), 4 control pins, 1 data/command pin, 2 LED pins

Table 2: Specifications with LCD display

I2C Module for LCD (IIC/I2C/TWI/SPI Serial Interface Board Module Port for 1602 LCD Display PCF8574T):

This I2C module is used to connect the LCD display to the micro-controller to provide a streamlined and efficient method of communication, reducing the number of required pins as it requires only 4 pins instead of using 8 pins in the direct connection, simplifying wiring, enabling multiple addressable devices, and benefiting from existing software libraries.

This module is compatible with 16x2 LCD displays providing the necessary connections and control signals. The back light and the contrast of the LCD display can be controlled by the jumper and the variable resistor embedded with the I2C

Key Pad:

A 3x4 key pad enables user to enter the required key chamber number after entering the fingerprint. This key pad consists of 7 wires, 3 wired dedicated to columns and 4 wires dedicated to rows. Those wires are connected to the micro-controller to read the user input. Then that input needs to be transferred to the database over the Wi-Fi module.

Specifications:

Operating Voltage	12V (DC)
Current across each button	3mA
Dimensions	70mm x 77mm x 1mm
Pins	7 pins (3 columns, 4 rows)

Table 3: Specifications of the Keypad

I2C for the keypad (I/O Expander Module PCF8574T):

The PCF8574T I/O expander module is used with a keypad to effectively manage the inputs from the keypad while reducing pin usage, simplifying wiring, and leveraging existing libraries.

AS608 Fingerprint Sensor:

This sensor is used to read the fingerprints of the users and check their validity. This sensor uses an optical sensor to capture the fingerprint images and incorporated with a powerful fingerprint recognition algorithm which is capable of converting fingerprint image into a unique fingerprint template. 162 fingerprint templates can be stored on the sensor itself and those stored templates are used for comparison and verifying the authorized fingerprints. When a user entered a fingerprint and if it matches with the pre-stored fingerprint in the sensor, the sensor sends the fingerprint ID to Arduino Uno.

In AS608 Fingerprint Sensor, the intelligence lies on the software algorithms implemented in the module. These algorithms are capable of creating a fingerprint template by analyzing the captured fingerprint and extracting unique features. Then those templates are compared with the stored templates in the process of verification. Other than this, the module is not able to learn or adapt on its own.

Specifications:

Operating Voltage	3.6V – 6V (DC)
Operating Current	120mA
Peak Current	150mA
Fingerprint imaging time	<0.1s
Window area	14mm x 18mm
Dimensions	56mm x 20mm x 21.5mm
Memory	256 bytes- Signature file, 512 bytes Template file
Storage capacity	162 templates

Table 4: Specifications of the fingerprint sensor

A3144 Hall Effect Sensor:

In this system twelve Hall Effects sensors are used in each key chamber to detect the presence of the keys in the chamber. The key tags of the keys consist a magnet in it and the Hall Effect sensors which have the ability of generating a voltage difference across a magnetic field are used to detect the keys in the key chamber. When the sensor is not detecting a magnetic field that is when there is no key in the chamber, the sensor uses an external pill-up resistor to provide a logic-level output signal. When a user entered the number of the key hall, the output signal of the relevant chamber is sent to the micro-controller through a dedicated so that the state of the required chamber (occupied/empty) can be displayed on the LCD display.

Specifications:

Operating Voltage	4.5V – 28V (Typically 5V)
Output Current	25mA
Peak Current	150mA
Fingerprint imaging time	<0.1s
Window area	14mm x 18mm
Dimensions	56mm x 20mm x 21.5mm
Memory	256 bytes- Signature file, 512 bytes Template file
Storage capacity	162 templates

Table 5: Specifications of the Hall Effect Sensor

Node MCU:

Node MCU module is used to enable the Wi-Fi connectivity which needs to send the fingerprint ID received from the fingerprint sensor, Key chamber number received from the keypad, whether key is taken or kept detected by the hall effect sensors, date and time of the performed action to the database. The servo motor and the LED bulbs are also connected to the node MCU This module communicates with the database using UART (Universal Asynchronous Receiver-Transmitter) interface.

Specifications:

Operating Voltage	3.3V
Operating Current	Average 80mA
Input Voltage	4.5V- 10V
Clock Speed	80MHz
Flash memory	4MB
SRAM	64KB
Dimensions	49mm x 26mm
Pins	30 Pins 8 power pins(4-GND, 3-3v3, 1-vin), 17 GPIO pins(4-UART pins, 1 Analog pin, 11 Digital pins), 2 Control pins(EN, RST), 4 SPI pins (SD0, SD1, CMD, CLK)

Table 6: Specifications of Node MCU

Nema 17 Stepper motor:

This stepper motor is used to rotate the plate and access the required key chamber at the door of the structure. The circular plate is divided into 12 parts at the center, each partition is in 30^0 angle. The program is coded to rotate the plate in required angle when the key chamber number is inserted. This motor rotates 1.8 degrees per step so that it takes nearly 17 steps to rotate from one chamber to another.

Another same type of stepper motor is used to operate the door of the system. The door is mounted on a thread and that is connected to the stepper motor. In the process of opening the door, the motor rotates to one side so that the door moves upwards along the thread. In the process of closing the door, the motor rotates to the opposite direction so that the door moves down along the thread.

These motors require a special motor driver to control its operation as it is configured as a Bipolar motors.

Specifications:

Operating Voltage	12V
Operating Current	1.7A
Step angle	1.8º
Torque	0.45Ncm
Weight	320g
Pins	6 pins (Coil 1- Coil 4, 2 Center Tap pins)

Table 7: Specifications of Nema 17 Stepper motor

L298N Stepper motor driver:

This is a dual H-bridge motor driver IC which uses to control the stepper motors in the system. The H-bridge controls the direction and the speed of the motors by controlling the current. The above task is controlled by the digital input signals provided by the Arduino Uno.

In terms of intelligence, this motor driver itself provides the necessary power amplification and current control for the stepper motor and also the advanced intelligence features can be implemented in the controlling device (micro-controller) interfacing with the driver.

Specifications:

Supply Voltage Range	2V-46V
Driver Voltage	5V-35V
Driver Current	2A
Maximum Power	25W
Pins	13 pins VCC, GND, 5V, 2 Enable pins (ENA, ENB), 4 input pins, 4 output pins.

Table 8: Specifications of L298N Stepper motor driver

SG90 Servo Motor:

After rotating the relevant key chamber, the gear of the SG90 Servo motor rotates 90degrees and locks the accessed key chamber preventing the manual rotation of the chambers.

Specifications:

Operating Voltage	+5V
Operating Current	150mA- 200mA
Stall Torque	1.8kg/cm
Operating speed	0.1s/60º
Rotation	0 º- 180 º
Weight	9gm
Pins	3 Pins GND, VCC, Control pin

Table 9: Specifications of the SG90 Servo motor

LED bulbs:

There are 12 LED bulbs in the system dedicated to each chamber. The role of these bulbs is indicating whether the particular chamber is already occupied or empty. The bulbs are lit in red as long as there is a key in the chamber. After the hall effect sensor detected that the key is taken out, the bulb dedicated to the respective chamber goes off.

KDT-1250 AC/DC Adapter for the Power Supply:

This adapter is used to power up the AKMS. The input voltage is 100-240V (AC) while the output voltage is 12V and the output current is 5A.

6. Implementation of AKMS

Hardware and Technologies:

- The main hardware technology used in our project is Arduino UNO microcontroller.
- The mechanical parts of the system are, the rotating plate and the door.
- To operate these two mechanical parts we use two stepper motors separately,
  - Nema 17 to operate the rotating plate.
  - Nema 17 to operate the door.
- A 16x2 LCD screen is used to display the instructions to be followed by the user and an I2C module is used to implement the serial communication between the LCD and the arduino board.
- The AS608 fingerprint sensor is capable of storing up to 162 fingerprints. Therefore we use those pre-stored fingerprints in the sensor itself to check whether the entered fingerprint is valid.
- A 3x4 keypad enables user to enter the required key hall number and the validity of that input is checked by using an algorithm to check whether the entered number is in the range of 1 to 12.
- Twelve A3144 hall effect sensors are used to detect whether the keys are in the chambers or not and their outputs are sent to the arduino board using the physical connections with wires.
- Twelve LEDs, each dedicated to each key chamber indicates the state of the key chamber (occupied or empty) according to the data sent by the hall effect sensors.
- Wi-Fi is used as the communication protocol to send data from the arduino board to the database.
- Another ESP8266-01 is used to establish the Wi-Fi connection and send the Fingerprint ID, Key hall number, Date, Time and the Performed action from the arduino board to the database over the Wi-Fi network.
- A Printed Circuit Board (PCB) is used to mount all the components and to create the connections.
- SG90 Servo motor is used to prevent the manual rotation of the key chambers.
- 12v 5A adapter is used to power up the system.

Software and Technologies:

- C algorithms are written to each hardware part separately to achieve the specific functionalities.
- Finally, all the sub parts are aggregated to form the main code of the system.
- The database is designed using MySQL and hosted on the local server.
- The website is created using the web technologies such as HTML and CSS.
- The connection between the database and the website is established and the data are sent using PHP.

Database

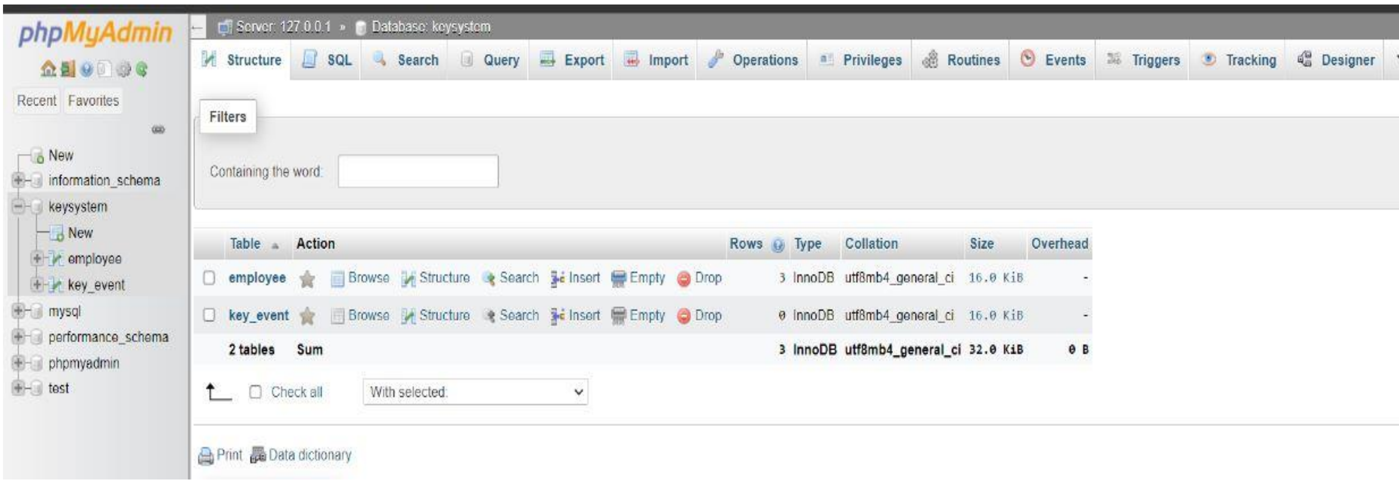

Figure 8: Screen shot of the Database

Web page

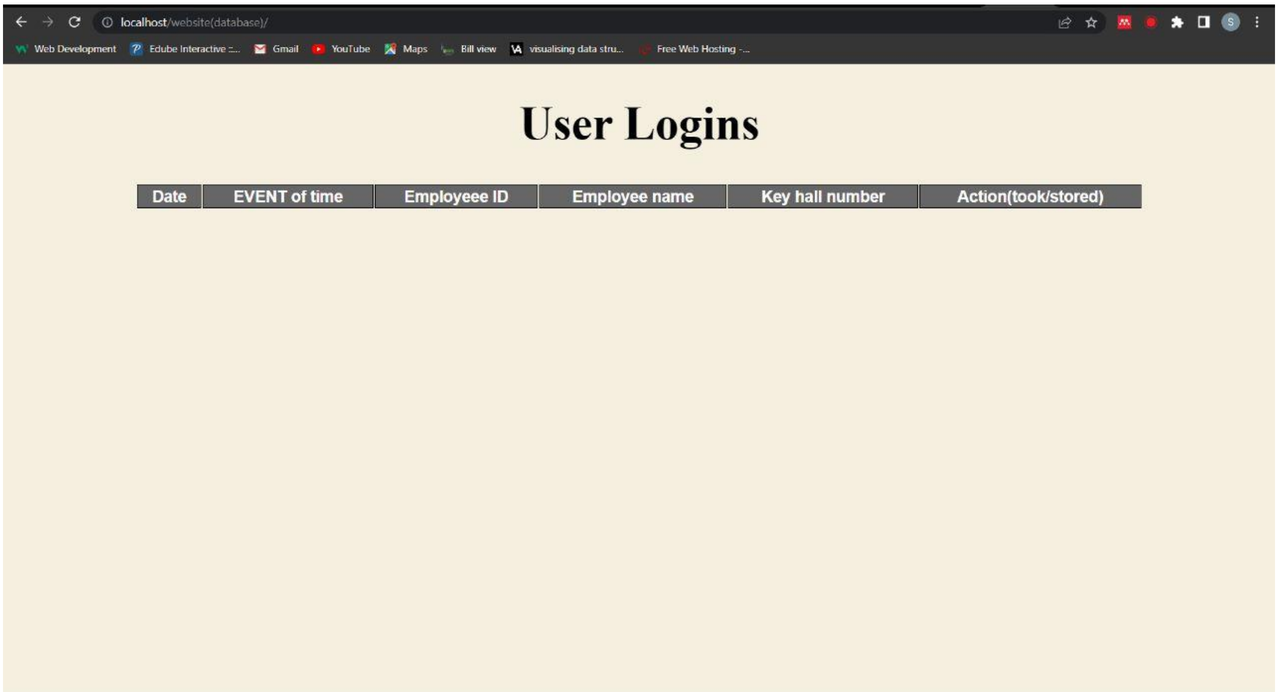

Figure 9: Screenshot of the Web Page

7. Evaluation of AKMS

The final output of the AKMS was evaluated by operating the machine with various test cases.
Registered particular user with an available key chamber and checked whether the machine could perform the relevant functions, authentication process, issuing the key or accepting the key, recording the details of the event occurrence in the database and displaying the relevant information on the web page when the user credentials are given.
The accuracy of the machine was evaluated by inputting the unauthorized user credentials to check whether the machine denies the access to the unauthorized users.
The AKMS successfully performed its functions with the authenticated user credentials and denied unauthorized user credentials, asking the user to try again informing that the provided credentials are not authorized.

8. Conclusion

In conclusion, this project successfully addresses the challenges and difficulties faced with the manual key management process. Mainly this through this project, many tasks related to manual key management have been automated so that the process has been more secure, efficient and the human intervention has been reduced to the minimum.

The AKMS improves security by ensuring that only authorized individuals can access the particular key in which the administration has granted the access and by preventing the manual rotation of key chambers. The system reduces the risk of unauthorized access or loss of keys. This enhances the overall security of the institution.

Also, the project has improved operational efficiency. The manual processes of key issuance, return, and tracking are prone to errors, delays, and inefficiencies. With the automated system, key transactions are streamlined, reducing operation time and saving time for both staff and users. The system's user-friendly interface simplifies the key management process, making it more convenient and accessible.

Additionally, the automated key management system provides real-time visibility over key availability. Users can quickly check the availability of keys in the respective chamber.

Moreover, the project has improved accountability. With the system's ability to track key usage and generate comprehensive reports, it becomes easier to identify responsible individuals for any key-related incidents or discrepancies. This promotes a sense of responsibility and discourages misuse or negligence.

By attending with this project all the group members could get hands on experience on working with different types of hardware components, sensors and incorporated software. Most importantly we could learn how these hardware components can use to create different types of intelligent machines and how to perform the intelligent tasks with the help of coding and algorithms. Every group member has got a vast knowledge about hardware components and software related to their assigned task by studying individually as well as a good knowledge about the interconnected system by working as a group. All the group members contributed to make the project on Automate Key Management System a success.

As further developments we are planning to increase the number of keys can be stored in the system and to introduce the AKMS in various dimensions according to the user requirement.

Also we are planning to increase the security of the system by introducing more advanced security mechanisms using biometrics and more secure physical structure to prevent accessing the other keys through one key chamber to enhance the protection of the keys.

References

[[1] "definition of a machine - Google Search." https://www.google.com/search?client=firefox-b-d&q=definition+of+a+machine (accessed May 10, 2023).

[2] "Simple machine | Definition, Types, Examples, List, & Facts | Britannica," Apr. 25, 2023. https://www.britannica.com/technology/simple-machine (accessed May 10, 2023).

[3] R. Kurzweil, *The Age of Intelligent Machines*. The MIT Press, 1992.

[4] C. Zhang and J. Yang, "Ancient Machines," 2020, pp. 11–64. doi: 10.1007/978-981-15-0833-2_2.

[5] M. Richardson and R. Clesham, "Rise of the machines? The evolving role of AI technologies in high-stakes assessment," *Lond. Rev. Educ.*, vol. 19, no. 1, 2021, doi: 10.14324/LRE.19.1.09.

[6] "Industrial Revolution | Definition, History, Dates, Summary, & Facts | Britannica," Jun. 08, 2023. https://www.britannica.com/event/Industrial-Revolution (accessed Jun. 26, 2023).

[7] SITNFlash, "The History of Artificial Intelligence," *Science in the News*, Aug. 28, 2017. https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/ (accessed Jun. 26, 2023).

[8] A. Khan, "Engineering: An Illustrated History from Ancient Craft to Modern Technology," *Engineering Passion*, Dec. 08, 2021. https://www.engineeringpassion.com/engineering-an-illustrated-history-from-ancient-craft-to-modern-technology/ (accessed Jun. 23, 2023).

[9] "Pascaline | technology | Britannica." https://www.britannica.com/technology/Pascaline (accessed Jun. 26, 2023).

[10] "Flying shuttle | weaving | Britannica." https://www.britannica.com/technology/flying-shuttle (accessed Jun. 26, 2023).

[11] T. Koetsier, "On the prehistory of programmable machines: musical automata, looms, calculators," *Mech. Mach. Theory*, vol. 36, no. 5, pp. 589–603, May 2001, doi: 10.1016/S0094-114X(01)00005-2.

[12] "Electron tube | Vacuum Tubes, Cathode Rays, & Applications | Britannica." https://www.britannica.com/technology/electron-tube (accessed Jun. 26, 2023).

[13] S. Institution, "Punch Cards for Data Processing," *Smithsonian Institution*. https://www.si.edu/spotlight/punch-cards/punch-cards-data-processing (accessed Jun. 26, 2023).

[14] "Boolean Logic - an overview | ScienceDirect Topics." https://www.sciencedirect.com/topics/computer-science/boolean-logic (accessed Jun. 26, 2023).

[15] *The Computer Age: A Twenty-Year View*. 1980. doi: 10.7551/mitpress/2034.001.0001.

[16] "Von Neumann Architecture - an overview | ScienceDirect Topics." https://www.sciencedirect.com/topics/computer-science/von-neumann-architecture (accessed Jun. 26, 2023).

[17] L. C. Jain, A. Quteishat, and C. P. Lim, "Intelligent Machines: An Introduction," in *Innovations in Intelligent Machines - 1*, J. S. Chahl, L. C. Jain, A. Mizutani, and M. Sato-Ilic, Eds., in Studies in Computational Intelligence. Berlin, Heidelberg: Springer, 2007, pp. 1–9. doi: 10.1007/978-3-540-72696-8_1.

[18] K. Darlington, "The Emergence of the Age of AI," *OpenMind*, Jan. 04, 2017. https://www.bbvaopenmind.com/en/technology/artificial-intelligence/the-emergence-of-the-age-of-ai/ (accessed Jun. 26, 2023).

[19] L. De Mol, "Turing Machines," in *The Stanford Encyclopedia of Philosophy*, E. N. Zalta, Ed., Winter 2021.Metaphysics Research Lab, Stanford University, 2021. Accessed: Jun. 26, 2023. [Online]. Available: https://plato.stanford.edu/archives/win2021/entriesuring-machine/

[20] "IBM100 - Deep Blue." https://www.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/ (accessed Jun. 26, 2023).

[21] “Enigma | Definition, Machine, History, Alan Turing, & Facts | Britannica,” Jun. 24, 2023. https://www.britannica.com/topic/Enigma-German-code-device (accessed Jun. 26, 2023).
[22] “What is Machine Learning? | IBM.” https://www.ibm.com/topics/machine-learning (accessed Jun. 26, 2023).
[23] “Expert Systems,” *Wiley Online Library*. https://onlinelibrary.wiley.com/journal/14680394 (accessed Jun. 26, 2023).
[24] “Deep Learning.” https://www.deeplearningbook.org/ (accessed Jun. 23, 2023).
[25] “What is Natural Language Processing? | IBM.” https://www.ibm.com/topics/natural-language-processing (accessed Jun. 26, 2023).
[26] “Image Recognition - an overview | ScienceDirect Topics.” https://www.sciencedirect.com/topics/engineering/image-recognition (accessed Jun. 26, 2023).
[27] “What is automation? | IBM.” https://www.ibm.com/topics/automation (accessed Jun. 26, 2023).
[28] “MYCIN | artificial intelligence program | Britannica.” https://www.britannica.com/technology/MYCIN (accessed Jun. 26, 2023).
[29] “DENDRAL | expert system | Britannica.” https://www.britannica.com/technology/DENDRAL (accessed Jun. 26, 2023).
[30] “About Spam Filters | Mailchimp.” https://mailchimp.com/help/about-spam-filters/ (accessed Jun. 26, 2023).
[31] A. Hannun *et al.*, “Deep Speech: Scaling up end-to-end speech recognition.” arXiv, Dec. 19, 2014. doi: 10.48550/arXiv.1412.5567.
[32] “ChatGPT: Everything you need to know about OpenAI’s GPT-4 upgrade | BBC Science Focus Magazine.” https://www.sciencefocus.com/future-technology/gpt-3/ (accessed Jun. 26, 2023).
[33] C. K. Lo and K. F. Hew, “A review of integrating AI-based chatbots into flipped learning: new possibilities and challenges,” *Front. Educ.*, vol. 8, 2023, Accessed: Jun. 26, 2023. [Online]. Available: https://www.frontiersin.org/articles/10.3389/feduc.2023.1175715
[34] D. Unzueta, “AlphaGo: How AI Mastered the Game of Go,” *Medium*, Aug. 29, 2022. https://towardsdatascience.com/alphago-how-ai-mastered-the-game-of-go-b1355937c98d (accessed Jun. 26, 2023).
[35] “Rotary Parking System.” https://www.tytcorp.com.sg/rotary-parking-system (accessed May 11, 2023).