ES101

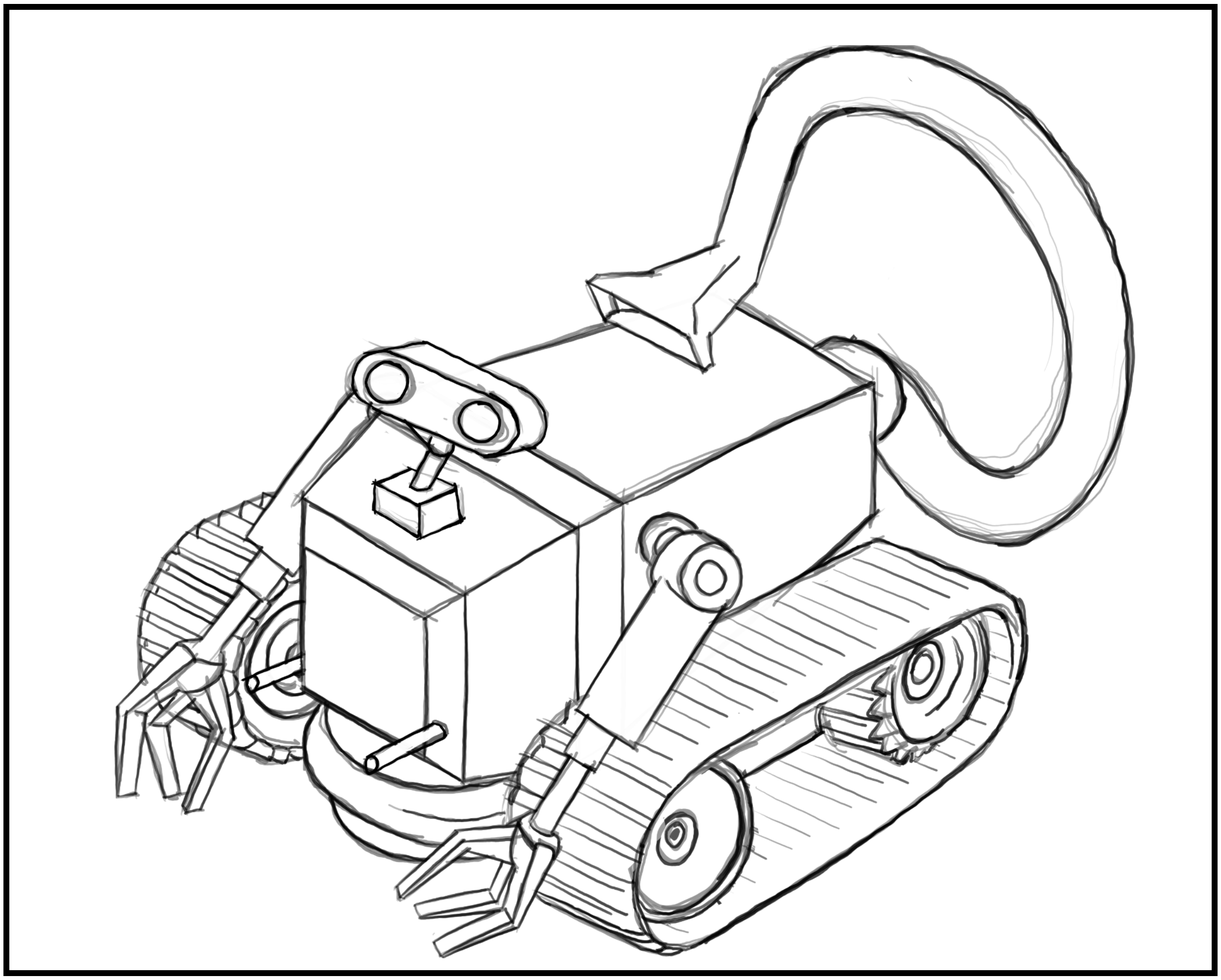
Engineering Graphics

SPARC-BOT

(Scorpion-Styled Precision Agile Robust Cleansing Bot)

Project Proposal

Group - 9



SPARC-BOT

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Term: Summer 2023

Group 9

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Introduction and Motivation

In the fast-paced world we live in, the demand for innovative solutions to everyday problems continues to grow. One area that has seen remarkable advancements in robotics is where intelligent machines are designed to perform tasks autonomously. One such remarkable creation is the SPARC bot, a multipurpose cleaning robot that aims to revolutionize the way we maintain cleanliness and hygiene in our homes and workplaces.

Maintaining cleanliness and hygiene is an essential aspect of our daily lives. However, the demands of modern living often leave us with limited time and energy to devote to cleaning tasks. Traditional cleaning methods often require significant time and effort. By developing a cleaning robot like SPARC-BOT, we aim to streamline the cleaning process and significantly reduce the time and effort required. The robot's autonomous capabilities will enable it to navigate through various spaces efficiently, ensuring thorough cleaning without the need for human intervention. The motivation behind the SPARC bot stems from the need to address this challenge by providing an efficient and reliable solution that can assist us in maintaining a clean environment effortlessly.

Automating various cleaning processes eliminates the need for manual labor and repetitive chores. This not only saves time but also allows users to focus on other essential aspects of their lives or work. The SPARC-BOT may be employed in various workplace environments, including offices, college or school campuses, supermarkets, malls, and other places. By designing a cleaning robot like SPARC-BOT, we aim to reduce the use of chemical cleaning agents and minimize water consumption through efficient cleaning methods. The robot's ability to perform cleaning tasks autonomously eliminates the need for human-operated cleaning equipment, reducing energy consumption and carbon emissions.

The design of SPARC-BOT includes various functional components that contribute to its cleaning capabilities. Including body compartments allow for storing cleaning supplies and tools, ensuring easy access during the cleaning process. The vacuum tube and vacuum pump enable the robot to effectively suction dust and debris, while the water pump and water sprinkler facilitate efficient mopping and floor cleaning.

The inspiration behind the development of the SPARC bot can be traced back to our innate human desire for convenience and efficiency. As our lives become increasingly fast-paced and demanding, finding ways to simplify everyday tasks becomes paramount. The idea of a cleaning robot that can autonomously perform cleaning tasks is not just born out of technological innovation but also from a deep understanding of individuals' challenges in maintaining cleanliness and hygiene.

The inspiration for SPARC-BOT also stems from the ongoing advancements in robotics and artificial intelligence. With breakthroughs in sensor technology, machine learning, and autonomous navigation, the creators saw the potential to create a brilliant cleaning robot that could adapt to different environments and provide thorough cleaning without humans.

intervention. The rapid progress in robotics inspired them to push the boundaries of what was previously thought possible, leading to the birth of SPARC-BOT.

Furthermore, the inspiration also came from the positive impact that technology has had in various aspects of our lives. Technology has transformed how we communicate, work, and live, from smartphones to smart home devices. They saw an opportunity to harness the power of technology to revolutionize the cleaning industry and make a tangible difference in people's lives.

Observing the struggles and time constraints busy individuals face, the SPARC-BOT recognized the need for a solution to alleviate the burden of cleaning chores or large spaces. A robot that could seamlessly integrate into our lives, taking care of the cleaning tasks while we focus on more meaningful pursuits. The desire to reclaim precious time and energy that would otherwise be spent on repetitive cleaning tasks fueled the development of SPARC-BOT.

Additionally, the motivation came from the desire to revolutionize traditional cleaning practices and minimize the negative impact on the environment. They recognized that traditional cleaning methods often rely on harsh chemicals and excessive water usage, which can harm human health and the planet. By designing a cleaning robot that employs efficient cleaning techniques and reduces reliance on harmful substances, the creators aimed to provide a sustainable and eco-friendly alternative.

In conclusion, the inspiration behind the SPARC bot emerges from a deep understanding of individuals' challenges in maintaining cleanliness and hygiene. It stems from the desire to provide a convenient, time-saving solution that aligns with our modern lifestyle. Moreover, the aspiration to promote sustainable practices and minimize environmental impact has been a driving force behind the development of SPARC-BOT. By combining technological advancements, innovation, and a deep understanding of user needs, the creators have set out to create a cleaning robot that not only simplifies our lives but also contributes to a cleaner, healthier, and more sustainable future.

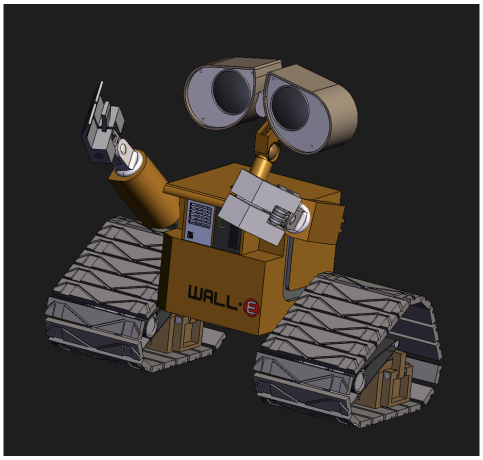


Fig. 0.1 Inspired from WALL-E

Part Name - Claw and Hydraulic Arm

Farhan Obaid (22110081)

Introduction

Our group is working on modeling a multipurpose cleaning robot called the SPARC bot. And a hydraulic arm serves as a pivotal component of the cleaning bot, which enables it to perform various tasks requiring precise movements and gripping capabilities. This versatile mechanism mimics the functioning of a human arm, offering a wide range of motion and strength through hydraulic power. The hydraulic arm serves as the main manipulator of the cleaning bot, allowing it to perform a wide range of tasks. Its primary purpose is to provide the bot with a versatile and powerful tool for picking up objects, moving debris, and performing various cleaning operations. The hydraulic arm utilizes hydraulic power to exert force and control its movements, making it efficient and flexible for different applications.
The claw is a crucial component of the multipurpose cleaning bot's hydraulic arm, serving as the end effector for gripping objects and performing various cleaning tasks. Its design should be tailored to the intended application of the cleaning bot. The claw may feature movable fingers, sensors, or specialized gripping mechanisms to enhance its functionality. The primary purpose of the claw is to provide the hydraulic arm with the ability to grasp and manipulate objects effectively. It enables the cleaning bot to pick up debris, move objects, and perform intricate cleaning operations. The design of the claw is optimized for versatility, allowing it to adapt to different object shapes and sizes.

Hydraulic Arm

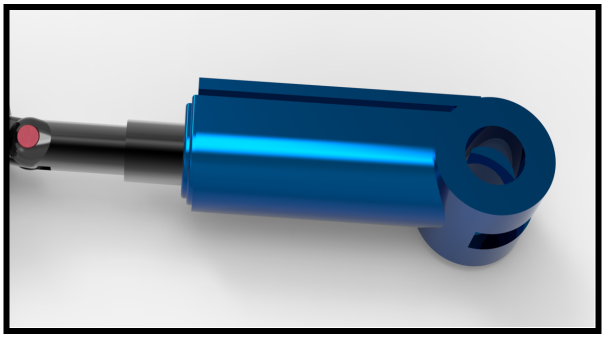


Fig. 1.1 Hydraulic Arm

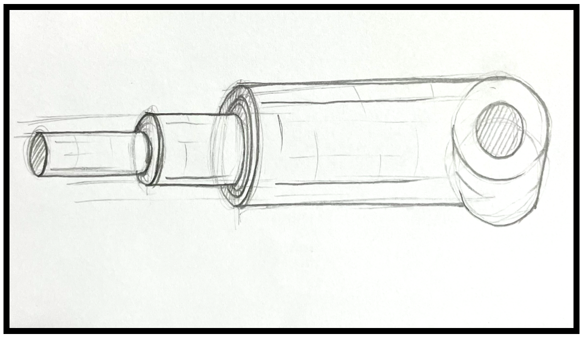


Fig. 1.2 Hydraulic Arm Sketch

- ### Structure and Functions

The design of the hydraulic arm is based on a series of interconnected components that work together to achieve the desired functionality. The arm typically consists of a series of hydraulic cylinders, joints, linkages, and an end effector, such as a claw, for gripping objects. The structure of the arm needs to be robust yet lightweight, to ensure optimal performance and minimize energy consumption.

Components:

1. **Hydraulic Cylinders**: Hydraulic cylinders are the primary power source of the arm. They consist of a cylindrical tube and a piston that moves within it. Both the main tube and the piston will be cylindrical in shape.

2. **Joints and Linkages**: Joints and linkages will be used for connecting simultaneous parts to provide articulation and flexibility to the hydraulic arm. It will be used to connect the hydraulic arm to the claw. They allow the arm to bend, rotate, and reach various positions. Typically, different types of joints, such as hinge joints, pivot joints, or ball joints, are used to enable specific movements. Linkages are often designed as rods or bars that connect the joints. These components are typically cylindrical in shape and made of materials such as steel or aluminum. They provide the necessary rigidity while allowing for lightweight construction.

3. **Mounting and Support**: The hydraulic arm needs to be securely mounted and supported to the main body of the cleaning bot. Mounting brackets, brackets with bearings, or other connection mechanisms can be used to ensure the connection of the arm to the body and provide stability and proper alignment.

Functioning:

The functioning of the hydraulic arm relies on the principles of fluid mechanics and mechanical engineering. The arm incorporates hydraulic cylinders that contain a piston and a cylinder filled with hydraulic fluid. When pressurized fluid is supplied to one side of the piston, it pushes the piston, extending the arm. Conversely, supplying fluid to the opposite side retracts the arm. By controlling the hydraulic pressure and fluid flow, precise and controlled movements of the arm can be achieved. The hydraulic arm's movement is facilitated by joints and linkages, which allow the arm to articulate and reach various positions. These joints are typically equipped with bearings to ensure smooth rotation and minimize friction.

- ## Possible Challenges

The hydraulic arm consists of multiple components that need to be accurately positioned and interconnected. Since we are new to AutoCAD Inventor, ensuring proper alignment and joint functionality within the software can be challenging, requiring careful attention to detail. Some components, such as the hydraulic cylinders and joints, may have intricate geometries that need to be modeled accurately in order to fit in the joints of the claw and the connector attached to the body. Attention must be given to the shape, size, and internal mechanisms of these parts to ensure proper functionality and integration. Parts and joints with holes of specific shapes and sizes might be challenging to model. Difficulty might arise while designing the hinges, joints, and linkages which connect the hydraulic arm to other components like the body and the Claw.

Sources

- https://www.universal-robots.com/in/blog/robotic-arm-mechanism/
- https://en.wikipedia.org/wiki/Hydraulic_cylinder
- https://grabcad.com/library/wall-e-hand-1

Claw

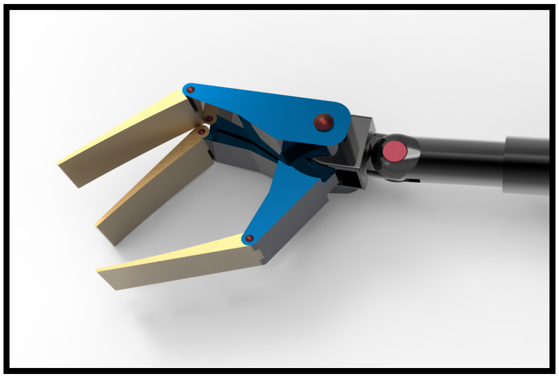


Fig. 2.1 Claw

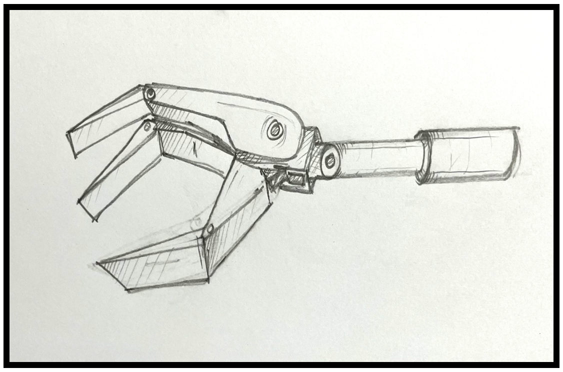


Fig. 2.2 Claw Sketch

- ### Structure and Functions

The claw comprises several components carefully designed to ensure effective grasping and manipulation. Its structure typically includes a set of opposing jaws or fingers that can open and close to secure objects. The claw is connected to the hydraulic arm's last segment, which provides the necessary movement and control for opening and closing the jaws. This movement is achieved using additional hydraulic cylinders or mechanical linkages, allowing precise control of the claw's grip.

Components:

1. **Claw Jaws/Fingers:** The claw jaws are the primary gripping elements responsible for securely holding objects. They are typically composed of two opposing jaws that come together to create a gripping action. The **shape** of the jaws can vary from straight to curved or even serrated, depending on the objects the claw is intended to grip. Straight jaws are versatile and suitable for gripping objects of different shapes, while curved or serrated jaws provide enhanced grip on specific surfaces or materials. When closed, the clearance between the jaws should be carefully designed to accommodate the range of object sizes the claw is expected to handle. The sufficient clearance allows the claw to grip small and large objects effectively.

2. **Pivot Point:** The pivot point is the joint connecting the claw to the hydraulic arm. It enables the claw to rotate and adapt to the orientation of the objects being grasped. The pivot point should be designed with low-friction bearings or joints to allow smooth and precise rotation of the claw jaws. This ensures the claw can effectively adjust its position and angle to grip objects from different orientations.

Functioning:

The functioning of the claw involves the coordinated action of hydraulic or mechanical systems. When the hydraulic arm's last segment is actuated, it triggers the corresponding movement of the claw's jaws. The hydraulic or mechanical linkages transmit the force, allowing the claw to open or close based on the desired grip strength. The functioning of the claw relies on the actuation mechanism and design of the gripping jaws. The actuation mechanism controls the opening and closing of the claw jaws. It allows the user to adjust the grip force and accommodate objects of different sizes. Actuation mechanisms commonly include mechanical linkages, pneumatic cylinders, or electric motors. The choice of the mechanism depends on factors such as desired grip force, response time, and control precision.

- ### Possible Challenges

The claw's design may involve intricate geometry and detailed features, such as the shape of the jaws. As visible in the picture, the claw fingers/jaws are non-uniform in shape. They are thick at the joints and thin on the front/top. Modeling these components accurately in AutoCAD Inventor requires attention to detail and may require advanced surfacing techniques or the use of specialized modeling tools. Furthermore, the claw must be seamlessly integrated with the hydraulic arm model to ensure proper functionality and interaction. Modeling a pivot joint that connects the claw with the hydraulic arm can be challenging. Designing a claw model to combine fingers/jaws so they stick together like a hand and work in a coordinated manner needs some thinking and good practice at AutoCad Inventor.

Sources

- https://www.universal-robots.com/in/blog/robotic-arm-mechanism/
- https://grabcad.com/library/wall-e-hand-1

Part Name - Arduino Uno Board

Gamre Ketki Shailendra (22110082)

Introduction

Arduino, the popular open-source electronics platform, offers a powerful and flexible solution for controlling robots with precise movements and functionalities. With Arduino, it is possible to program the bot to move in all directions and rotate its head, allowing for versatile and dynamic robotic behaviors.

To move the bot in different directions, motor controllers are commonly employed. These controllers will interpret the signals received from the Arduino and regulate the speed and direction of the robot's motors. By programming the Arduino board, we will define specific commands and algorithms to accurately control the robot's movement. For instance, by activating different motor combinations, the bot can move forward, backward, turn left or right, and perform complex maneuvers.

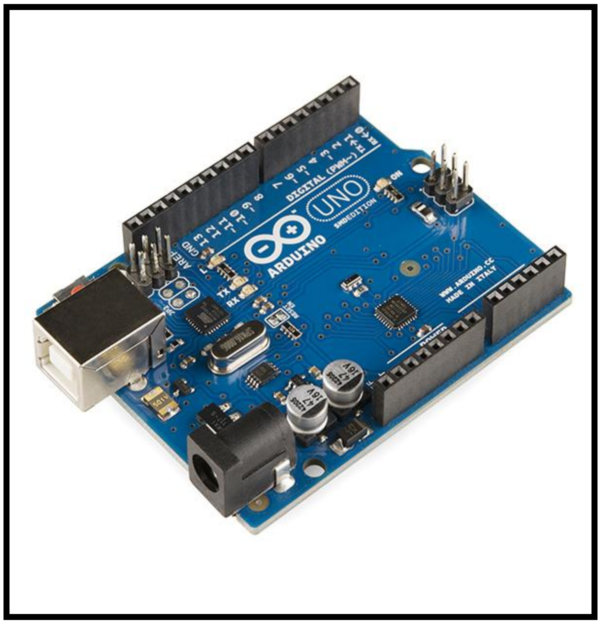


Fig. 3.1 Arduino Uno Board

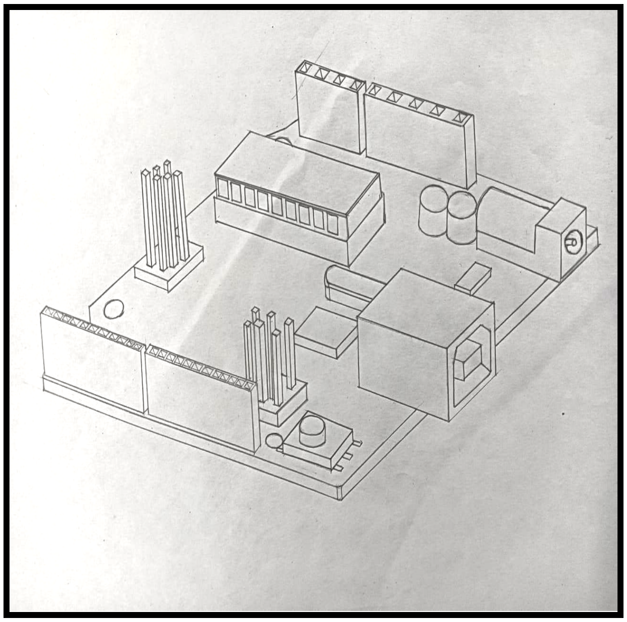


Fig. 3.2 Proposed sketch of the Arduino

Arduino Uno Board

- ## Structure and Functions

The structure of the Arduino Uno board revolves around its main microcontroller, the ATmega328P. This microcontroller is the board's brain, executing the uploaded code and controlling the interaction with various input and output devices. The Arduino Uno board features a set of digital and analog input/output pins, which allow for connecting sensors, actuators, and other electronic components. It also includes a USB connector for programming and power supply, a power jack, a voltage regulator, indicator LEDs, and a reset button. These components collectively form the structure of the Arduino Uno board, providing a solid foundation for building and controlling a wide range of electronic projects.

General pin functions:

1. **LED:** A built-in LED is driven by a digital pin 13. When the pin is high value, the LED is on. When the pin is low, it is off.
2. **VIN:** The input voltage to the Arduino/Genuino board when it is using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
3. **5V:** This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 20V), the USB connector (5V), or the VIN pin of the board (7-20V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator and can damage the board.
4. **3V3:** A 3.3-volt supply is generated by the onboard regulator. The maximum current draw is 50 mA.
5. **GND:** Ground pins.
6. **IOREF:** This pin on the Arduino/Genuino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage, select the appropriate power source, or enable voltage translators on the outputs to work with the 5V or 3.3V.

Reset: Typically used to add a reset button to shields that block the one on the board.

Special pin functions:

1. **Serial / UART:** pins 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL serial chip. External interrupts: pins 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
2. **PWM (pulse-width modulation):** pins 3, 5, 6, 9, 10, and 11. Can provide 8-bit PWM output with the analogWrite() function.
3. **SPI (Serial Peripheral Interface):** pins 10 (SS), 11 (MOSI), 12 (MISO), and 13 (SCK). These pins support SPI communication using the SPI library.
4. **TWI (two-wire interface) / I^2C:** pin SDA (A4) and pin SCL (A5). Support TWI communication using the Wire library.
5. **AREF (analog reference)**: Reference voltage for the analog inputs.

- ### Possible Challenges

Designing the Arduino Uno board on Autodesk Inventor Professional will present us with a few challenges. Firstly, accurately modeling the intricate details and dimensions of the board's components, such as the microcontroller and connectors, would be time-consuming and require precise measurements. Secondly, ensuring the proper alignment and placement of the components within the board's layout will be challenging, especially considering the limited space available. Additionally, accurately representing the electrical connections and wiring within the software can be complex, as it requires understanding the board's circuitry. Overcoming these challenges often involves a deep understanding of the board's design and functionality, meticulous attention to detail, and proficiency using Autodesk Inventor Professional software.

Sources

- https://store.arduino.cc/products/arduino-uno-rev3
- https://en.wikipedia.org/wiki/Arduino_Uno

Part Name - Water Pump and Vacuum Pump

Gangannagudem Siri (22110083)

Introduction

In the SPARC-BOT, the water pump and vacuum pump are among the essential parts of the system. They regulate the water flow and ensure the movement of the parts. As the sparc-bot functions based on the lifting and transferring of items, the vacuum pump can be incorporated into the system to facilitate the lifting. Vacuum pumps aid in the cleaning process by sucking up dust and dirt. It can effectively help in cleaning using vacuum tubes.

The water pump in the SPARC-BOT can be used to power the sprinkler system and also used to supply water to the cleaning mop. Supplying pressurized water to the sprinkler ensures controlled water flow from sprinkler nozzles. Also, the cleaning mop provides a consistent flow to clean effectively.

Water Pump

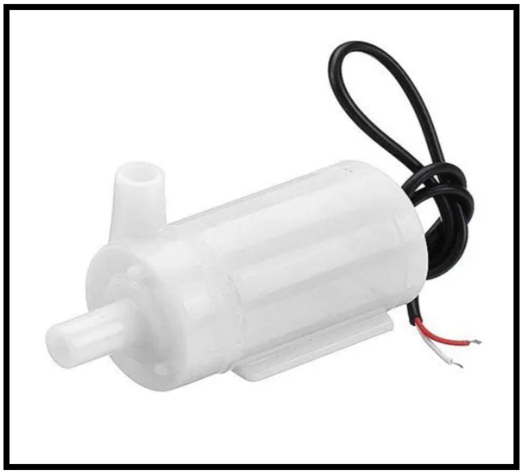


Fig. 4.1 Miniature water pump

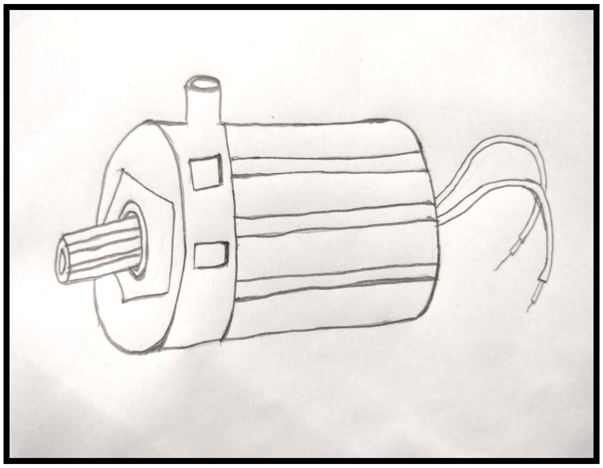


Fig. 4.2 The Sketch of the pump

- ### Structure and Functions

The water pump is a mechanical device that is designed to maintain and transfer water by creating pressure inside it. It basically contains a casing, impeller, inlet and outlet, shaft, and motor.

Components:

1. **Casing:** The casing is the outer shell of the water pump. It encloses and protects the internal components and provides mounting points for the pump.

2. **Impeller:** The impeller is a rotating pump component with curved blades or vanes. As it spins, the impeller imparts centrifugal force to the water, creating pressure and directing flow towards the outlet.

3. **Inlet and Outlet:** The inlet is the entry point through which water is drawn into the pump. The outlet is the discharging point through which water exits after being pressurized by the pump.
4. **Motor:** It provides mechanical energy for the motor to drive the pump. Eclectic motors can also be used. The shaft connects the motor and impeller, while the electric motor is connected with wires.

• Possible Challenges

While designing this water pump in Autodesk inventor, we may face a few challenges in the 3D modeling of this component. We have to take the exact dimensions of the pump so that it exactly should fit into the body of the sparc bot. The design outside the casing may have to be simple, but we need to check the angles at which they are aligned and where they end. The inlet and outlet look simple but should be correctly assembled and joined.

Vacuum Pump

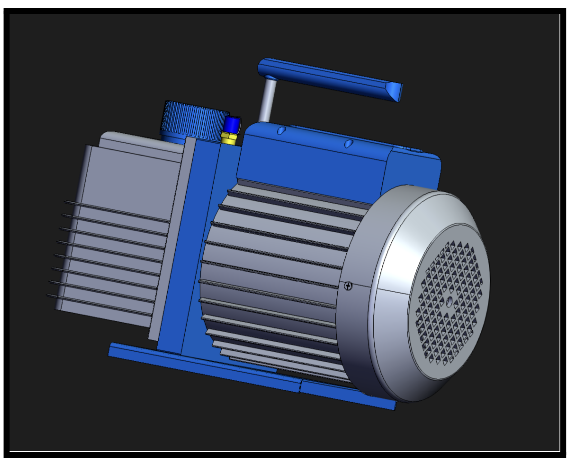


Fig. 5.1 Vacuum Pump Model

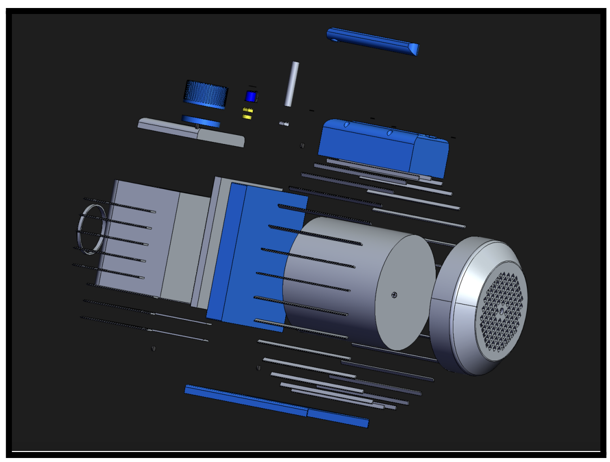


Fig. 5.2 Vacuum Pump Model Exploded

• Structure and Functions

The Vacuum pump plays a crucial role in the sparc bot working mechanism. It creates suction for manipulating the objects, allowing the bot to hold onto objects securely. The significant parts are the housing, electric motor, impeller, inlet port, and power supply.

Components:

1. **Vacuum pump housing:** The vacuum pump housing is the outer casing that encloses and protects the internal components of the vacuum pump.
2. **Electric Motor:** The vacuum pump is powered by an electric motor. The motor provides the necessary rotational energy to drive the pump and create the vacuum.
3. **Impeller:** The impeller is a rotating component inside the vacuum pump that helps generate the vacuum. It typically consists of blades or veins that draw in and accelerate air or gas.
4. **Inlet port:** The inlet port is the entry point through which air and waste materials are drawn into the vacuum system. It is connected to the vacuum tube that comes in contact with the waste to be picked up and also to the claw to hold and transfer the waste it collected.

The vacuum pump in the SPARC-BOT is used for two purposes. One is connected to the vacuum tube, which collects the dust particles into it. The other is connected to the claws to make the claw hold and transfer waste of bigger size.

• Possible Challenges

The parts in the vacuum pump should be appropriately assembled. The pump is connected to the vacuum tube and also the claws. Hence we need to take care of the position to place it inside the body of the sparc bot. The casing design may require a few advanced settings to get the angles and structure. Its complex structure may require intricate passages, curves, and recesses that are difficult to model. It requires attention to detail, and also we should be able to use the Autodesk inventor's features and functionalities. The compeller and motor are the crucial parts of this pump hence they must be with exact dimensions and all the curves to fit in the pump.

Sources

- https://www.amazon.in/Aquarium-School-Projects-Submersible-Fountain/dp/B0BW4QKXG8
- https://grabcad.com/library/vacuum-pump-11

Part Name - Body Base and Sprinkler

Garima Nama (22110084)

Introduction

Maintaining a clean and sanitary living or working environment is critical for our health and well-being. Traditional mopping is time-consuming and labor-intensive, making it challenging to keep floors spotless. A sprinkler developed exclusively for mopping cleaning can provide effective and convenient floor care to speed up the mopping and cleaning technique.

The body base of the water sprinkler system is the most vital part since the whole body of the model is resting on the base. It can attach directly to the wheels' axle, ensuring enhanced stability and maximizing its overall functionality.

Sprinkler

- Structure and Functions

1. **Integrated Water Dispersion:** The sprinkler has an incorporated water dispersion system that distributes water uniformly throughout the floor surface. This mechanism ensures the mop is consistently wet, preventing excessive moisture or dry areas and allowing for complete cleaning.
2. **Adjustable Spray Pattern:** The sprinkler features adjustable spray patterns, enabling customized water flow for different floor types like hardwood, tiles, or linoleum. It ensures optimal moisture levels without causing damage or excess water. It also contributes to water conservation ensuring minimal wastage and efficient use of resources.
3. **Time and Effort Savings:** The sprinkler's efficient water dispersion system saves time and effort by repeatedly eliminating the need for manually wetting the mop. Users can cover larger areas without interruption, making it ideal for commercial or large residential spaces.
4. **Cleaning Solution Compatibility:** The sprinkler is compatible with a variety of cleaning solutions, enhancing cleaning performance and allowing customers to target specific demands such as stain removal and odor reduction.
5. **Irrigation:** Since the model can move around the fields while dispersing water with wheels, it may also be used for irrigation.

Body Base

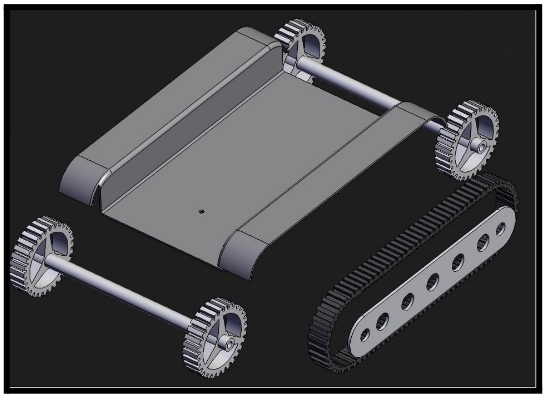


Fig. 6.1 The Base Assembly

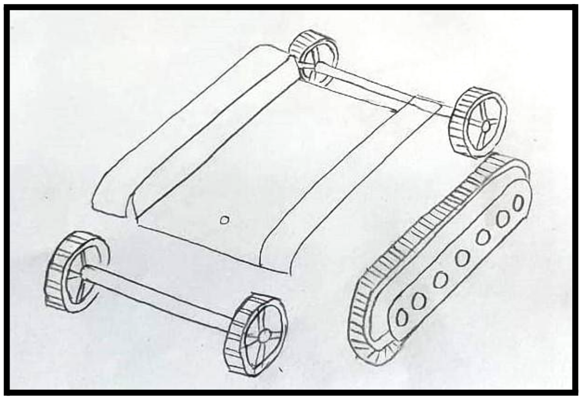


Fig. 6.2 Sketch of the base Assembly

Structure and Functions

1. **Weight Distribution:** The axle-attached body base ensures optimal weight distribution by attaching directly to the wheels' axle. This balanced weight distribution prevents strain on the wheels and enhances stability, enabling effective navigation through different landscapes.
2. **Height Adjustment Mechanism:** The height adjustment mechanism in the sprinkler system's axle-attached body base enables users to raise or lower the sprinkler heads, accommodating various plant heights and irrigation needs.
3. **Reinforced Chassis:** The body base has a reinforced chassis made of durable materials, providing a reliable platform for the sprinkler system during floor cleaning, even on rough surfaces.
4. **Solid Attachment:** The body base securely attaches to the wheels' axle, forming a stable and integrated unit. This solid attachment minimizes wobbling or displacement during movement, providing a strong foundation for even water distribution without compromising stability.
5. **Easy Maneuverability:** The body base's attachment to the axle enables easy maneuverability for the sprinkler system. It can make precise turns and navigate tight spaces, efficiently covering the desired area for comprehensive water distribution.

Possible Challenges

Despite the secure attachment of the body base to the axle, stability on extremely uneven surfaces, such as rocky or hilly terrains, may still pose a challenge. The axle-attached body base must handle the water storage weight and the system itself. Ensuring that the axle and chassis can support the anticipated load capacity is essential to maintain stability and prevent damage. As the body base is designed to attach to the sprinkler system's specific axle and wheel configuration, ensuring compatibility and customization options are challenging. Correctly positioning the body base and water storage unit to achieve an optimal center of gravity is crucial for stability and maneuverability.

Part Name - Cleaning Mop Assembly

Gaurav Budhwani (22110085)

Introduction

At the heart of our project, which focuses on the development of the S.P.A.R.C-B.O.T(Scorpion-style Precision Agile Robust Cleansing Brilliant Operations Technology) cleaning robot, lies the pursuit of an efficient and innovative solution for a wide range of cleaning tasks. The cleaning mop assembly emerges as a fundamental tool, empowering the S.P.A.R.C-B.O.T with exceptional cleaning capabilities.

The mopper, an integral component of our cleaning robot, is crucial in effectively and efficiently maintaining cleanliness across various surfaces. Designed to meet the demands of modern cleaning requirements, the mopper combines intelligent design and advanced technology to deliver versatile cleaning functionality, making it anis crucial in the cleaning arsenal of the robot.

Cleaning Mop Assembly

- Structure and Functions

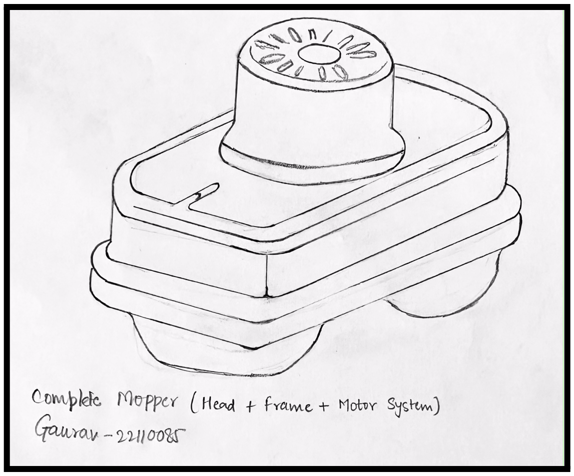


Fig. 7.1 Mopping Cleaner Sketch

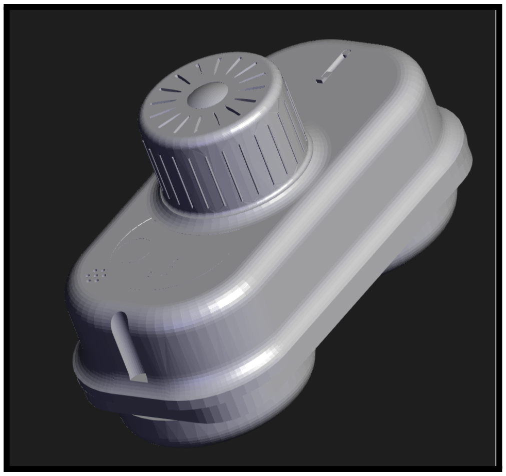


Fig. 7.2 Mopping Cleaner

The cleaning mop assembly consists of several vital components carefully designed to achieve optional cleaning performance. These components work together to ensure the cleaning of different surfaces.

Components:

1. **Mop Head:** The mop head is the primary element of the assembly responsible for contacting and cleaning the surface. It typically comprises high-quality microfiber or other suitable materials with excellent dust and dirt absorption characteristics. Depending on cleaning needs, the mop head may feature different shapes and sizes, but we have chosen a circular-shaped mop head, the most versatile of them all.
2. **Mop Frame:** The mop frame provides structural support to the mop head and serves as the attachment point for connecting it to the robotic system. It is designed to be lightweight yet durable, allowing smooth movement and precise control during the cleaning process. The mop frame also incorporates sensors that help detect obstacles and adjust the cleaning pattern accordingly.
3. **Cleaning Mechanism:** The cleaning mechanism within the mop head utilizes rotating brushes, vibrating elements, or other innovative technologies to dislodge dirt, dust, and debris from the surface. The cleaning mechanism is carefully designed to minimize the damage to the delicate surfaces.

- ### Possible Challenges

Designing the cleaning mop assembly within Autodesk Inventor poses its own unique set of challenges. While the software provides powerful tools for 3D modeling and assembly design, certain complexities may arise when creating a detailed and functional cleaning mop assembly.

1. **Complex Geometry:** The cleaning mop assembly comprises various components with intricate shapes and geometries, such as the head and frame. Modeling these components accurately within Autodesk Inventor can be challenging, especially when dealing with curved surfaces, irregular shapes, or components with non-uniform thickness.
2. **Component Interactions:** Ensuring proper alignment, movement, and interaction between the mop head, mop frame, and robotic arm attachment is crucial for seamless functionality. Integrating these components within Autodesk Inventor requires meticulous attention to detail, as any misalignments or improper connections can lead to mechanical issues or hinder the assembly's performance.
3. **Assembly Constraints:** Assembling the various components of the cleaning mop assembly within Autodesk Inventor requires careful consideration of the constraints and connections between parts. Aligning joints, defining proper clearances, and ensuring the correct movement and interaction between components can be challenging, especially when dealing with intricate designs and complex assemblies. Balancing functionality, manufacturability, and ease of assembly within the software can be demanding.

Sources

- https://grabcad.com/library/window-cleaning-robot-1

Part Name - Neck and Ultrasonic Sensors

Gosalia Samyak (22110086)

Neck

Introduction

The neck part of the SPARC-BOT is an essential component that enables its precision, agility, and robustness in performing cleaning tasks. A 360-degree rotatable neck adds versatility and enhances the robot's ability to access various areas for effective cleaning.

- Structure and Functions

The primary function of the 360-degree rotatable neck is to provide the SPARC-BOT with enhanced maneuverability and reach. The robot can access tight corners, narrow spaces, and hard-to-reach areas for thorough cleaning. The rotatable neck enables the SPARC-BOT to adapt to different cleaning scenarios and effectively target specific areas, contributing to its sparkling cleaning capabilities.

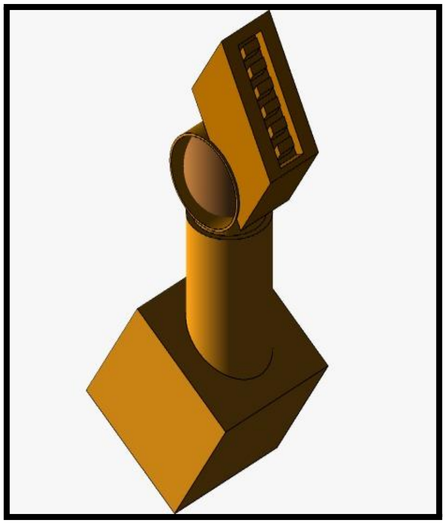


Fig. 8.1 The Neck Segment

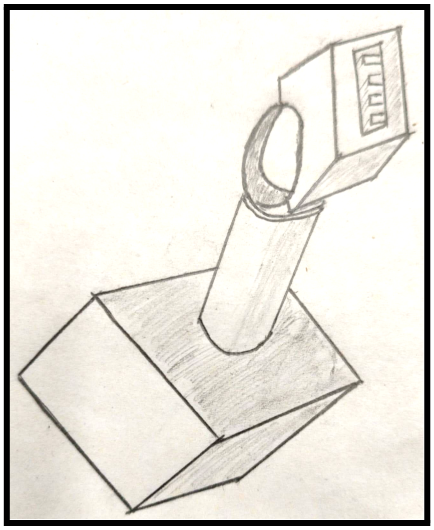


Fig. 8.2 The Neck Segment Sketch

- Principle

The design principles guiding the neck's development revolve around balancing flexibility and strength. The neck should allow the robot's head to rotate smoothly in any direction, ensuring maximum coverage during cleaning tasks. At the same time, it needs to withstand external forces, vibrations, and shocks encountered during operation. The principles of mechanical engineerings, such as load distribution, material selection, and joint mechanics, play a significant role in ensuring the neck's performance and durability.

- Design

The design of the neck incorporates various considerations to fulfill the functional requirements of SPARC-BOT. It involves determining the optimal number of joints and their placement to facilitate 360-degree rotation. The joint mechanism may involve the use of gears, linkages, or other suitable mechanisms to enable the desired motion. Additionally, the design should allow for easy maintenance and potential future upgrades or modifications.

- Possible Challenges

During the development and implementation of the neck part, several challenges may arise. These challenges can include optimizing the mechanical design to ensure smooth and precise rotation, minimizing friction and wear on the moving components, and integrating the neck mechanism seamlessly with the SPARC-BOT's control system. Overcoming challenges in design and implementation ensures the reliable performance of the neck part, contributing to the overall success of the SPARC-BOT in its cleaning operations.

- Conclusion

The neck part of SPARC-BOT plays a vital role in enabling the robot's head to rotate 360 degrees, allowing for versatile cleaning capabilities. A well-designed neck can contribute to the cleaning robot's overall functionality, efficiency, and reliability by carefully considering design principles, structural elements, materials, and challenges. The successful implementation of the neck design will bring us closer to achieving our goal of developing a SPARC-BOT that embodies precision, agility, robustness, and sparkling cleansing capabilities.

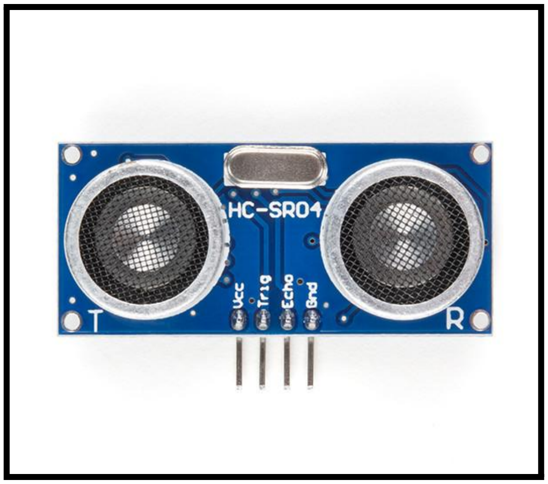
Ultrasonic Sensors

Introduction

Ultrasonic sensors are an integral part of the SPARC-BOT, contributing to its precision, agility, and robustness in navigating and avoiding obstacles. By incorporating ultrasonic sensors into the robot's design, we aim to enhance its ability to detect and react to its surroundings, ensuring safe and efficient cleaning operations.

- Structure and Functions

The ultrasonic sensor system consists of multiple ultrasonic sensors strategically placed within the SPARC-BOT's body. These sensors emit high-frequency sound waves and receive the reflected waves, enabling the robot to perceive its environment. The sensors are typically positioned to provide a wide coverage area and ensure comprehensive obstacle detection.
The ultrasonic sensors are connected to the SPARC-BOT's control system, which processes the received signals and determines the presence and distance of obstacles. Based on this information, the robot's navigation system can make intelligent decisions like changing direction, adjusting speed, or stopping to avoid collisions. The sensors continuously monitor the surroundings, providing real-time data for obstacle avoidance.



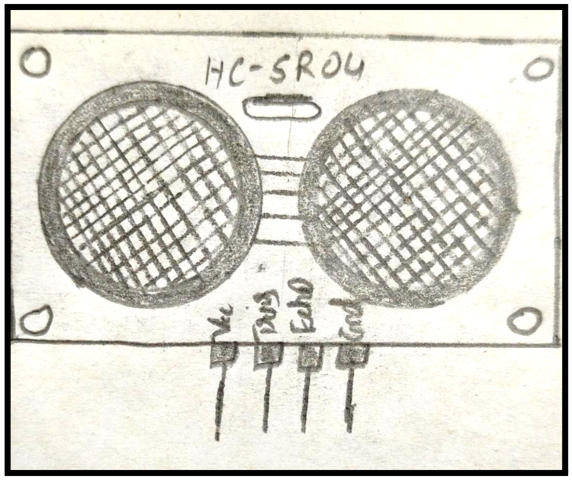


Fig. 9.1 Ultrasonic Sensor

Fig. 9.2 Ultrasonic Sensor 2D Sketch

- ## Principle

Ultrasonic sensors operate on sound wave reflection and echo detection principles. The sensor emits ultrasonic waves at a frequency beyond the range of human hearing. These waves propagate through the air until they encounter an obstacle. When the waves hit the obstacle, they bounce back and are detected by the sensor. By measuring the time it takes for the waves to travel to the obstacle and back, the sensor can calculate the distance to the obstacle.

- ## Design

The design of the ultrasonic sensor system involves selecting appropriate transducers and determining their placement within the SPARC-BOT. Factors such as detection range, beam angle, and sensitivity are considered during the design phase to ensure optimal performance and reliability. The sensors are positioned to cover the robot's front, sides, and rear, allowing for comprehensive obstacle detection from all directions.

- ## Possible Challenges

During the development and implementation of the ultrasonic sensor system, several challenges may arise. These challenges can include optimizing the sensor placement to ensure maximum coverage and minimal blind spots, minimizing interference from ambient noise or other ultrasonic sources, and fine-tuning the sensor parameters to achieve accurate distance measurements in various environmental conditions.

- ## Conclusion

The integration of ultrasonic sensors into the SPARC-BOT's design enhances its ability to detect and navigate around obstacles, contributing to its sparkling cleaning capabilities. The ultrasonic sensors play a crucial role in ensuring the SPARC-BOT's precision, agility, and robustness in obstacle detection and avoidance by employing sound wave reflection principles, carefully designing the sensor system, and considering factors such as materials and challenges.

Sources:

- https://grabcad.com/library/wall-e-57
- https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcSwJkdTf684aH9NvP2qSextO2qcWLZEJ79jJQ&usqp=CAU

Part Name - Body Structure and Components

Govale Parth Vilas (22110087)

Introduction

The design of a cleaning robot's body plays a crucial role in its overall functionality and effectiveness. In the case of the cleaning robot inspired by a scorpion, the body design is visually striking and purposefully engineered to enhance its cleaning capabilities. This design adds a touch of aesthetic appeal and serves a functional purpose. The scorpion-like structure allows the robot to navigate effortlessly through tight spaces and reach inaccessible areas, ensuring a thorough cleaning experience. Its compact and streamlined form enables efficient movement while maintaining stability, allowing the robot to maneuver with agility and precision. It can easily glide under furniture, navigate obstacles, and clean hard-to-reach corners. This versatility ensures that the cleaning robot can perform thoroughly and efficiently throughout the living space.

The body of the cleaning bot plays a crucial role in its functioning by providing support and integration of components such as the hydraulic arm, claw, sensors, and actuators. It ensures proper alignment and connection, enabling smooth operation. Additionally, the body protects sensitive components, including the main circuitry, shielding them from dust, moisture, and impacts. Specialized compartments within the body allow for organized storage of cleaning materials, enhancing overall performance.

Body Structure and Compartments

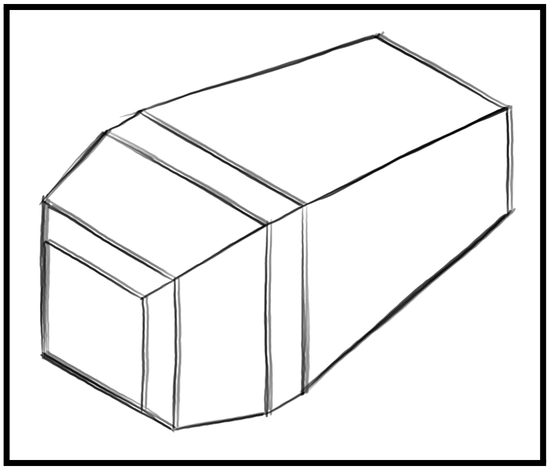


Fig. 10.1 Scorpion Body

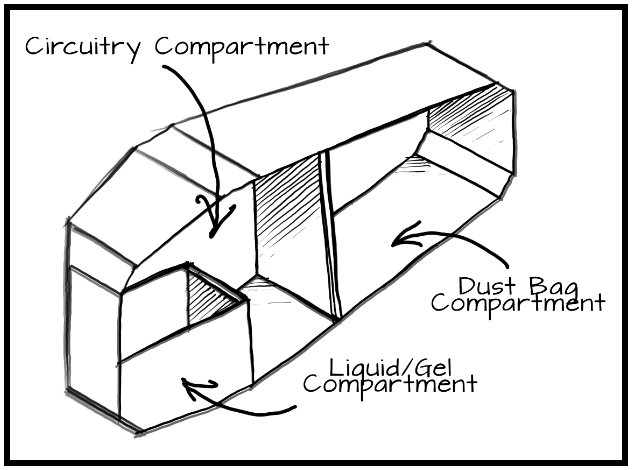


Fig. 10.2 Inner View of the Body

Structure and Functions

The body of the cleaning robot is ingeniously inspired by a scorpion's sleek shape, enabling it to navigate tight spaces and reach inaccessible areas effortlessly. Its compact and streamlined structure ensures efficient movement while maintaining stability and adding an attractive aesthetic appeal to any home. It serves as the central structure, housing the core circuitry and connecting all components. It incorporates compartments for the dust bag, liquid container, and gel compartments, optimizing cleaning performance. The body's design ensures stability, balance, and efficient weight distribution. It accommodates the Arduino microcontroller, the robot's brain, enabling intelligent control and coordination of cleaning operations. Overall, the body is vital in providing support, organization, and seamless functionalities integration, contributing to a cohesive and efficient cleaning experience.

Components:

1. **Dust Bag Compartment:** Embedded within the robot's body is an advanced dust collection system that takes over half of the body's space featuring strategically placed dust bags for efficient dirt and debris collection. The powerful vacuum pump within the body also generates the necessary suction for effective dirt collection and storage. Also, have an open close lid to remove the dust bag for cleaning.
2. **Liquid and Gel Compartments:** To enhance the cleaning capabilities beyond vacuuming, the cleaning robot incorporates two small containers for water and gel within its body. The intelligent positioning of these containers ensures a balanced weight distribution. The water container supplies water to the robot's mopping mechanism, while the gel container holds cleaning solution or disinfectant gel, enhancing the effectiveness of the mopping function.
3. **Circuitry Compartment:** The body houses the main circuitry responsible for controlling the cleaning bot's operations. An Arduino microcontroller, the intelligent control system, is at the core of the cleaning robot's functionality. This Arduino-based circuitry enables precise and adaptive control of the robot's movements, allowing it to navigate complex environments accurately. Efficient thermal management must be considered to prevent overheating and ensure the reliability of the circuitry. The body is designed with appropriate ventilation and cable management provisions to ensure efficient heat dissipation and organized wiring.
4. **Attachment Points:** The body features attachment points and interfaces to connect and integrate other components, like the hydraulic arm of the cleaning bot. These attachment points allow for secure mounting and proper alignment of parts, ensuring stability and efficient transfer of forces between components. It is essential to consider the design of these attachment points to accommodate the specific requirements of each attached component.

Possible Challenges

Designing the body shape of the cleaning robot inspired by a submarine in Autodesk Inventor presents several unique challenges due to its unconventional shape and compartments. The streamlined and sleek shape of the submarine-inspired body requires careful consideration to maintain stability and balance while ensuring optimal functionality. Achieving the desired weight distribution and structural integrity while accommodating the dust bags, vacuum pump, water and gel containers, sprinkler system, and Arduino board can be challenging. The placement of these components within the limited space of the body shape needs to be carefully engineered to prevent interference and ensure accessibility for maintenance and replacement. Integrating the Arduino-based circuitry within the body while managing heat dissipation and space constraints presents further challenges that must be addressed during the design process.

Part Name - Wheels and Belt

Guntas Singh Saran (22110089)

Introduction

Robot tank wheels play a crucial role in the mobility and maneuverability of robotic vehicles. These wheels are specifically designed to withstand rugged terrains, allowing robots to traverse uneven surfaces, obstacles, and challenging environments. When equipped with tank wheels, the SPARC-BOT can autonomously traverse cluttered areas, maneuver around furniture, and easily access tight corners.

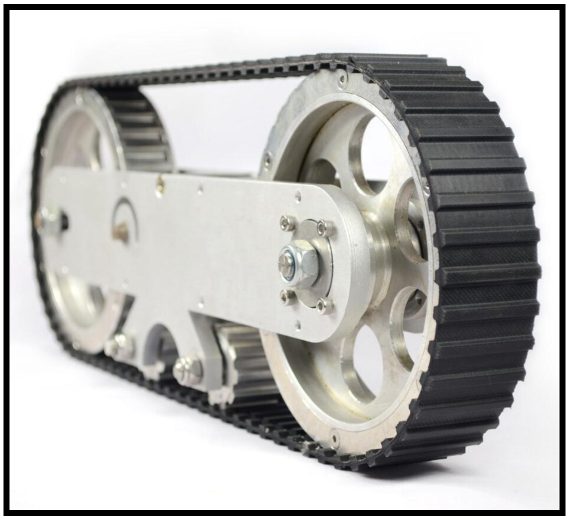


Fig. 11.1 Overall Belt Wheel Design

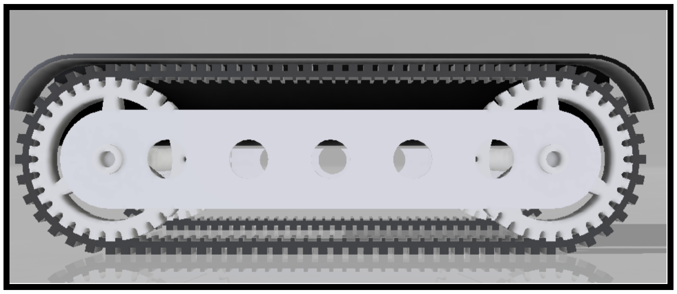


Fig. 11.2 The Arrangement of Wheels

Wheels

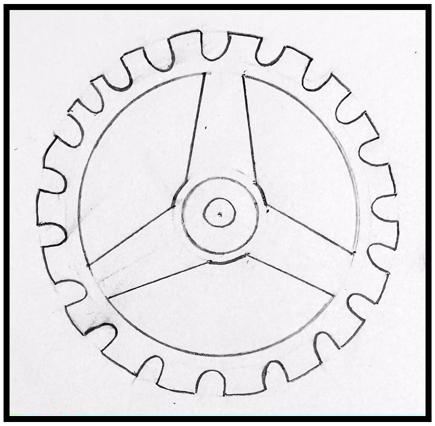


Fig. 12.1 Sketch of Spoked Wheel

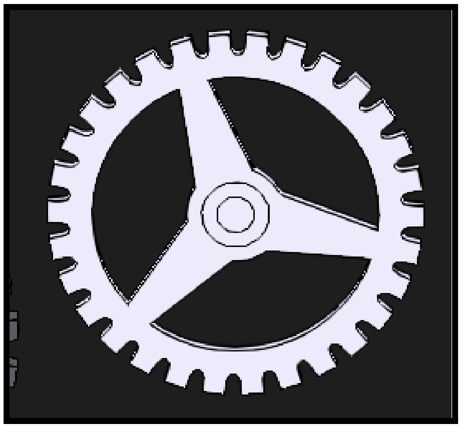


Fig. 12.2 Spoked Wheel

- Structure and Functions

1. **Wheel Design:** Robot tank wheels are typically designed with a combination of rigid and flexible materials to provide strength, durability, and traction. The structure consists of a hub, spokes, rim, and tread.
2. **Hub:** The hub is the central component of the wheel that attaches it to the robot's drivetrain. It contains a motor or gearbox to provide rotational power.
3. **Spokes:** Spokes connect the hub to the rim, providing stability and support to the wheel structure.
4. **Rim:** The rim is the wheel's outer ring and holds the tire or tread in place. It may feature specialized features like teeth, lugs, or other gripping mechanisms to enhance traction.
5. **Tread:** The tread is the wheel's outer surface that comes into contact with the ground. It is designed to provide grip, traction, and shock absorption, depending on the specific terrain requirements.

Several of the wheels' functions are Movability on any rugged terrain, Traction, and Load Bearing. The design is such that it may even allow for the SPARC-BOT to even climb on vertical surfaces.

- Possible Challenges

We will encounter several challenges while actually making the CAD design. Since the sketches presented here are rough illustrations, the actual Engineering Drawings must have specific dimensions labeled. The axle's length dimension must be such that it can be compatible with the body of the SPARC-BOT. Apart from that, the design is really simple, with a few circular sketches and extrusions for holes. The task for wheels may be achieved with simplicity. The circular holes on the periphery will be achieved by generating the sketch by circular pattern.

Belt

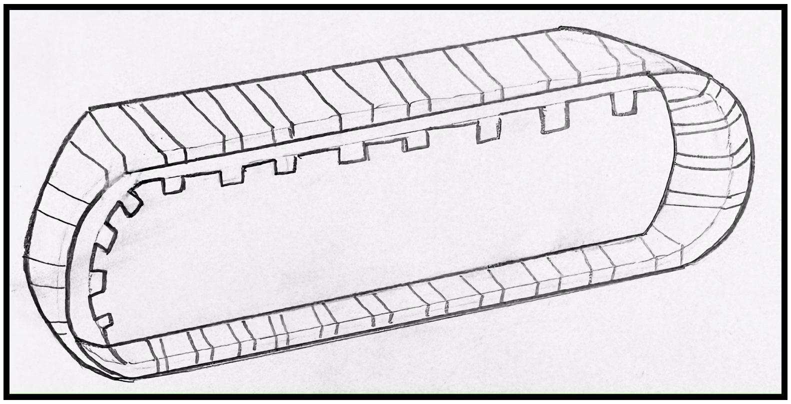


Fig. 13.1 The Sketch of the Belt

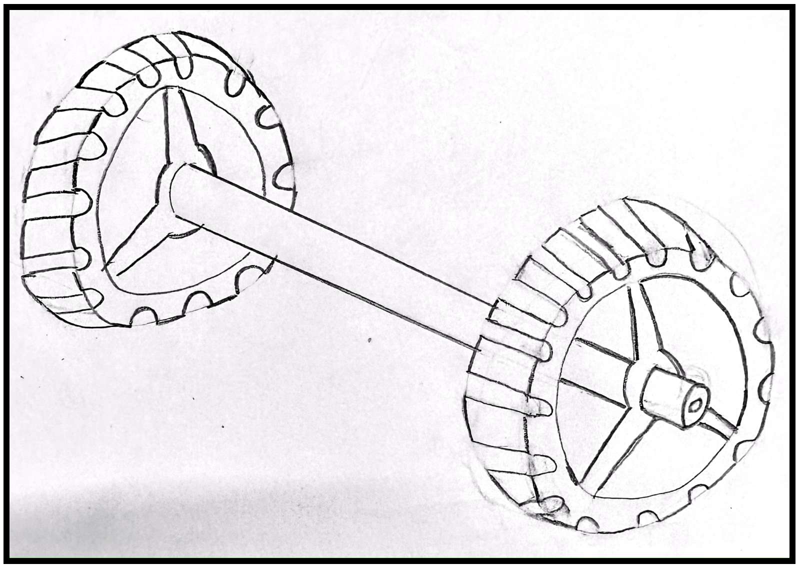


Fig. 13.2 The Sketch of Wheel Assembly with Axles

- ### Structure and Functions

Belt Teeth are specialized features on the belt surface that provide traction and grip on uneven or challenging terrains. The Belt supports the wheels, providing a large surface area for the BOT to move on. They provide all essential shaping to the body of the BOT. The ridges on the belt provide traction with any surface. The belt's continuity allows the wheels to independently tackle over rugged terrains and uneven surfaces easily without any restriction of movement. In practicality, the belts are built from modular chain links that compose a closed chain. The links are joined by a hinge, which allows the track to be flexible and wrap around a set of wheels to make an endless loop. The overall design allows for the uniform distribution of the assembly's weight.

- ### Possible Challenges

Considering the wheel design to have been sketched with proper dimensions, we must ensure that the radius of the belt is aligned with the wheel radius. The basic construction of the CAD model will involve creating a 2D sketch of the side view with the spacing between the ridges of the belt matching precisely with those of the cut extrusions of the wheels. Any uneven spacing would result in the wheel holes not fitting with the belt ridges. Furthermore, we are still unaware of the joining segment of parts in AutoDesk Inventor. Hence we need to make proper protrusions for the parts/components to fit in or constrain each other.

Sources

- https://grabcad.com/library/track-wheel-bot-1
- https://www.nodna.de/Nexus-Robot-tank-wheels-set-2-pieces-45-x-16-x-10-cm-14152
- https://en.wikipedia.org/wiki/Continuous_track

Part Name - Vacuum Nozzle and Battery

Hansin Rakesh Shah (22110090)

Introduction

Our group's project is focused on designing an efficient multi-purpose robot named SPARC-BOT (Sparking Precision Agile Robust Cleansing Brilliant Operations Technology. Our project consists of about 15 parts, of which I have been assigned **a Battery** and **Vacuum tube**. Both these components play a vital role in the working of our robot as power is supplied through the battery, and a vacuum tube is required for waste collection and management.

Vacuum Nozzle

- Structure and Functions

1. **Inlet Nozzle:** It is located at the front end, designed to intake waste materials. It has a suction mechanism to create the necessary vacuum within the tube.
2. **Sealing Mechanism:** It is situated at the connection point between the nozzle and the waste storage container. This ensures an airtight seal, preventing air leakage and maintaining suction efficiency during waste collection.
3. **Transparent Tube:** The main body of the vacuum tube is a transparent cylinder, This transparency aids in identifying when the tube needs emptying or when an obstruction occurs.
4. **Waste Storage Container:** A waste storage container is located at the end of the vacuum tube. This container securely holds the collected waste materials until they can be appropriately disposed of or recycled. The container is detachable for easy removal and emptying.
5. **Waste Collection:** The primary function of the vacuum tube is to collect waste materials. SPARC-BOT utilizes the suction mechanism within the inlet nozzle to create a vacuum, drawing in debris, garbage, and other waste items from the surrounding environment.
6. **Efficient Waste Transportation:** The vacuum tube acts as a conduit for transporting the collected waste materials from the point of collection to the waste storage container. The vacuum created within the tube helps propel the waste through the system, minimizing friction and obstructions that may impede transportation.
7. **Waste Storage and Capacity:** The vacuum tube's connection to the waste storage container allows SPARC-BOT to store a considerable amount of waste before requiring emptying.
8. **Maintenance and Cleaning:** The transparent vacuum tube offers practical benefits beyond waste monitoring. SPARC-BOT's operators or maintenance personnel can inspect the tube for potential blockages or malfunctions. This visibility facilitates more manageable maintenance and cleaning, ensuring the tube remains debris-free and operates optimally.

- ## Possible Challenges

Designing the vacuum tube of SPARC-BOT on AutoCAD presents challenges related to complex geometry, transparent material representation, connection points, suction mechanism, space optimization, integration with the overall design, and realistic visualization. The CAD design would involve using a lot of fillets with appropriate radii. Any deformation in the radii would result in deviation from the smoothness of the vacuum tube.

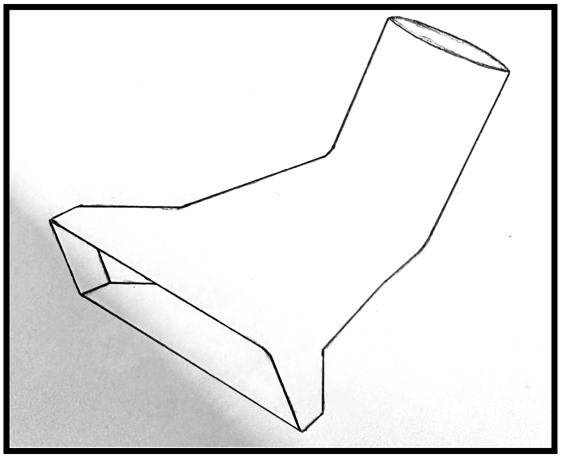


Fig. 14.1 Sketch of the Vacuum Nozzle

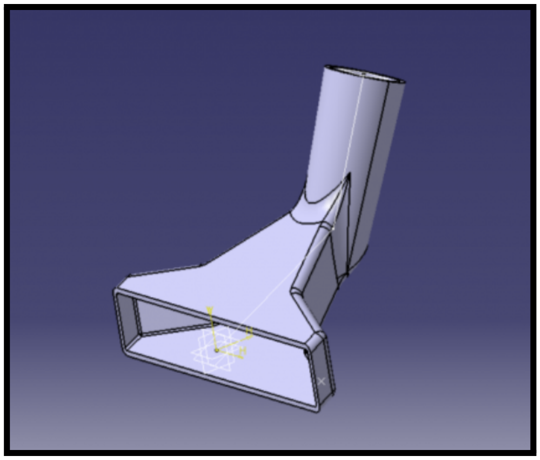


Fig. 14.2 Sharp Filleted Model

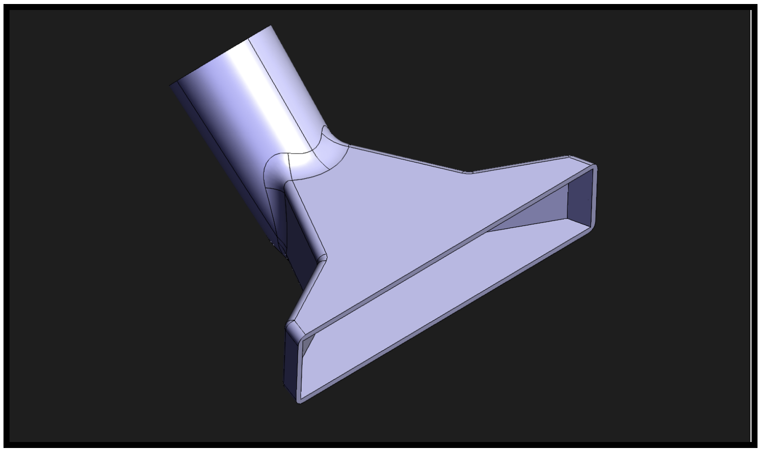


Fig. 14.3 Smooth Fillet Model

Sources

- https://grabcad.com/library/nozzle-of-vacuum-cleaner-1
- https://www.cadblocksfree.com/en/3d-cad-models/autocad/vacuum-cleaner-nozzle.catpart.html

Battery

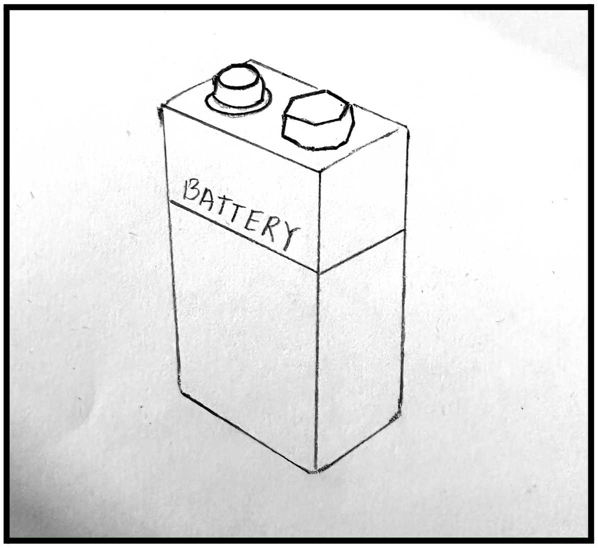


Fig. 15.1 Sketch of the Battery Component

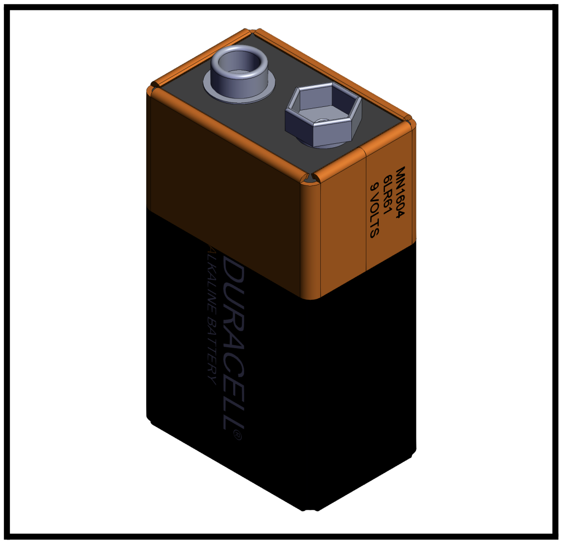


Fig. 15.2 The Battery Model

- ## Structure and Functions

1. **Lithium-ion cells:** the battery consists of a collection of lithium-ion cells. These cells comprise a cathode(made of lithium cobalt oxide), anode(made of graphite), and an electrolyte between them.
2. **Battery Management System (BMS):** The BMS monitors and controls the charging and discharging processes, balances cell voltages, and prevents overcharging, hence optimizing the battery's lifespan.
3. **Housing and Cooling**: The battery pack is enclosed within a protective housing to safeguard it from external impacts. Efficient cooling mechanisms, such as heat sinks or fans, may be used to dissipate excess heat generated during charging and discharging, preventing thermal damage.
4. **Power Supply:** The battery's primary function is to supply electrical energy to SPARC-BOT. It provides the necessary power to drive the robot's motors, actuators, and other electrical components, allowing it to move, lift objects, and perform various tasks.
5. **Energy Storage:** The battery acts as an energy reservoir, storing electrical energy when the SPARC-BOT is not actively consuming power. This allows the robot to operate for

extended periods without requiring an external power source, enabling autonomy and mobility.

6. **Rechargeability:** The battery in SPARC-BOT is rechargeable, meaning it can be replenished with energy to restore its capacity for future use.
7. **Power Density and Weight:** The battery design emphasizes a high power density while maintaining a compact form factor. The lightweight materials used in the battery's construction ensure that it does not significantly add to the overall weight of the robot, facilitating its mobility and maneuverability.

• Possible Challenges

I believe that this part of the SPARC-BOT is relatively easy to design as there isn't really a need to make the inner components of the battery, so there are hardly any challenges that I might have to face while modeling this part. But, the fillets on the edges need to have a suitable radius to account for the scale of the design.

Sources

- https://www.3dcontentcentral.com/Download-Model.aspx?catalogid=171&id=538831
- https://grabcad.com/library/nozzle-of-vacuum-cleaner-1
- https://www.cadblocksfree.com/en/3d-cad-models/autocad/vacuum-cleaner-nozzle.catpart.html

Part Name - Camera in Eyes and Wheel Motors

Hardik Jain (22110091)

Eyes

Introduction

The eyes of the SPARC-BOT are one of the most vital components as they enable the robot to identify specific objects, such as dirt, debris, or waste, which it can then target for cleaning. The eyes are designed using advanced cameras and image processing abilities, which equip the bot to take in visual information, process it, identify the target object, and make decisions based on the information received. This ability empowers the bot to work autonomously, making the cleaning process very smooth and also providing users with a very effective cleaning solution.

- Structure and Functions

1. **Cameras:** This is the primary component of the eyes. Both eyes are equipped with one camera each. These cameras capture real-time videos and images of the surroundings, providing the image processing unit with visual input.
2. **Image sensors:** Image sensors convert the incoming light into digital signals. They are responsible for capturing and converting the visual information into usable data.
3. **Image processing unit:** The image processing unit analyzes the visual data. It contains various software with algorithms for object detection, recognition, and tracking. After analyzing the visual data, this unit further provides decision-making information.
4. **Depth sensors:** Depth sensors provide information about objects' distance and three-dimensional structure near the bot.

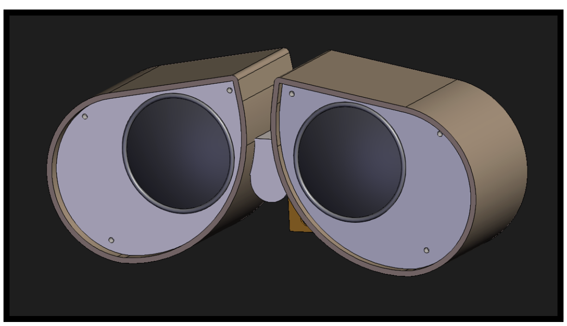


Fig. 16.1 The Eyes

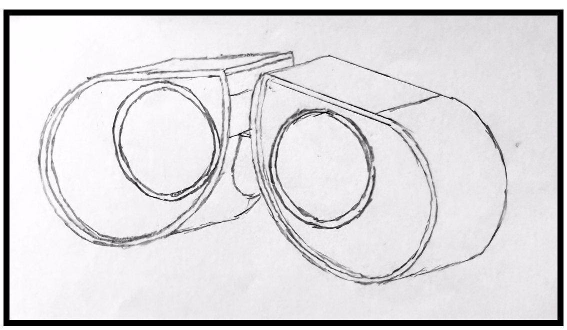


Fig. 16.2 Sketch of the Eyes

- Possible Challenges

  Sketching the perfect outline of the eyes on Autodesk Inventor can pose a challenge as the curves need to be smooth and should also be precise in terms of dimensions. After completing the sketch, the extrusion part would be pretty simple. Another challenge that can be encountered is to fillet the model in the right places and by the right radius.

Wheel Motors

Introduction

The motors of the SPARC-BOT also play a very important role in the successful functioning of the bot. They play a vital role in its mobility and maneuverability. The motors convert electrical and mechanical energy, setting the bot in motion. By controlling the speed and torque applied to each wheel using motor control systems, precise turning and movement can be achieved. The motors should be such that they are well suited for the bot, i.e., they should provide just the right amount of speed and torque to the wheels so that the bot does not lose balance and maintains its smooth and accurate movement.

- ### Structure and Functions

1. **Stator:** The stator is the stationary part of the motor and contains the core, winding, and magnetic poles. It provides the magnetic field required for the motor's operation. The stator windings carry the electrical current that produces the magnetic field around the rotor, making it rotate.
2. **Rotor:** The rotor is the moving part of the motor. It is typically composed of a core and conductive bars or coils. The rotor rotates within the stator's magnetic field, generating mechanical motion. Depending on the motor type, the rotor can be either a permanent magnet rotor or an electromagnetic rotor.
3. **Commutator (in DC Motors):** The commutator is a cylindrical device attached to the rotor. The commutator helps control the direction of current flow in the rotor windings, allowing for continuous rotation. In contact with the commutator, the brushes transfer electrical current to the rotor windings.
4. **Brushes (in DC Motors):** Brushes are conductive components that maintain electrical contact with the commutator in DC motors. They supply electrical current to the rotor windings, enabling the motor's operation.
5. **Shaft:** The shaft is a rotating component connected to the rotor, extending from the motor's body. It transfers the rotational motion of the rotor to the wheels.

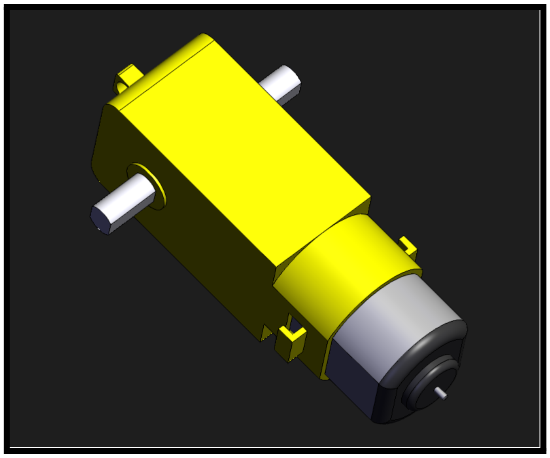


Fig. 17.1 Model of a Wheel Motor

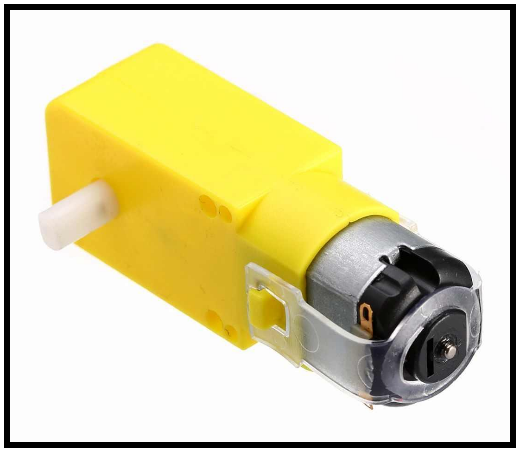


Fig. 17.2 A Wheel Motor

- Possible Challenges

  Some of the challenges that can be encountered while making the CAD design of the DC motor are making multiple sketches. All the sketches need to be extruded differently as well. Also, the design has a significant number of curves in it, so incorporating them into the design can be a little challenging.

Sources

- https://grabcad.com/library/geared-dc-motor-for-arduino-applications-1
- https://wiraelectrical.com/parts-of-a-dc-motor/
- https://images.app.goo.gl/bRdvHvmgdfWQenPGA