CHAPTER 4

UNMANNED GROUND VEHICLE WITH INTEGRATION OF ROBOTIC ARM AND OTHER FEATURES

Roshahliza M Ramli, Nurul Aqilah Binti Herman, Mohd Azrul Hisham Mohd Adib, Nur Fatihah Azmi

ABSTRACT

Many academics from across the world are working to reduce the epidemic effect by using robots and drones. The worst thing was after the face mask rule took effect on 1 August, 2020. In Malaysia, millions of contaminated face masks pose a deadly hazard for humans and wildlife. Besides that, there are many Unmanned Ground vehicles (UGV) equipped with a manipulator nowadays, but the main issue was the lack of stability in picking and placing objects. UGV plays an important role as the equipment that can reduce the risk of infection to cleaners to reduce COVID-19 for disposal. In addition, another aim of this research is to define the generalised coordinates for the robot arm. Thus, UGV had been developed by using hardware and software requirements. In terms of hardware, the robotic arm consists of 4 DC servo motors to control the movement of the robotic arm and 1 DC Servo motor to control the movement of the gripper. Besides that, the rocker boogie consists of 6 DC motors that had been switched by using a dual H- Bridge and controlled by Arduino

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Mega. In terms of software, it used Robo Analyser software to identify the value of position and orientation of each joint correctly, as all these values needed to be used by the controller to tackle stability issues for further research. As a result, this project has novelties that reduced the risk of personnel death by making the disposal process more reliable than the current way, and the safety of the authorities can be improved. Finally, the End Effector position was also successfully retrieved by using the Denavit-Hartenberg method and Forward Kinematic Analysis.

Keywords Robot arm, gripper, remote operated vehicle, UGV

INTRODUCTION

COVID-19 first arrived in Malaysia in January 2020, with the largest cluster being linked to a Tablighi Jamaat religious gathering. According to web-based real-time disease tracking as of 3 July, 2020, at least 8,643 confirmed cases and 121 deaths had been reported. (Aghamohammadi, Ramakreshnan and Fong, 2021). The COVID-19 epidemic has resulted in a global health disaster. In the framework of COVID-19, China's pandemic control plans and problems are examined. The analysis looks at seven solutions, including nucleic acid testing for all employees, vaccination and long-term quarantine systems (Ding and Zhang, 2022). Hence, to combat the disease, the countries use a variety of techniques and policies.

According to literature evaluations, several researchers across the world are working to combat the epidemic by using robots and drones. Applications based on machine learning and artificial intelligence (AI) are greatly assisting in the detection and diagnosis process. Another strategy used to improve health care is the science of robotics. (Sodhi et al., 2022). For the usage of drones in medical circumstances, no algorithm has been created. Previous applications were based on knowledge gathered in non-epidemic situations. Drones can collect data for management, as well as deliver public information. They can also assist in health care and disinfection by doing logistical chores. (Restás, 2022).

Other researchers have the same opinion too that robots may be able to assist in the fight against the pandemic (Khamis et al., 2022). However, drones are not yet an effective disinfection tool.

Currently, based on the previous literature reviews, healthcare personnel are more likely to become infected as a result of their work with patients (Woon et al., 2021). Under the circumstances of the Corona epidemic, the study emphasises the need for health systems in crisis management. The Chinese health system's ability to manage the crisis was largely due to the use of existing modern and advanced technologies. The study, which focused mostly on artificial intelligence, concluded that sophisticated AI-based solutions in the health industry should be adopted (Boutora and Louafi, 2022).

Researchers discussed the role of robots in the COVID-19 epidemic in this study. They made recommendations for robotics use in health care. In the healthcare industry, robotics adoption is still in its development phase, and there is room for further primary research (Bakshi, Kumar, and Puranik, 2022). Chest CT and ultrasound may be more useful for ruling out COVID-19 infection than for distinguishing SARSCoV2 infection from other respiratory illnesses. Future diagnostic accuracy studies should characterise positive imaging findings in advance, with direct comparisons of different modalities, and improve reporting processes (Islam et al., 2021). The impacts of the COVID-19 epidemic are being reduced largely due to robots. By restricting inter-personal contact, they have helped to lower the possibilities of the illness spreading (Bogue, 2020). During the COVID-19 pandemic, service robots were able to limit direct contact between front-line healthcare workers and the infected by distancing them from infection. UVC disinfection is more effective than hydrogen peroxide disinfection and other chemical disinfectants (Yadav et al., 2022).

In India, based on Figure 1, the second wave of the coronavirus illness 2019 (COVID-19) caused panic. The use of steroids, antibiotics and oxygen masks regularly aided the spread of opportunistic diseases such as mucormycosis (Azhar et al., 2022). Mucormycosis of the skin is the third most prevalent clinical form. The majority of the articles came from North America (256 cases, or 36.9%) and Asia (216 cases, 31.2%). Diabetes and blood cancer were the worst common risk factors (Skiada et al., 2022). Mucormycosis emerged after the SARS-CoV-2 virus spread around the world, especially in Asian countries. Uncontrolled diabetes, obesity, and immunosuppression gained by steroid medication appeared to be the main risk factors. The primary cause of the increase in cases is elevated iron levels in the serum of COVID survivors (Pushparaj et al., 2022)

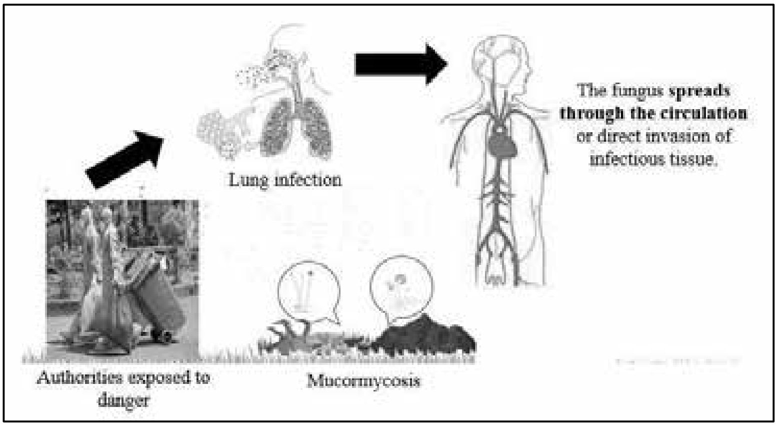


Figure 1: Mask infection from Mucormycosis

Hence, the COVID-19 pandemic has once again underlined the importance of plastic items in our daily lives. The public has widely used disposable face masks constructed of polymer materials as effective and inexpensive personal protective equipment (PPE) to prevent virus transmission (Du, Huang and Wang, 2022). The COVID-19 epidemic has resulted in several industry closures around the world. Because of the impact on people's daily lives, infrastructure and maintenance initiatives have not been halted. During the epidemic, the World Health Organization advises wearing a face mask and keeping a safe distance (Razavi et al., 2021). Due to these literature reviews, the masks lead to covid waste management.

Thus, this research aims to deploy UGV in handling covid waste management. Plus, Unmanned Ground Vehicles (UGVs) with all-wheel independent actuation (AWIA) are designed to take the role of humans (Zhang et al., 2022). Based on other literature reviews, Mehta mentioned that the epidemic of COVID-19 has highlighted the need for a more effective disinfection strategy. UVGI (ultraviolet germicidal irradiation) is a well-proven disinfection and sterilisation method. In addition, Mobile manipulators with end-effectors equipped with far-UVC excimer lamps make up this system (Mehta et al., 2022). This research describes a preventative robot that can both warn and assist people who are infected with the deadly Coronavirus. The proposed robot is user-friendly and performs four functions, which are detecting masks on individuals, spraying-disinfectant or sanitizers, detecting temperature, and finally traveling from one location to another in the hospital (Rooban et al., 2022). As a result, this research focuses on improving a robotic rover, which is a smart unmanned ground vehicle. Rather than placing the rescuer's life in danger, the rover will secure and protect it. In addition, the rover design from this previous research (Herman et al., 2020) had already been modified with additional features, especially a robot arm to lift masks and spray the sanitiser to fulfil the requirement to handle covid waste management.

METHODOLOGY

Using this UGV as equipment to decrease the risk of infection to cleaners is the most effective way to combat COVID-19 for disposal. The purpose of this UGV is to assist authorities in disposing masks in a timely and efficient manner. After that, gather and remove the mask, and finally, offer authorities with visual information. A robotic arm for picking up and depositing trash is also included, and a rocker boogie mechanism for attempting to climb obstructions.

Developments and Designs

This section outlines the process used to construct the Unmanned Ground Vehicle, from its conception through its operation. The SolidWorks software is used to design the Unmanned Ground Vehicle. Each segment and component of the object's construction and drawing is drawn to the same specifications as the original UGV. The segments and parts that must be created are obvious in detail. All pieces are firmly joined in SolidWorks to make the prototype design. Figure 2 shows an orthographic and isometric perspective of the latest design, as well as the entire UGV component.

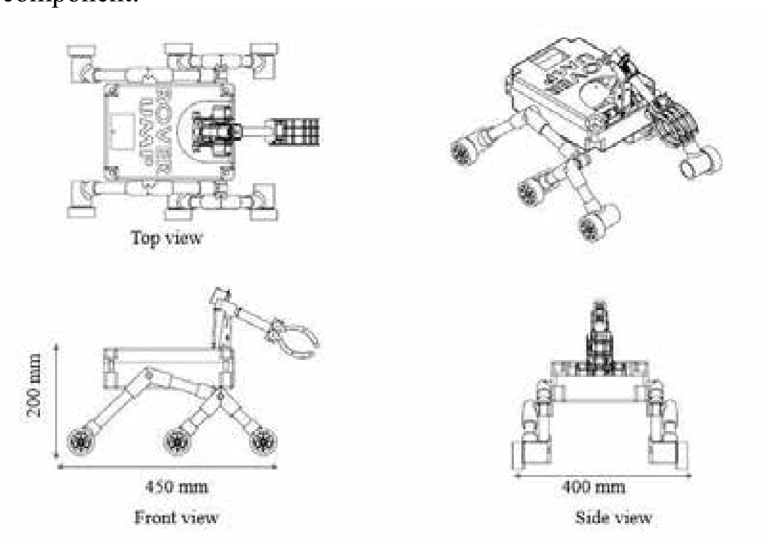


Figure 2: Various views of the proposed Unmanned Ground Vehicle (UGV).

Figure 3 depicts the design and development process for the UGV. Mechanical and electrical parts are the two types of fabrication processes for this UGV. The basic components of the mechanical section are an aluminium steel bar and Acrylonitrile butadiene styrene (ABS). The basic components of the mechanical section are an aluminium steel bar and Acrylonitrile butadiene styrene (ABS). The ABS is utilised on all connectors on the UGV, and aluminium steel is cut depending on the dimensions that have already been designed using SolidWorks.

The connector design was generated in SolidWorks before being transferred to the CURA program. CURA software was used to 3D print all the connectors, and it was necessary to tweak the thickness and infill to produce a better final product from 3D printing. The connector was joined with the aluminium to be assembled as the UGV chassis part.

To move the UGV, a DC motor and Lippo battery were utilised as the power supply for the electrical components as a controller. An Arduino-Mega acts as a coding controller, executing the specified command in the system. To conduct the multipurpose UGV, the coding is done in conjunction with the Wi-Fi camera and hand sanitiser. The design and flexibility of locomotion, as well as the speed of UGV, must also be considered to finalise the UGV's ultimate design.

Finally, after the mechanical and electrical pieces have finished fabricating, the assembly process will be completed to present the UGV with multifunction. These smart UGV functions include the ability to travel around obstacles using a rocker-bogie mechanism, capture real-time visuals using a Wi-Fi camera, lift the mask by using a robot arm, and sanitiser spray to disinfect the robot arm after the operation is completed.

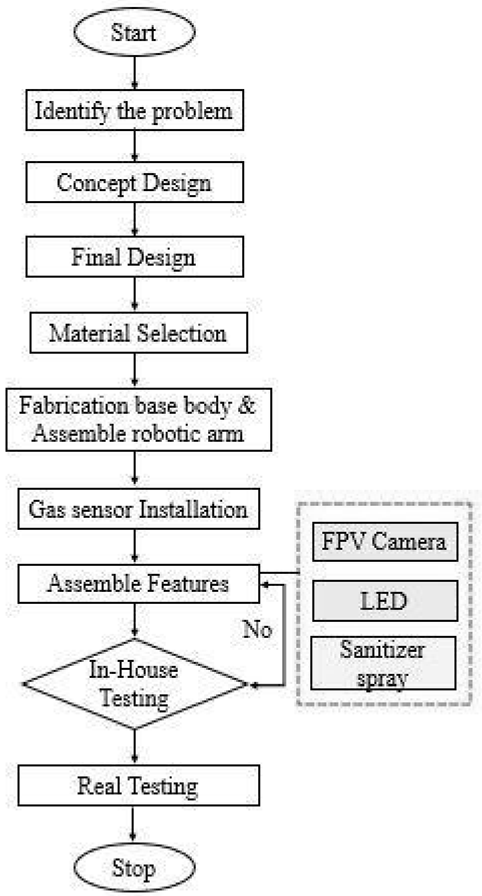


Figure 3: Design and Development process of UGV

Specifications and Materials

Five main materials are chosen to produce the whole part of UGV, which are Aluminium 1060-H16, Hard Aluminium Alloy + Copper pillar, Rubber, Acrylonitrile butadiene styrene (ABS) filament, and Polyvinyl Chloride (PVC). Figure 4 illustrates the isometric drawing of the developed UGV with the materials used for its parts. Meanwhile, Table 1 lists the specifications of the materials, which are aluminium, hard aluminium alloy, rubber and

PVC. In this table, an additional parameter for rubber is also given and considered.

These different materials are used for different parts of UGV development. As shown in Figure 4, the aluminium 1060-H16 is used for the robotic arm, aluminium alloy is for the gripper, rubber is for tires and PVC is used for chassis connectors for this UGV. Table 2 shows the specification for ABS, the material used for the box cover that becomes the housing for electrical electronics components, as well as for the chassis connector used in the UGV development.

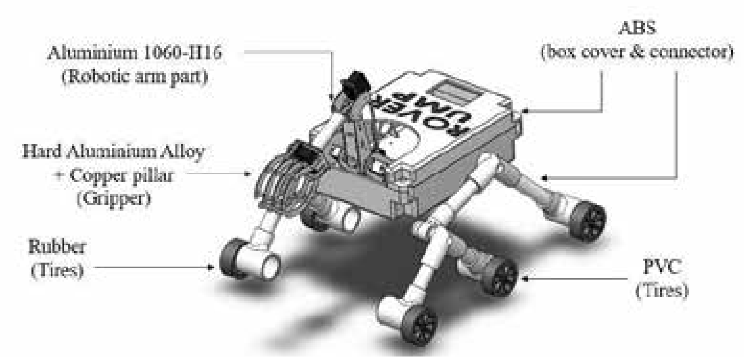


Figure 4: Materials selection of Unmanned Ground Vehicle

Table 1 shows the specifications in terms of Elastic Modulus, Poisson's Ratio, Shear Modulus, and Mass Density. All these specifications are very important, especially if we want to choose the best material. One of the most essential qualities of properties of the material is the elastic modulus, which is a material parameter that describes stiffness. T is the ratio of stress to strain when deformation is entirely elastic. In simple words, strain is defined as elongation or contraction per unit length, whereas stress is defined as force per unit area. In addition, in engineering analysis, Poisson's ratio is a necessary constant for estimating the stress and deflection properties of materials such as plastics or metals. Next, the shear modulus refers to the ratio of shear stress to shear strain and lastly, mass density plays an important feature because it will help us to determine which compounds will float and which will sink in a liquid.

Table 1: Specification of Aluminium 1060-H16, hard aluminium alloy, rubber, and PVC.

Specifications	**Aluminium 1060-H16**	**Hard Aluminium Alloy**	**Rubber**	**PVC**
Elastic Modulus (N/m^2)	6.9^e+010 N/m^2	1.1^e+011	10000	6000000
Poisson's Ratio	0.33	0.3	0.45	0.47
Shear Modulus (N/m^2)	2.6^e+010	4.3^e+010	-	2000000
Mass Density (kg/m^3)	2705	7400	960	1290
Tensile Strength (N/m^2)	-	-	20000000	-
Parts of UGV	Robotic arm	Gripper	Tires	Chassis connectors

Table 2: Specification of ABS Materials

Specifications	**Details**	**Units**
Printer temperature	220-250	°C
ABS diameter	1.75 ± 0.05	mm
ABS length	330	mm
Printing speed recommendation	30-70	mm/s

Principles of operation

The purpose of this project was to build a UGV called a smart robotic rover to move it across obstacles, detect dangerous gas leaks, sanitise the robot arm and monitor data collection in hazardous environments. This part will cover the hardware and surface interface of UGV, working principles of the features involved, and step by step to control UGV as a user.

As we can see, Figure 5 shows the Unmanned Ground Vehicle Hardware and Software Interface. We separated the hardware and software interface to design the UGV. The hardware interface consists of input, processing and output stages, with the outputs being routed to the software interface for the application. Three major batteries have been used to power each of the components. This UGV comprises two primary components, which are, the rocker boogie and the robotic arm with a gripper, as well as various optional features such as a gas sensor, LED, spray and an FPV camera. Aside from that, the rocker boogie is made up of 6 DC motors that have been switched using a dual H-bridge and are controlled by an Arduino Mega. The dual H-bridge switches the polarity of a voltage given to a load. These circuits are typically utilised to allow DC motors to move forward or backward in robotics and other applications. Apart from that, the coding was applied to three separate parts of the rocker boogie, particularly for the front, middle and rear boogies, to regulate the movement of the rocker boogie. As a result, the user may simply control the movement of the rocker boogie using the PS2 joypad.

The robotic arm is then made up of four DC servo motors that control the robotic arm's movement and one DC servo motor that controls the gripper's movement. The Arduino Analog Sensor Shield V4.0 board is used to link all the DC servo motors. The Arduino Sensor Shield is a device that allows us to connect DC servos to an Arduino board without the need for soldering. Meanwhile, the HC-06 Bluetooth is used as a Bluetooth device that communicates using Serial UART. As a result, the user can only use the phone to control the movement of the robotic arm and gripper. The UGV then used the MQ2 as a gas sensor. This is a sensor that detects combustible gases, as well as smoke. The Raspberry Pi does not have an ADC chip built-in. As a result, it is unable to independently evaluate analogue input. Thus, the MCP analogue to digital converter will be required because it allows us to construct circuits using analogue input. For a reason, the MCP3002 is an excellent choice for pairing with a Raspberry Pi.

Therefore, the user may monitor the gas sensor findings simply using their phone. Moreover, the UGV included an FPV camera as one of its extra features to make it easier for the user to watch the area. Users can also use the LED light to control the UGV during the night or in low-light conditions. After executing the pick-and-place operation, the user can sterilise the robotic arm.

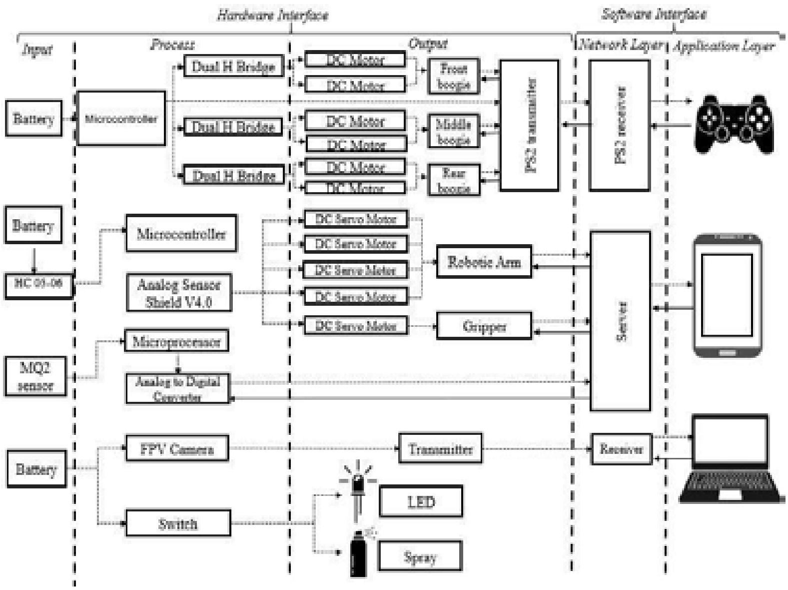


Figure 5: Hardware & Software Interface of Unmanned Ground Vehicle

Finally, Figure 6 summarises all the steps for the users, while Figure 7 and 8 show details of procedures that need to be taken by the users to control the UGV.

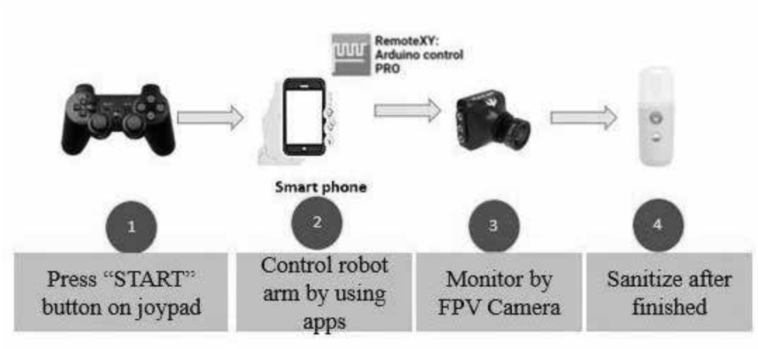


Figure 6: Summarisation of Working principle of UGV

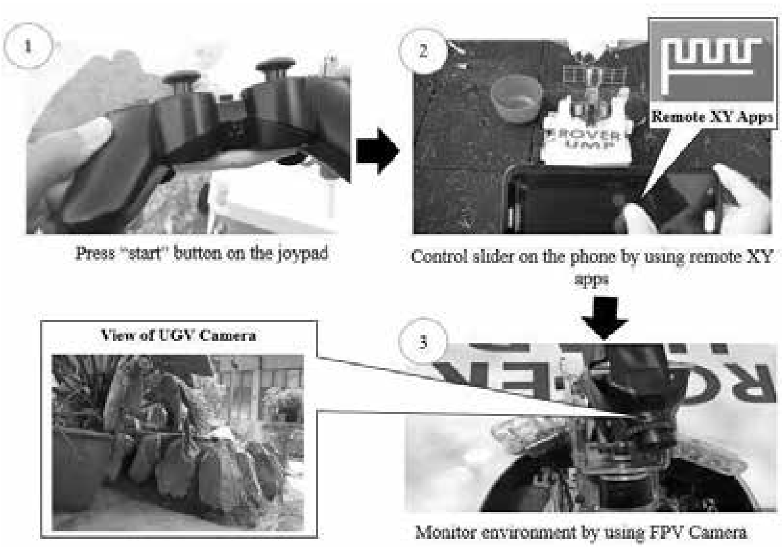


Figure 7: Step by step to control UGV

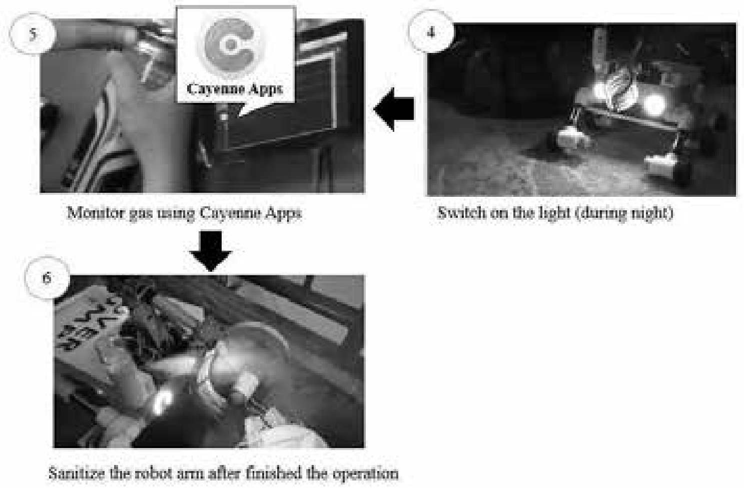


Figure 8: Continuous steps to control UGV

Denavit-Harternberg in Software implementation

The scope of the research is much more focused on robotic arm part development. Thus, the robot arm implemented Forward Kinematic Analysis to determine the position and orientation of the gripper. In addition, all these values are required by the controller to address the stability issues of the robot arm. Figure 9 summarises the visual concept of the Forward Kinematic Analysis.

The robot arm is another word used for the manipulator. It consists of joints and links. The Joint is a part that allows all the robot motion while the link is a part that connects all joints. As shown in Figure 9, we used 6 joints. We called the last link of the robot arm as the End Effector. In addition, Kinematic Diagram is a diagram that will show how all the joints and links are connected when all the joint variables have a value of 0. In simple words, the kinematic diagram is used to show the initial position of the robot. Therefore, we also need to know that there is a particular method to represent the displacement and orientation of the robot. In our case, displacement represents position while rotation represents orientation.

Thus, we required a method that can record the position and rotation values of the robot arm. The method that can be used is the Denavit-Hartenberg method. In Denavit-Hartenberg, there are 4 parameters, which are di as joint offset, θi as joint angle, ai as link length, and αi as twist angle. All the values of these parameters are shown in Table 3.

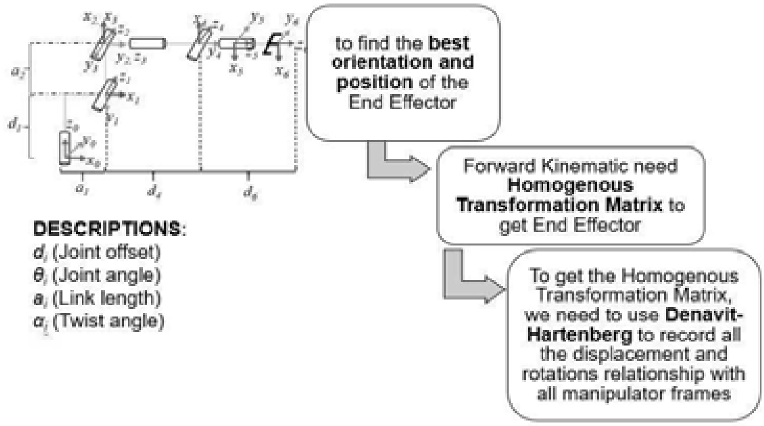


Figure 9: Kinematic Diagram of Robot Arm with Forward Kinematic Analysis visual concept

Table 3: Denavit-Hartenberg Parameter Table

Joints	D-H Parameters			
	d_i (mm)	a_i (mm)	α_i (deg)	θ_i (deg)
1	0.065	0.025	-90	0
2	0	0.135	0	-90
3	0	0	-90	0
4	0.08	0	90	0
5	0	0	90	180
6	0.045	0	0	0

All the visual simulations are conducted in a visual simulation software called Robo Analyser software, as shown in Figure 10. In addition, we need to insert all the D-H Parameters values into the table provided in the software. The purpose to do this is it will help us to generate a 3D kinematic diagram and finally derive the Final Transformation Matrix. Furthermore, Figure 11 shows the representation of the Kinematic Diagram links in the 2D Kinematic Diagram for the real links consisting of the real robot arm.

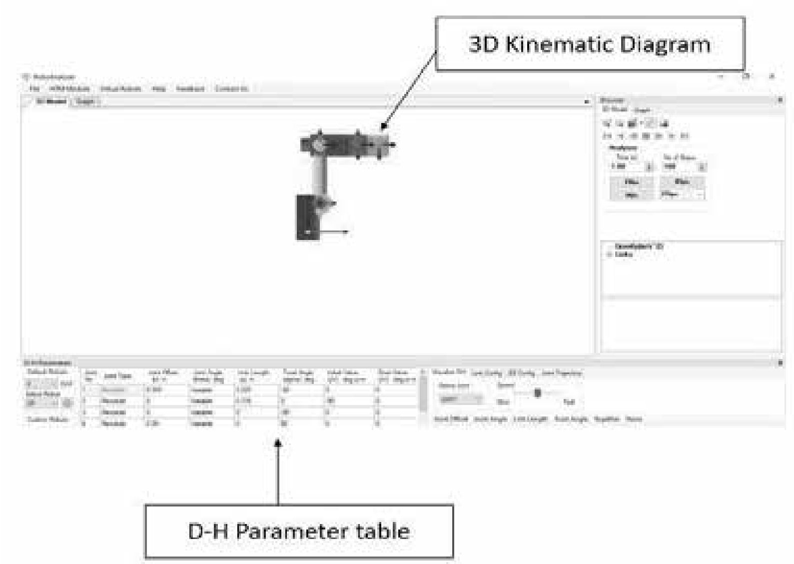


Figure 10: Kinematic Diagram of Robot Arm with Forward Kinematic Analysis visual concept

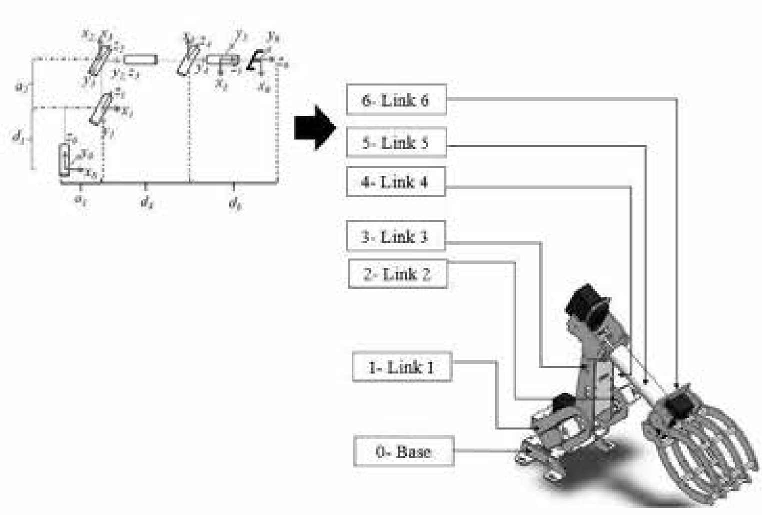


Figure 11: Links that represent Kinetic Diagram of the real robot arm.

Then, to control the robotic arm, we simply need to use the "remote XY" apps on the phone. As shown in Figure 12, we had coded all six DC Servo motors that are linked to the slider on the phone. Thus, Table 4 shows the joint connection towards all DC Servo motors in the robot arm part.

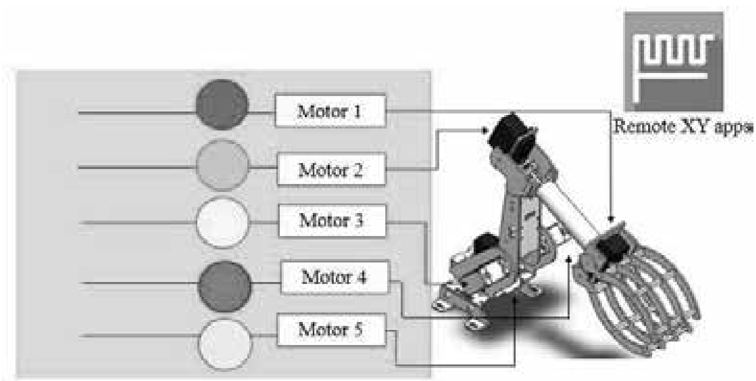


Figure 12: Slider in the apps to control Motors for the Links

Table 4: Joints connection to Motors

Joints	Motors
Base	5
1	3
2	4
3	2
4	1

RESULTS & DISCUSSION

This section elaborates and discusses UGV results in terms of UGV Manufacturing results, experimentations conducted in the lab, validation of its functionality, and reviews of the responses from the users.

Manufacturing of Unmanned Ground Vehicle

In this study, the prototype UGV is finely developed. The UGV mainly focuses on three functions, which are, picking and placing objects, monitoring the dangerous condition, and detecting hazardous gases, and climbing obstacles. Figure 13 shows the complete developed UGV with its main components, as designed in Figure 4.

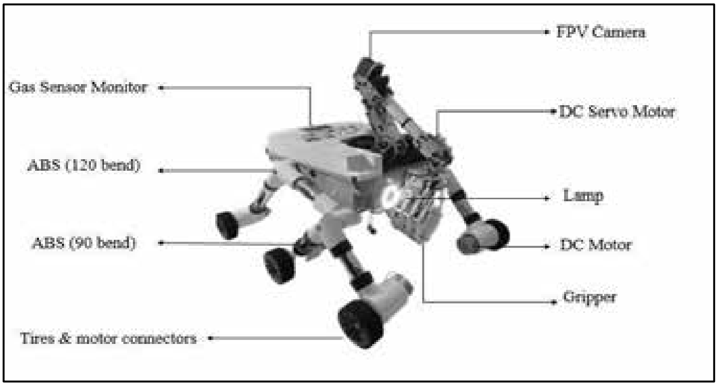


Figure 13: Characteristics of UGV

Experimentations in the lab

We developed the robotic arm part and chassis part separately. Firstly, once the robotic arm part had been developed and the coding run successfully, its functions to lift objects had been experimented with within the lab. Figures 14 and 15 validated the function and as proof, its ability to lift an object is great because it is still able to lift an object with a weight of 300g. Thus, Table 5 summarises the capabilities of the robotic arm. Besides that, experiments on the UGV chassis also had been tested, especially on its ability to climb the stairs. Hence, Figure 16 validates the climbing abilities of the UGV. Lastly, we tested the other abilities of UGV in terms of its additional features. Thus, Figure 17 validates the effectiveness of UGV in detecting hazardous gases and it displayed the gas sensor result successfully by using Cayenne Apps.

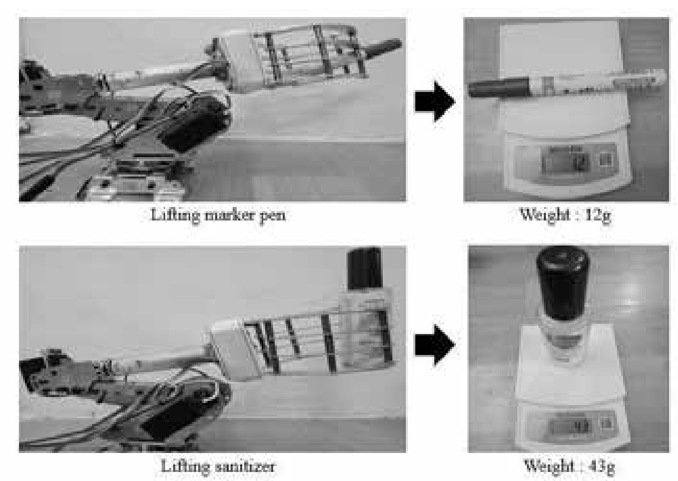


Figure 14: Robotic-arm lab performance to lift marker pen and sanitiser

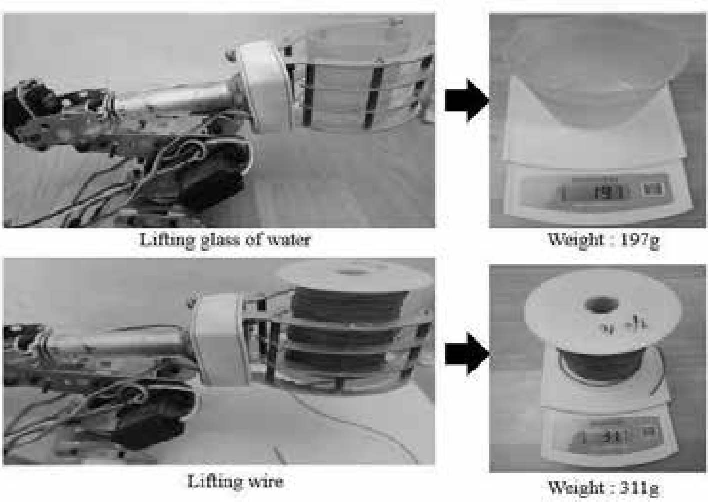


Figure 15: Robotic-arm lab performance to lift a glass of water and a thread of wire

Table 5: The capability of the robotic arm to lift an object

Objects	Weight (g)
Marker pen	12
Sanitiser	43
Glass of water	197
Wire	311

Climbing the stairs

Figure 16: Validation of the UGV's ability to climb stairs

Testing the gas sensor

Result for gas sensor

Figure 17: Gas sensor testing experiment

Validation of Functionality

Aside from testing the UGV abilities inside the lab, we also conducted the experiment based on its real application. Figure 11 shows that the UGV can be used in various places, whether in indoor or outdoor places such as school corridors, LRT stations or school fields. All the pictures validate that the UGV can be used to lift masks during the COVID-19 pandemic situation. By having this robot, it can help in managing waste and avoiding the possibility of being infected by the disease.

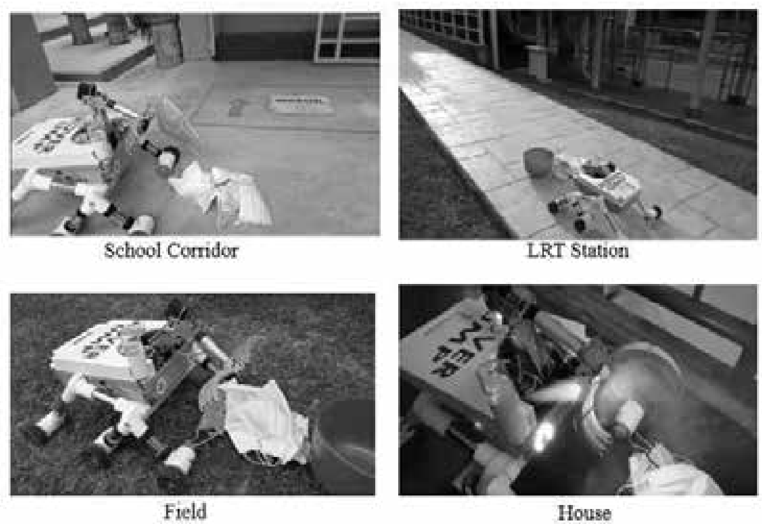


Figure 18: Application Areas for UGV

Response from the user's point of view

Based on Figure 19, according to the preliminary study on the current UGV, approximately 30% of the 30 respondents indicated that price will become the primary priority in the eyes of potential users. The percentages for function, easy handling, portable and weight are approximately 20%, 15%, 10% and 8%, respectively. However, as shown in the figure, the brand and size of the device are nearly identical. The users responded positively and feel safe when operating the current rover. There was no negative feedback or complaints while handling this UGV.

Thus, it clearly shows price is the most important feature for the user to buy this UGV. In terms of commercialisation, this is a new idea, especially for COVID waste management by using UGV. Most of the robots focused on disinfection tools. The outcome had not been commercialised yet, but it had already been experimented with and translated into practice. In addition, potential users of the invention are the authorities, especially for cleaner staff. Besides that, the geographical scale for this application is targeted for National. Hence, the impact of outcome from the perspective of healthcare is it can prevent the risk of infection. Plus, non-similar products are identified in the local market and as information, similar products already exist overseas but are very expensive. Thus, outside competitors do exist but with a different purpose and currently, this UGV is focused on research purposes only.

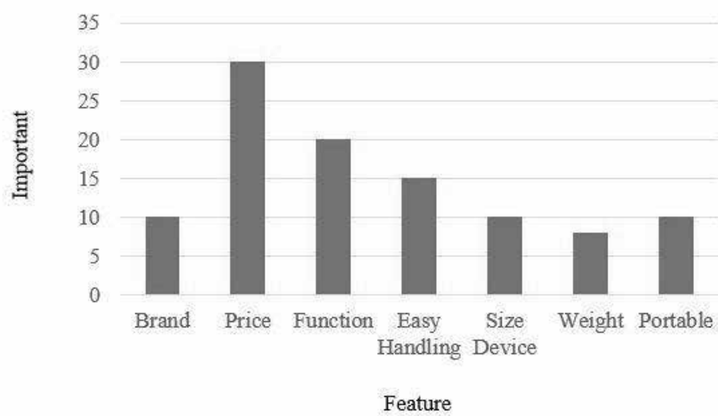


Figure 19: Users' perspectives on the features of the robotic rover in a preliminary survey

Matrix form results from Denavit-Hatenberg Method

The simulation results shown in Figure 21, 22, 23 and 24 depict a Forward Kinematic Analysis of the 6 degrees of freedom (DOF) of a robotic arm kit generated by the Robo Analyser software. All the results were gained from the Denavit-Hartenberg Method. Equation 1, which is the Transformation Matrix Value, recorded all the position and rotation values from Link 0 until Link 6. The Transformation Matrix is gained from the multiplication of 6 joint matrices.

$$T^0{}_6 = T^0{}_1\, T^1{}_2\, T^2{}_3\, T^3{}_4\, T^4{}_5\, T^5{}_6 \qquad (1)$$

$$T_6^0 = \left[R_6^0(q)\ o_6^0\ (q)\ 0\ 1\right] \tag{2}$$

$$T_6^0 = T_1^0\ T_2^1\ T_4^3\ T_5^4\ T_6^5 = \begin{bmatrix} r_{11} & r_{12} & r_{13} & p_x \\ r_{21} & r_{22} & r_{23} & p_y \\ r_{31} & r_{32} & r_{33} & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{3}$$

Next, all matrix multiplication results must take the form of the resultant matrix shown in Equation 2, which will show the orientation in the upper left corner of the 1 x1 matrix, and the position of *x*, *y* and *z* in the upper right corner of 1x1 matrix. We also can write the result of the Resultant Matrix Form into the Matrix form, as shown in Equation 3. This is because the matrix form in the upper left corner of the 3x3 matrix shows the detail orientation values represented by variables r_{11}, r_{12}, r_{13}, r_{21}, r_{22}, r_{23}, r_{31}, r_{32}, and r_{33}. Meanwhile, p_x, p_y, *and* P_z in the upper right corner of the 1x1 matrix show detailed coordinate joint position values. Thus, Table 6 summarises the finding results and finally, we retrieved the End Effector position, which is 0.058 for x, 0.023 for *y,* and 0.048 for the z position. Finally, Figure 20 summarises all the equation concepts.

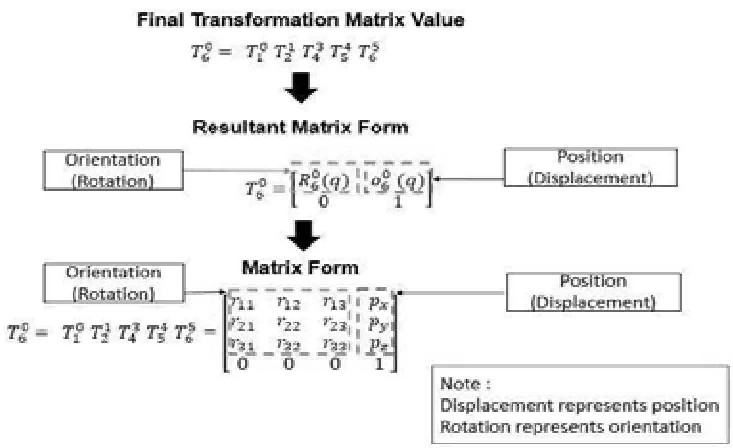


Figure 20: Summarisation concept of DH parameters, Final Transformation Matrix, Resultant Matrix Form and Matrix Form

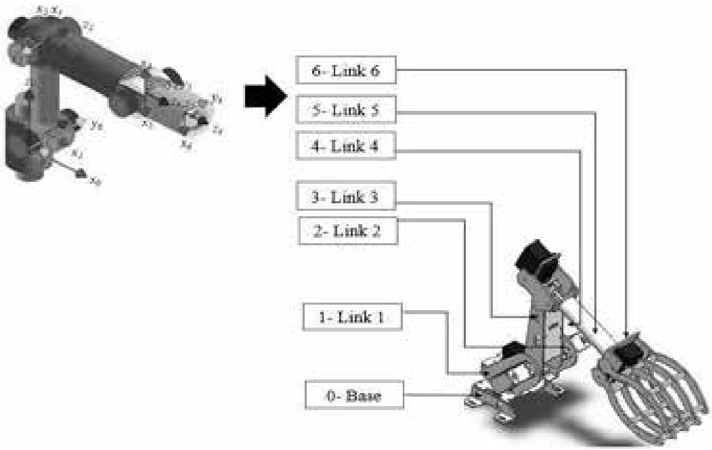


Figure 21: Kinematic Diagram result generated by Robo Analyser that represents the Links of the robot arm.

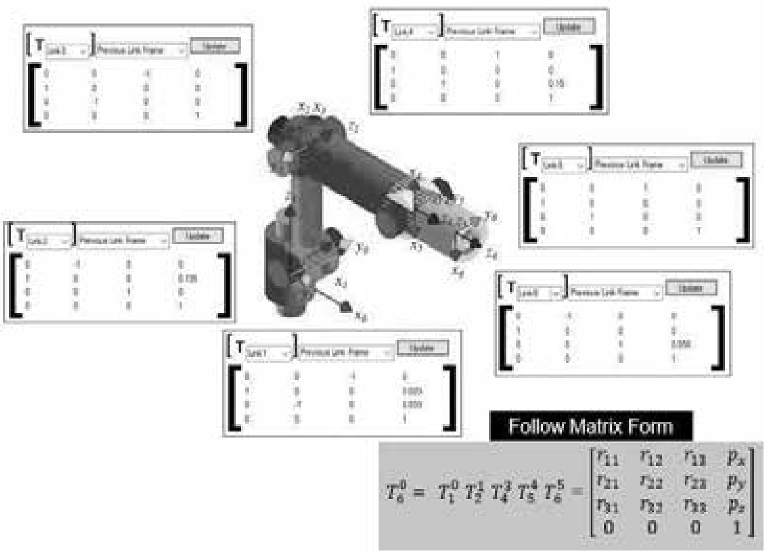


Figure 22: Homogenous Transformation Matrix results generated in Robo Analyser from Link 1 until 6

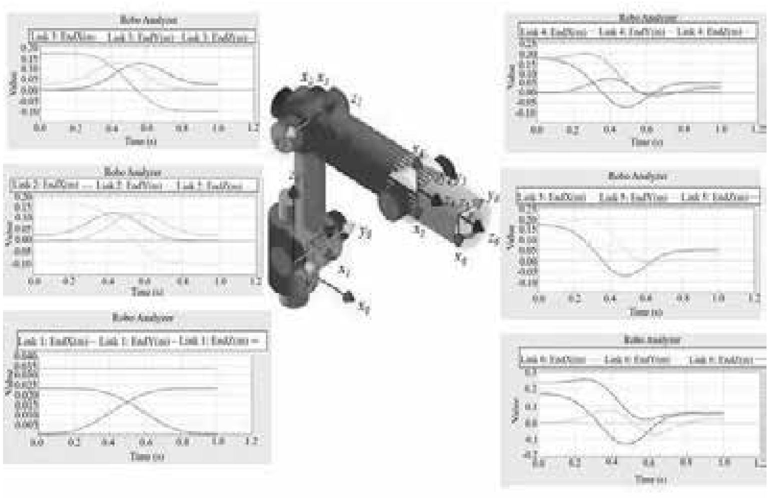
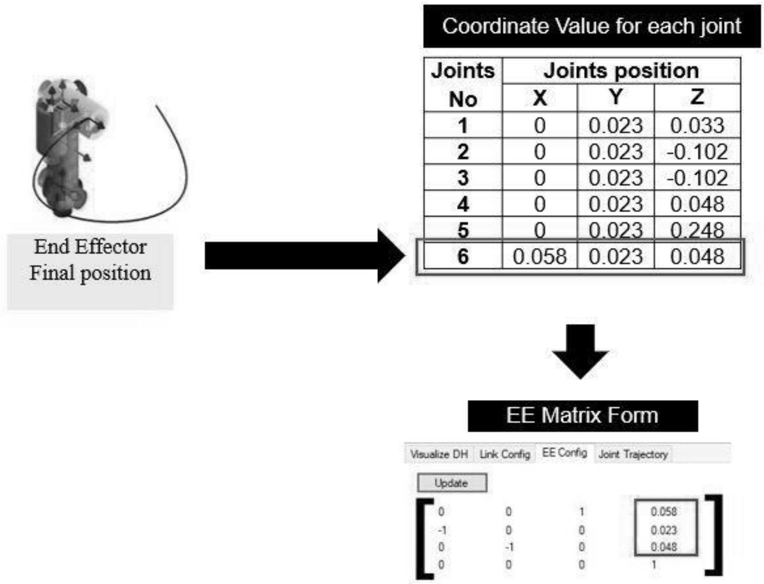


Figure 23: Coordinate Values of Joints results generated in Robo Analyser from Link 1 until 6

Table 6: Coordinate Values for each joint

Joints	Joint positions		
	X	Y	Z
1	0	0.023.	0.033
2	0	0.023.	-0.102
3	0	0.023.	-0.102
4	0	0.023.	0.048
5	0	0.023.	0.248
6	0.058	0.023.	0.048



Joints No	Joints position X	Y	Z
1	0	0.023	0.033
2	0	0.023	-0.102
3	0	0.023	-0.102
4	0	0.023	0.048
5	0	0.023	0.248
6	0.058	0.023	0.048

$$\begin{bmatrix} 0 & 0 & 1 & 0.058 \\ -1 & 0 & 0 & 0.023 \\ 0 & -1 & 0 & 0.048 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Figure 24: End Effector Final Position in the form of Kinematic translated in Matrix Form

CONCLUSION

In conclusion, an electrical and mechanical approach integration was established for a small-scale UGV to handle COVID waste management. Besides that, it could be improved to use other waste instead of COVID-19 waste because we are in an endemic phase and masks are not required in many places. In addition, all elements are firmly bonded together in the SolidWorks program to ensure complete construction and precise measurement of each item by the manufacturer's standards. The mechanical part's major components are aluminium steel and Acrylonitrile butadiene styrene (ABS). It also features two primary components, which are the rocker boogie and the robotic arm with a gripper. In addition, a gas sensor, LED, spray and an FPV camera are among the enhanced features equipped on the UGV.

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