SMART ELEVATOR

الأسانسير الذكي

A graduation project is submitted to the faculty of artificial intelligence in partial fulfillment of the requirements for the degree of Bachelor of Science in Artificial Intelligence.

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ABSTRACT

Smart elevator is a modern technology that enhances the user experience by utilizing advanced technologies such as face recognition, hand detection, or speech recognition. In this paper, we propose a smart elevator that utilizes face recognition and hand detection or speech recognition technology to improve the efficiency, safety, and user-friendliness of the elevator system.

The face recognition technology enables the smart elevator to identify the user and automatically summon the elevator to their desired floor, eliminating the need to press buttons or use a key card. The hand detection technology further enhances the user experience by allowing users to control the elevator with hand gestures, eliminating the need to touch buttons or keypads. In situations where hand detection is not preferred, speech recognition technology can be used as an alternative, where users can simply speak their desired floor, and the elevator will automatically take them there.

The proposed smart elevator system provides a safe and convenient solution for users in public spaces, such as airports, hospitals, and shopping malls, where there are people with diverse backgrounds and needs. The integration of face recognition and hand detection or speech recognition technology in elevators can revolutionize the way we interact with elevators, making them safer, faster, and more accessible to everyone.

Smart elevators that use face recognition and hand detection technologies are designed to enhance accessibility These elevators use cameras and software to recognize and authenticate users based on their facial features, allowing for a seamless and secure user experience. In addition, smart elevators using hand detection technology can detect and interpret finger count gestures, allowing individuals who are deaf or hard of hearing to communicate with the elevator system and receive visual feedback. This technology can also be used to display real-time information, such as elevator status and announcements, in finger count format. The integration of face recognition and hand detection technologies in smart elevators can significantly improve accessibility and inclusivity, making it easier and more convenient

الملخص

المصعد الذكي هو تقنية حديثة تعزز تجربة المستخدم من خلال استخدام التقنيات المتقدمة مثل التعرف على الوجوه أو اكتشاف اليد أو التعرف على الكلام. في هذا البحث ، نقترح مصعدًا ذكيًا يستخدم تقنية التعرف على الوجوه والكشف اليدوي أو تقنية التعرف على الكلام لتحسين كفاءة نظام المصعد وسلامته وسهولة استخدامه.

تتيح تقنية التعرف على الوجه للمصعد الذكي التعرف على المستخدم واستدعاء المصعد تلقائيًا إلى الطابق المطلوب ، مما يلغي الحاجة إلى الضغط على الأزرار أو استخدام بطاقة مفتاح. تعمل تقنية الكشف عن اليد على تحسين تجربة المستخدم من خلال السماح للمستخدمين بالتحكم في المصعد بإيماءات اليد ، مما يلغي الحاجة إلى لمس الأزرار أو لوحات المفاتيح. في الحالات التي لا يُفضل فيها اكتشاف اليد ، يمكن استخدام تقنية التعرف على الكلام كبديل ، حيث يمكن للمستخدمين ببساطة التحدث بالطابق الذي يرغبون فيه ، وسيأخذهم المصعد تلقائيًا إلى هناك.

يوفر نظام المصعد الذكي المقترح حلاً آمنًا ومناسبًا للمستخدمين في الأماكن العامة ، مثل المطارات والمستشفيات ومراكز التسوق ، حيث يوجد أشخاص لديهم خلفيات واحتياجات متنوعة. يمكن أن يؤدي دمج تقنية التعرف على الوجوه والكشف عن اليد أو التعرف على الكلام في المصاعد إلى إحداث ثورة في الطريقة التي نتفاعل بها مع المصاعد ، مما يجعلها أكثر أمانًا وأسرع ويسهل الوصول إليها للجميع.

تم تصميم المصاعد الذكية التي تستخدم تقنيات التعرف على الوجوه ولغة الإشارة لتعزيز إمكانية الوصول ، وتستخدم هذه المصاعد كاميرات وبرامج للتعرف على المستخدمين والمصادقة عليهم بناءً على ميزات وجوههم ، مما يسمح بتجربة مستخدم سلسة وآمنة. بالإضافة إلى ذلك ، يمكن للمصاعد الذكية التي تستخدم تقنية لغة الإشارة اكتشاف وتفسير إيماءات لغة الإشارة ، مما يسمح للأفراد الصم أو ضعاف السمع بالتواصل مع نظام المصعد وتلقي ردود الفعل المرئية. يمكن أيضًا استخدام هذه التقنية لعرض معلومات في الوقت الفعلي ، مثل حالة المصعد والإعلانات ، بتنسيق لغة الإشارة. يمكن أن يؤدي دمج تقنيات التعرف على الوجوه ولغة الإشارة في المصاعد الذكية إلى تحسين إمكانية الوصول والشمولية بشكل كبير ، مما يجعلها أسهل وأكثر ملاءمة .

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CHAPTER 1

INTRODUCTION

Smart elevators are a revolutionary breakthrough in the field of modern technology. The concept of a smart elevator is to use advanced technologies to make elevators more efficient, safe, and user-friendly. One such technology is face recognition and hand detection, which can be used to enhance the elevator experience.

With face recognition technology, the smart elevator can identify the user and automatically summon the elevator to their desired floor, eliminating the need to press buttons or use a key card. This saves time and enhances security by preventing unauthorized access.

Hand detection technology further enhances the user experience by allowing users to control the elevator with hand gestures, eliminating the need to touch buttons or keypads. This technology is particularly useful in scenarios where touching surfaces can pose a health risk, such as during a pandemic.

However, if hand detection is not preferred, speech recognition can be used as an alternative. With speech recognition technology, users can simply speak their desired floor, and the elevator will automatically take them there, making the process effortless and convenient.

1.1 MOTIVATION

There are several motivations for creating a smart elevator:

- 1.1.1 Saving time: If the elevator is in college, that elevator will be allocated to professors to save them time, and if there is a hospital, it will be reserved for doctors to catch up with patients and critical conditions.

- 1.1.2 Safety: A smart elevator can include safety features such as emergency stop buttons, automatic door sensors, and real-time monitoring of elevator performance to prevent accidents and ensure safe operation.

- 1.1.3 Coronavirus: We know that coronavirus is a way of transmitting it. It is transmitted through touch. This is motivated by the most important motivation that motivated us to work on this project, which has almost no contact at all and reduces the spread of any infection, whether coronavirus or otherwise.

Fig. (1.1.3)

- 1.1.4 Convenience: A smart elevator can provide added convenience and comfort for building occupants by allowing them to easily access the floors they need and providing real-time information on elevator status and wait times.

- 1.1.5 Future-proofing: As technology advances, smart elevators can be easily updated and adapted to incorporate new features and capabilities, ensuring that the building remains current and competitive over time.

- 1.1.6 Efficiency: A smart elevator can improve the efficiency of a building by reducing wait times and travel times for occupants. This can lead to higher productivity and less frustration for building occupants.

- 1.1.7 Energy savings: A smart elevator can optimize energy usage by using sensors and algorithms to determine the most efficient way to move people through a building. This can lead to significant energy savings over time.

1.2 EXPECTED PROBLEMS

While the integration of face recognition and hand detection technology into smart elevators has the potential to improve efficiency, safety, and inclusivity, there are also several potential problems that need to be addressed.

- 1.2.1 Privacy concerns: The use of face recognition technology raises concerns about privacy and data security. Building owners and managers need to ensure that personal data collected by the elevator system is stored securely and used only for authorized purposes.

- 1.2.2 Accuracy of face recognition: Face recognition technology may not always be accurate, especially when dealing with people of different ages, races, and genders. This can lead to errors in identifying individuals and potentially cause delays or other issues in the elevator system.

- 1.2.4 Integration with existing systems: Integrating face recognition and hand detection technology into existing elevator systems may be challenging, especially in older buildings with outdated infrastructure. Building owners and managers need to consider the costs and technical requirements of integrating new technology into their existing systems.

- 1.2.5 Maintenance and upkeep: Smart elevators with face recognition and hand detection technology may require more maintenance and upkeep than traditional elevators, as the technology is more complex and may require specialized expertise to repair or upgrade.

Overall, while the integration of face recognition and hand detection technology into smart elevators presents many potential benefits, it is important to carefully consider these potential problems and address them in order to ensure a successful implementation that improves efficiency, safety, and inclusivity for all building occupants.

1.3 PROBLEM DEFINITION

The problem definition for elevators can be broadly defined as the need to efficiently transport people or goods between different floors of a building. The specific problems that may arise in relation to elevators can vary depending on the building's design, the number of floors, and the volume of people or goods being transported. Some common problems include:

- 1.3.1 Waiting times: Long wait times for elevators can be frustrating for users and can result in crowding in the lobby area.

- 1.3.2 Capacity and speed: Elevators must be able to transport people or goods quickly and efficiently, and must have sufficient capacity to accommodate peak demand periods.

- 1.3.3 Safety: Elevators must be designed and maintained to ensure the safety of users, with features such as emergency stop buttons and safety interlocks.

- 1.3.4 Maintenance and reliability: Elevators require regular maintenance to ensure they operate reliably and safely, and downtime due to maintenance or repairs can be disruptive to building occupants.

- 1.3.5 Energy efficiency: Elevators can consume significant amounts of energy, and energy-efficient designs and operation can help to reduce operating costs and environmental impact.

- 1.3.6 Security: Elevators must be secure and prevent unauthorized access to restricted floors or areas.

1.4 OBJECTIVES

- 1.4.1 Improved efficiency: By using face recognition technology, smart elevators can identify building occupants and provide a personalized elevator experience, This can reduce wait times and travel times, leading to higher productivity and less frustration for building occupants.

- 1.4.2 Enhanced safety: Smart elevators with face recognition technology can improve safety by preventing unauthorized access to floors and providing real-time monitoring of elevator performance to prevent accidents and ensure safe operation.

- 1.4.3 Greater inclusivity: By incorporating hand detection technology, smart elevators can provide a more inclusive experience for deaf or hard-of-hearing individuals. This technology can interpret the user's signs and display information on the elevator screen in real-time, allowing for a seamless and inclusive elevator experience.

- 1.4.4 Future-proofing: By integrating the latest technology into elevator systems, building owners and managers can future-proof their buildings and ensure that they remain current and competitive over time.

1.5 SOLUTION TECHNIQUES

To ensure a secure elevator access control system, it is essential to install a camera on each floor. This will help to prevent any unauthorized access to the building and protect any confidential or sensitive information. Additionally, it is advisable to install access control readers at office doors, or turnstiles for larger buildings, to mitigate the risk of elevator access control. By doing this, it will help to ensure that only credentialed individuals can enter the building. Furthermore, it is important to maintain these measures regularly to ensure the system remains secure and up-to-date.

Having an elevator management system with the right settings in place is an important part of keeping your building secure. One potential security vulnerability is the use of stolen or otherwise unauthorized keycards to call and access unauthorized floors in the building. To help prevent this vulnerability, you should utilize your elevator management system settings to require elevator riders to use their keycards both when calling the elevator and when selecting the desired floor. This way, if someone attempts to use a stolen keycard, it will be detected and the elevator will not move. Furthermore, if someone attempts to access an unauthorized floor, the elevator will not be able to complete the journey. By using this system setting, you can help ensure that only authorized personnel can access secure areas of the building.

1.5.1 Face Recognition Technology

Face recognition technology is quickly becoming an invaluable tool for improving security and reliability in a number of different areas. By utilizing this technology, we can solve a variety of problems, such as identity verification, access control, and surveillance. With face recognition, we can authenticate people’s identities without the need for additional physical identification, which increases reliability and security. Additionally, face recognition can be used to detect anomalies

in the environment, such as intruders, which can help to improve the safety of a given area.

Face recognition technology can also be used to monitor and track people's movements in real-time, which can help to improve security and reliability. By providing accurate and up-to-date information, face recognition can alert the authorities to suspicious activity and help them to identify potential threats. Additionally, face recognition can be used to create detailed records of people's activities, which can be used to monitor and analyze behavior over time.

Face recognition technology can be used to automate processes that require the identification of people. This can help to speed up processes and increase reliability and security. For example, face recognition can be used to automatically grant access to restricted areas or to validate identity in areas such as airports or banks.

1.5.2 Hand Recognition

The implementation of hand recognition as an elevator access system has been a breakthrough for the modern world. Instead of having to press a manual button for each floor, this new system allows users to simply place their hand against the scanner and be directed to the desired floor. This system eliminates the need to constantly press a button, removing any cross-contamination, and providing a more efficient and safer way to access the elevator.

The hand recognition system works by scanning the user's hand and assigning a numerical code to it, which is then used to access the desired floor. This system is highly secure, as the hand recognition system is designed to recognize only the hand of the registered user. Additionally, the system eliminates the need to enter multiple passwords or identification numbers, making it easier and faster to access the elevator.

The hand recognition system is a convenient and reliable way to access the elevator. Not only does it provide a more efficient and secure way to reach the desired floor, but it also eliminates the need to manually press a button for each floor. This system has revolutionized the way elevator riders access their desired floors, making it a highly efficient and secure system.

CHAPTER 2

METHODOLOGY

the methodology for building a smart elevator using Raspberry Pi, face recognition, and hand detection involves developing algorithms for face recognition and hand detection recognition, integrating them into a user interface, and connecting the user interface to the elevator control system. This project has the potential to make elevators more accessible and user-friendly for people with disabilities, particularly those who are deaf or hard of hearing. The methodology for building a smart elevator using Raspberry Pi, face recognition, and hand detection can be broken down into the following steps:

- 2.1 Hardware Setup: The first step is to set up the hardware components required for the project. This includes a Raspberry Pi board, a camera module and a display module. The camera module is used to capture the image of the user's face, while the display module are used to display and communicate information to the user. (And we will explain the components later)

Fig. (2.1)

- 2.2 Face recognition: The next step is to develop a face recognition algorithm using OpenCV and Python. This algorithm will be used to recognize the user's face and authenticate their identity. The algorithm should be trained on a dataset of faces and should be able to detect the user's face from different angles and lighting conditions.

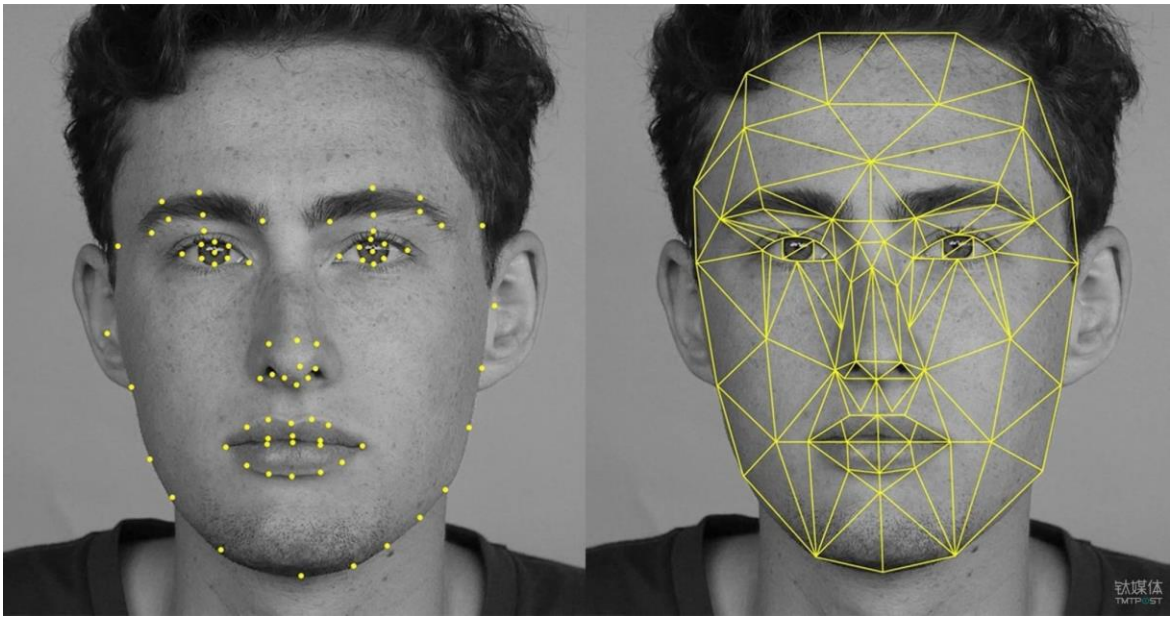


Fig. (2.2)

- 2.3 Hand Detection and Finger count: The third step is to develop a hand detection algorithm using machine learning. This algorithm will be used to recognize the user's finger count gestures and translate them into text or speech. The algorithm should be trained on a dataset of finger count gestures and should be able to recognize the user's gestures accurately.

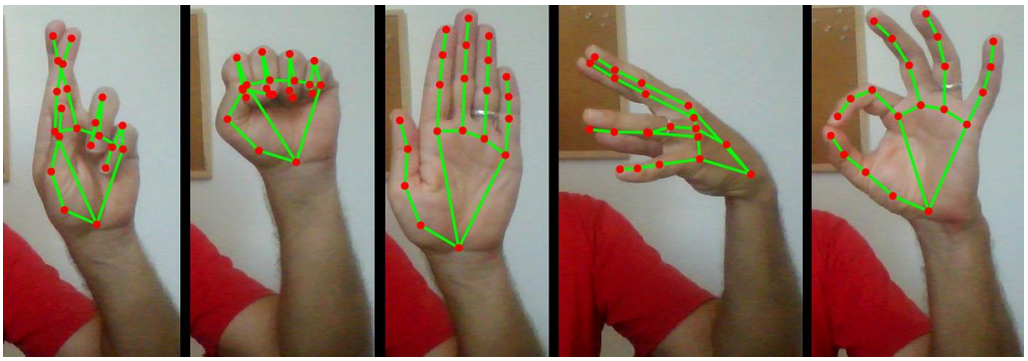


Fig. (2.3)

- 2.4Speech recognition technology is a cutting-edge innovation that has the potential to revolutionize the way we interact with smart elevators. With speech recognition, users can simply speak their desired floor, and the elevator will automatically take them there, making the process effortless and convenient.

Fig. (2.4)

- 2.5 User interface: The fourth step is to develop a user interface that integrates the face recognition and hand detection algorithms. The user interface should allow the user to interact with the elevator using hand detection gestures and should display information such as floor number and elevator status.

- 2.6 Elevator control: The final step is to integrate the user interface with the elevator control system. This involves connecting the Raspberry Pi board to the elevator's control system and programming it to respond to the user's finger count gestures. For example, the user can make a fingercount gesture for the desired floor, and the Raspberry Pi board will communicate with the elevator control system to take the user to that floor. The Raspberry Pi board can also display information such as elevator status and floor number on the display module.

CHAPTER 3

HAREWARE COMPONENTS

- 3.1 The 25GA370 DC Gear Motor with Encoder 200RPM 12Vdc

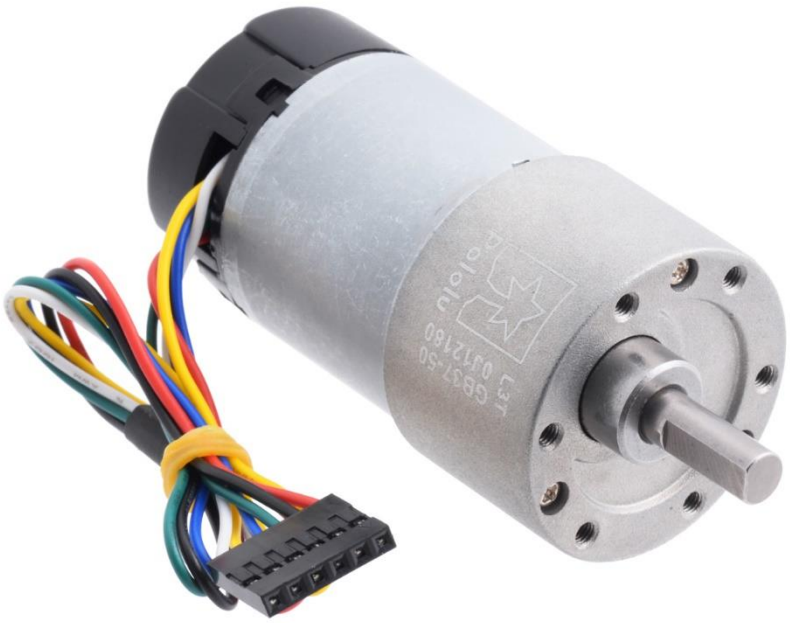


Fig. (3.1)

The 25GA370 DC Gear Motor with Encoder 200RPM 12Vdc is a type of electric motor that is commonly used in various applications that require precise control of motor speed and position.

The “25GA370” refers to the specific model of the motor, which has a diameter of 25mm and a gearbox ratio of 370:1. The “DC” stands for direct current, which means that the motor runs on a DC power source, such as a battery or a power supply.

The “Gear Motor” part of the name refers to the fact that the motor has a gearbox attached to it, which helps to increase the torque output of the motor. The “Encoder” part of the name refers to the fact that the motor has an encoder built into it, which allows for precise control of the motor’s speed and position.

The motor has a rated speed of 200 revolutions per minute (RPM) and operates on a 12V DC power supply. It is commonly used in robotics, automation, and other applications that require precise control of motor speed and position.

- 3.2 L298N Motor Driver Module

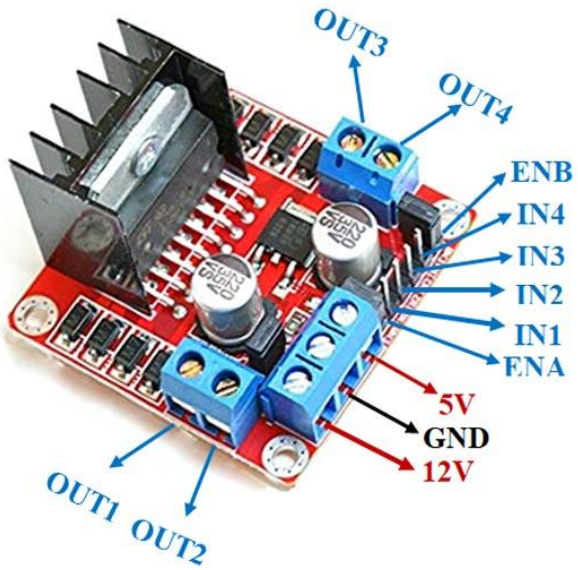


Fig. (3.2)

The L298N Motor Driver Module is an electronic component used to control and power DC motors and stepper motors. It is a popular motor driver module due to its low cost, high power capability, and ease of use.

The L298N module features two H-bridge circuits, which allow it to control the direction and speed of two DC motors or one stepper motor. It can handle a maximum current of 2A per channel and a maximum voltage of 46V. It also has built-in protection features, such as over-current protection and over-temperature shutdown.

The module can be controlled by a microcontroller, such as an Arduino, and can be used in a wide range of applications, including robotics, automation, and hobby projects. It is commonly used to drive motors in small robots, CNC machines, and 3D printers.

To use the L298N module, the motor power supply and control signal are typically connected to the module's input pins, and the motor output is connected to the module's output pins. The module can be controlled using PWM signals to adjust the motor speed, and direction can be controlled by switching the direction of the motor's power supply.

- 3.3 MG90S Micro Servo Motor 2.2 kg.cm Metal Gear

Fig. (3.3)

The MG90S Micro Servo Motor is a small and lightweight motor commonly used in hobbyist projects, such as Remote Control cars, planes, and boats, as well as in robotics and automation applications.

The "Micro" in the name indicates that it is a small motor, with dimensions of approximately 23mm x 12mm x 29mm. The "Servo" in the name indicates that it is a type of motor that is designed to rotate to a specific angle, based on the input signal it receives.

The MG90S motor has a torque rating of 2.2 kg.cm, which means it is capable of exerting a maximum force of 2.2 kilograms at a distance of one centimeter from the motor's axis of rotation. It also has metal gears, which provide increased durability and strength compared to plastic gears.

The motor operates on a voltage range of 4.8 – 6.0V and has a speed of 0.12 seconds per 60 degrees of rotation. It typically uses a three-wire connection, with one wire for power, one wire for ground, and one wire for the control signal.

The MG90S Micro Servo Motor is a popular choice for hobbyists and makers due to its small size, lightweight, and precise control of rotation angle.

- 3.4 GT2 Open Belt 6mm Wide 1 Meter, White

Fig. (3.4)

The GT2 Open Belt 6mm Wide 1 Meter is a type of timing belt commonly used in 3D printing and other precision machinery applications.

The "GT2" in the name refers to the belt's tooth profile, which is designed to mesh with pulleys that have corresponding GT2 tooth profiles. The tooth profile allows for precise positioning and timing of the belt and pulley system.

The belt is "Open," which means that it has no seam or loop and is designed to be cut to a specific length as needed. It is "6mm Wide," which refers to the width of the belt, and "1 Meter" refers to the length of the belt.

The color “White” is simply an aesthetic choice and has no impact on the functionality of the belt.

The GT2 Open Belt is a popular choice for 3D printing and other precision machinery applications due to its precise timing and positioning capabilities. It is also relatively easy to install and maintain, making it a convenient option for hobbyists and professionals alike.

- 3.5 20Teeth GT2 Idler Pulley – 5mm Bore

Fig. (3.5)

The 20Teeth GT2 Idler Pulley – 5mm Bore is a mechanical component used in 3D printers and other precision machinery that use a GT2 timing belt.

The “20Teeth” in the name refers to the number of teeth on the pulley. The GT2 tooth profile on the pulley is designed to mesh with the corresponding GT2 tooth profile on the timing belt, allowing for precise positioning and timing of the belt and pulley system.

The “Idler Pulley” part of the name refers to the fact that this pulley is used to guide the timing belt, rather than drive it. In other words, it is not

directly connected to the motor or other driving mechanism, but rather provides support and guidance for the timing belt.

The “5mm Bore” part of the name refers to the diameter of the hole in the center of the pulley, which is designed to fit onto a 5mm shaft or rod. This allows the pulley to rotate freely on the shaft or rod while still maintaining its position in the system.

The 20Teeth GT2 Idler Pulley – 5mm Bore is a key component in a GT2 timing belt system, providing support and guidance for the belt and ensuring precise positioning and timing of the system.

- 3.6 20Teeth GT2 Timing Belt Pulley – 6.35mm Bore

Fig. (3.6)

The 20Teeth GT2 Timing Belt Pulley – 6.35mm Bore is a mechanical component used in 3D printers and other precision machinery that use a GT2 timing belt.

The “20Teeth” in the name refers to the number of teeth on the pulley. The GT2 tooth profile on the pulley is designed to mesh with the

corresponding GT2 tooth profile on the timing belt, allowing for precise positioning and timing of the belt and pulley system.

The “Timing Belt Pulley” part of the name refers to the fact that this pulley is used to drive the timing belt. In other words, it is directly connected to the motor or other driving mechanism, and its rotation drives the timing belt, which in turn drives other components in the system.

The “6.35mm Bore” part of the name refers to the diameter of the hole in the center of the pulley, which is designed to fit onto a 6.35mm shaft or rod. This allows the pulley to rotate freely on the shaft or rod while still maintaining its position in the system.

The 20Teeth GT2 Timing Belt Pulley – 6.35mm Bore is a key component in a GT2 timing belt system, providing the driving force for the belt and ensuring precise positioning and timing of the system.

- 3.7 Cable Drag Chain 10*10mm

Fig. (3.7)

A Cable Drag Chain, also known as a cable carrier or energy chain, is a mechanical component used to protect and guide cables and wires in moving applications.

The 10*10mm in the name refers to the dimensions of the drag chain. Specifically, it means that the internal dimensions of the drag chain are 10mm by 10mm, which is the amount of space available for cables and wires to pass through.

The drag chain is typically made up of a series of interconnected links, which can be opened and closed to add or remove cables as needed. The links also allow the drag chain to bend and flex as it moves, while still maintaining protection and guidance for the cables and wires inside.

The drag chain is commonly used in CNC machines, 3D printers, and other machinery that have moving parts that require cables and wires to move along with them it helps to prevent damage to the cables, as well as to prevent tangling or snagging of the cables, which can cause malfunctions or accidents.

The Cable Drag Chain 10*10mm is a useful component in many applications where cables and wires need to move along with other parts of a machine or system.

- 3.8 8x1000mm Linear Rail Shaft Stainless Steel

Fig. (3.8)

The 8x1000mm Linear Rail Shaft is a mechanical component used in various applications, such as CNC machines, robotics, and automation systems, to guide and support linear motion.

The “8x1000mm” in the name refers to the dimensions of the shaft. Specifically, it means that the shaft has a diameter of 8mm and a length of 1000mm. The shaft is typically made of stainless steel, which provides strength and durability while also resisting corrosion and wear.

The linear rail shaft is designed to work in conjunction with linear bearings, which slide along the shaft to guide and support linear motion. The linear bearings are typically mounted to a carriage or other moving component, allowing the component to move smoothly and accurately along the shaft.

The linear rail shaft is commonly used in applications where precise and smooth linear motion is required, such as in CNC machines, 3D printers, and other automated systems. It is also used in applications where the shaft may be exposed to harsh environments, such as in outdoor or industrial applications.

The 8x1000mm Linear Rail Shaft Stainless Steel is a useful component in many applications where precise, smooth, and durable linear motion is required.

- 3.9 LM08UU Linear Motion Bearing 8mm inner Diameter

The “LM08UU” in the name refers to the specific model of the linear bearing is a type of linear bearing used in various applications, such as CNC machines, 3D printers, and robotics, to provide smooth and precise linear motion.

The “LM” stands for linear motion, while “08” refers to the inner diameter of the bearing, which is 8mm. The “UU” at the end of the name indicates that the bearing is double-sealed to protect against dust and debris.

Fig. (3.9)

The LM08UU bearing is designed to work in conjunction with a linear rail or shaft, such as the 8x1000mm Linear Rail Shaft Stainless Steel. The bearing slides along the rail or shaft to guide and support linear motion.

The LM08UU bearing typically has a ball or roller mechanism inside, which reduces friction and allows for smooth motion. The bearing is typically mounted to a carriage or other moving component, which allows the component to move smoothly and accurately along the rail or shaft.

The LM08UU Linear Motion Bearing is a useful component in various applications where smooth and precise linear motion is required. Its small size and affordable cost make it a popular choice for hobbyists and makers, as well as professionals in various industries.

- 3.10 Micro Limit Switch (MS.2 – 20.0×10.0x6.0mm)

Fig. (3.10)

A Micro Limit Switch is a type of electromechanical switch used to detect the presence or absence of an object, typically at the end of a travel path or in other specific positions.

The “MS.2 – 20.0x10.0x6.0mm” in the name refers to the specific model of the switch and its dimensions. The “MS.2” indicates the model number, while “20.0x10.0x6.0mm” refers to the length, width, and height of the switch, which are 20.0mm, 10.0mm, and 6.0mm, respectively.

The Micro Limit Switch typically consists of a lever or button that is actuated by the presence or absence of an object. When the object makes contact with the lever or button, the switch is activated, and an electrical signal is sent to a control system or other device.

The Micro Limit Switch is commonly used in various applications, such as robotics, automation, and machinery, to provide precise and reliable detection of object positions and movement. They are often used to trigger

safety mechanisms, to detect the end of a travel path for a moving component, or to provide other types of feedback to a control system.

The Micro Limit Switch (MS.2 – 20.0x10.0x6.0mm) is a useful component in many applications where reliable and precise object detection is required, in a small and compact package.

- 3.11 Female DC Power Plug to 2-Pin Screw Terminal

Fig. (3.11)

A Female DC Power Plug to 2-Pin Screw Terminal is an adapter used to convert the connection of a DC power plug into a 2-pin screw terminal connection.

The “Female DC Power Plug” part of the name refers to the input side of the adapter, which typically consists of a female connector that accepts a DC power plug. The DC power plug is typically used to connect a power supply or other DC power source to a device or component.

The “2-Pin Screw Terminal” part of the name refers to the output side of the adapter, which typically consists of two screw terminal connectors that provide a way to connect wires or cables to the device or component. The screw terminal connectors are designed to securely hold the wires or cables in place using a screwdriver or other tool.

The Female DC Power Plug to 2-Pin Screw Terminal adapter is commonly used in various applications, such as in DIY electronics projects or in industrial automation systems, where a DC power source needs to be connected to a device or component using screw terminal connectors. And it is a useful component for converting the connection of a DC power plug into a screw terminal connection, providing a flexible and reliable way to connect DC power sources to devices or components.

- 3.12 Female to Female – 20cm 10 Pin Jumper Wire Set

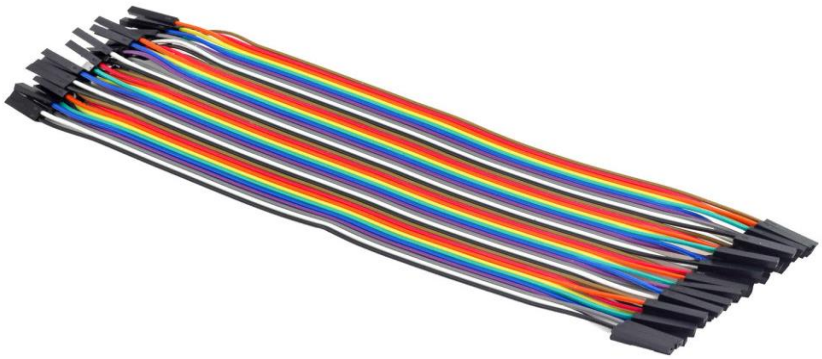


Fig. (3.12)

A Female to Female – 20cm 10 Pin Jumper Wire Set is a set of 10 jumper wires that have female connectors on both ends, with a length of 20cm.

The “Female to Female” part of the name refers to the type of connectors on the wires. Both ends of the wires have female connectors, which are designed to fit onto male pins or headers on a circuit board or other electronic component. This makes the wires useful for connecting different components together, such as a microcontroller board to a sensor or actuator.

The “20cm” part of the name refers to the length of the wires, which is approximately 20 centimeters (or about 8 inches). This gives the wires

enough length to reach between different components while still being compact enough to keep the wiring neat and organized.

The 10 Pin Jumper Wire Set typically consists of 10 wires of different colors, which can be used to help keep track of which wire is connected to which pin or header on a circuit board or other component. The wires are also typically flexible and durable, allowing them to be bent and twisted without breaking or losing their electrical connection. And it is a useful component for connecting different electronic components together, providing a flexible and reliable way to create electrical connections without the need for soldering or other permanent connections.

- 3.13 5” LCD Touch Screen HDMI For Raspberry Pi 800*480

Fig. (3.13)

The 5” LCD Touch Screen HDMI For Raspberry Pi 800*480 is a small display screen designed specifically for use with the Raspberry Pi single-board computer.

The “5” in the name refers to the size of the screen, which measures 5 inches diagonally. The screen has a resolution of 800x480 pixels, which

provides clear and sharp images and text. The screen is also touch-sensitive, allowing users to interact with the Raspberry Pi using their fingers or a stylus.

The “HDMI” in the name refers to the type of connection used to connect the screen to the Raspberry Pi. The screen connects to the Raspberry Pi using an HDMI cable, which provides both video and audio signals.

The 5” LCD Touch Screen HDMI For Raspberry Pi is typically used in various applications, such as in DIY electronics projects or in industrial automation systems, where a compact and portable display is needed to interact with the Raspberry Pi. The touch screen feature also makes it useful for creating interactive user interfaces or for controlling devices or systems remotely. And it is a useful component for creating a compact and portable display for the Raspberry Pi, providing a high-resolution display and touch-sensitive interface for a variety of applications.

- 3.14 5MP Raspberry Pi Camera Module Rev 1.3 with Cable

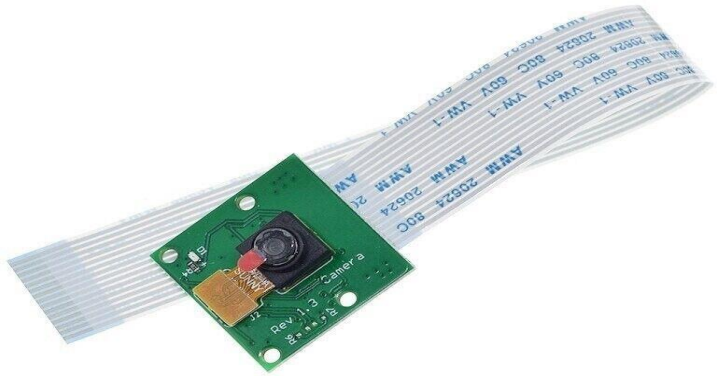


Fig. (3.14)

The 5MP Raspberry Pi Camera Module Rev 1.3 with Cable is a small camera module designed specifically for use with the Raspberry Pi single-board computer.

The “5MP” in the name refers to the resolution of the camera, which is 5 megapixels. This provides high-quality images and videos. The camera is also capable of capturing 1080p video at 30 frames per second, or 720p video at 60 frames per second.

The camera module connects to the Raspberry Pi using a ribbon cable, which provides both power and data connections to the camera. The cable is typically included with the camera module, making it easy to connect to the Raspberry Pi.

The 5MP Raspberry Pi Camera Module Rev 1.3 is typically used in various applications, such as in surveillance systems, robotics, or other projects where a small and high-quality camera is needed. The camera module can be controlled using software libraries available for the Raspberry Pi, allowing users to take photos or videos, adjust camera settings, or stream video to other devices. And it is a useful component for adding a high-quality camera to the Raspberry Pi, providing a versatile and compact camera solution for a variety of applications.

- 3.15 Micro-HDMI to HDMI Cable For Raspberry Pi 4B – 1m

Fig. (3.15)

The Micro-HDMI to HDMI Cable For Raspberry Pi 4B – 1m is a cable used to connect the Raspberry Pi 4B single-board computer to an external display or monitor.

The cable features a Micro-HDMI connector on one end, which plugs into the Micro-HDMI port on the Raspberry Pi 4B board. The other end of the cable features a standard HDMI connector, which plugs into an HDMI port on an external display or monitor. The cable has a length of 1 meter (or approximately 3.3 feet), which provides enough length for connecting the Raspberry Pi to a display located some distance away.

The cable is specifically designed for use with the Raspberry Pi 4B, which features a Micro-HDMI port for connecting to an external display. The cable supports high-definition video and audio signals, allowing users to display high-quality images and videos on an external display or monitor. And it is a useful component for connecting the Raspberry Pi 4B to an external display or monitor, providing a high-quality video and audio connection with a convenient length of 1 meter.

- 3.16 Raspberry Pi Camera Clear Acrylic Case

Fig. (3.16)

The Raspberry Pi Camera Clear Acrylic Case is a protective case designed specifically for the Raspberry Pi camera module. The case is made of clear acrylic material, which provides a transparent view of the camera module inside the case. The case is designed to fit the camera module snugly, providing protection against dust, scratches, and minor impacts.

The case typically features cutouts and holes that allow easy access to the camera module's lens, connectors, and other features. This allows users to use the camera module while it is inside the case without having to remove it from the case.

The Raspberry Pi Camera Clear Acrylic Case is commonly used in various applications such as in robotics, drones, surveillance systems, or other DIY electronics projects where the camera module needs protection from the environment or from accidental damage. And it is a useful component that provides a clear and durable enclosure for the Raspberry Pi camera module, allowing users to use the camera module while it is inside the case and also protect it from any potential damage.

- 3.17 Enclosure for Raspberry Pi 4B – 9 Layers Acrylic + Cooling Fan

Fig. (3.17)

The Enclosure for Raspberry Pi 4B – 9 Layers Acrylic + Cooling Fan is a protective case designed specifically for the Raspberry Pi 4B single-board computer.

The case is made of 9 layers of clear acrylic material, which provides a transparent view of the Raspberry Pi 4B board inside the case. The layers are typically stacked on top of each other and held together with screws, providing a sturdy and protective enclosure for the Raspberry Pi 4B board.

The case typically features cutouts and holes that allow easy access to the Raspberry Pi's ports, connectors, and other features. This allows users to use the Raspberry Pi while it is inside the case, without having to remove it from the case.

The case also typically includes a cooling fan to help keep the Raspberry Pi 4B board cool during operation. The fan is typically connected to the Raspberry Pi's GPIO header and can be controlled using software to adjust its speed and operation.

The Enclosure for Raspberry Pi 4B – 9 Layers Acrylic + Cooling Fan is commonly used in various applications such as in robotics, home automation, or other DIY electronics projects where the Raspberry Pi 4B board needs protection and cooling. And it is a useful component that provides a transparent and protective enclosure for the Raspberry Pi 4B board, along with a cooling fan to help keep the board cool during operation.

- 3.18 AC Power Adapter 12Vdc / 2A

Fig. (3.18)

An AC Power Adapter 12Vdc / 2A is a type of power supply that provides a DC voltage of 12 volts with a current output of up to 2 amps.

The “AC” in the name refers to the type of input power that the adapter is designed to accept, which is typically AC power from a wall outlet. The adapter typically has a plug that can be inserted into a standard wall outlet, allowing it to convert the AC power to DC power that can be used to power electronic devices or components.

The “12Vdc / 2A” in the name refers to the output voltage and current of the adapter. The adapter outputs a DC voltage of 12 volts, which is commonly used to power a variety of electronic devices such as LED strips, routers, or other devices that require 12V DC power. The current output of 2 amps provides enough power to drive devices that require up to 24 watts of power.

The AC Power Adapter 12Vdc / 2A is commonly used in various applications such as in DIY electronics projects, LED lighting systems, or

other devices that require 12V DC power. And it is a useful component that provides a reliable and efficient power supply for a variety of electronic devices that require 12V DC power.

- 3.19 Matrix Keypad 16 Key (4×4)

Fig. (3.19)

A Matrix Keypad 16 Key (4×4) is a type of input device that consists of 16 keys arranged in a 4x4 matrix format.

Each key on the keypad is typically made of a conductive material such as metal or carbon, and the keys are arranged in a grid pattern with four rows and four columns. When a key on the keypad is pressed, it creates a connection between a specific row and column, which can be detected by a microcontroller or other electronic device connected to the keypad.

The Matrix Keypad 16 Key (4×4) is typically used in various applications such as in security systems, access control systems, or other DIY electronics projects where a user input is required. The keypad can be connected to a microcontroller or other electronic device using a simple wiring scheme, allowing users to read input from the keypad and use it to

control other components or devices. And it is a useful component that provides a simple and reliable way to input data or commands into an electronic system, providing a compact and efficient user interface for a variety of applications.

- 3.20 Male to Female – 20cm 10 Pin Jumper Wire Set

Fig. (3.20)

A Male to Female – 20cm 10 Pin Jumper Wire Set is a collection of 10 individual wires used to connect electronic components together, typically in a breadboard or prototyping board.

The wires are typically made of stranded copper wire with a male pin connector on one end and a female pin connector on the other end. The male pin connector is typically inserted into a female pin connector on a component, while the female pin connector is typically inserted into a male pin connector on another component.

The jumper wires are typically used to create connections between components on a breadboard, prototyping board, or other electronic circuit. The 20cm length of the wires provides enough length to create connections between components that are spaced some distance apart.

The 10 Pin Jumper Wire Set typically includes 10 wires of different colors, making it easy to distinguish between the wires and keep track of their connections. The set is commonly used in various applications such as in DIY electronics projects, prototyping, or other electronic circuits where a simple and reliable wiring connection is required. And it is a useful component that provides a simple and efficient way to connect electronic components together, allowing users to create complex circuits and prototypes with ease.

- 3.21 Raspberry Pi _ v4

Fig. (3.21)

The Raspberry Pi 4 is the latest model in the Raspberry Pi series of single-board computers.

It was released by the Raspberry Pi Foundation in June 2019 and is the successor to the Raspberry Pi 3 Model B+. The Raspberry Pi 4 features a quad-core ARM Cortex-A72 CPU with clock speeds up to 1.5GHz, up to 8GB of RAM, Gigabit Ethernet, dual-band 802.11ac wireless networking, Bluetooth 5.0, two USB 3.0 ports, two USB 2.0 ports, two micro-HDMI ports supporting up to 4K resolution, and a 40-pin GPIO header. It is a versatile

and affordable computer that can be used for a wide range of projects, including home automation, media centers, game emulation, and more.

Raspberry Pi is a small, low-cost computer that has gained immense popularity since its introduction in 2012. It is widely used for a variety of purposes, including:

- Education: Raspberry Pi is an excellent tool for teaching computer science and programming to students. It is small, affordable and easy to use, which makes it a great choice for classroom environments.

- Media center: Raspberry Pi can be used as a media center, allowing you to stream movies, music and TV shows on your TV. You can install software like Kodi or Plex to manage your media collection.

- Home automation: Raspberry Pi can be used to control various aspects of your home, including lighting, temperature, and security systems. You can use it to create a smart home that is controlled by your smartphone or tablet.

- Gaming: Raspberry Pi can be used as a gaming console. You can install software like RetroPie or Lakka to play classic games from consoles like NES, SNES, and Sega Genesis.

- Internet of Things (IoT): Raspberry Pi can be used to create IoT devices, such as sensors and cameras. You can use it to monitor temperature, humidity, and other environmental factors.

- Robotics: Raspberry Pi can be used to build robots. You can use it to control motors, sensors, and other components of your robot.

- Description Raspberry Pi_v4

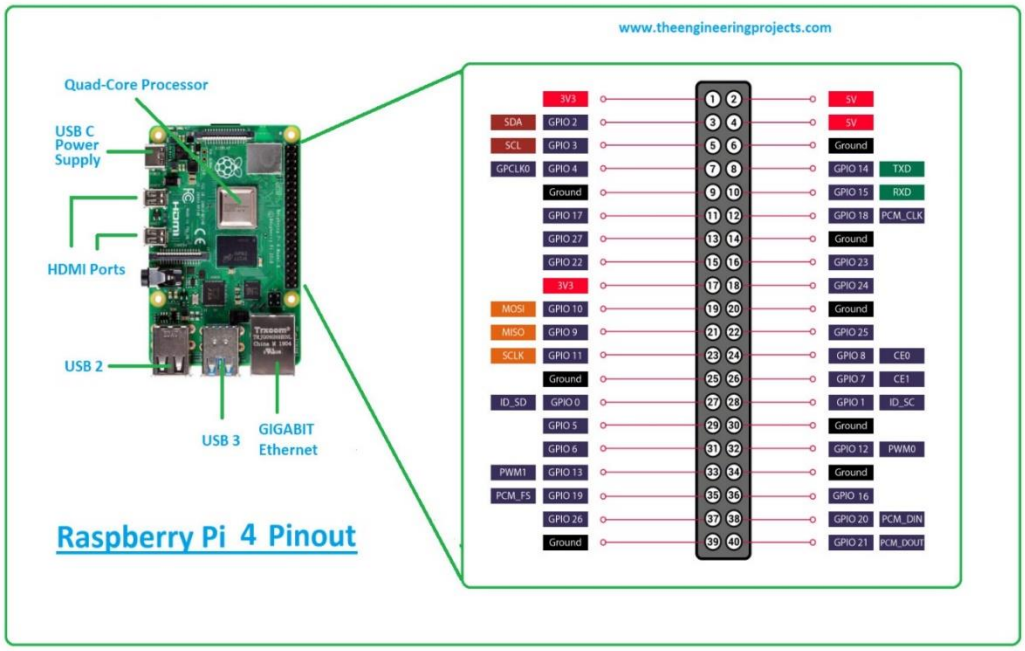


Fig. (3.22)

	Pi3 Model B	Pi3 Model B+	Pi4 Model B
Processor	Broadcom BCM2837A1(B0), Quad-core Cortex-A53 64-bit SoC@ 1.2GHz	Broadcom BCM2837B0, Quad-core Cortex-A53 64-bit SoC@ 1.4GHz	**Broadcom 2711, Quad-core Cortex-A72 64-bit SoC @ 1.5GHz**
Memory	1GB LPDDR2 SDRAM	1GB LPDDR2 SDRAM	**1GB, 2GB or 4GB LPDDR4 SDRAM**
Connectivity	2.4GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.1, BLE 4 x USB 2.0 ports	2.4GHz / 5.0GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE 4 x USB 2.0 ports, Gigabit Ethernet over USB2.0 (max. 300MPS)	2.4GHz / 5.0GHz IEEE 802.11.b/g/n/ac wireless LAN, **Bluetooth 5.0**, BLE **2 x USB 2.0 / 2 x USB 3.0 ports delivering true Gigabit Ethernet**
Access	Extended 40-pin GPIO header	Extended 40-pin GPIO header	Extended 40-pin GPIO header
Video & Sound	1 x full size HDMI, 1 X MIPI DSI display port 1 X MIPI CSI camera port 4 pole stereo output and composite video port	1 x full size HDMI, 1 X MIPI DSI display port 1 X MIPI CSI camera port 4 pole stereo output and composite video port	**2 x micro HDMI, 4k video** 1 X MIPI DSI display port 1 X MIPI CSI camera port 4 pole stereo output and composite video port
Multimedia	H.264, MPEG-4 decode (1080p30), H.264 encode (1080p30), OpenGL ES 1.1, 2.0 graphics	H.264, MPEG-4 decode (1080p30), H.264 encode (1080p30), OpenGL ES 1.1, 2.0 graphics	**H.265 decode (4kp60)** **H.264 decode (1080p60),** H.264 encode (1080p30), **OpenGL ES 1.1, 2.0, 3.0 graphics**
SD card support	Micro SD format for loading OS & data storage	Micro SD format for loading OS & data storage	Micro SD format for loading OS & data storage
Input Power	5V/2.5A DC via micro USB connector 5V DC via GPIO	5V/2.5A DC via micro USB connector 5V DC via GPIO PoE enabled	**5V/3A DC via USB type C connector** 5V DC via GPIO PoE enabled

Fig. (3.23)

CHAPTER 4

CODING AND PROGRAMMING

4.1 Hand Detection and Tracking

In Computer Vision, feature detection is key to implementing a good and functional application. Some basic feature detection methods like edge and corner detection can be calculated and mathematically implemented, others can be rather more complex and require a Machine Learning-based approach.

Identifying and tracking hands can be useful in various applications, such as: implementing gesture control, interpreting finger count , or improving solutions for augmented reality applications. Furthermore, working with this feature might be challenging, because hands can be presented in various positions, often occluding some fingers or one another.

In this part of project , it processes the input from web camera.Then, It can identifies 21 landmark points of hands , after that it will count the raised fingers for each hand and provide the final value of counter for the next part of the project. It runs on CPU.

We will discuss a simple hand tracking and finger counting Python application using OpenCV and MediaPipe.

- What is MediaPipe

MediaPipe is an open-source framework for building pipelines to perform computer vision inference over arbitrary sensory data such as video or audio.

In computer vision pipelines, those components include model inference, media processing algorithms, data transformations, etc. Sensory data such as video streams enter the graph, and perceived descriptions such as object-localization or face-keypoint streams exit the graph.

It was built for machine learning (ML) teams and software developers who implement production-ready ML applications, or students and researchers who publish code and prototypes as part of their research work.

It facilitates the deployment of computer vision applications into demos and applications on different hardware platforms. The configuration language and evaluation tools enable teams to incrementally improve computer vision pipelines.

You can build models like:

- Face Detection
- Face Mesh
- Iris Detection
- Hands Detection
- Pose Detection
- and more...

- Code implementation

The implementation below works by running the MediaPipe Hands *process* function in each frame of the webcam video capture. For each frame, the results provide a 3D landmark model for each hand detected. For each of the hands detected, these are the steps followed:

1. Check detected hand label.
2. Store x and y coordinates of each landmark.
3. Check each finger's coordinates to determine if it is raised to increase finger count.
4. Draw hand landmarks with *draw_landmarks* function.

```
import cv2
import time
import mediapipe as mp

mp_drawing = mp.solutions.drawing_utils
mp_drawing_styles = mp.solutions.drawing_styles
mp_hands = mp.solutions.hands


pTime = 0
confirmation = []
cap = cv2.VideoCapture(0)

with mp_hands.Hands(
    model_complexity=0,
    min_detection_confidence=0.5,
    min_tracking_confidence=0.5) as hands:

    while cap.isOpened():
        success, image = cap.read()
        if not success:
            print("Ignoring empty camera frame.")
          # If loading a video, use 'break' instead of
'continue'.
            continue

        if cv2.waitKey(1) & 0xFF == ord('q'):
            break

        image = cv2.flip(image,1)

        "---------- FPS : ----------"
        cTime = time.time()
        fps = int(1/(cTime-pTime))
        pTime = cTime # update

        "------- Show FPS : --------"
        cv2.putText(image,f"{fps}
FPS",(10,30),cv2.FONT_HERSHEY_COMPLEX,0.8,(0,244,0),2,16)

        # To improve performance, optionally mark the image
as not writeable to
        # pass by reference.
        image.flags.writeable = False
        image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
        results = hands.process(image)

        # Draw the hand annotations on the image.
        image.flags.writeable = True
```

```
        image = cv2.cvtColor(image, cv2.COLOR_RGB2BGR)

        # Initially set finger count to 0 for each cap
        fingerCount = 0

        if results.multi_hand_landmarks:

            for hand_landmarks in
results.multi_hand_landmarks:
                # Get hand index to check label (left or
right)
                handIndex =
results.multi_hand_landmarks.index(hand_landmarks)
                handLabel =
results.multi_handedness[handIndex].classification[0].label

                # Set variable to keep landmarks positions
(x and y)
                handLandmarks = []

                # Fill list with x and y positions of each
landmark
                for landmarks in hand_landmarks.landmark:
                    handLandmarks.append([landmarks.x,
landmarks.y])

                # Test conditions for each finger
                if handLabel == "Left" and
handLandmarks[4][0] > handLandmarks[3][0]:
                    fingerCount = fingerCount+1
                elif handLabel == "Right" and
handLandmarks[4][0] < handLandmarks[3][0]:
                    fingerCount = fingerCount+1

                # Other fingers: TIP y position must be
lower than PIP y position,
                #   as image origin is in the upper left
corner.
                if handLandmarks[8][1] <
handLandmarks[6][1]:       #Index finger
                    fingerCount = fingerCount+1
                if handLandmarks[12][1] <
handLandmarks[10][1]:     #Middle finger
                    fingerCount = fingerCount+1
                if handLandmarks[16][1] <
handLandmarks[14][1]:     #Ring finger
                    fingerCount = fingerCount+1
                if handLandmarks[20][1] <
handLandmarks[18][1]:     #Pinky
                    fingerCount = fingerCount+1
```

```
                # Draw hand landmarks
                mp_drawing.draw_landmarks(
                    image,
                    hand_landmarks,
                    mp_hands.HAND_CONNECTIONS,

mp_drawing_styles.DrawingSpec(color=(237,149,100),thickness=
-1,circle_radius=6))



            ########### CONFIRMATION OF COUNTER###########
            confirmation.append(fingerCount)

#             print(confirmation)

            if len(confirmation) == 5:

                if confirmation[0] == confirmation[1] and
confirmation[1] == confirmation[2] and confirmation[2] ==
confirmation[3] and confirmation[3] == confirmation[4]:
                    fingerCount = confirmation[0]
                    print(f"I GOT IT , You Mean number
( {fingerCount} ) !")

                confirmation = []
            ##############################################



        # Display finger count
        cv2.putText(image, str(fingerCount),
((image.shape[1]//2)-
40,60),cv2.FONT_HERSHEY_COMPLEX,2,(0,255,255),3,cv2.LINE_AA)

        # Display image
        cv2.imshow('MediaPipe Hands', image)


cap.release()
cv2.destroyAllWindows()
```

<<Now, let’s discuss it line by line.>>

```
1 import cv2
2 import time
3 import mediapipe as mp
```

Fig. (4.1.1)

- Here , we imported opencv library for computer vision and image processing purpose ,
  time library for calculating the frame per second (FPS) on webcam and mediapipe library for hand tracking purpose.

```
5 mp_drawing = mp.solutions.drawing_utils
6 mp_drawing_styles = mp.solutions.drawing_styles
7 mp_hands = mp.solutions.hands
```

Fig. (4.1.2)

- Here , we take an object of each class
- mp_drawing for drawing landmarks on hands.
- mp_drawing_styles for customizing landmarks styles.
- mp_hands for detect and tracking the hands.

```
10 pTime = 0
11 confirmation = []
12 cap = cv2.VideoCapture(0)
```

Fig. (4.1.3)

- In line 10 , we initialize the previous time as 0 for future use in FPS calculating.
- Line 11 , initialize a confirmation list for future use to ensure that the landmarks detected are the final decision from the user.
- Line 12 , initialize video camera

```
14 with mp_hands.Hands(
15     model_complexity=0,
16     min_detection_confidence=0.5,
17     min_tracking_confidence=0.5) as hands:
18
19     while cap.isOpened():
```

Fig. (4.1.4)

- Line 14 , take an object of the class Hands and tuning its parameters
- model_complexity is the input a static image [False]

```
19     while cap.isOpened():
20         success, image = cap.read()
21         if not success:
22             print("Ignoring empty camera frame.")
23           # If loading a video, use 'break' instead of 'continue'.
24             continue
```

Fig. (4.1.5)

- min_detection , min_tracking confidences equals to 0.5
- success is a boolean variable, if cam is launched and starts taking frames from the camera it will be True , else Fasel.
- Line 21 , if it False (no frame received from the camera) Ignore it

```
26         if cv2.waitKey(1) & 0xFF == ord('q'):
27             break
```

Fig. (4.1.6)

- If user pressed on ‘q’ in keyboard , it will terminate the running.

```
29         image = cv2.flip(image,1)
```

Fig. (4.1.7)

- Here we made a horizontal flip of the frame , Because we are using the webcam input capture, the left hand is located as “right”, and the right hand is located as “left”.

```
31          "---------- FPS : ----------"
32          cTime = time.time()
33          fps = int(1/(cTime-pTime))
34          pTime = cTime # update
35
36          "------- Show FPS : --------"
37          cv2.putText(image,f"{fps} FPS",(10,30),cv2.FONT_HERSHEY_COMPLEX,0.8,(0,244,0),2,16)
```

Fig. (4.1.8)

- calculating FPS
  FPS = 1 / (Current Time – Previous Time)
  previous_time will be equal to current_time in the next frame

- In line 37, we show the fps on the frame.

```
39          # To improve performance, optionally mark the image as not writeable to
40          # pass by reference.
41          image.flags.writeable = False
42          image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
```

Fig. (4.1.9)

- Line 41 , for better use of hand tracking algorithm , we mark the image as not writable

- Line 42 , convert color space of image from BGR to RGB to be ready as an input for the hand tracking algorithm.

As we know that opencv deals with images in BGR color space so we have to convert the color space to RGB for now.

```
43          results = hands.process(image)
```

Fig. (4.1.10)

- Start processing (hand detection & tracking) , store the landmarks in results variable

```
45          # Draw the hand annotations on the image.
46          image.flags.writeable = True
47          image = cv2.cvtColor(image, cv2.COLOR_RGB2BGR)
48
49          # Initially set finger count to 0 for each cap
50          fingerCount = 0
```

Fig. (4.1.11)

- Line 46 , after processing , return the image as writable

- Line 47 , return the color space to BGR again for displaying the image in opencv way.

- Line 50 , we initialize a fingerCount variable as a final result of detection and tracking (the golden value) that we will depend on for the hardware code

```
52      if results.multi_hand_landmarks:
53
54          for hand_landmarks in results.multi_hand_landmarks:
55              # Get hand index to check label (left or right)
56              handIndex = results.multi_hand_landmarks.index(hand_landmarks)
57              handLabel = results.multi_handedness[handIndex].classification[0].label
```

Fig. (4.1.12)

- Line 52 , if we have detected a landmarks in the image , will iterate on each hand detected.

- Line 56 , get the index for the detected hand if right hand (index=0) , left hand (index=1) and so on.

- Line 57 , get the name of that index (Right or Left) for the detected hand index.

```
59              # Set variable to keep landmarks positions (x and y)
60              handLandmarks = []
61
62              # Fill list with x and y positions of each landmark
63              for landmarks in hand_landmarks.landmark:
64                  handLandmarks.append([landmarks.x, landmarks.y])
65
66              # Test conditions for each finger
67              if handLabel == "Left" and handLandmarks[4][0] > handLandmarks[3][0]:
68                  fingerCount = fingerCount+1
69              elif handLabel == "Right" and handLandmarks[4][0] < handLandmarks[3][0]:
70                  fingerCount = fingerCount+1
```

Fig. (4.1.13)

- Line 60 , HandLandmarks is a list that will store the landmarks of the detected hand.

- Line 63 , will iterate in each landmark in the landmarks for the detected hand , and append x , y of each landmark into handLandmarks list.

- Line 67 , For the thumb, we'll check the values of the THUMB_TIP and THUMB_IP **x** coordinates, and the hand label. The thumb is considered raised if the _TIP is located to the right of the _IP, for the left hand, and the opposite for the right hand.
  It is different in two hands so we need to check which hand we will work on.
  If hand label is left and landmark 4 of (x) is bigger than landmark 3 of

(x) , it means that the thumb finger is opened , so will increase the counter by 1.

- the same as the hand label is Right but in case of landmark 4 of (x) is lower than landmark 3 of (x).

so , the following figure will let you understand the previous code

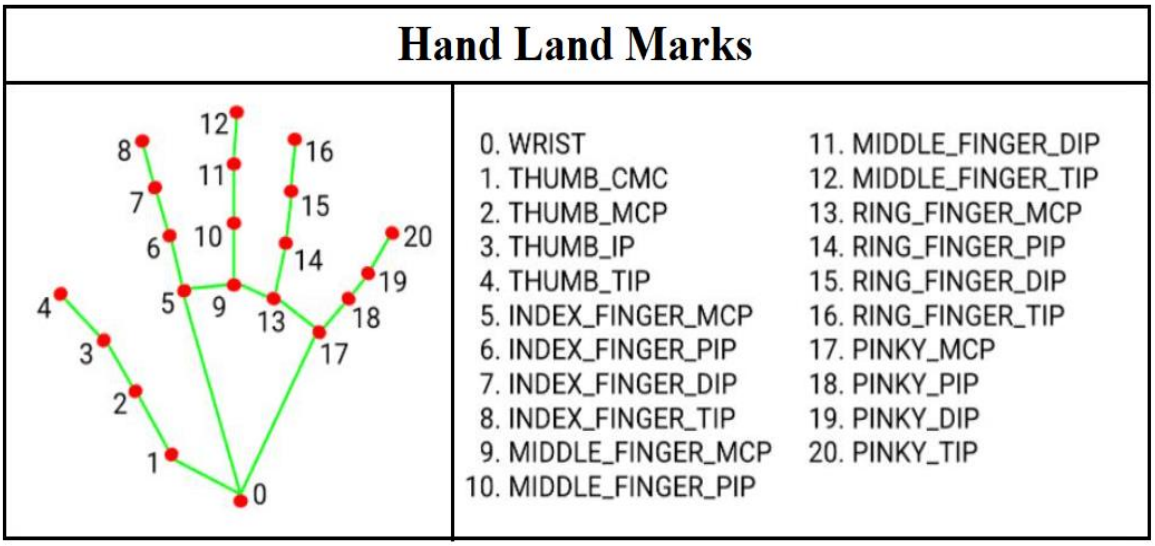


Fig. (4.1.14)

let's continue with the rest of the code.

```
72                # Other fingers: TIP y position must be lower than PIP y position,
73                #   as image origin is in the upper left corner.
74                if handLandmarks[8][1] < handLandmarks[6][1]:       #Index finger
75                    fingerCount = fingerCount+1
76                if handLandmarks[12][1] < handLandmarks[10][1]:     #Middle finger
77                    fingerCount = fingerCount+1
78                if handLandmarks[16][1] < handLandmarks[14][1]:     #Ring finger
79                    fingerCount = fingerCount+1
80                if handLandmarks[20][1] < handLandmarks[18][1]:     #Pinky
81                    fingerCount = fingerCount+1
```

Fig. (4.1.15)

- For the other fingers, we'll check the values of the _TIP and _PIP **y** coordinates. The finger is considered raised if the _TIP is located higher than the _PIP

  as previous figure.

```
                # Draw hand landmarks
                mp_drawing.draw_landmarks(
                    image,
                    hand_landmarks,
                    mp_hands.HAND_CONNECTIONS,
                    mp_drawing_styles.DrawingSpec(color=(237,149,100),thickness=-1,circle_radius=6))

```

Fig. (4.1.16)

- After counting the fingers , let's draw its landmarks

```
            ########## CONFIRMATION OF COUNTER##########
            confirmation.append(fingerCount)

#             print(confirmation)

            if len(confirmation) == 5:

                if confirmation[0] == confirmation[1] and confirmation[1] == confirmation[2] and confirmation[2]
                    fingerCount = confirmation[0]
                    print(f"I GOT IT , You Mean number ( {fingerCount} ) !")

                confirmation = []
            ############################################
```

Fig. (4.1.17)

- Here, it's an important stage of code

- After the user gives the camera a number by its hand, we does not need to take action immediately, we will hold 5 frames for submit the decision of the user.

If the finger counter value is same through the 5 frames, we will take this value as the final result from the code.

```
        # Display finger count
        cv2.putText(image, str(fingerCount), ((image.shape[1]//2)-40,60),cv2.FONT_HERSHEY_COMPLEX,2,(0,255,255),
        # Display image
        cv2.imshow('MediaPipe Hands', image)
```

Fig. (4.1.18)

- Here we will show the frame, and put the finger counter value on the frame as a text

```
cap.release()
cv2.destroyAllWindows()
```

Fig. (4.1.19)

- In case of quit the while loop , it will release the video camera , and destroy the windows.

4.2 Keypad and Servo Motor.

A keypad is a set of buttons or keys arranged on a pad that bear digits, symbols, oralphabetical letters, which can be used as an efficient input device. A keypad may be purely numeric that is found on most computer keyboards, allowing an individual to easily enter numeric values into a computer. It is mainly used for people who have to perform calculations or deal with numbers frequently with a software calculator.

Numeric keypads are found on the devices that require mainly numeric input suchas vending machines, Point of Sale devices, calculators, digital door locks,
push-button telephones, and combination locks. A row of number keys is locatedon the upper side of a computer keyboard, including a separate numerical pad onthe right side used for efficient data entry.

A Servo Motor is a small device that has an output shaft. This shaft can be positioned to specific angular positions by sending the servo a coded signal. Aslong as the coded signal exists on the input line, the servo will maintain the angular position of the shaft.

servos are used in radio-controlled airplanes to position control surfaces like the elevators and rudders. They are also used in radio-controlled cars, puppets, and ofcourse, robots.

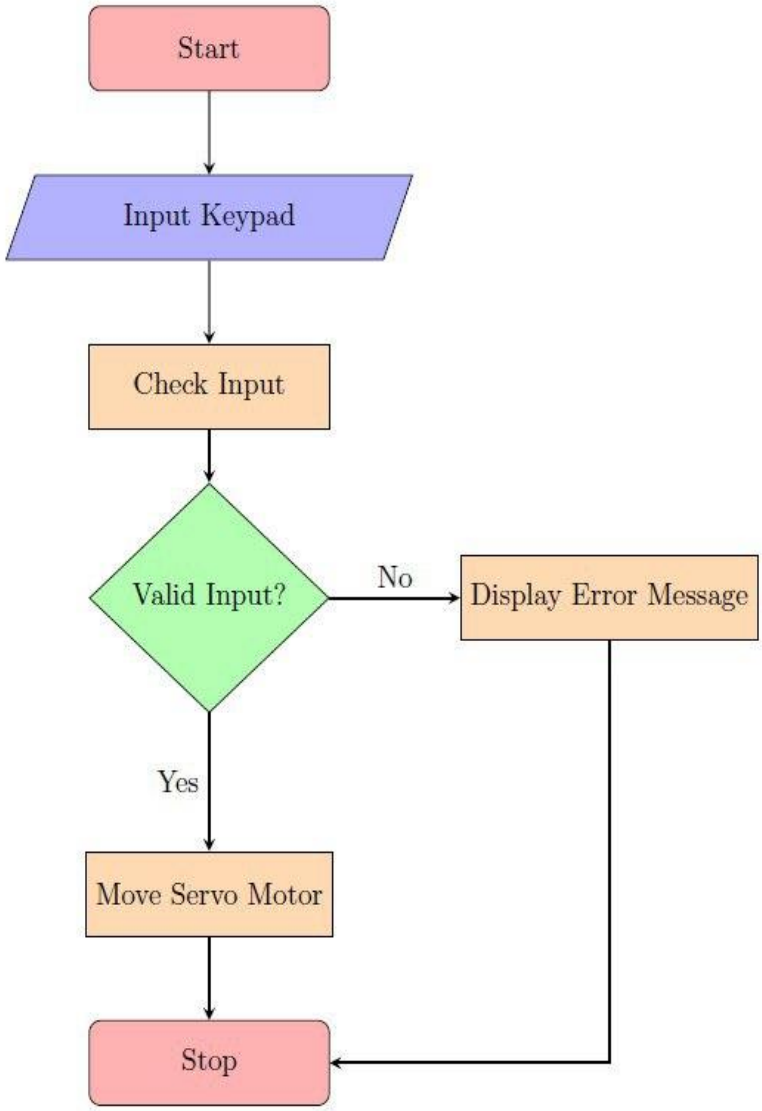
We will use pad4pi and time libraries.

- What is pad4pi and time libraries?

Pad4pi library is an interrupt-based Python 2/3 library for reading matrix keypad key presses using Raspberry Pi GPIO pins.

Time library is a library which contains functions and type definitions for time calculations in the UNIX time format which counts the number of seconds sincethe "epoch".

- Flowchart


Start
Input Keypad
Check Input
Valid Input?
No
Display Error Message
Yes
Move Servo Motor
Stop

- The Code.

```
import RPi.GPIO as GPIO
import time
import drivers ##
from pad4pi import rpi_gpio

KEYPAD = [
    [1, 2, 3, "A"],
    [4, 5, 6, "B"],
    [7, 8, 9, "C"],
    ["*", 0, "#", "D"]
]
ROW_PINS = [17, 27, 22, 5] # BCM numbering
COL_PINS = [23, 24, 25, 16] # BCM numbering

# setup RPi
GPIO.setwarnings(False)

#setup servo config
servo_pin = 12
GPIO.setmode(GPIO.BCM)
GPIO.setup(servo_pin,GPIO.OUT)

# Initialize pwm pin to 20 ms Period or 50HZ frequency
pwm = GPIO.PWM(servo_pin,50)
pwm.start(0)

display = drivers.Lcd()   ##

# Constants
```

```
DEFAULT_INDENT = "     "
input_key_codes = DEFAULT_INDENT
DEFAULT_KEYCODE_LENGTH = 6

def open_lock():
    print("Opening lock...")
    pwm.ChangeDutyCycle(11)
    time.sleep(5)
    print("Closing lock after 5 secs...")
    close_lock()
    pwm.ChangeDutyCycle(0)  # prevent servo from jittering
when not receiving any signal

def close_lock():
    print("Closing lock...")
    pwm.ChangeDutyCycle(2)
    time.sleep(1)

def cleanup():
    pwm.stop()
    GPIO.cleanup()
    display.lcd_clear()     ##
    print("Releasing resources and stopping our
Program...")

def display_to_lcd(data, position = 2, show_input_keycode =
False, duration = 1):    ##
    display.lcd_clear()

    if show_input_keycode:
        display.lcd_display_string("Input Keycode:", 1)
```

```
        display.lcd_display_string(input_key_codes, 2)
        time.sleep(0.1)

    if data is not None:
        display.lcd_display_string(data, position)
    if duration is not None:
        time.sleep(duration)
def init_keypad_driver():
    factory = rpi_gpio.KeypadFactory()
    keypad =
factory.create_keypad(keypad=KEYPAD,row_pins=ROW_PINS,
col_pins=COL_PINS, key_delay=100)

    keypad.registerKeyPressHandler(handle_keypad_press)

def handle_keypad_press(key):
    global input_key_codes

    if key == '*':
        print("Clearing input..")
        input_key_codes = DEFAULT_INDENT
        display_to_lcd(None, None, show_input_keycode =
True)      ##
    elif key == '#':
        if len(input_key_codes.strip()) <
DEFAULT_KEYCODE_LENGTH:
            display_to_lcd("Incomplete!!!", 2,
show_input_keycode = False, duration=1)     ##
            display_to_lcd(None, None, show_input_keycode =
True)      ##
            return
        print("Connecting to REST API Server..")
```

```
        display_to_lcd("Checking......", 2,
show_input_keycode = False)     ##
        with_right = validate_keycode(input_key_codes)
#
        # If with error then do nothing as this will be
displayed in the LCD
        if with_right:
            display_to_lcd("Valid Keycode!", 2,
show_input_keycode = False, duration=1)      ##
            input_key_codes = DEFAULT_INDENT
            open_lock()
            display_to_lcd(None, None, show_input_keycode =
True)               ##
        else:
            display_to_lcd("Invalid Keycode!", 2,
show_input_keycode = False, duration=1)       ##
            input_key_codes = DEFAULT_INDENT
            display_to_lcd(None, None, show_input_keycode =
True)    ##
    else:
        if len(input_key_codes.strip()) ==
DEFAULT_KEYCODE_LENGTH:
            display_to_lcd("Exceed Limit!!!", 2,
show_input_keycode = False, duration=1)    ##
            display_to_lcd(None, None, show_input_keycode =
True)       ##
            return
        input_key_codes += str(key)
        print(f"input_key_codes:: {input_key_codes}")
        display_to_lcd(None, None, show_input_keycode =
True, duration=0.2)      ##


def validate_keycode(keycode):           #
    with_right = False
```

```
    keycode= keycode.strip()
    print(keycode)
    password ="123789"  # The password to open the elevator

    if (password==keycode):
        with_right = True

    return with_right
def main():
    print("Starting our RPi Keypad Database Security
System..")

    display_to_lcd("Initializing..", 1)      ##

    init_keypad_driver()

    display_to_lcd(None, None, show_input_keycode = True)
##
    print("Press buttons on your keypad. Ctrl+C to exit.")

if name == "__main__":
    try:
        while True:
            time.sleep(1)
main()
    except KeyboardInterrupt:
        pass
    finally:
        cleanup()
```

<< Now, let's discuss it line by line >>

➢ Code Explanation

Import Libraries

```
import RPi.GPIO as GPIO
import time
import drivers
from pad4pi import rpi_gpio
```

Fig. (4.2.1)

These are the initial keypad settings and you can alter the GPIO pin assignments here if you want. Also, the Keypad setup can be configured if you have a different keypad membrane like a 3×4.

```
KEYPAD = [
    [1, 2, 3, "A"],
    [4, 5, 6, "B"],
    [7, 8, 9, "C"],
    ["*", 0, "#", "D"]
]

ROW_PINS = [17, 27, 22, 5] # BCM numbering
COL_PINS = [23, 24, 25, 16] # BCM numbering
```

Fig. (4.2.2)

We set up the RPi.gpio settings here and declare the LCD and PWM pin servo as well as starting the PWM at 50Hz frequency.

```
# setup RPi
GPIO.setwarnings(False)

#setup servo config
servo_pin = 12
GPIO.setmode(GPIO.BCM)
GPIO.setup(servo_pin,GPIO.OUT)

# Initialize pwm pin to 20 ms Period or 50HZ frequency
pwm = GPIO.PWM(servo_pin,50)
pwm.start(0)

display = drivers.Lcd()   ##
```

Fig. (4.2.3)

These are the constants needed to display properly in the I2C LCD

```
# Constants
DEFAULT_INDENT = "      "
input_key_codes = DEFAULT_INDENT
DEFAULT_KEYCODE_LENGTH = 6
```

Fig. (4.2.4)

The open_lock and close_lock functions are needed to open or close the lock. It works by changing the duty cycle of the servo motor.

```
def open_lock():
    print("Opening lock...")
    pwm.ChangeDutyCycle(11)
    time.sleep(5)
    print("Closing lock after 5 secs...")
    close_lock()
    pwm.ChangeDutyCycle(0)  # prevent servo from jittering when not receiving any signal

def close_lock():
    print("Closing lock...")
    pwm.ChangeDutyCycle(2)
    time.sleep(1)
```

Fig. (4.2.5)

The cleanup function is used to release resources when we exit our code.

```
def cleanup():
    pwm.stop()
    GPIO.cleanup()
    display.lcd_clear()     ##
    print("Releasing resources and stopping our Program...")
```

Fig. (4.2.6)

The display_to_lcd function is used to display text in our LCD.

```
def display_to_lcd(data, position = 2, show_input_keycode = False, duration = 1):
    display.lcd_clear()

    if show_input_keycode:
        display.lcd_display_string("Input Keycode:", 1)
        display.lcd_display_string(input_key_codes, 2)
        time.sleep(0.1)

    if data is not None:
        display.lcd_display_string(data, position)
    if duration is not None:
        time.sleep(duration)
```

Fig. (4.2.7)

The handle_keypad_press handles the core processing of our project. This function does the following things:

- It reads the keys entered in our keypad and updates the variable input_key_codes .
- It responds to special keys "*" or "#" that will clear the LCD display or call our check password to validate the inputted keycodes.
- It does validation of keycodes and tells the user if an error occurs or if everything is successful or not by displaying it through the LCD.
- It opens and closes the door lock when the inputted keycodes are correct or not.

```
def handle_keypad_press(key):
    global input_key_codes

    if key == '*':
        print("Clearing input..")
        input_key_codes = DEFAULT_INDENT
        display_to_lcd(None, None, show_input_keycode = True)      ##
    elif key == '#':
        if len(input_key_codes.strip()) < DEFAULT_KEYCODE_LENGTH:
            display_to_lcd("Incomplete!!!", 2, show_input_keycode = False, duration=1)
            display_to_lcd(None, None, show_input_keycode = True)      ##
            return


        print("Connecting to REST API Server..")
        display_to_lcd("Checking......", 2, show_input_keycode = False)     ##
        with_right = validate_keycode(input_key_codes)          #

        # If with error then do nothing as this will be displayed in the LCD
        if with_right:
            display_to_lcd("Valid Keycode!", 2, show_input_keycode = False, duration=1)
            input_key_codes = DEFAULT_INDENT
            open_lock()
            display_to_lcd(None, None, show_input_keycode = True)               ##
        else:
            display_to_lcd("Invalid Keycode!", 2, show_input_keycode = False, duration=1)
            input_key_codes = DEFAULT_INDENT
            display_to_lcd(None, None, show_input_keycode = True)    ##
```

```
    else:
        if len(input_key_codes.strip()) == DEFAULT_KEYCODE_LENGTH:
            display_to_lcd("Exceed Limit!!!", 2, show_input_keycode = False, duration=1)    ##
            display_to_lcd(None, None, show_input_keycode = True)       ##
            return
        input_key_codes += str(key)
        print(f"input_key_codes:: {input_key_codes}")
        display_to_lcd(None, None, show_input_keycode = True, duration=0.2)      ##
```

Fig. (4.2.8)

This validate_keycode It checks the password that was entered by the user, if it is correct, the elevator doors will be opened, and if it is wrong, the elevator doors will not be opened. It handles the error as well.

```
def validate_keycode(keycode):            #
    with_right = False
    keycode= keycode.strip()
    print(keycode)
    password ="123789"  # The password to open the elevator

    if (password==keycode):
        with_right = True

    return with_right
```

Fig. (4.2.9)

This is the main function of our project and this serves as the entry point of everything. it bootstraps all the necessary drivers for the LCD or the keypad or the servo.

```
def main():
    print("Starting our RPi Keypad Database Security System..")

    display_to_lcd("Initializing..", 1)      ##

    init_keypad_driver()

    display_to_lcd(None, None, show_input_keycode = True)    ##

    print("Press buttons on your keypad. Ctrl+C to exit.")
```

Fig. (4.2.10)

This function keeps our project running in the background.

```
if __name__ == "__main__":
    try:
        while True:
            time.sleep(1)
            main()
    except KeyboardInterrupt:
        pass
    finally:
        cleanup()
```

Fig. (4.2.11)

4.3 Face Recognition

Facial recognition is a way of identifying or confirming an individual's identity using their face. Facial recognition systems can be used to identify people in photos, videos, or in real-time.

Facial recognition is a category of biometric security. Other forms of biometric software include voice recognition, fingerprint recognition, and eye retina or iris recognition. The technology is mostly used for security and law enforcement, though there is increasing interest in other areas of use.

➢ How it works?

Many people are familiar with facial recognition technology thanks to Face ID, which is now widely used in the mobile market. Typically, facial recognition doesn't use a huge database of photos to determine a person's identity; it merely identifies and recognizes one person as the sole owner of the device, limiting access to others. Facial recognition systems are used in several domains today, but in general they follow this type of operation:

- Step 1: Face Detection

The camera detects and locates an image of a face, either alone or in a crowd. The image may depict the person looking straight at the camera or in profile.

- Step 2: Face Analysis

The face image is captured and analyzed. The software examines the geometry of the face and some key factors, which include variables such as the distance between the eyes, the depth of the eye sockets, the distance between the forehead and the chin, the shape of the cheekbones and the contour of the lips, eyes and chin. They aim to identify the main features of the face and are essential to distinguish it.

- Step 3: Convert the image into data

The face capture process transforms the information about the face into a set of digital information. This set of information is stored in the form of a

numeric code called a faceprint. A person's faceprint is as unique as their fingerprints.

- Step 4: Finding a match

The subject's faceprint is compared to a database of known faces. For example, the FBI can access up to 650 million photos from various government databases. On Facebook, any photo tagged with a person's name is entered into Facebook's database, which can be used for facial recognition. If the facial fingerprint matches an image in a facial recognition database, identification is performed.

➢ Code and its implementation line by line:

The whole code:

```
import cv2
import numpy as np
import face_recognition
import os

#path = 'persons'
path = '/home/mahana/code/ras pi/Face-recognition-python-project-main/persons'
images = []
classNames = []
personsList = os.listdir(path)

for cl in personsList:
    curPersonn = cv2.imread(f'{path}/{cl}')
    images.append(curPersonn)
    classNames.append(os.path.splitext(cl)[0])
print("classNames ", classNames)

def findEncodeings(image):
    encodeList = []
    for img in images:
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
        encode = face_recognition.face_encodings(img)[0]
        encodeList.append(encode)
    return encodeList

encodeListKnown = findEncodeings(images)
print('Encoding Complete.')
```

Fig. (4.3.1)

```
cap = cv2.VideoCapture(0)

while True:
    _, img = cap.read()

    imgS = cv2.resize(img, (0,0), None, 0.25, 0.25)
    imgS = cv2.cvtColor(imgS, cv2.COLOR_BGR2RGB)

    faceCurentFrame = face_recognition.face_locations(imgS)
    encodeCurentFrame = face_recognition.face_encodings(imgS, faceCurentFrame)

    for encodeface, faceLoc in zip(encodeCurentFrame, faceCurentFrame):
        matches = face_recognition.compare_faces(encodeListKnown, encodeface)
        faceDis = face_recognition.face_distance(encodeListKnown, encodeface)
        matchIndex = np.argmin(faceDis)

        if matches[matchIndex]:
            name = classNames[matchIndex].upper()
            #print(name)
            name = ''.join((z for z in name if not z.isdigit()))
            y1, x2, y2, x1 = faceLoc
            y1, x2, y2, x1 = y1*4, x2*4, y2*4, x1*4
            cv2.rectangle(img, (x1, y1), (x2, y2), (0,0,255), 2)
            cv2.rectangle(img, (x1,y2-35), (x2,y2), (0,0,255), cv2.FILLED)
            cv2.putText(img, name, (x1+6, y2-6), cv2.FONT_HERSHEY_COMPLEX, 1, (255,255,255), 2)
            name = classNames[matchIndex].upper()

        else:
            name = "unknown"
            #print(name)
            y1, x2, y2, x1 = faceLoc
            y1, x2, y2, x1 = y1*4, x2*4, y2*4, x1*4
            cv2.rectangle(img, (x1, y1), (x2, y2), (0,0,255), 2)
            cv2.rectangle(img, (x1,y2-35), (x2,y2), (0,0,255), cv2.FILLED)
            cv2.putText(img, name, (x1+6, y2-6), cv2.FONT_HERSHEY_COMPLEX, 1, (255,255,255), 2)
```



```
            print(name)

        cv2.imshow('Face Recogntion', img)

        if cv2.waitKey(1) & 0xFF == ord('q'):
            break
cap.release()
cv2.destroyAllWindows()
```

Fig. (4.3.2)

<<Now, let's explain it line by line>>

1- Import necessary libraries

```
import cv2
import numpy as np
import face_recognition
import os
```

Fig. (4.3.3)

Here, we imported all the libraries that we will need for the rest of the code to work. Which they are:

- The OpenCV (cv2) library is imported, which is used for working with images and videos.
- The numpy library is imported, which is used for scientific computing and working with arrays.
- The face_recognition library is imported, which is a simple library for easilly apply face recognition technology.
- The os library is imported, which provides a way of using operating system dependent functionality.

2- Set the path to the directory containing the images of known people, and load the images and their respective names into memor

```
path = 'persons'
images = []
classNames = []
personsList = os.listdir(path)

for cl in personsList:
    curPersonn = cv2.imread(f'{path}/{cl}')
    images.append(curPersonn)
    classNames.append(os.path.splitext(cl)[0])
print("classNames ", classNames)
```

Fig. (4.3.4)

- path is the path to the directry containing the images of known people.
- images is a list of all the images of known people
- classNames is a list of the names of the known people.
- os.listdir(path) returns a list of all the files in the directory specified by path.

- cv2.imread() is used to read the image file from disk.
- os.path.splitext() is used to split the file name and extension, and return only the file name
- The print() statement at the end simply prints out the list of person name

3- Define a function to encode the face images:

```
def findEncodeings(image):
    encodeList = []
    for img in images:
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
        encode = face_recognition.face_encodings(img)[0]
        encodeList.append(encode)
    return encodeList

encodeListKnown = findEncodeings(images)
print('Encoding Complete.')
```

Fig. (4.3.5)

- findEncodeings() takes an image as input and returns a list of face encodings.
- cv2.cvtColor() is used to convert the image from BGR to RGB, which is the color format used by face_recognition.
- face_recognition.face_encodings() is used to encode the face in the image.
- The resulting encodings are added to the encodeList and returned.

4- Start the video capture and loop through each frame of the video:

```
encodeListKnown = findEncodeings(images)
print('Encoding Complete.')

cap = cv2.VideoCapture(0)
```

Fig. (4.3.6)

- cv2.VideoCapture() is used to start the video capture from the default camera (camera 1).
- cap.read() is used to read the next frame from the video capture.

5- Resize the image, detect faces, and encode the faces:

```
imgS = cv2.resize(img, (0,0), None, 0.25, 0.25)
imgS = cv2.cvtColor(imgS, cv2.COLOR_BGR2RGB)

faceCurentFrame = face_recognition.face_locations(imgS)
encodeCurentFrame = face_recognition.face_encodings(imgS, faceCurentFrame)
```

Fig. (4.3.7)

- cv2.resize() is used to resize the image to a smaller size for faster processing.
- face_recognition.face_locations() is used to detect the location of faces in the resized image.
- face_recognition.face_encodings() is used to encode the faces detected in the image.

6- Loop through each encoded face and compare it to the known faces:

```
for encodeface, faceLoc in zip(encodeCurentFrame, faceCurentFrame):
    matches = face_recognition.compare_faces(encodeListKnown, encodeface)
    faceDis = face_recognition.face_distance(encodeListKnown, encodeface)
    matchIndex = np.argmin(faceDis)

    if matches[matchIndex]:
        name = classNames[matchIndex].upper()
        #print(name)
        name = '' .join((z for z in name if not z.isdigit()))
        y1, x2, y2, x1 = faceLoc
        y1, x2, y2, x1 = y1*4, x2*4, y2*4, x1*4
        cv2.rectangle(img, (x1, y1), (x2, y2), (0,0,255), 2)
        cv2.rectangle(img, (x1,y2-35), (x2,y2), (0,0,255), cv2.FILLED)
        cv2.putText(img, name, (x1+6, y2-6), cv2.FONT_HERSHEY_COMPLEX, 1, (255,255,255), 2)
        name = classNames[matchIndex].upper()

    else:
        name = "unknown"
        #print(name)
        y1, x2, y2, x1 = faceLoc
        y1, x2, y2, x1 = y1*4, x2*4, y2*4, x1*4
        cv2.rectangle(img, (x1, y1), (x2, y2), (0,0,255), 2)
        cv2.rectangle(img, (x1,y2-35), (x2,y2), (0,0,255), cv2.FILLED)
        cv2.putText(img, name, (x1+6, y2-6), cv2.FONT_HERSHEY_COMPLEX, 1, (255,255,255), 2)

    print(name)
```

Fig. (4.3.8)

- zip() is used to iterate over two lists simultaneously (encodeCurentFrame and faceCurentFrame).
- face_recognition.compare_faces() is used to compare the face encodings of the current frame with the known face encodings.
- face_recognition.face_distance() is used to calculate the distance between the face encodings of the current frame and the known face encodings.
- np.argmin() is used to get the index of the minimum distance.
- If there is a match, the name of the person is obtained from the classNames list and displayed on the screen along with a bounding box around the face.
- If there is no match, the name "unknown" is displayed on the screen along with a bounding box around the face.
- cv2.rectangle() is used to draw a rectangle around the face.
- cv2.putText() is used to display the name of the person on the screen next to the bounding box.

7- Display the image with the detected faces:

```
    cv2.imshow('Face Recogntion', img)

    if cv2.waitKey(1) & 0xFF == ord('q'):
        break
cap.release()
cv2.destroyAllWindows()
```

Fig. (4.3.9)

- cv2.imshow() is used to display the image with the detected faces.
- if cv2.waitKey(1) & 0xFF == ord('q'): waits for a key event for 1 millisecond. If the key pressed is 'q', it breaks out of the loop. The 0xFF is a bit mask which sets all bits to 1, so that it can remove

any extra bits that may be added by the OS. This is done for cross-platform compatibility.

- cap.release() releases the camera resource that was being used for image capture.
- cv2.destroyAllWindows() closes the windows that were created by the cv2.imshow() function.

4.4 Encoder

A DC geared motor with an encoder is a type of electric motor that is commonly used in robotics, automation, and other applications that require precise control over the motor's speed and position. The motor is designed with a gearbox that reduces the motor's speed and increases its torque. The encoder provides feedback on the motor's position and speed, enabling the motor to be controlled with greater accuracy.

The motor typically has two sets of electrical contacts, one for power (positive and negative) and one for the encoder. The encoder is a sensor that detects the rotation of the motor's output shaft and provides feedback on the position and speed of the motor. This allows the motor to be precisely controlled and positioned.

DC geared motors with encoders are available in a range of sizes and specifications, including different gear ratios, motor speeds, torque ratings, and encoder resolutions. They can be controlled with a variety of motor drivers and controllers, including microcontrollers, motor control boards, and specialized motor control chips.

When selecting a DC geared motor with an encoder, it is important to consider the specific requirements of your application, including the motor's speed, torque, and power requirements, as well as the precision and accuracy of the encoder. Additionally, it is important to select a motor that is compatible with your motor driver or controller, and to ensure that the motor's physical dimensions and mounting options are suitable for your application.

- SPECIFICATION

Motor Rated Voltage: 6V

Encoder Rated Voltage: 3.3 / 5V

Reducer Reduction Ratio: 1: 34

No load Speed: 210RPM@0.13A

Maximum Efficiency Point: load 2.0kg·cm/170RPM/2.0W/0.6A

Maximum Power point: Load 5.2kg·cm/110RPM/3.1W/1.1A

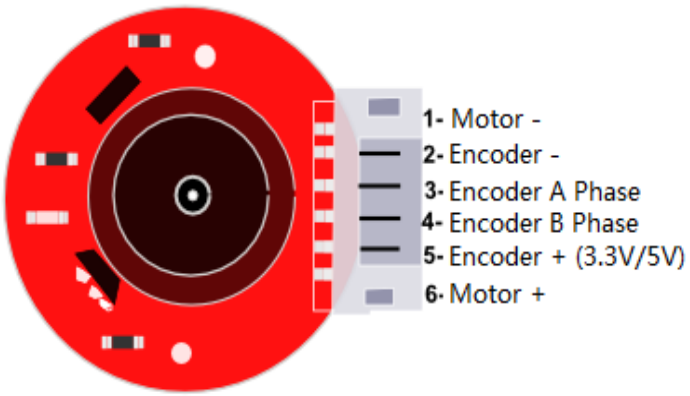
Stall Torque: 10kg·cm

Stall Current: 3.2A

Hall Resolution: Hall Resolution 11x Precision Reduction Ratio 34.02 = 341.2PPR

Dimension: 52 * Φ24.4 mm / 2.05 * Φ0.96inches

Weight: 96g



➢ Code and its implementation line by line:

The whole code:

```
# Set GPIO pin numbers
import RPi.GPIO as GPIO
import time
IN1 = 16
IN2 = 18
EN = 32
sp_forward= 1.743
sp_backward= 1.494

#Set GPIO mode and pin direction
GPIO.setmode(GPIO.BOARD)
GPIO.setup(IN1, GPIO.OUT)
GPIO.setup(IN2, GPIO.OUT)
GPIO.setup(EN, GPIO.OUT)

# Create PWM object
pwm = GPIO.PWM(EN, 10)  # 1 kHz frequency

# Start PWM at 0% duty cycle
pwm.start(0)

# Function to drive motor forward
def motor_forward(num_floors):
    GPIO.output(IN1,True)
    GPIO.output(IN2, False)
    pwm.ChangeDutyCycle(100)  # 50% duty cycle
    time.sleep(sp_forward * num_floors)
    motor_stop()
# Function to drive motor backward
def motor_backward(num_floors):
    time.sleep(1)
    GPIO.output(IN2, True)
    GPIO.output(IN1, False)
    pwm.ChangeDutyCycle(100)  # 50% duty cycle
    time.sleep(sp_backward * num_floors)
    motor_stop()

# Function to stop motor
def motor_stop():
    GPIO.output(IN1, False)
    GPIO.output(IN2, False)
    pwm.ChangeDutyCycle(0)  # 0% duty cycle

motor_forward(1)
time.sleep(1)
motor_backward(1)
```

Fig. (4.4.1)

<<Now, let's explain it line by line>>

1- Import libs and set pins:

```
# Set GPIO pin numbers
import RPi.GPIO as GPIO
import time
IN1 = 16
IN2 = 18
EN = 32
sp_forward= 1.743
sp_backward= 1.494
```

Fig. (4.4.2)

- The first few lines set up the necessary imports and define some constants. Specifically, this code sets the pin numbers for three GPIO pins on a Raspberry Pi board (IN1, IN2, and EN) and defines two speed constants (sp_forward and sp_backward).

2- Config the GPIO mode and pin direction:

```
#Set GPIO mode and pin direction
GPIO.setmode(GPIO.BOARD)
GPIO.setup(IN1, GPIO.OUT)
GPIO.setup(IN2, GPIO.OUT)
GPIO.setup(EN, GPIO.OUT)
```

Fig. (4.4.3)

- These lines configure the GPIO mode and pin direction using the RPi.GPIO library. Specifically, it sets the mode to GPIO.BOARD (which uses the physical pin numbers on the board rather than the BCM GPIO numbers), and sets IN1, IN2, and EN as output pins.

3- Create PWM object with initial 0% duty cycle:

```
pwm = GPIO.PWM(EN, 10)  # 1 kHz frequency
pwm.start(0)
```

Fig. (4.4.4)

- These lines create a Pulse Width Modulation (PWM) object using the RPi.GPIO library, using EN as the pin and a frequency of 10 Hz. It then starts the PWM with a duty cycle of 0%.

4- Function for forward movement:

```
def motor_forward(num_floors):
    GPIO.output(IN1,True)
    GPIO.output(IN2, False)
    pwm.ChangeDutyCycle(100)
    time.sleep(sp_forward * num_floors)
    motor_stop()
```

Fig. (4.4.5)

- This code defines a function called motor_forward that takes one argument, num_floors. When called, the function sets IN1 to True (i.e., sets it High) and IN2 to False (i.e., sets it Low), sets the PWM duty cycle to 100% (i.e., sets it to High), sleeps for a duration of sp_forward * num_floors seconds, and then calls the motor_stop function to stop the motor.

5- Function for backward movement:

```
def motor_backward(num_floors):
    time.sleep(1)
    GPIO.output(IN2, True)
    GPIO.output(IN1, False)
    pwm.ChangeDutyCycle(100)
    time.sleep(sp_backward * num_floors)
    motor_stop()
```

Fig. (4.4.6)

- This code defines a function called motor_backward that takes one argument, num_floors. When called, the function sleeps for 1 second, sets IN2 to True (i.e., sets it High) and IN1 to False (i.e., sets it Low), sets the PWM duty cycle to 100% (i.e., sets it to High), sleeps for a duration of sp_backward * num_floors seconds, and then calls the motor_stop function to stop the motor.

6- Function to stop motor movement:

```
def motor_stop():
    GPIO.output(IN1, False)
    GPIO.output(IN2, False)
    pwm.ChangeDutyCycle(0)  # 0% duty cycle
```

Fig. (4.4.7)

- This code defines a function called motor_stop that stops the motor by setting IN1 and IN2 to False and setting the PWM duty cycle to 0%.

7- Call and test the movement functions:

```
motor_forward(1)
time.sleep(1)
motor_backward(1)
```

Fig. (4.4.8)

- Finally, this code calls the motor_forward function with an argument of 1, sleeps for 1 second, and then calls the motor_backward function with an argument of 1. This will cause the motor to move forward for I floor , then stop for 1 second, and then move backward for 1 floor before stopping again.

4.5 Speech Recognition

```
import speech_recognition as sr

# Initialize the recognizer
r = sr.Recognizer()

# Use the default microphone as the source
with sr.Microphone() as source:
    print("Say something...")
    audio = r.listen(source)
```

Fig. (4.5.1)

This code slide demonstrates how to use the SpeechRecognition library to capture audio from the default microphone source and convert it to text. Here's an overview of the code:

- The code initializes a recognizer object `r` from the `Recognizer` class in the SpeechRecognition module.

- The default microphone is set as the audio source using the `Microphone` class.
- Inside the `with` statement, the code creates a context for the microphone as the source. This ensures that the microphone resource is properly released after use, even if an exception occurs.
- The code prints "Say something..." to the console, prompting the user to speak.
- The `listen()` method of the recognizer object is called with the microphone source as the argument. This captures the audio input from the microphone.
- The captured audio is stored in the `audio` variable.

This code snippet sets up the speech recognition system to listen to audio input from the default microphone source. Once the audio is captured, it can be further processed using speech recognition algorithms to convert it into text.

```
try:
        # Recognize speech using Google Speech Recognition
        text = r.recognize_google(audio)
        print("You said: " + text)

        # Convert recognized text to lowercase for easier comparison
        text = text.lower()

        # Check the recognized text and print the corresponding number
        if any(word in text for word in ["done", "run", "gun", "1", "anas" ,"one" ," done " , "run " , " gun " , " one " , "
            print("wait floor one")
        elif any(word in text for word in ["two", "too", "2", "to" ,"Too" , "To" ,"zoo" ,"do", "Two" , "Tow" ,"toe" ,"teo"
            print("wait floor two")
        elif any(word in text for word in ["three", "triad", "3", "trine" , "trio" , "threo" , "sree" , "sre" , "threo" , "t
            print("wait floor three")
        elif any(word in text for word in ["four", "for", "fur", "4" ,"word" , "fuor" ,"fuar" , "foor", "Ford" ,"foar","faor
            print("wait floor four")
        elif any(word in text for word in ["five", "vive", "files", "5" , "five" , "vive" ,"fife" , "faif", "feif", "faife"
            print("wait floor five")
        else:
            print("The last floor is the fifth. Please choose between 1 to.... 5 floors")

    except sr.UnknownValueError:
        print("Google Speech Recognition could not understand audio")
    except sr.RequestError as e:
        print("Could not request results from Google Speech Recognition service; {0}".format(e))
```

Fig. (4.5.2)

This code slide demonstrates the process of recognizing speech input using Google Speech Recognition and determining a corresponding floor number based on the recognized text. Here's a breakdown of the code:

- The code is wrapped in a `try-except` block to handle potential exceptions that may occur during speech recognition.
- Within the `try` block, the captured audio from the previous slide is passed to the `recognize_google()` method of the recognizer object `r`. This method uses Google Speech Recognition service to convert the audio to text.
- The recognized text is stored in the variable `text`.
- The code prints "You said: " followed by the recognized text to the console.
- The recognized text is converted to lowercase for easier comparison.
- The code checks the recognized text for specific keywords using the `any()` function and compares them to different lists of words associated with each floor number.
- If any of the keywords match, it prints the corresponding floor number.
- If none of the keywords match, it prints a message indicating that the last floor is the fifth and prompts the user to choose between 1 and 5 floors.
- In case of an `sr.UnknownValueError`, which occurs when the speech recognition system fails to understand the audio, it prints a corresponding message.
- In case of an `sr.RequestError`, which occurs when there is an error in accessing the Google Speech Recognition service, it prints an error message with the specific error details.

Overall, this code slide processes the recognized text, compares it with predefined keywords for different floor numbers, and prints the corresponding floor number or an error message if the recognition process fails.

CHAPTER 5

MANUAL USER GUIDE

Welcome to the user guide for the smart elevator using face recognition and hand detection or speech recognition technology. This guide will provide you with the necessary instructions to use the elevator efficiently and safely.

1- Face Recognition Technology:

- Stand in front of the elevator camera.

Fig. (5.1.1)

- The camera will recognize your face and display your name on the screen.

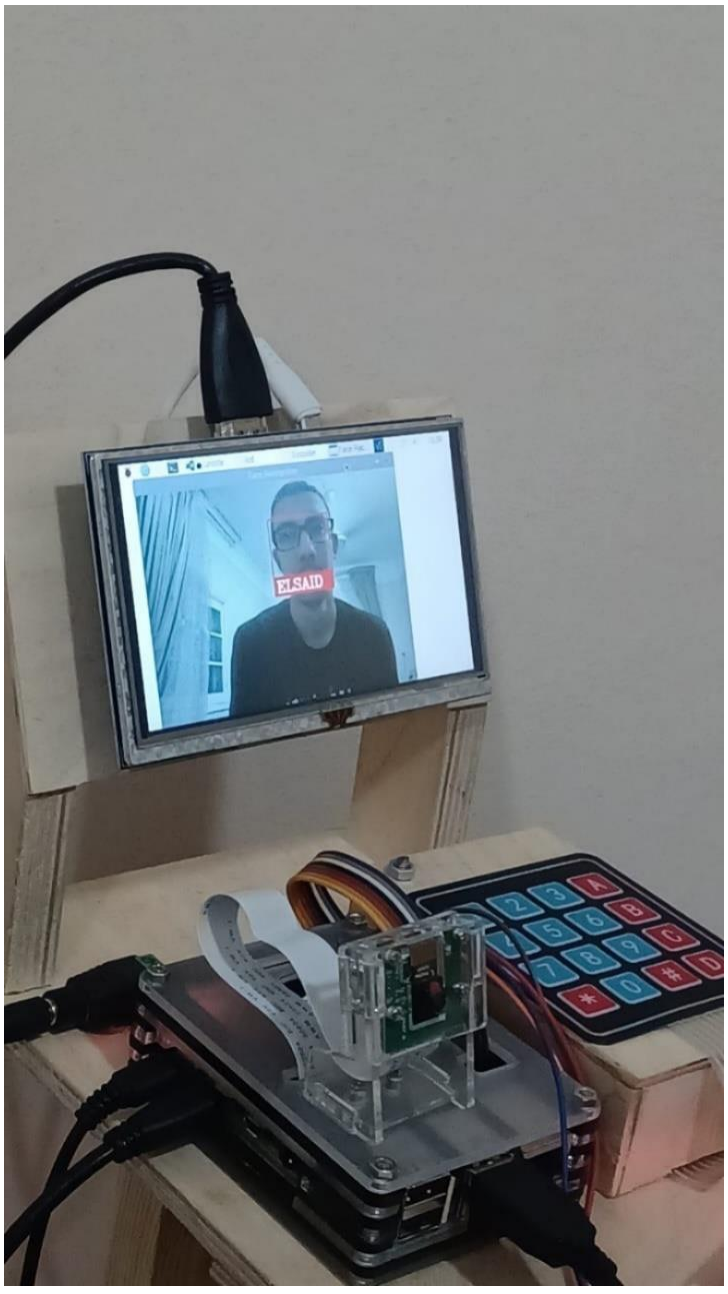


Fig. (5.1.2)

After that you will go to the second part of the project

2- Hand Detection Technology:

- Stand in front of the elevator camera.
- Raise your hand and make a gesture towards the display screen.

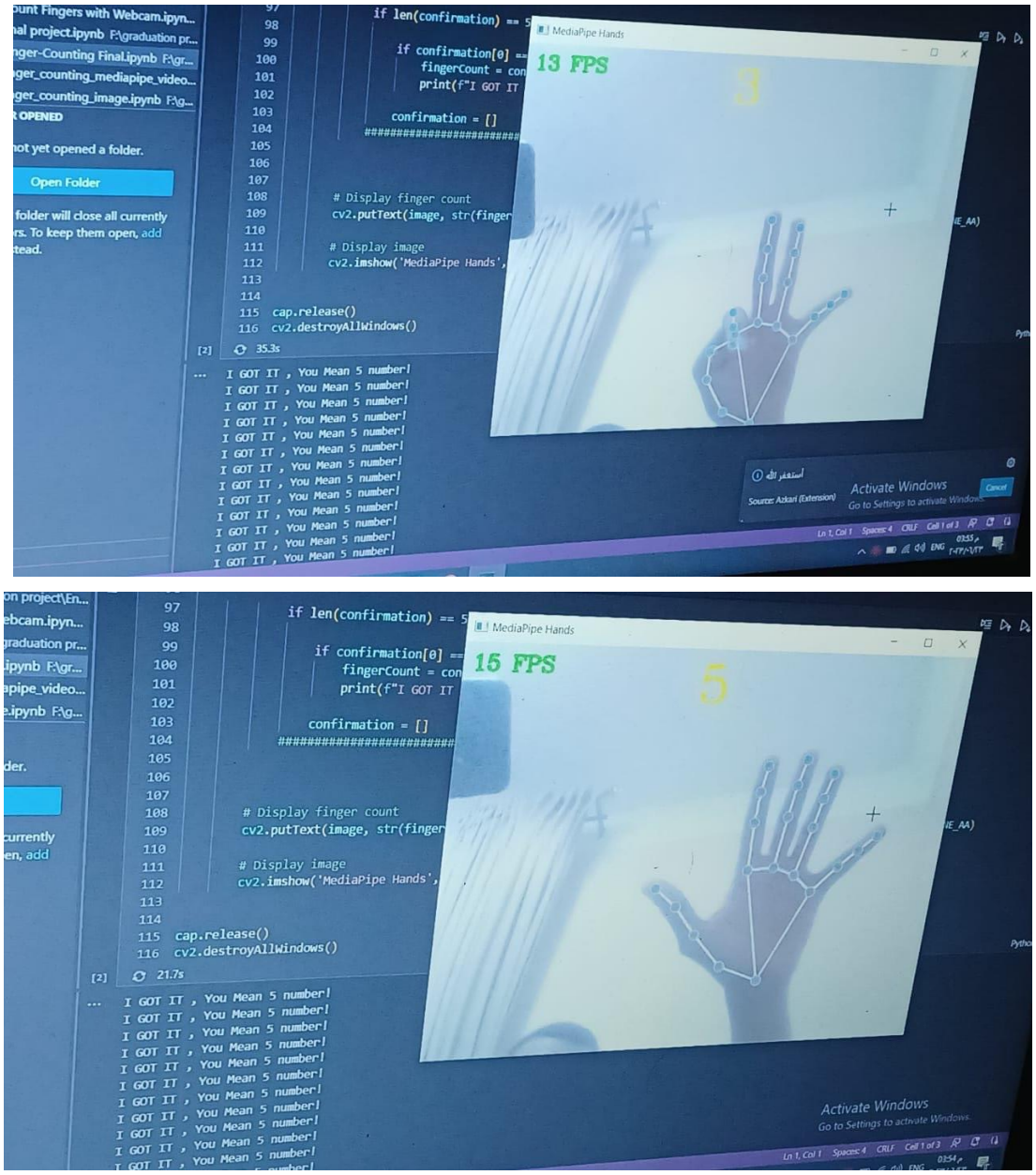


Fig. (5.2.1)

- The camera will recognize your gesture and display a menu of floor options.

- Select your desired floor by making a gesture towards the corresponding floor number.
- The elevator will automatically take you to your desired floor.

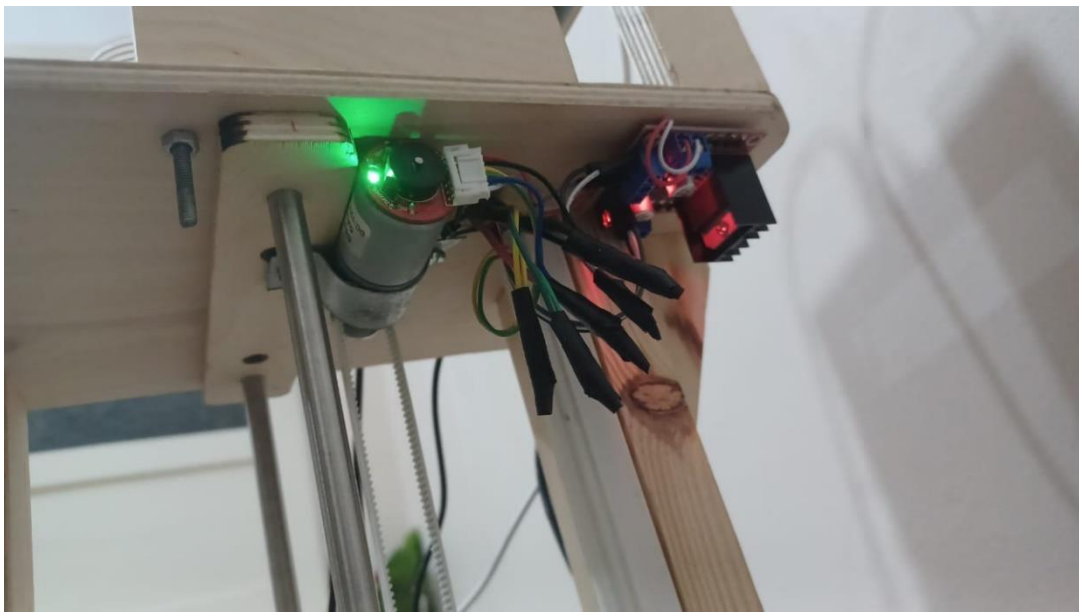


Fig. (5.2.2)

Fig. (5.2.3)

CHAPTER 6

FUTURE-PROOFING

The construction market worldwide is estimated to reach $24,334.9 billion in the coming years, and the demand for smarter elevators is on the rise, boosting the IoT-driven elevator market.

Some countries in North America and Europe even have regulations to maintain records of the usage, inspections, and maintenance of elevators. Smart elevator solutions are helpful for safer use and regulatory compliance related to residential and commercial amenities.

The recent advancements in the elevator industry use IoT and AI, enabling it to become more efficient, safe, and reliable. These innovations have been introduced to improve passenger experience as well as increase revenue generation for companies by eliminating downtime from maintenance work.

➢ 6.1 Why deploying a smart elevator solution is a good idea?

Adopting the new generation of smart elevators is more beneficial than using the traditional ones as they are highly efficient. They eliminate the need for manual maintenance, testing, and tracking records of every machine individually. Installing a smart elevator system is cost-effective, and managing it is less time-consuming. Here is why deploying a smart elevator solution a good idea:

- Avoid unauthorized access

Smart elevators can allow access to only authorized personnel through fingerprint or face ID.

The information is verified in real time, and the person has access to the elevator only if he is authorized to use it. Smart cards are used in many five-star hotel chains to give customers access to certain floors according to their membership status in the hotel.

- 2- Predict destination

The smart elevator system uses AI for face recognition and retrieves user information from the IoT-enabled cloud in real-time. The ML algorithm reviews historical data to define the destination floor of the user. If the user data indicates visits to multiple floors, then the VoIP protocol is activated to communicate with the user. A voice message from the elevator enquires about the destination and records the user's response. Users can define the destination floor using a voice command. It is a smart solution to avoid contacting surfaces in a sensitive environment or during a pandemic.

➢ 6.2 Features of smart elevators

Smart elevators can make real-time maintenance decisions, monitor performance, offer advanced reporting and provide updated status. A smart elevator has the following features:

- Predictive maintenance

The use of IoT in the elevator and escalator industry is being recognized for its potential to reduce costly downtime. Smart elevators can tap into the power of predictive maintenance and detect problems before they arise.

This leads to greater efficiency and lesser expenses due to limited repair work. The system automates maintenance monitoring to minimize human intervention and reduce downtime. Which manager does not want that?

- Edge computing

To ensure the safety and security of passengers in an emergency, you need to initiate a faster response time from an elevator. In smart elevators, the edge computing nodes of the network collect video and images of the interiors to quickly share the information with the facility manager and the elevator's geographic position to prevent any mishaps or security lapses.

- Flexible customization

Elevators can be customized in many different ways. You can choose the lights and wall panels of your elevator's interiors and pick varying materials for the exterior. You can personalize the ambiance using sensors and hardware controlled by a mobile app.

This level of customization helps create a space that suits different moods and meets changing needs of the customer base.

➢ 6.3 Types of smart sensors that will be used in the future.

We need to develop our project in future, so there are some sensors we need to add them to keep in touch with people and make it more comfortable.

• 6.3.1 Smoker Sensor

Fig. (6.3.1)

A smoke sensor detects fire through the presence of smoke and temperature changes in an environment. It triggers an alarm and indicates through light in case of a fire. The device also sends notifications over your mobile phone to keep you informed even when you are away.

- 6.3.2 Photoelectric Sensor

Fig. (6.3.2)

The photoelectric sensor is a device that can determine the presence of an object by measuring how much light reaches its receiver. These sensors often find use in industrial manufacturing facilities. The sensors also help in estimating the distance. The three types of sensors are opposed (through-beam), retro-reflective, and proximity-sensing (diffused).

Or we can use Motion Sensor

- 6.3.3 Motion Sensor

Fig. (6.3.3)

A motion sensor detects and measures movement using a sensor unit. The embedded computer processes the signals to activate connected systems and trigger alarms. Depending upon their components and usage, the sensors may be classified as active motion sensors and passive motion sensors.

- r6.3.4 Earthquake Sensor

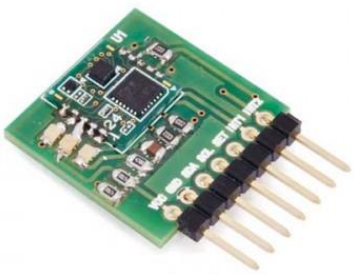


Fig. (6.3.4)

Seismic sensors are velocity sensors or accelerometers that detect earthquake vibrations or tremors. They may trigger an alarm or even automatically shut off fuel or electricity supplies in the elevator. Such sensors may be classified as P-wave sensors that detect the initial tremors and S-wave sensors that detect the major earthquakes.

- 6.3.5 Proximity Sensor

Fig. (6.3.5)

Proximity sensors emit electromagnetic radiation for detecting the presence of objects without any physical contact. Differentiation of sensors is based on the material to be sensed. Capacitive proximity sensors or photoelectric sensors are suitable for plastic targets. On the other hand, an inductive proximity sensor helps detect metal targets.

If this elevator is located in an airport or a sensitive government facility, then this sensor will be an additional confirmation after inspection

- Temperature sensor

Fig. (6.3.6)

Temperature sensor If the elevator is air-conditioned, it can determine the temperature and control it by reading the temperature, in order to give an order to the air conditioner to turn on or off, for example, if the temperature is above 24 degrees Celsius, it can turn on the air conditioner, and if the temperature is 24 degrees Celsius or At least he can turn off the air conditioner to save energy

CHAPTER 7
CONCLUSION

In conclusion, a smart elevator system using face recognition and hand detection technology offers a highly secure and convenient way to move between floors. This cutting-edge technology brings a new level of convenience to the elevator experience by providing a touchless interface that eliminates the need for physical contact and reduces the risk of viral transmission.

The system's face recognition technology allows for quick and accurate identification of authorized users, ensuring that only those who are authorized can access the elevator.

In addition to facial recognition, the system also uses hand detection technology to detect when a user wants to call the elevator or select a floor. This functionality further enhances the user experience by providing a highly intuitive and responsive interface that requires minimal effort to use.

The smart elevator system is also designed with safety in mind. In the event of an emergency, the system is equipped with a manual override function that allows users to safely exit the elevator. This feature provides added peace of mind and ensures that users are always able to evacuate the elevator quickly and safely.

Overall, a smart elevator system using face recognition and hand detection technology is an innovative and reliable way to enhance the efficiency and safety of vertical transportation. By using advanced biometric technologies, this system provides a highly secure and convenient user experience that is unmatched by traditional elevator systems. As technology continues to evolve, we can expect to see even more exciting innovations in the field of smart elevators that will continue to improve the way we move between floors.

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