Shri Vile Parle Kelavani Mandal's
DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING
(Autonomous College Affiliated to the University of Mumbai)
NAAC Accredited with "A" Grade (CGPA : 3.18)

Electronics & Telecommunication Engineering Department

INNOVATIVE PRODUCT DEVELOPMENT (DJ STRIKE)

Project Work

On

"UV Sanitization system"

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Group No.: 21

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A. Abstract

The motive behind using UV light is because it is an effective sterilization measure against a wide range of different microorganisms that are present within the environment. The use of UV sterilizing equipment is becoming more widespread, particularly in reaction to the ongoing COVID-19 pandemic. However, Ultraviolet rays are harmful to human beings, so this robot will be armed with a Human Detection System using OpenCV with the help of a camera module. The system will be directly linked to UV lights so whenever the camera module will detect human beings it will turn off the UV lights for human safety. The camera module will be installed on a servo motor which automatically rotates at regular intervals to avoid blindspots and to detect human beings. Since OpenCV is used, it is easy to integrate with Raspberry Pi instead of Arduino UNO. A 6 wheeled mechanism chassis will be implemented. This automation will be done using Ultrasonic sensors.

B. Keywords — Sanitization, Autonomous, UV light, Covid-19, Human and Object detection system, Rocker Bogie Mechanism.

C. Introduction

These past several months have shown us how much healthcare providers go through to offer us with appropriate medical care, and it has been difficult for us all. We must regularly wash our hands, wear masks, and keep social distance. But, first and foremost, we must avoid traveling to locations where the virus can be highly infected, such as schools, colleges, hospitals, banks, business offices, government offices, and so on. However, our frontline personnel who sanitize public spaces are unable to avoid entering severely contaminated areas. Because their job is dangerous and life-threatening, the major goal of this project is to provide them with a system that automatically sanitizes the infected area with the same level of efficiency as a human.

UV lights can help us sustain in the current situation and are helpful if similar situations like the pandemic arrive. UV light can stop the transmission of many contagious diseases. It can disinfect surfaces. Upon researching an article showed us a detailed study on the ultraviolet light benefits. It has a large-scale success rate against the spread of novel coronavirus and the SARS CoV-2. There are different types of ultraviolet light. UV-A and UV-B are a natural gift to the Earth for these UV lights purify the air and the water. UV-C has proven to be the most efficient for sanitization purposes. To make the UV sanitization system efficiently work in households, colleges, schools, and other domestic purposes we need to assemble the system in such a way that anyone can operate it from a distance. Therefore for the convenience of using open CV, raspberry pi would be utilized to its best. The system should also be able to climb and surpass a wide variety of terrains. The Rocker Bogie mechanism can climb a slope of 45˚ thus has the capacity to sanitize a corridor and stairs as well. UV lights are harmful to humans and risk melanoma of the skin. UV light-emitting devices are carcinogenic to humans. This mandates us to have a system that protects humans

from exposure to UV light.

D. Literature Survey

Some related work on the sanitization system. Starting with [1] it shows us how UV lights can help us sustain in the current pandemic. UV light can stop the transmission of many contagious diseases. It can disinfect surfaces. The article showed us a detailed study on the ultraviolet light benefits. It has a large-scale success rate against the spread of novel coronavirus and the SARS CoV-2. There are different types of ultraviolet light. UV-A and UV-B are a natural gift to the Earth for these UV lights purify the air and the water. UV-C has proven to be the most efficient for sanitization purposes. [2] To make the UV sanitization system efficiently work in households, colleges, schools, and other domestic purposes we need to assemble the system in such a way that anyone can operate it from a distance. Therefore for the convenience of using open CV, raspberry pi would be utilized to its best. [3]The system should also be able to climb and surpass a wide variety of terrains. The Rocker Bogie mechanism can climb a slope of 45˚ thus has the capacity to sanitize a corridor and stairs as well. [4] UV lights are harmful to humans and risk melanoma of the skin. UV light-emitting devices are carcinogenic to humans. This mandates us to have a system that protects humans from exposure to UV light. The system should be automated in such a way that it can detect humans and also stop emitting UV light when there is any human in the vicinity. [5] The algorithm to be used for human detection is Faster R-CNN. Being a deep convolutional network is used for object detection, that appears to the user as a single, end-to-end, unified network. The network can accurately and quickly predict the locations of different objects.

E. Theory

a. Working Principle

The motive behind using UV light is because it is an effective sterilization measure against a wide range of different microorganisms that are present within the environment. The use of UV sterilizing equipment is becoming more widespread, particularly in reaction to the ongoing COVID-19 pandemic.

- However, Ultraviolet rays are harmful to human beings, so this robot will be armed with a Human Detection System using OpenCV with the help of a camera module.
- The system will be directly linked to UV lights so whenever the camera module will detect human beings it will turn off the UV lights for human safety.
- The camera module will be installed on a servo motor which automatically rotates at regular intervals to avoid blindspots and to detect human beings.
- Since OpenCV is used, it is easy to integrate with Raspberry Pi instead of Arduino UNO.
- A 6 wheeled mechanism chassis will be implemented and automatically maneuvered using 12V DC motors.
- This automation will be done using Ultrasonic sensors.

b. Block diagrams

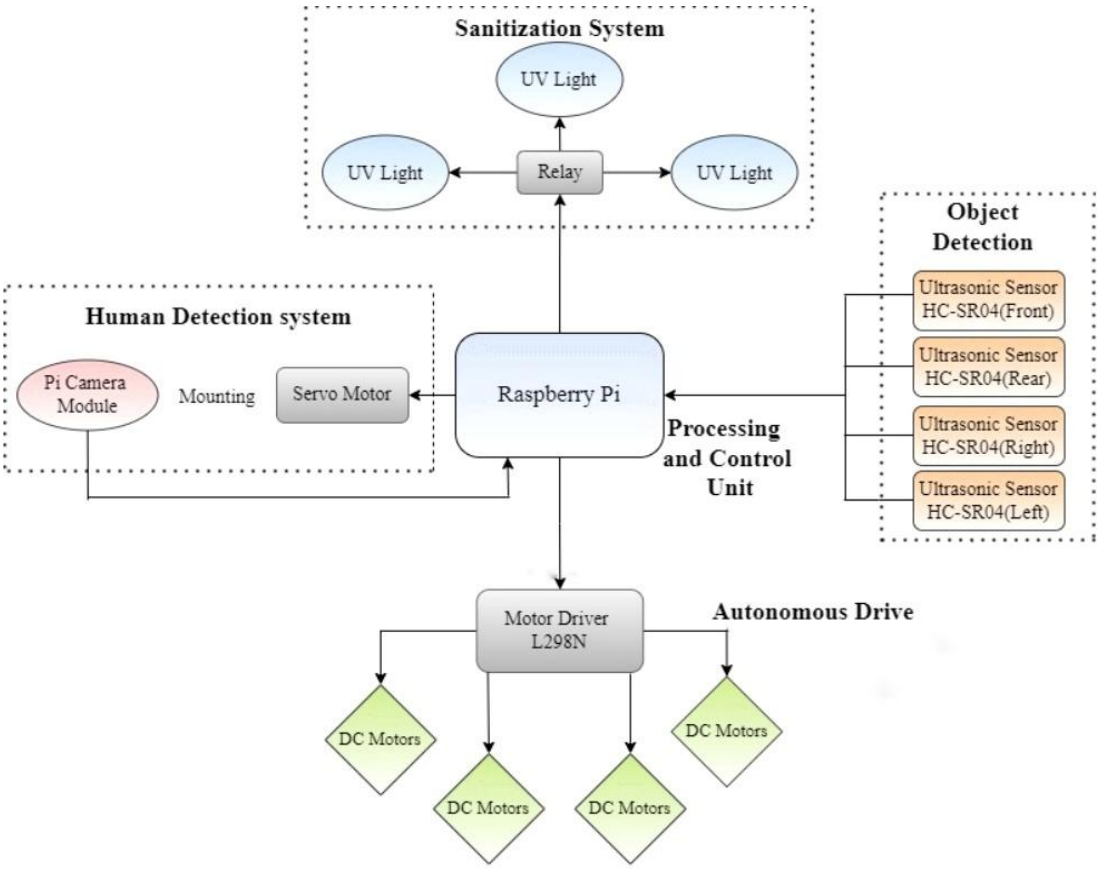

Fig.1 *Proposed System Block Diagram*

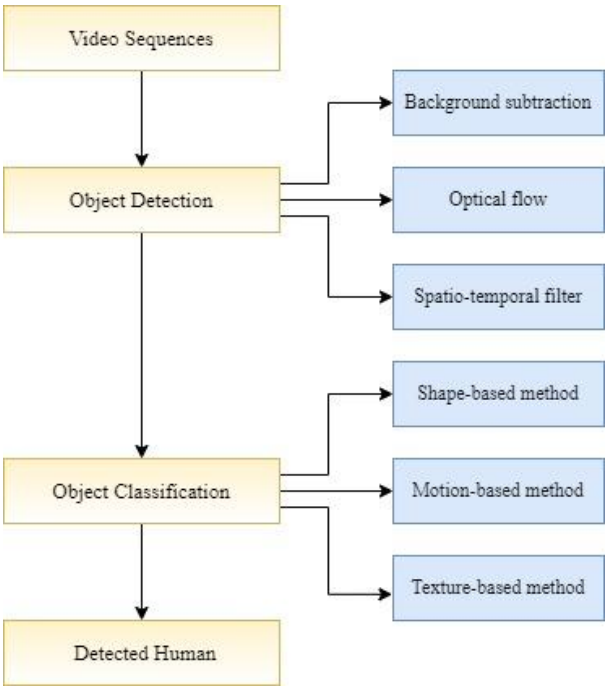

Fig.2 *Flowchart for object and human detection*

c. Complete Circuit diagram and description in detail

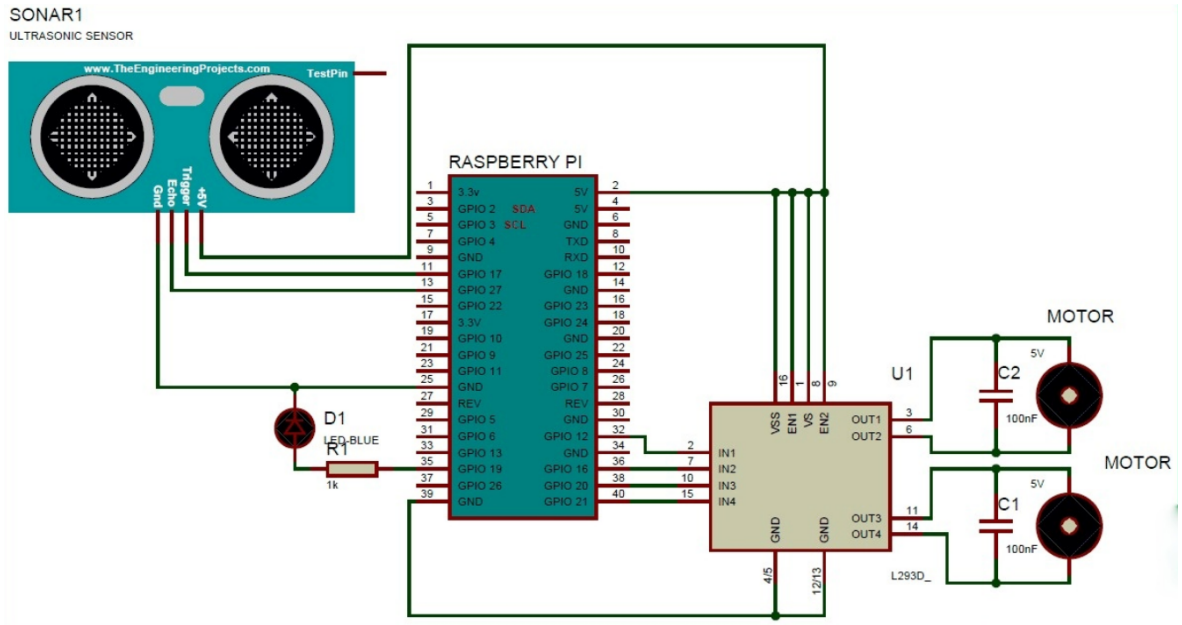

Fig.3 *Schematic Diagram*

d. Outcome of the Project

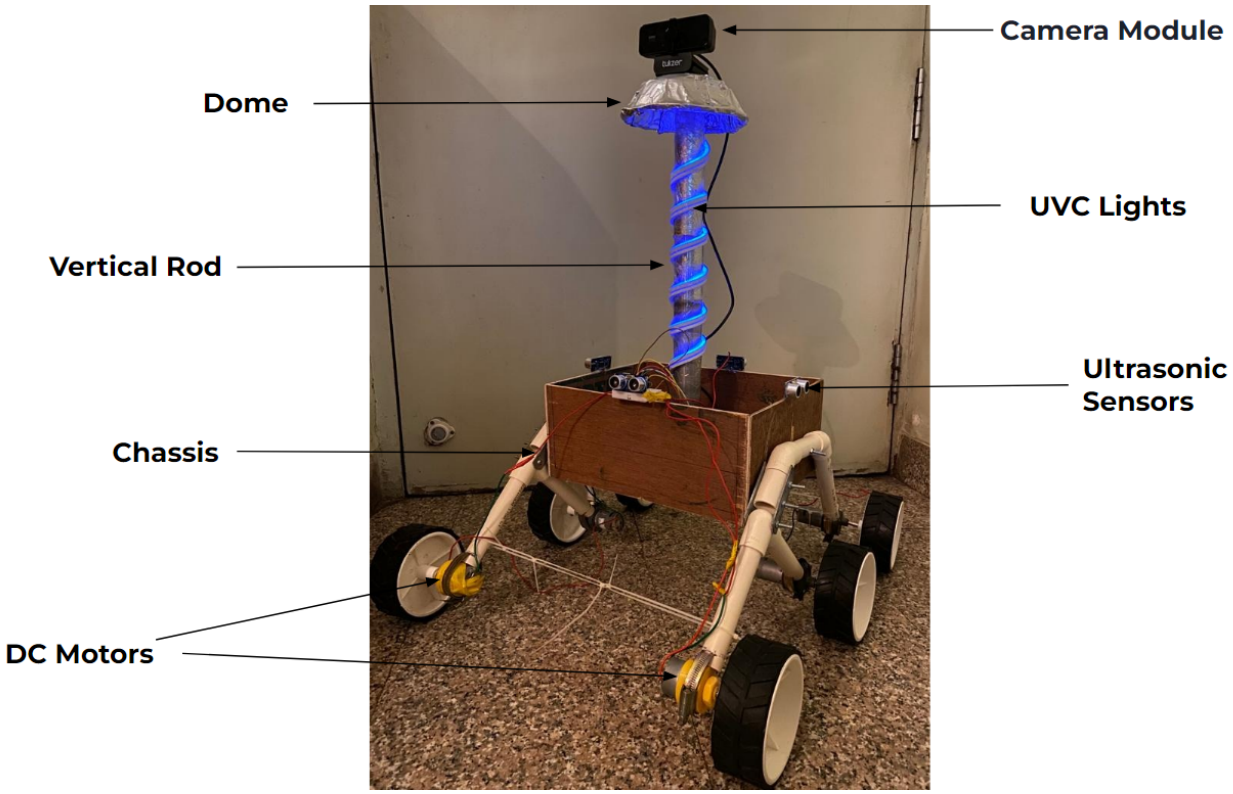

Fig.3 *Outcome of the Project*

1) Chassis

The main objective of using the Rocker bogie mechanism in our project (Autonomous UV Sanitization System) is to make our system armed with a mechanism that can also climb stairs and also not affect its maneuverability. This mechanism is capable of climbing an inclination of up to 45 degrees. This will help our system to sanitize the stairs area. This mechanism also doesn't affect the maneuverability of the system while sanitizing the indoors.

(i) Design and Calculations:

The important factor in the manufacturing of rocker-bogie mechanisms is to determine the dimensions of rocker and bogie linkages and angles between them. The lengths and angles of this mechanism can be changed as per requirement. In the work, the aim is to manufacture the rocker-bogie mechanism which can overcome the obstacles of 150 mm height (like stones, wooden blocks) and can climb over stairs of height 150 mm. Also, another target is to climb any surface at an angle of 45˚. To achieve the above targets we had to design the rocker-bogie model by assuming stair height 150 mm and length 370 mm. Using Pythagoras theorems, find the dimensions of the model. It has both angles of linkages at 90˚.

To achieve proper stair climbing the dimensions of linkages should be proper. Assume the stair height and length are 150 mm and 370 mm respectively. To climb stairs with higher stability, it is required that only one pair of wheels should be in a rising position at a time. Hence to find the dimension of bogie linkages, the first pair of wheels should be placed at the horizontal position at the end of the rising as shown in Fig. And the second pair should be placed just before the start of rising. There should be some distance between the vertical edge of the stair and the second pair of wheels to the striking of the wheels.

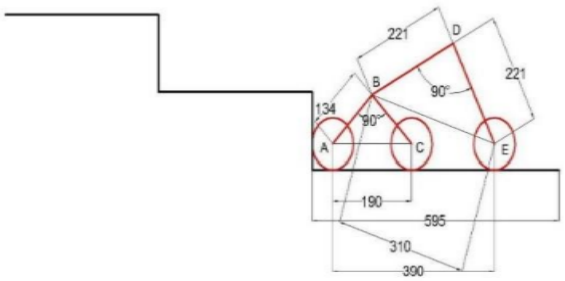

Fig.4(A) *Rocker Bogie Mechanism*

Now, to obtain the distance between the first and second wheel through CAD software (190 mm). Considering the right-angled triangle ABC,

Using Pythagoras in ΔABC (Fig.4(A).) assume lengths AB and BC are x.

$AC^2 = AB^2 + BC^2$

$190^2 = x^2 + x^2$

$190^2 = 2x^2$

$x = 134$ mm

Hence, AB = BC =134 mm

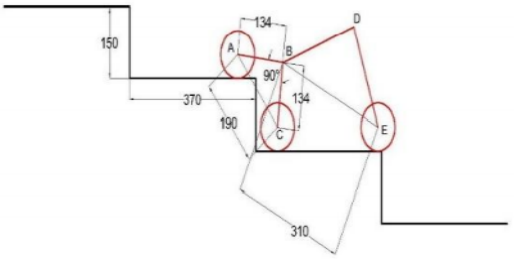

Fig.4(B) *Rocker Bogie Mechanism(2)*

Similarly, the first two wheel pairs should be positioned horizontally to establish measurements for rocker linkages. Before starting the first pair of wheels, the third wheel pair should be virtually finished rising. We acquired the dimension of connection BC by positioning the wheel in this manner (311mm).

Now consider ΔBDE ,

$BE^2 = BD^2 + DE^2$

$311^2 = 2y^2$

$y = 221$ mm

Hence, BD = DE = 221 mm

By considering all these lengths and angles we have drawn the whole mechanism. Above Fig. 4, shows all dimensions of the robot.

At a speed of up to 0.5 m/s, a wheel design is necessary. Assume a motor speed of 60-100 rpm. The assumed speed is derived using the velocity relation. The diameter of the wheel is 95.35 mm, according to the estimated velocity value. As a result, we choose a wheel with a diameter of 100 mm (standard wheel). The rubber tread glued to the wheel is light and durable, and it provides good traction and friction.

To determine the wheel's diameter,

Required velocity (v) = 0.5m/s.

Motor rpm (n) = 100 rpm

We know that,

$\omega = (2\pi n) \div 60$

$= (2 \times \pi \times 100) \div 60$

$\omega = 10.471$ rad/sec

For circular motion,

$v = \omega \times r$

So, $r = v / \omega$

$= 0.5 / 10.471$

$r = 0.04775$ m = 47.75 mm

So, our diameter will be,

d = 2×r = 95.5 mm.

On flat terrain, a typical robot needs to accelerate to about half of its maximum velocity. The robot's top speed is 0.5 meters per second. As a result, the robot's acceleration will be 0.5/2, or 0.25 m/s2. This indicates that reaching maximum speed would take 2 seconds. Due to gravity, increased acceleration is required when the robot is traveling up inclines or through rugged terrain. We needed to increase the tilt to 45 degrees. Hence,

Acceleration of inclines

= (9.81 × sin(angle of inclination) × π) / 180

= (9.81 × sin(45°) × π) / 180

= 0.121 m/s2

Total Acceleration

= 0.25+0.121 = 0.371 m/s2

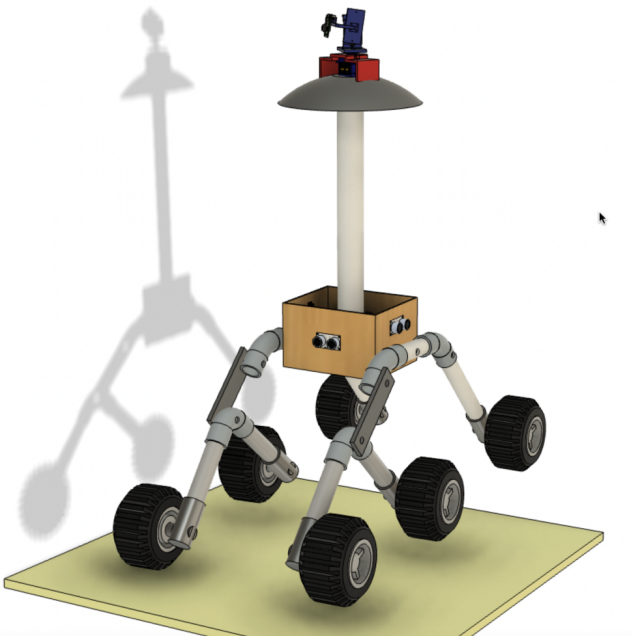

Fig.5(A) *CAD Model*

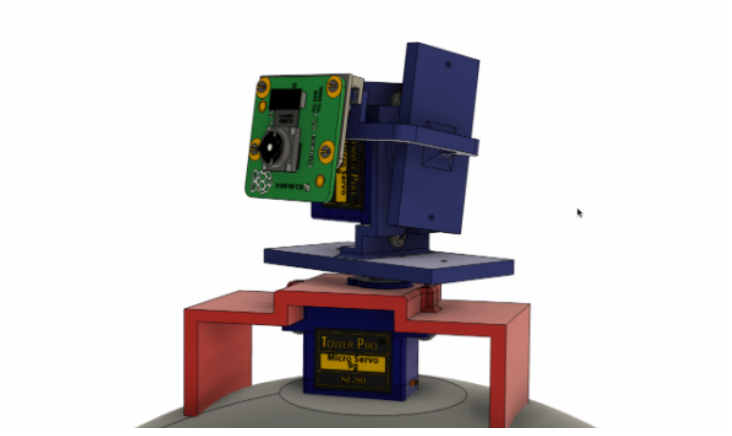

Fig.5(B) *CAD Model for Pi Camera*

2) Hardware

(i) UV Light:

Ultraviolet (UV) is already used in industrial processes and in medical and dental practices for a variety of purposes, one of them is killing bacteria. Light exposure is a direct antibacterial method with a lengthy track record of success against many strains of airborne viruses. A low-pressure mercury-vapor arc lamp generating around 254 nm is the most often utilized form of UV light for germicidal purposes; more recently, xenon lamp technology has been utilized, which provides a broad UV spectrum. A single UV-C LED with a power output of roughly 2.5W can cover a 5cm surface with 99.9% irradiation. UV light serves the project's aim while also lowering the weight and human intervention associated with spraying sanitizers.

(ii) Raspberry Pi:

Raspberry Pi is a cheap computer that runs Linux, while it also provides a set of general purpose input/output pins known as GPIO. It gives us flexibility and allows us to control electronic components for physical computing and explore the Internet of Things (IoT). The features that helped are the vast peripheral support with the 26 GPIO pins(very useful for embedded projects and interfacing hardware). These pins are useful in learning about component interfacing and interfacing multiple sensors at a time. Connection of various displays, modules, sensors, etc...to it. It came in handy while interfacing the pi camera module and the 4 ultrasonic sensors. Different types of codes and different languages were used while interfacing all the electronic devices. The Linux desktop environment is friendly to all languages, be it C, C++, Ruby, Java, Python, etc.

(iii) Ultrasonic Sensors

They measure the distance to the target by measuring the time between the emission and reception. This helped us determine the distance between the obstacle and the bot and make it fully autonomous. Ultrasonic sensing serves the best purpose for us, as it senses the proximity and detects levels with high reliability. The sensor measures the distance to an object using ultrasonic sound waves. The ultrasonic sensor works with using a transducer to send and receive ultrasonic pulses that relay back information about an object’s proximity. Distinct echo patterns are produced by high frequency sound waves that reflect from the boundaries. The distance is measured to the target by the sensor by measuring the time lapses between the sending and receiving of the ultrasonic pulse. The ultrasonic pulse is sent which bounces back to the sensor, if there is an object or obstacle,Distance is calculated by the calculation of the travel time and the speed of the sound. Ultrasonic sensors can detect the presence of an object, human, irrespective of the color, surface or material until it is a very soft material(one that can absorb sound. Ultrasonic is more reliable than others because other optical technologies can fail to detect transparent objects but ultrasonic sensors can detect those too. HC-SR04 ultrasonic distance sensor has an ultrasonic transmitter, a receiver, and a control circuit.

3) Human Detection and Object Detection

Computer vision will be used to extract features to quantify the human body. These characteristics can be fed into machine learning models, which can then be used to detect and track humans in pictures and video streams after being trained. When this device identifies a human, it sends a signal to the UV light, which turns off immediately.

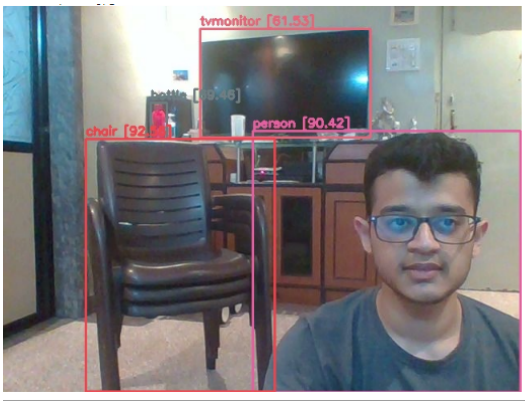

Fig.6 *Human and Object Detection*

The Chamfer distance transform of the edge map of the target picture region is represented by C. Template T is a binary image that is 0 everywhere except for the silhouette pixels, which have a value of 1. The distance between the target image area i and a template T can be found by the equation mentioned.

$$D(I,T) = \frac{1}{|T|}\sum_{i} C_i T_i$$

The number of silhouette pixels in T is |T|, the pixel number I in T is Ti, and the Chamfer distance value at pixel number I in I is Ci. For our human detection, we used RCNN. Convolutional neural networks with rectangular regions (R-CNN) combine rectangular region suggestions with convolutional neural network characteristics. The R-CNN algorithm is a two-stage detection method. The first stage finds a selection of image regions that could contain an object. The modified version of Fast RCNN is Faster RCNN. The main distinction is that Fast RCNN generates Regions of Interest via selective search, whereas Faster RCNN employs Region Proposal Network.

During implementation the detection is done through 3 mediums. 1st an image is uploaded and then the object type and humans are detected. The 2nd kind of testing is done on images captured by the webcam. 3rd is when humans, pets and other multiple objects are detected by the algorithm in a live feed.
It entails building a neural network that processes an image's individual pixels. To "train" these networks how to detect comparable images, we feed them as many pre-labeled images as possible.
Invoking the detection algorithm is the responsibility of this module. The detection algorithm should ideally be run on each input frame. However, the system will be unable to meet its real-time needs as a result of this. Instead, in our approach, the detection algorithms are called every two seconds. A queue of pointers to frames is shared data between the frame capturing module and the human detecting module.

F. Application of your project

These past few months have made us realize how much the healthcare providers go through an ordeal to provide us with apt medical care and it has been challenging for all of us. We need to wash our hands regularly, wear masks and maintain social distance. But, at the top of the list, we need to avoid unnecessarily going to places that can be highly contaminated with the virus for eg. schools, colleges, hospitals, banks, corporate offices, government offices, etc. But our frontline workers who sanitize public places cannot avoid going to the highly contaminated zones. This makes their job dangerous and life-threatening and therefore the main aim of this project is to aid them with a system that automatically sanitizes the infected area at the same level of efficiency that a human does.

A cost efficient and a portable sanitization system is the need of the hour due to the pandemic. Since the schools, colleges, entertainment centers and offices have opened up a sanitization system that is easy to manage is a must. Our UV sanitization system is just the missing piece in the puzzle. It is easily portable, can climb stairs and sanitize the lobby easily, cost effective and a great help to the cleaning, nursing staff. The risk faced by the front line workers is reduced to a great extent. The system can be used in every domain, domestic, hospitality, comercial, etc. The system also has broad scope of optimization.

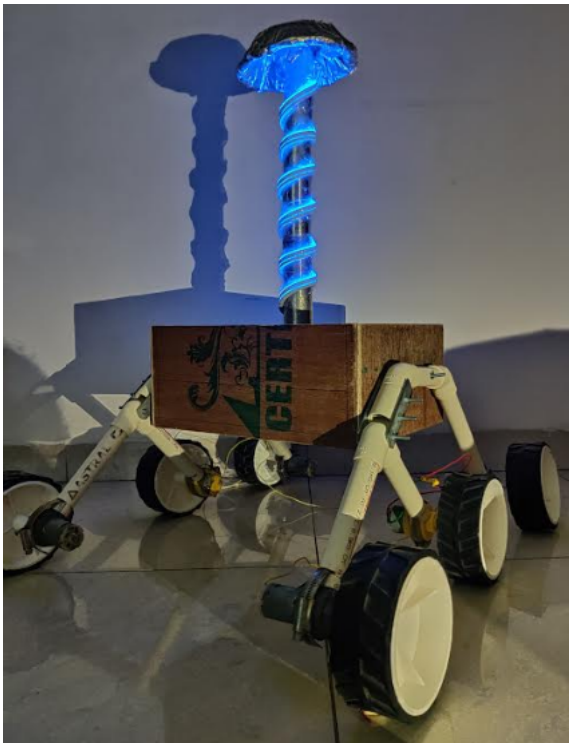

Fig.7 *The Final Implementation*

G. Project Budget Sheet

Sr. No.	Component	No. of component	Price(INR)
1.	Raspberry pi 4	1	4400/-
2.	Pi Camera Module	1	300/-
3.	UVC led light	-	400/-
4.	DC Motor	6	1000/-
5.	Ultrasonic Sensors	4	480/-
6.	Motor Driver (L298N)	1	45/-
7.	Miscellaneous		100/-
	Total		6725/-

H. Future Scope

These past few months have made us realize how much the healthcare providers go through an ordeal to provide us with apt medical care and it has been challenging for all of us. We need to wash our hands regularly, wear masks and maintain social distance. But, at the top of the list, we need to avoid unnecessarily going to places that can be highly contaminated with the virus for eg. schools, colleges, hospitals, banks, corporate offices, government offices, etc. But our frontline workers who sanitize public places cannot avoid going to the highly contaminated zones. This makes their job dangerous and life-threatening and therefore the main aim of this project is to aid them with a system that automatically sanitizes the infected area at the same level of efficiency that a human does.

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J. Appendix – Bibliography / Literature

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