COV'ATCH

(Smart Virus Control)

By

Nayab Fatima Noor

Alina Azhar

Syeda Fatima Haider

Ammar Pervaiz Khan

Hassan Javed

Supervised by:
Dr Mir Yasir Umair

Co-supervised by:
Dr Alina Mirza

Submitted to the faculty of Department of Electrical Engineering,
Military College of Signals, National University of Sciences and Technology, Islamabad,
in partial fulfillment for the requirements of B.E Degree in Electrical Engineering.
June 2022

In the name of ALLAH, the Most benevolent, the Most Courteous

CERTIFICATE OF CORRECTNESS AND APPROVAL

This is to officially state that the thesis work contained in this report

"COV'ATCH"

is carried out by

Nayab Fatima Noor

Alina Azhar

Syeda Fatima Haider

Ammar Pervaiz Khan

Hassan Javed

under my supervision and that in my judgment, it is fully ample, in scope and excellence, for the degree of Bachelor of Electrical Engineering in Military College of Signals, National University of Sciences and Technology (NUST), Islamabad.

Approved by

Supervisor
Dr Mir Yasir Umair
Department of EE, MCS
Date: 22-05-2022

DECLARATION OF ORIGINALITY

We hereby declare that no portion of work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

ACKNOWLEDGEMENTS

Allah Subhan'Wa'Tala is the sole guidance in all domains.

Our parents, colleagues and most of all supervisor, Dr Mir Yasir Umair and co-supervisor, Dr Alina Mirza without your guidance.

The group members, who through all adversities worked steadfastly.

Plagiarism Certificate (Turnitin Report)

This thesis has 15% similarity index. Turnitin report endorsed by Supervisor is attached.

Nayab Fatima Noor
00000246816

Alina Azhar
00000271821

Syeda Fatima Haider
00000280962

Ammar Pervaiz
00000258787

Hassan Javed
00000278783

Signature of Supervisor

ABSTRACT

The world has seen a lot of viruses and global pandemics throughout its course for example swine flu, influenza, cholera etc. Similarly, COVID’19 is also one of the most challenging pandemics faced by the world recently. To bring our lives back to normal and fight the pandemic, countries all over the world came up with vaccines. But everybody soon realized that the virus kept mutating and vaccines are not a permanent solution. So it became necessary to follow a list of precautions/SOPs issued by WHO. Not just COVID, but any virus can be controlled in this way. Our project is an autonomous robot that will monitor these SOPs and ensure compliance. The tasks done by our project will be monitoring social distance, ensuring people are wearing masks and sanitizing the environment after fixed time intervals. It also has a dispenser to provide masks and hand sanitizer to people. The aim of our project is to reduce the spreading of the virus in crowded spaces like hospitals and provide ease to healthcare workers as the robot will autonomously perform human tasks. We will use artificial intelligence and digital image processing to carry out these tasks.

Table of Contents

List of Figures

Chapter 1: Introduction

With the rapid evolution of technology, especially artificial intelligence, the world is shifting towards the use of robots to perform their daily life tasks. Initially, the robots were mainly used in offices and workplaces but after a global pandemic like COVID-19, the use of robots became very common in all sectors. Since it was necessary to avoid human contact during this pandemic, robots were used to perform tasks like temperature sensing, sanitization facilities, mask detection, etc.

Our project aims to develop a robot that is intelligent enough to move around autonomously and perform the required tasks without any human involvement. It will have the ability to detect face masks, provide sanitization facilities, and monitor social distance. We aim to deploy it in crowded areas mainly hospitals as they are most prone to viral infections. It will be in the waiting rooms of hospitals to ensure people are following the SOP i.e. everyone is wearing a mask, if anyone is found without a mask, it will not only generate a message on the LCD to wear a mask but will also provide a mask through its dispenser, Similarly it will also monitor that people maintain a 6 feet distance between them, if anybody is seen violating this SOP< the robot will generate an alert and display the required message on the LCD. Moreover, it will sanitize the environment after fixed intervals and also has a sanitizer dispenser attached to it. If a person puts their hand under the sanitizer, the sensor will send a signal to the servo motor to dispense the sanitizer.

The project's main focus is to provide ease to healthcare workers. With COV'ATCH we will develop a contactless surveillance system. In this way, the healthcare workers will be less exposed to the virus because their job will be done by a robot which will make sure SOPs are being followed. It will not only stop the spread of coronavirus but will also be beneficial in reducing the spread of other viral infections that are found in hospitals.

1.1 Background

The world awakened to a horrible reality on 11th March, 2020 when WHO announced that COVID-19 is a global viral pandemic [1, 2]. The virus had originated from Wuhan, China and spread across Japan, South Korea, Europe, United States and soon the whole world was fighting with this virus. It was soon realized after several reports and studies that the globe was heading towards a huge disaster in human history [3] . During a series of revelatory reports [4] [5] [6], specialists and researchers all over the world had long foreseen a worldwide pandemic and that it would disrupt the global supply chains and demands, hence leading to an economic disaster across borders of the world. By all accounts, the emerging chaos due to this pandemic exceeded everyone's prediction. More than 800,000 individuals have been killed by this virus. [7] The situation has been devastating all over the world. This pandemic has disrupted the cycles of everyone's life. It has disturbed our means of earning and has led to one of the biggest economic crises till this date [8]. Strict precautionary measures such as closure of borders, were taken by several countries to save the already infected people and further minimize the risk of more people contracting this virus.

In November 2020, the total COVID-19 cases were 57,639,631 with 1,373,294 deaths all over the world, as per the records of World Health Organization (WHO) [9]. These cases have now exceeded 524 374 327 with 6 293 401 confirmed deaths till present date, May 2022.

This virus affected human health and led to a huge loss of human lives all over the world. It not only infected numerous people but also led to long term physical and mental disorders. The mortality rate was notably high among people with lung diseases, breathing problems and old aged people. It put a complete halt to healthcare services and also affected the economic sector, education sector, traveling and trade and disrupted our day to day life. The virus keeps mutating and has a new variant after some time which led to a never ending disaster.

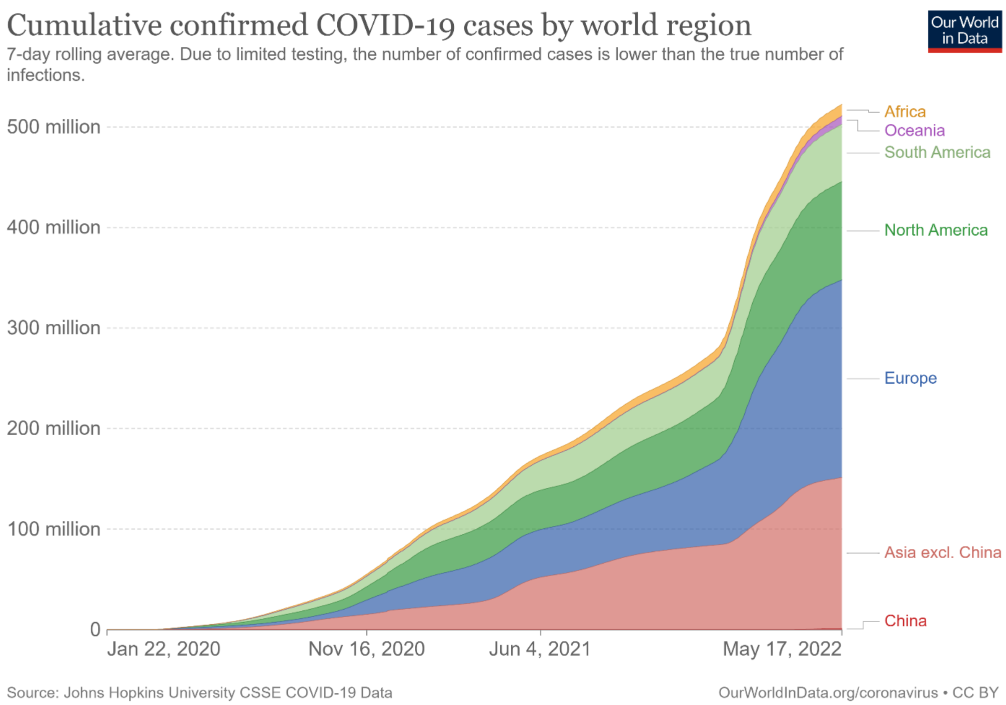

Fig 1: Graph of cumulative confirmed positive covid cases by world regions

1.2 Problem Statement

COVID-19 has disrupted our daily lives like any other global pandemic. It led to numerous deaths and caused a standstill to our day to day activities. Several vaccines were made all over the world for e.g.: Pfizer, Moderna, Sinopharm, Sputnik and many more. But with the virus mutating continuously, it became inevitable to control the spread of the virus with vaccines only. It became necessary to follow the precautions and SOPs issued by the World Health Organization.

1.3 Proposed Solution

As the world progresses, use of robots is becoming popular all over the world especially in a world of COVID where it is necessary to avoid human contact. Our aim is to also provide an autonomous covid surveillance system that will monitor and ensure that all SOPs are being followed without any human involvement. The SOPs that will be monitored include face mask detection, social distance monitoring and sanitization. It will not only be beneficial for health care workers but also reduce the spread of the virus, may it be COVID or any other virus.

1.4 Objectives

The ultimate objective is to develop a robotic workforce that does human tasks to avoid the spread of covid-19 and reduce contact between humans.

1.4.1 Research Objectives:

- To research and develop a robot that has state-of-the-art image processing abilities to avoid obstacles and move around crowded places and perform the required tasks autonomously.

1.4.2 Academic Objectives:

- To create awareness among people about the increasing use of technology to perform human tasks and make our lives easier.
- To develop a research group at NUST, working on topics like image processing and artificial intelligence.
- To create awareness among students and researchers about how to tackle a global pandemic using artificial intelligence and technology based solutions.
- To encourage multidisciplinary research at bachelors level to learn training and skills for the practical world. It is being implemented and practiced all over the world and should be incorporated in our country as well to compete with the rapidly developing world.

1.4.3 Industrial Objectives:

- To develop an autonomous surveillance robot which will ensure the compliance of COVID SOPs in crowded areas..
- If the project is successful it can be expanded to other areas locally and internationally. Not only for COVID but it can be used to combat any viral disease.

1.5 Scope

Our robot will be capable of autonomous surveillance and patrolling, monitor and ensure that people are wearing masks or not, whether social distance is being maintained, and also generate visual and audio alerts in case of violation. It will also be fully equipped to sanitize the surroundings after fixed intervals and provide face masks and hand sanitizer when needed. During operation, only the occasional presence of technical personnel is required to carry out maintenance of cov'atch's hardware. It will not only save the lives as well as energy of the health care workers but also reduce the spread of virus in crowded areas.

1.6 Deliverables

1.6.1 Mask Detection:

Provide mask detection through Object Detection and Machine Learning. A video feed would come from a camera, and bounding boxes would be created around the faces of the people, with green and red boxes indicating if they are wearing masks or not. In case of a violation an alert would be generated and a mask will be provided to the user. The results would be visible to the administrator and statistics can be stored. This will ensure that people are wearing masks.

1.6.2 Monitoring Social Distancing:

Provide social distance monitoring, by detecting people in frame and by segmentation, we can calculate the distance between the people and determine if they are not socially distant or not. If people are not following the protocols, a message will be displayed on the LCD display and authorities alerted. This will ensure people maintain social distancing.

1.6.3 Sanitization Services:

Provide sanitization services to both the people and the surroundings. Whenever someone places their hand near the sanitizer dispenser, they would be provided with hand sanitizer, and if they are seen not wearing a mask, the mask dispenser would open and allow them to take a mask. Alongside this the surroundings would be consistently sanitized with a spray after equal time intervals. Together these features ensure a sanitary and safe environment.

1.6.4 Live Surveillance and Movement:

Provide a live feed from the robot's camera, allowing the admin to monitor the surroundings alongside the detection results of mask and social distance detection. The admin can control movement of the robot through a Bluetooth module and navigate the surroundings.

1.7 Relevant Sustainable Development Goals

1.7.1 Good Health and Well-Being:

Preventing the spread of viral infectious diseases and helping keep the surroundings sanitary, Cov'atch falls into the Good Health and Well-Being sustainable development goal, promoting and ensuring caution to protect the public from diseases.

1.7.2 Industry, Innovation and Infrastructure:

By providing autonomous and remote detection of Mask and Social Distance violations, Cov'atch is a unique product which harnesses the power of computing and the internet to promote industry, innovation and infrastructure sustainable development goals.

1.8 Structure of thesis

Chapter 1 contains the introduction, problem statement, solution and deliverables, etc.

Chapter 2 contains the literature review and the background study.

Chapter 3 contains the design and detailed working of the project.

Chapter 4 contains the conclusion of the project.

Chapter 5 highlights the future work needed to be done for the commercialization of this project.

Chapter 2: Literature Review

2.1 Industrial Work

Humans have consistently tested to incorporate machines and robots in their daily lives for their work. There were many domains where humans could not perform more than their limit or capacity and the necessity of new advances to outperform the human limit was arisen. Consequently, advancement of science, technology and innovation embraced a way of constant development. Accordingly, Internet of things (IoT), Artificial intelligence, automation and robotics were rising center areas of scientists. [10]

There are numerous domains and places where robots are utilized , particularly where they can reduce difficult errands and carry out tasks that are risky for humans. Ongoing improvements in mechanical technology and AI are revolutionary business in society and our own lives.

Aside from being precise and steady, robots are capable of performing in any climate.. People no longer need to labor in dangerous situations because robots are capable of doing so. Robots have the ability to carry heavy weights, hazardous material, and repeated tasks. So this has helped in preventing various mishaps and also helped save money and time. Robots are used in the clinical field for difficult medical operations such as prostate cancer surgery. Robots are more precise as they can fit into places where the human hands are not capable of doing so. In the clinical field, automated benefits can be less intrusive methods that reduce pain for patients while they recover. [11]

2.1.1 Classification:

Robot classification in general is a difficult task. Partially classified robots are frequently explained, and one type of robot may appear in multiple criteria. Robots are designed with specific qualities in mind. These properties are named as automated areas. Different components have caused the presence of domains and robotic design is made to fit the domains. Also, covering of robots in various domains exists since the limits of the applications are hazy. Domain classification is depicted in Figure (2).

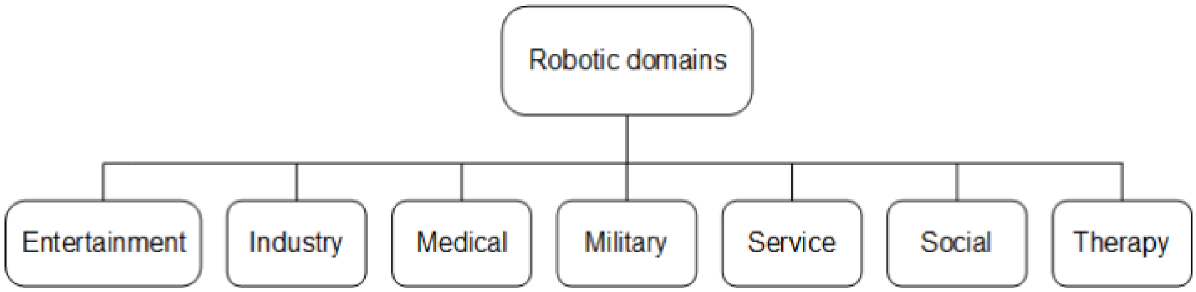

Fig 2: Robotic domains

There are 7 robotic domains picked as industry, military, administration, social, therapy and medical. An application-based robot arrangement is considered in this methodology.
Besides, Guizzo (2018) makes sense of the classes of robots extensively as aerospace, customer, reaction, education, entertainment, exoskeletons, humanoids, medical, military, telepresence and underwater.[12]

According to scholarly definitions, there are five key characteristics of social robots. A social robot must have a physical body, be independent, able to communicate with other robots and people, understand and comply with the rules of the society, be intelligent enough to sense and act accordingly to environmental cues. On the other hand, it is believed that a physical body is not required for a social robot. Social Robots like conversational agents are one example. Zhao (2006) goes on to claim that even humanoid social robots do not always have physical bodies. As a result, the social robotic literature discusses four robotic design characteristics in general. The four characteristics of social robots are:

- Embodiment
- Morphology
- Autonomy and
- Assistive role

To begin, embodiment refers to the system's interaction with its surroundings. A system is said to be embodied, according to Ziemke (2003), if it has a structural link to the environment In these scenarios, a physical body is not required. As a result, a social robot's physical body may or may not exist (Paauwe et al., 2015). The aim of this research is on physically embodied social robots with a three-dimensional form.

Second, social robots with physical bodies come in a variety of shapes and sizes. In nature, these can be either machine-like or human-like. Four types of robot morphology are described by various scholars. A robot can take the form of a human (anthropomorphic), an animal (zoomorphic), a functional object (functional), or an object that can represent any shape (morphic) (caricatured). A caricatured robot in the shape of a wine bottle is an example (Tung and Law, 2017).

Third, autonomy refers to the amount of human involvement required for a robot to perform properly. The range of autonomy is from zero to complete autonomy. There is no autonomy when a robot is directed remotely via teleoperation (Yanco and Drury, 2004), but there is full autonomy when there is no direct human input. The extent of autonomy of a social robot is determined by social roles, capabilities, and expectations. Autonomy problems include low-level interpretations, self-navigation difficulties, and even battery life (Duffy, 2003). A fully autonomous social robot is necessary to attain its full potential and deliver the desired values.

Finally, the assisting role refers to the social robot's application, service, purpose, or basic activities. As a result, social robots' helpful roles are a prominent functional area. [13]

2.2 Existing solutions and their drawbacks

2.2.1 Monitoring social distancing restrictions in interior situations with the COVID surveillance robot:

A vision-guided approach for monitoring situations and places that are overcrowded. COVID Surveillance robot (CS-robot) and wall-mounted CCTV cameras (if available) to detect extended interaction between persons. In this work, these scenarios are referred to as breach scenarios or social distancing breaches. When a violation is identified, The robot prioritizes the groups of people not complying with the SOPs based on their size, then navigates autonomously to the largest group, a mounted screen with an alarm message is displayed to convince them to follow the social distance regulations. The robot prioritizes attending to groups in dynamic circumstances based on their motions relative to the robot.

To avoid collisions, the robot employs frozone and drives autonomously to the groups that are violating the SOPs.. The robot employs low-cost visual sensors such an RGB-D camera and a 2-D lidar to feed data to Frozone for navigation, as well as pedestrian identification and tracking algorithms that identify and classify non-compliant pedestrians who break social distance limitations. In indoor contexts, this solution combines the CS-robot with a CCTV camera setup to improve compliance of SOPs and cover a larger area to monitor social distancing. The robot has a thermal camera mounted on the top that transmits thermal pictures remotely to healthcare staff, which aids in symptom monitoring. [14]

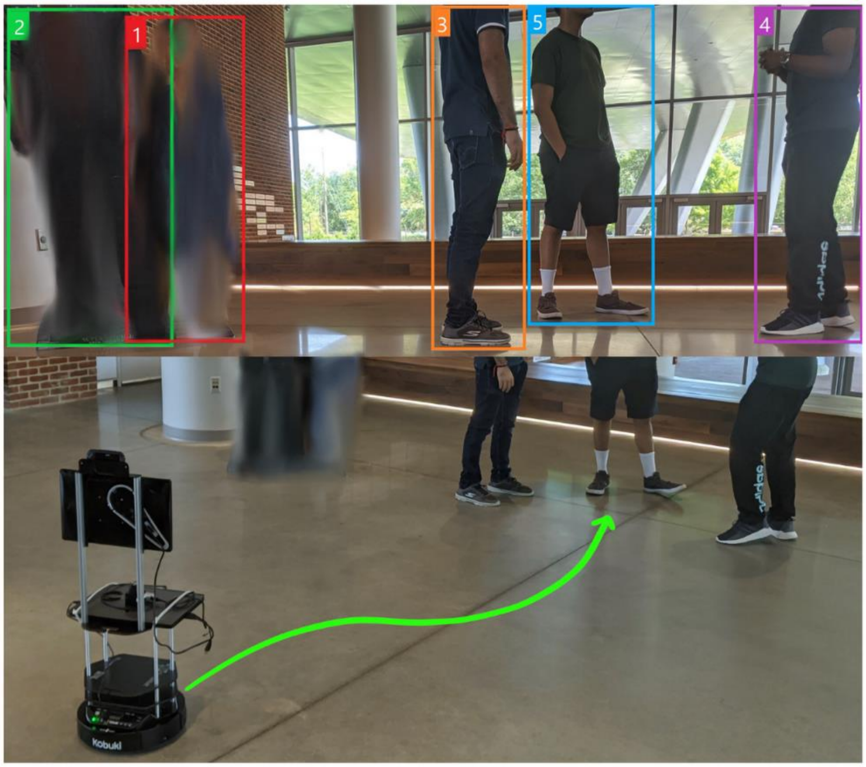

Fig 3: CS-Robot detecting social distancing

However there are certain limits to this strategy. It makes no distinction between strangers and household members. As a result, everyone in an indoor area is recommended to keep a 6-foot gap between them. The existing strategy of employing a monitor to issue a warning to the people not following the SOPs has some restrictions, and new human-robot interaction approaches are needed. As more of these surveillance robots are employed to monitor social distancing, pedestrian behavior in various circumstances may be affected. More research into the societal implications of such robots is required.

2.2.2 Examination Robots

The robot's utilization starts with patient evaluation, as the robot is responsible for mass screening to quickly confirm COVID-19 instances. A semi-automatic oropharyngeal swab robot was created to collect swab tests with patients. [15]. The swab robot has a remote camera, which allows the medical staff to perform the sampling with clear visibility but without having to touch the patient. The findings of the collections are satisfactory, with a sample success rate of 95%.

Fig 4: Semi-autonomous swab robot

The sonographer and the patient were isolated in Evans [16] using remote robotic ultrasound equipment to reduce disease exposure. In the meantime, it is not necessary to take the patient to a distant imaging facility. Similarly, using a telerobotic ultrasound device, obstetrical ultrasound exams are performed remotely. The system is in a remote part of Canada where there is insufficient access to obstetrical ultrasound machines. The ultrasound probe and settings are controlled remotely by a sonographer 605 kilometers away using the telerobotic technology. Despite the limitations of the test, the 81% success rate is nevertheless encouraging (nine cased out of eleven)

Fig 5: Tele-ultrasound using robot

2.2.3 Robotics in healthcare, telepresence, and monitoring

The patient must be taken to the hospital and kept in isolation once the sickness has been verified. The robot has been designed to act as a bridge or connection between the patients and the staff. Simple chores such as providing medication and supplies may be performed by the service robot, allowing caregivers to focus on more important responsibilities [17], [18]. Robots can be utilized in the healthcare sector as nurses, receptionists, serving robots, telemedicine robots, cleaning and spraying robots, and surgical robots. Robots can also help medical workers and physicians operate more efficiently by lowering their burden and supporting them in dealing with challenging situations more precisely. [19].

Based on human-robot interaction, a mobile robot platform with a multi-functional arm was developed for customized care and assistance [20]. During the COVID-19 pandemic, the planned robot was then adapted to do other activities including disinfection and body temperature measurement. The findings of using a Tele-Robotic Intelligent Nursing Assistant (TRINA) to deliver nursing jobs are promising [21]. Until recently, the remote servicing robot has only been able to communicate and interact with the patient on a rudimentary level. Even though it still has some restrictions in mobility and some functions. The 5 G network can be a useful tool for extending coverage of the working area while maintaining low-latency communication. The VisitOR1 robot provides remote access to others in a hybrid Operating Room (OR) [22]. The onsite staff controls the digital interfaces through which the live inputs, such as video, fluoroscopy, and echocardiography, are delivered. The remote expert can move the camera positioned on the robot's end to change the operational area and talk to the local staff. In the future, the AI technique could assist in processing the data sent to the remote participant and generating recommendations to make improvements.

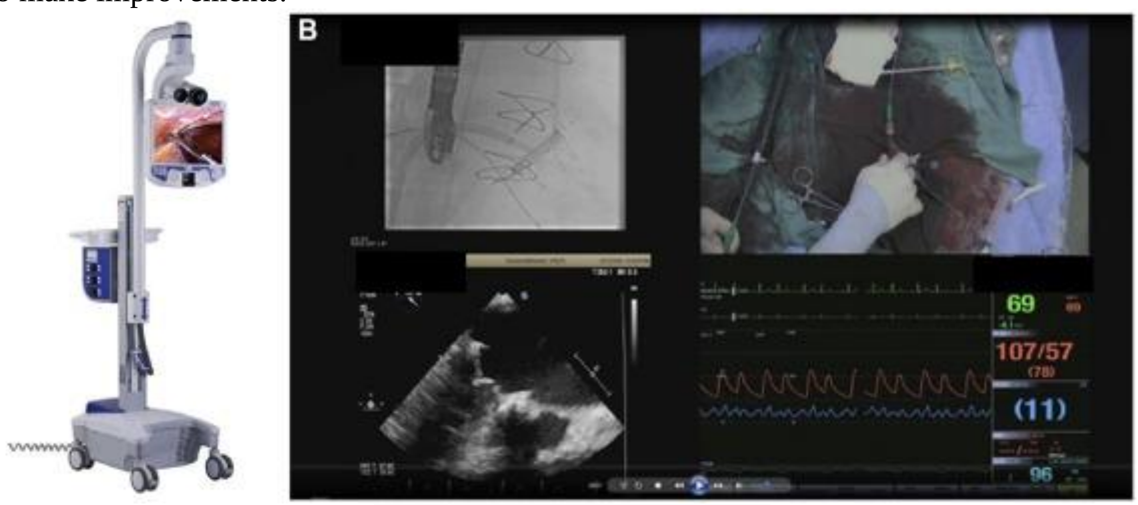

Fig 6: Remote access to an OR

2.2.4 Robots for Delivery and Logistics

In the 2003 SARS outbreak, Healthcare workers were most exposed to the virus and their lives were in danger, which meant they could not treat the patients or themselves properly.. Daily operations should be conducted by robots as much as feasible to decrease the medical staff's exposure [23]. In both public and healthcare settings, robotics research encouraged social separation. Future cities were also discussed, with AI and robotic reorganization taken into account. Simple tasks, such as food delivery and prescription distribution, have been demonstrated to be viable for semi-autonomous robots [24].

Peanut robots were deployed to deliver food in numerous Chinese cities and medical supplies. The robot is particularly beneficial in remote places or areas where virus is suspected. An economical mobile robot has been designed to aid paralysed people and those infected by the virus. [25]. It is capable of recognizing the gestures and signals given by the patients with the help of sensors. Like cleaning robots, delivery robots must carry out their tasks in complicated surroundings that can be supported by strong sensors and AI techniques.

Fig 7: Peanut Robot

However, it must be acknowledged that since present AI approaches are limited in their capabilities, robots cannot be incorporated completely in our everyday tasks. The wireless sensor network, on the other hand, can be used to improve the robot-based logistic system by acquiring dynamic status and queries, and then being directed by remote control methods towards reliable performance.

Chapter 3: Architecture and Working Methodology

3.1 Introduction

Since the robot is capable of performing multiple tasks simultaneously, it required a thorough research and a long brainstorming process to come up with the complete working and methodology of the robot. Before coming to the technical working, the figure below shows the complete architecture of the complete system. The technologies included in our project are:

- mask detection
- social distance monitoring
- sanitization of environment
- sanitizer and mask dispenser
- autonomous movement
- audio and visual alerts

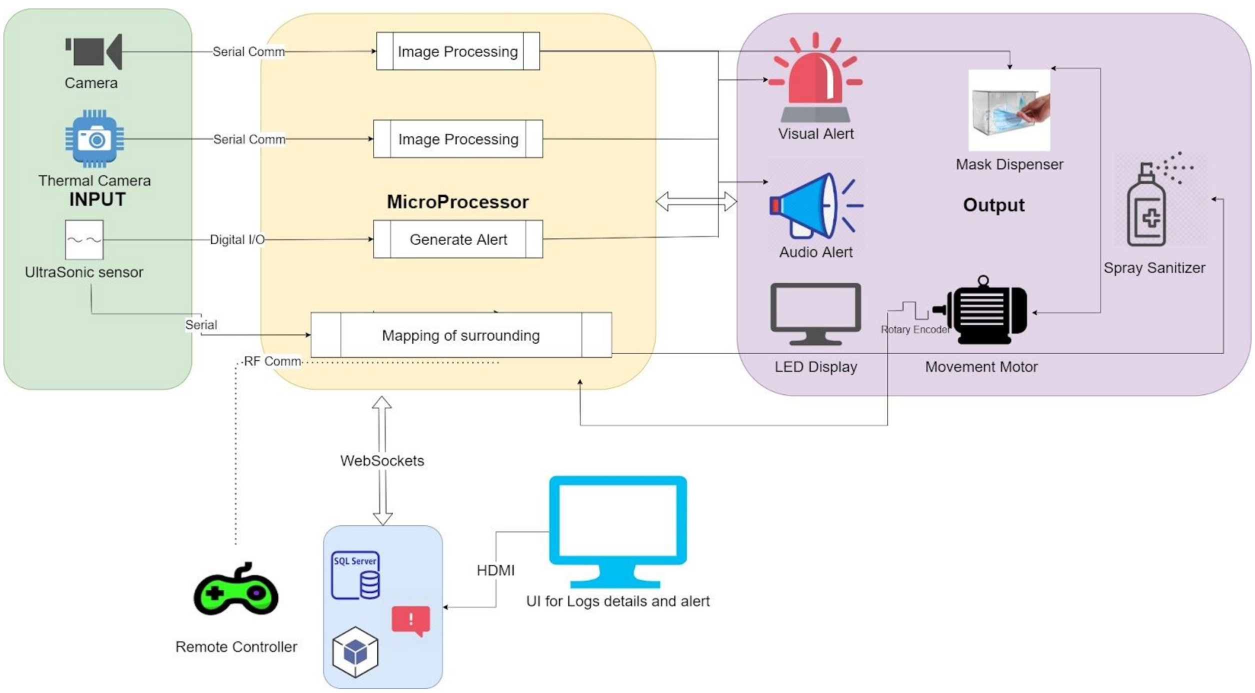

Fig 8: Block Diagram

The entire working is divided into three main parts namely the input, the processing and finally the output. The input will be mainly from a camera, bluetooth module, ultrasonic and IR sensors. The processing part includes digital image processing, the autonomous mobility, and detect presence of hand. As output, surroundings will be sanitized, hand sanitizer and mask will be dispensed, obstacles will be avoided, audio and visual alerts will be generated and social distance and mask will be detected. All this has been summarized in the flowchart below.

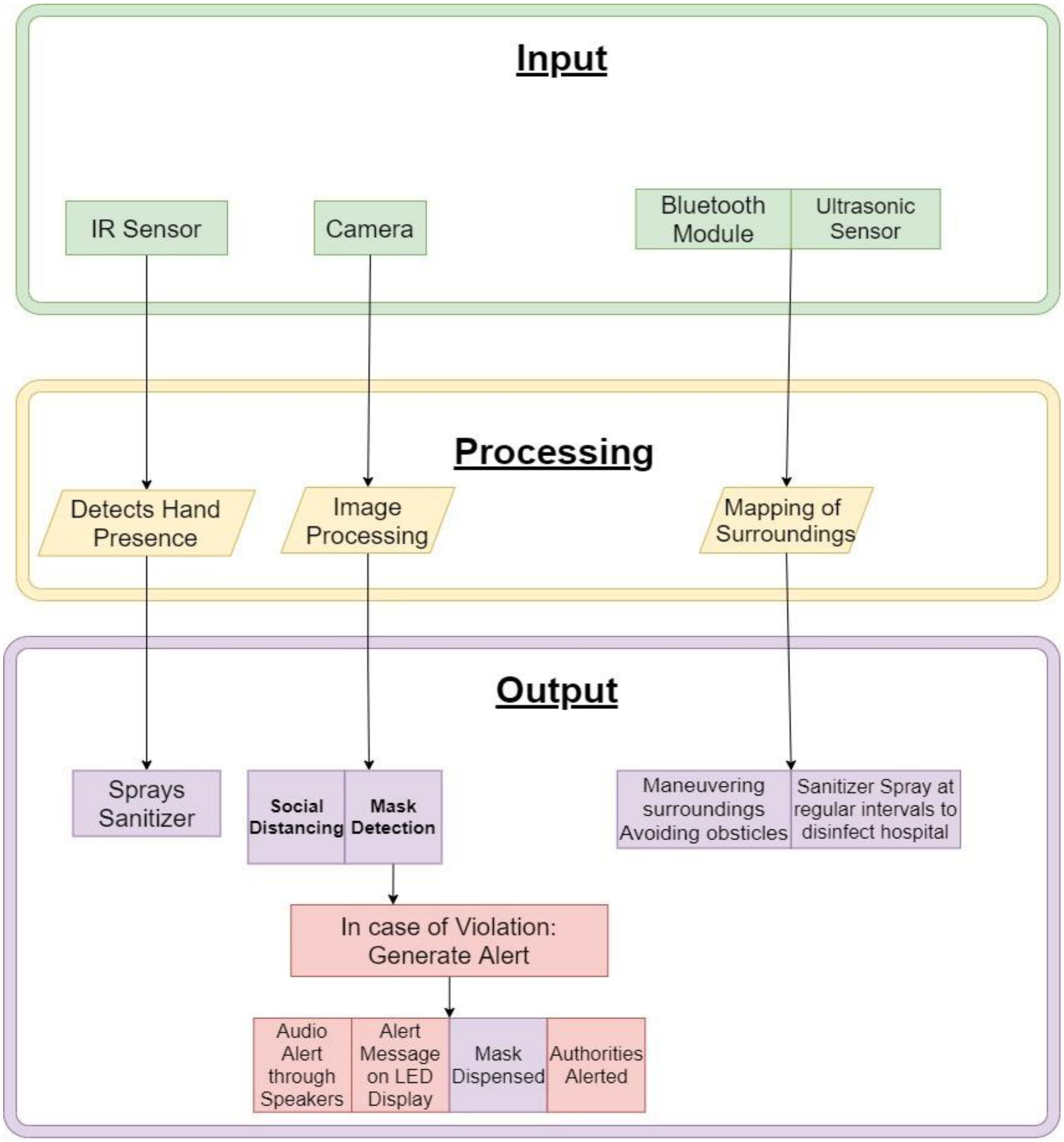

Fig 9: Flowchart

3.2 Research,Design and Manufacture

Robots are complex machines. In order to build them with all the desired capabilities requires careful thinking and planning. The Design process is the roadmap through this minefield. Design can help us utilize time efficiently and ensure precision and accuracy of the project as well.

To start off with the design process first we need to set up a plan and gather information that will be required in the process of manufacturing the robot. The table below shows the pre planning information process for Cov'atch.

Pre Planning Information Process		
What must the robot do?	How will the robot sense? How will the robot process? How will the robot respond? Movement of the robot Powering the robot	Sensing: • Cameras, • IR and Ultrasonic sensors Processing: • Image Processing to detect presence of Mask and monitoring distance between people • Processing signals from sensors through arduino Response: • generating alerts - Display on LCD, Buzzer beeps • automatic opening of mask dispenser Movement: • Using Arduino code to control dc motor and omniwheels • Using ultrasonic sensor for obstacle avoidance • Bluetooth module for manual control of movement Power: • Lipo Battery • Power Bank
What do we want our robot to look like?	Shape and of the robot? Mechanical Design? Aesthetic Qualities of our robot	Shape and mechanical design is determined based on calculations. Required calculation: • suitable geometry of chassis

		• stability:base to height ratio , center of gravity and weight distribution. • suitable geometry for fitting and functioning of motors and other components of the robot. Aesthetic qualities: • Color- Blue and White • Surface texture: Smooth
What material will be suitable for our robot?	What properties of material correspond to our desired design of robot? Material cost and availability analysis	Properties: • Good strength • durability • Light weight The material must be cost effective Possible materials: Wood, Acrylic and PLA
What can be the possible manufacturing methods?	• Construction methods will depend on material. • Fabrication and Assembly • Production Cost	Acrylic and wood - Laser cutting PLA - 3D printing Overall production should be budget friendly.

Next step after gathering information is designing a structure with the help of drawings, sketches, prototypes and CAD models. Starting from a simple sketch on paper, converting it into various small cardboard models and analyzing different CAD model designs we were finally able to come up with a suitable structure for Cov'atch. The figure (10) below shows the prototyping process for this project.

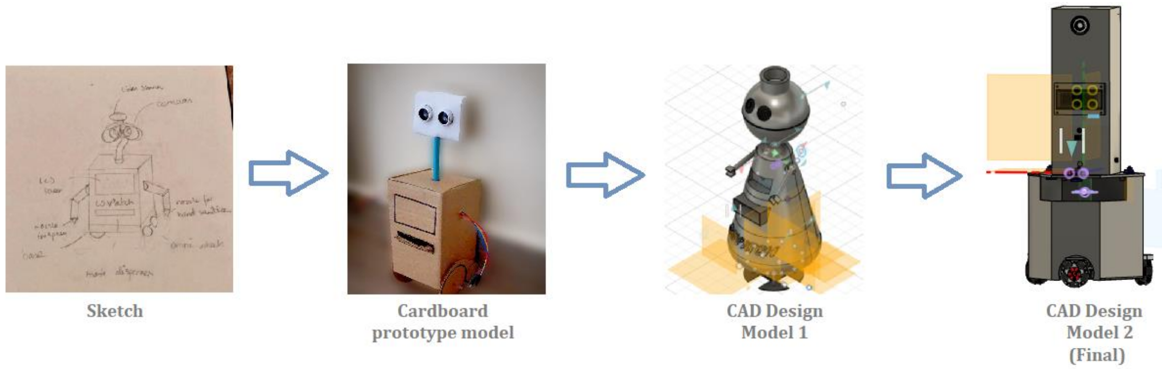

Fig 10: Prototyping process of Cov’atch

The CAD model lays the foundations for the construction process of the Robot. It provides us with the facility to design 3D models that can be used to analyze how all the components can fit together in one unit to provide us with a fully functional robot. It is essential to design the 3D model of the robot very carefully to avoid any problems in the structure or function later. There are various software available for this purpose. We used Autodesk Fusion360 to design our model. The 3D design process was divided into 3 main steps:

3.2.1 Designing the Chassis

This is the base of the Robot, which is designed to fit the wheels and the motors for the movement of the robot. Cov’atch was designed to have a 3-omni wheel chassis. The idea behind using 3 wheels is to increase the maneuverability and stability of the Robot which is quite limited in the case of 2-wheel robots. The figure below shows the geometry for the chassis of Cov'atch.

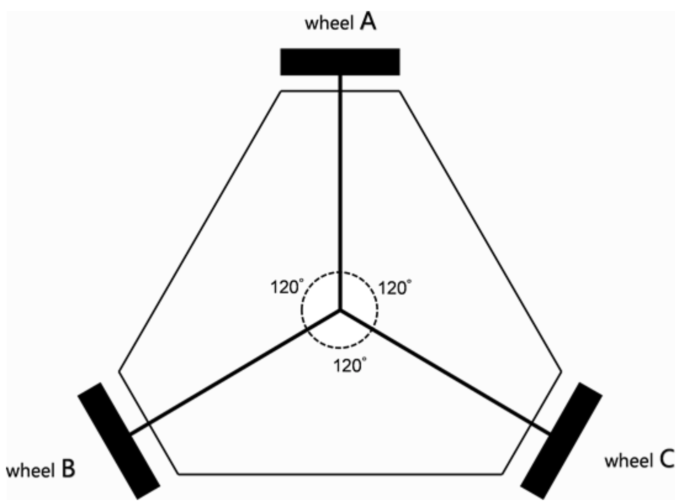

Fig 11: Chassis Design of Cov’atch

3.2.2 Designing the internal structure of Cov'atch

After finalizing the base structure, we designed the skeleton of Cov'atch. We used the GrabCad libraries to import the 3D models of the components such as Arduino, Nvidia, sensors, wheels, motors etc. into Fusion360 file. Using these component models it was fairly easy to design each part of the robot very precisely and accurately. The final look of our internal structure of Cov'atch is shown in the figure.

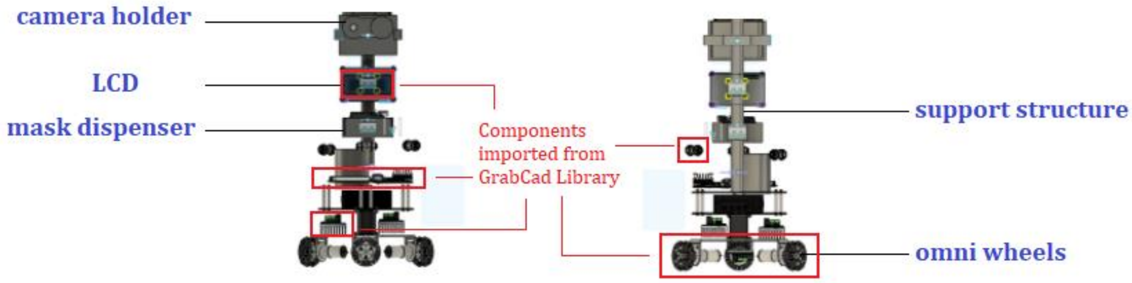

Fig 12: Internal structure of Cov'atch

After completing and testing the design for all possible loopholes the structure was constructed in hardware. Some parts of it were made in acrylic while others were 3D printed using PLA.

Actual electrical components were then fixed, and circuits were assembled in the hardware to test and ensure proper functioning before designing the final shell of Cov'atch.

3.2.3 Designing the shell of Covatch

This was the final stage of the designing process. The purpose of the shell is mainly to protect the internal structures of the robot and provide good aesthetic value to the project. The final look of Cov'atch is shown in figure (13). The shell of Cov'atch is made with thin sheets of acrylic mainly as it is a smooth and glossy material that provides the product with a fine and neat final look. Some parts of the shell are 3D printed as well as per the requirement of the construction and assembly parameter.

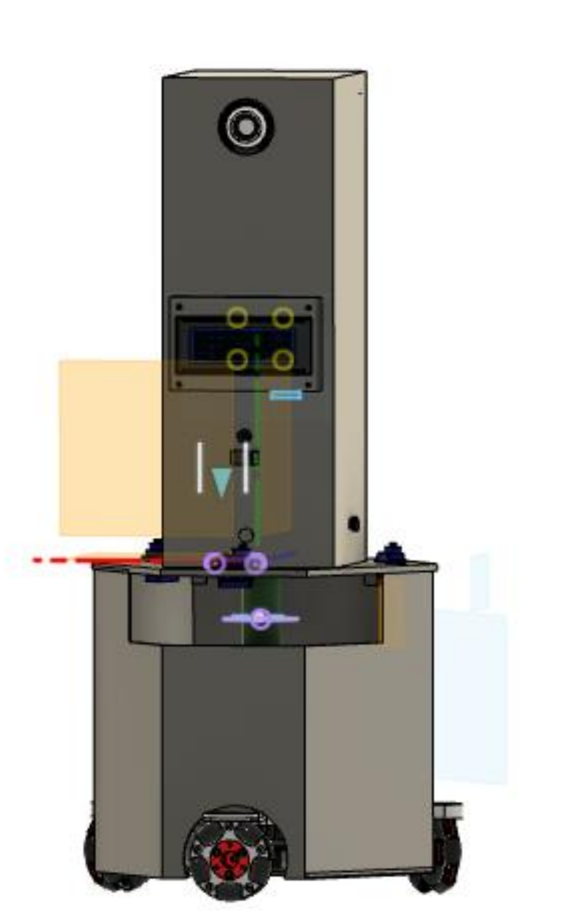

Fig 13: Complete Design of Cov'atch

3.3 Autonomous Movement

Cov'atch is designed to be a smart robot that can automatically detect and avoid obstacles in its path, hence it is capable of navigating anywhere on its own.

In order to understand the functionality of an autonomous obstacle avoidance robot, it is important to understand working principles of all components involved in controlling the motion of Cov'atch.

3.3.1 List of Components:

1. **Ultrasonic Sensor**

The ultrasonic sensor uses a transducer to transmit an ultrasonic beam and receive its echo pulse to calculate the proximity of an object as shown in figure (14). The sensor calculates the distance from the object by measuring the time lapse between the transmitted and received pulse.

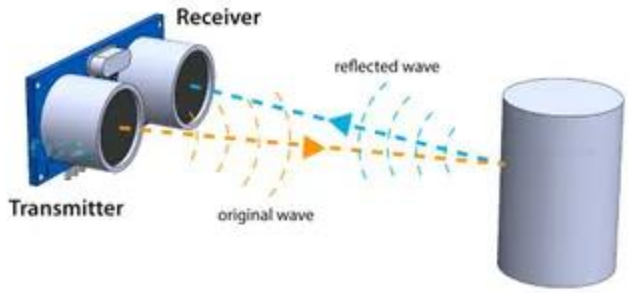

Fig 14: Ultrasonic Sensor

2. Servo Motor

A servo motor is a rotating device used to rotate parts of a machine precisely. It produces torque based on the principle of pulse width modulation and pulse duration is varied to control the angle at which it rotates. A servo motor is interfaced with an arduino as shown in figure (15). Power is given to the motor by connecting it to the 5V pin of the arduino through the red wire. The black wire is used to ground the motor by connecting it to the ground pin of the arduino. The yellow wire which is the signal wire is connected to any of the PWM pins (3,5,6,9,101,11). The arduino requires a library called 'servo' for its functioning.

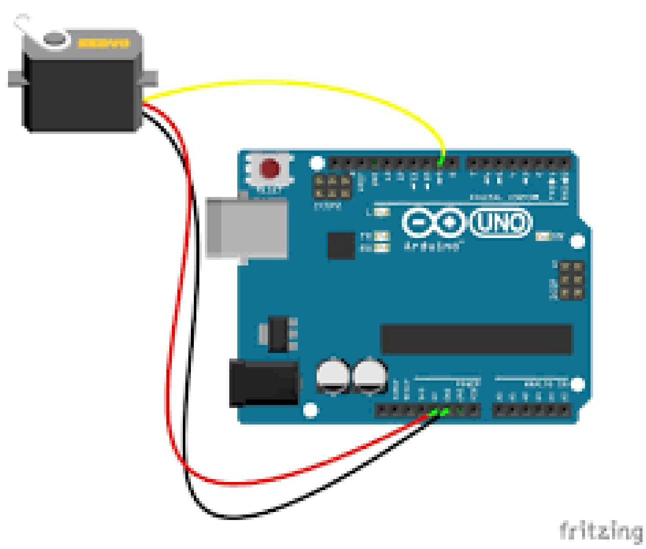

Fig 15: Servo motor interfacing with arduino

3. L298n Motor drivers

L298n is a dual H-bridge motor driver which is used to control the direction and speed of DC motors. It can control 2 DC motors simultaneously. The speed is controlled through Pulse Width Modulation technique where we vary the input voltage by sending a series of input pulses. and rotation direction is controlled by the H-bridge by changing the polarity of the input voltage . The table below shows the pin description of a motor driver and figure (16) shows the interfacing of the motor driver with the arduino.

Pin Name	**Description**
IN, IN2,IN3 & IN4	Motor A and B- input pins to control spinning direction
ENA & ANB	Enables PWM signal for Motor A and B
OUT1,OUT2,OUT3 & OUT4	Output pins of Motor A and B
12V	12V input from DC power Surcs
5V	Supplies power for the switching logic circuitry inside L298N IC
GND	Ground pin

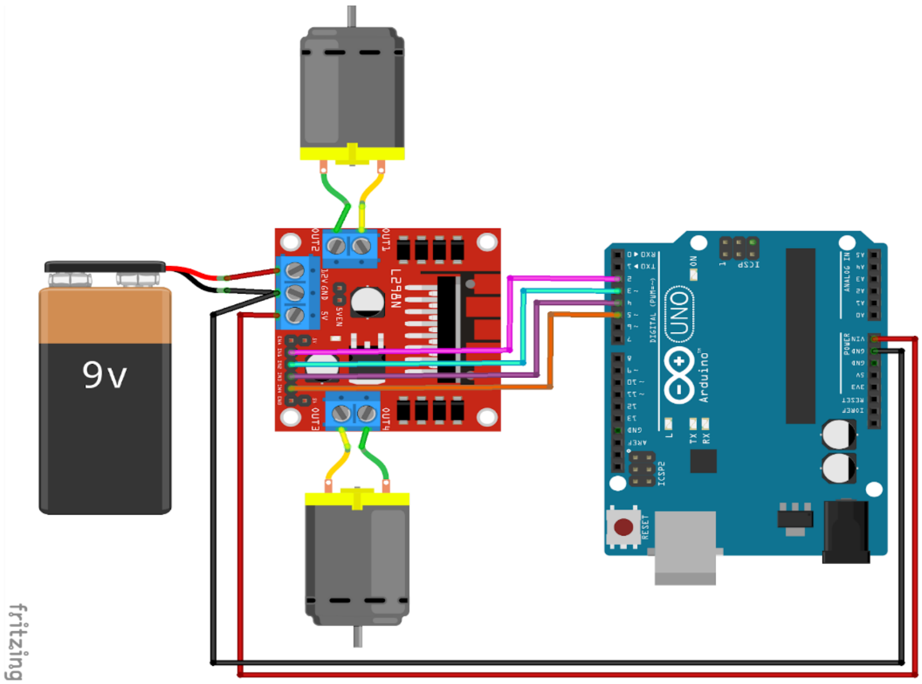

Fig 16: L298n Motor driver interfacing with arduino [26]

4. **Omni Wheels**

Omni wheels have rollers attached all around it which are perpendicular to the direction in which they turn. This makes them capable of moving and turning in 360 degrees, in all directions : left, right, front and back. They are made from high quality polymer and are highly durable and resistant to rust. They are mostly used in robots because they offer load stability.

3.3.2 Omnidirectional Movement

As shown in figure (11) three omni wheels are fixed in the chassis at an angle of 120 degrees from each other. Only two wheels are used for movement of the robot at a time and the third wheel is used to provide stability unless the robot has to rotate clockwise or counterclockwise Each wheel has a dc geared motor attached to it which is controlled by L298n motor drivers.

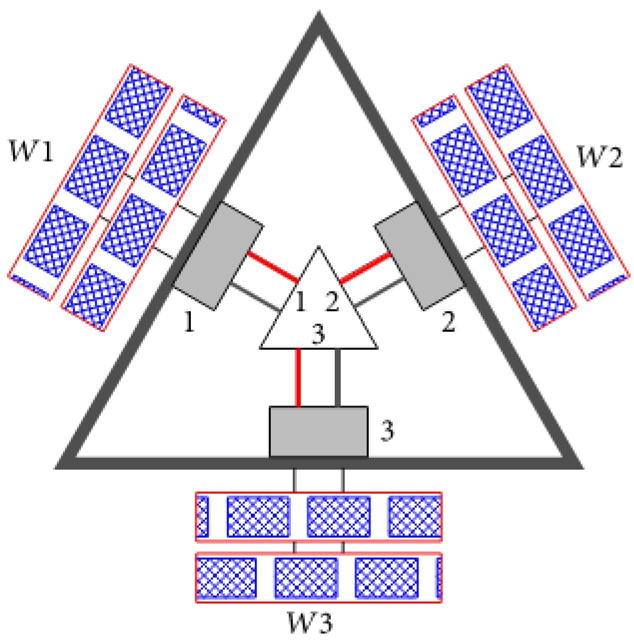

Fig 17: Circuit diagram of chassis (1, 2, and 3 are DC motors and W1,W2,W3 and are omni wheels). [27]

This arrangement of wheels allows the robot to move in all directions. For example, when the motor attached to the front wheel is stopped and both of the other motors are rotating in clockwise direction, the robot will be moving forward. Similarly, when the front motor is stopped and the other two motors rotate in anticlockwise direction, the robot will move in reverse direction. The figure (16) below explains the clockwise and counterclockwise rotation and the movement of Cov'atch in six different directions .

Fig 18: Movement of Robot in different directions [28]

3.3.3 Circuit working and operation

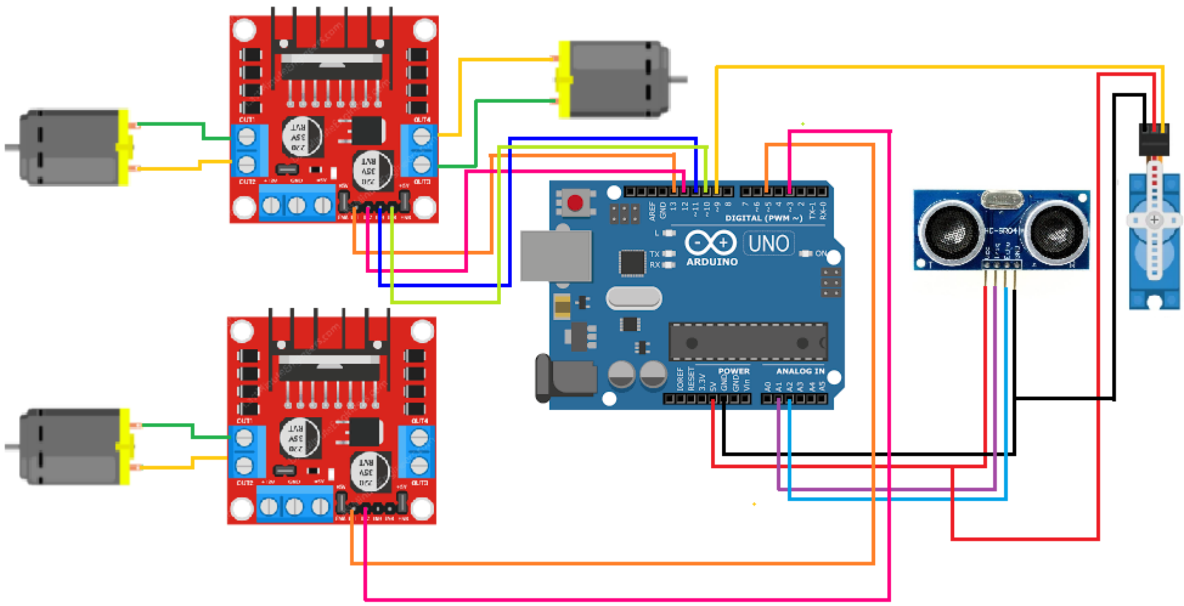

Fig 19: Circuit diagram and connection for Autonomous Movement of Cov'atch

When the robot is switched on it starts moving in the forward direction. While the robot is moving the ultrasonic sensor mounted on the servo motor is constantly monitoring and measuring distance from the objects that are in its line of sight. When it encounters an object that is less than 20 cm away, the arduino pins connected to Input pins of motor drivers are set to low voltage causing the robot to stop for a few seconds. While the robot is in its stationary state the servo motor receives the signal to enable the ultrasonic sensor to turn left and right; and measure the distance from obstacles around it. The robot then turns in the direction where it does not sense any obstacle and starts moving forward until it encounters another obstacle and the process repeats.

Cov'atch also has an additional feature that allows us to control its movement manually as well by using the bluetooth controller. This can be helpful in case the robot starts to malfunction at times. For example, if it gets stuck somewhere and is unable to get out on its own we can use the bluetooth controller to solve the problem. module which is controlled manually with the help of an arduino. The module used in this project is bluetooth module HC06 which enables serial communication between an arduino and mobile phone. We can install an application on our cell phone to communicate with the bluetooth module connected to the arduino. This allows us to control Cov'atch by using the following commands.

Character Commands	Robot Movement
F	Moves Forward
B	Moves Backwards
L	Moves Left
R	Moves Right
S	Stop

Fig 20: Table for Movement

3.4 Digital Image Processing

Image signal processing is the core tool that is used for mask detection and social distance monitoring. Image signal processing is basically a field that takes signals from a particular source, which in our case is a camera, and then converts it into the required information. These signals can be video, audio, ECG, sensor values, images, seismic data, etc. All these signals can be used for various purposes like displaying, storing, interpreting, segmenting, etc. For example: when images are acquired, signal processing is performed on it to get a more enhanced image structure to extract the required information. After modifying the image, the output is displayed in the form of an enhanced or altered image and required information is extracted.

We have used a webcam, mounted on the top of the robot. When the camera captures the required image or video, we apply image processing algorithms on the array of pixels obtained from the sensors in the camera. First step to apply spatial filtering and histogram technique to enhance the image which not only removes the noise but improves contrast. Next step is image restoration which uses probabilistic and mathematical models to further improve the image. After that, color image processing, wavelets and compression techniques are applied to adjust resolution and color of the acquired image.

After image processing comes the morphological processing which extracts components that are required for the description and representation of shapes in the image. Next step is dividing the image into parts through segmentation. The raw pixel data from segmentation is then transformed into a suitable form for computer processing. Last part is a description that extracts the attributes which brings out some useful and understandable information.

Object recognition is the last and final step that assigns a label to the object based on the description provided in the previous step.

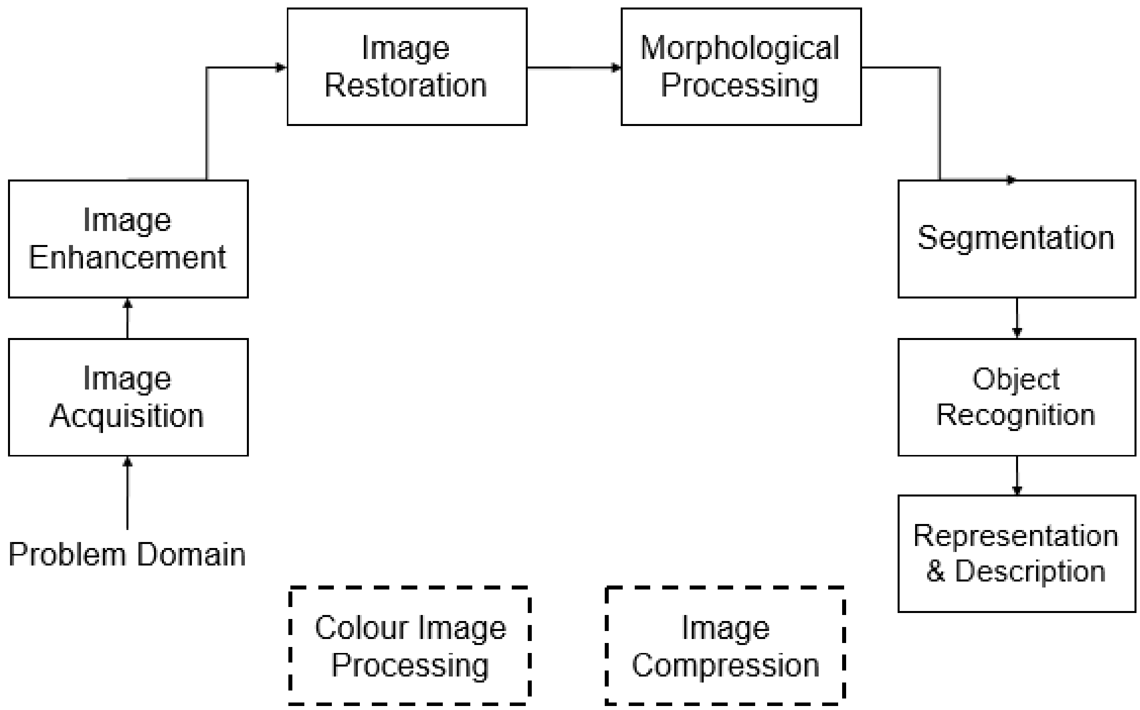

Fig 21: description of process of image signal processing [29]

3.4.1 Social Distance Monitoring

All these image processing techniques are applied for social distance monitoring. We have used an algorithm that detects people in an environment and calculates the distance between them. It has a database that recognizes people and applies the code to monitor the distance between them to control the spread of virus.

Firstly we use a webcam to acquire images and videos that contain people. Then through image processing we detect people in the images. All this image processing is done on an Nvidia Jetson nano which is a mini powerful computer which is used to run neural networks for different purposes. Next step is to determine how many people are in the particular image. When people are detected, they are encompassed in bounding boxes and then distance is calculated between the centers of these bounding boxes. As per our code, it will detect and act according to the color of the boxes. If there is a safe distance between the two boxes, the boxes will become green. But if it is detected that the distance between two people is less than the threshold distance, the boxes will turn red and an alert will be generated.

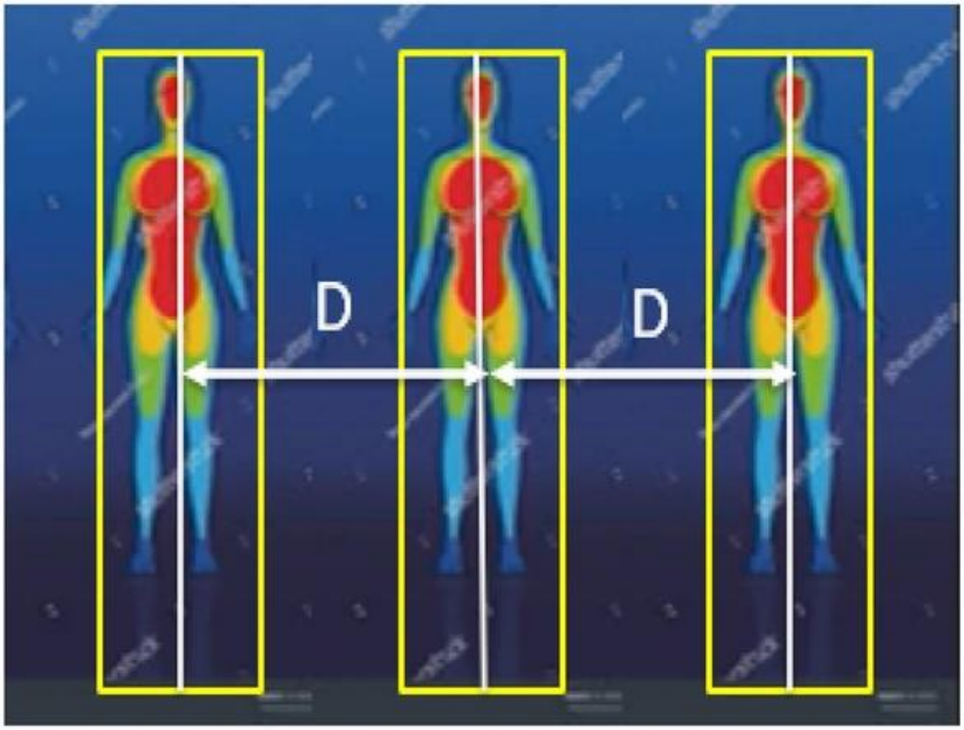

Fig 22: Distance (D) between centers of bounding boxes to monitor social distance

In our project we combined a python code with deep learning and computer vision to monitor social distancing. It is not possible to calculate distance between two pedestrians directly from an image without any extra information. So as mentioned previously, the python code takes as input, 4 points from the user to make 2 parallel lines. This region marked by the 4 points is called Region Of Interest which encompasses all the pedestrians in the frame which is known as the bird eye's view. Then we use a code that calculates the distance between 2 points. The people in the frame are identified and encompassed in bounding boxes.through deep learning. Then the algorithm then calculates the distance between the centroid of the boxes and compares with the threshold distance. [30]

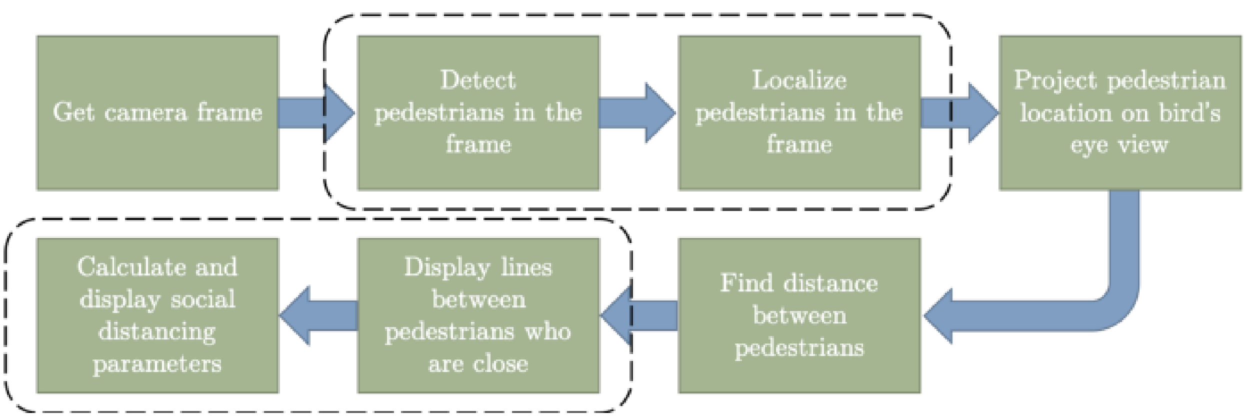

Fig 23: complete block diagram of the algorithm

3.4.2 Mask detection

Mask detection is also done using the similar image processing techniques as mentioned previously. Basically, we will gather a record of pictures with people wearing masks and people not wearing masks. The webcam is used to capture live images and videos. The images are then compared with the pre recorded data and if the person is detected with a mask, it will be encompassed in a green box and the box will become red when a person is not wearing a mask. When a person is detected without a mask, an alert will be generated and a signal will be sent to the mask dispenser to dispense a mask.

Figure 24: Real time face mask detection [31]

For this purpose, we used Nvidia along with an arduino. The key tools used are python script, tensorflow, keras and CNN (Convolutional Neural Network) to develop an algorithm for face mask detection. Our aim is to make a CNN model that is intelligent enough to detect masks on people from any angle. The first and foremost step is to extract characteristics from an image and divide them into the respective classes. The feature extraction is a step in the image processing steps that modifies and enhances the image for better understanding. As per the requirement, the dimensionality of the photograph can be adjusted. In our case, initially the input image is resized to 100*100 and then the features are extracted. This process is done in a python notebook. Some python libraries that were required are pandas, NumPy, matplotlib, sklearn, etc. Following libraries were used to make an intelligent and self sufficient CNN model:

TensorFlow 1.15.2, Keras 2.3.1, NumPy 1.18.2, SciPy 1.4.1, Imutils 0.5.3, OpenCV-python 4.2.0.

To train the face mask detector, the project is divided into two main parts:

1. Training: We gather data, face mask detection records and images of people with and without masks to form a model with tensorflow.

2. Deployment: After training, face recognition is performed which identifies people with and without masks so that necessary action can be taken.

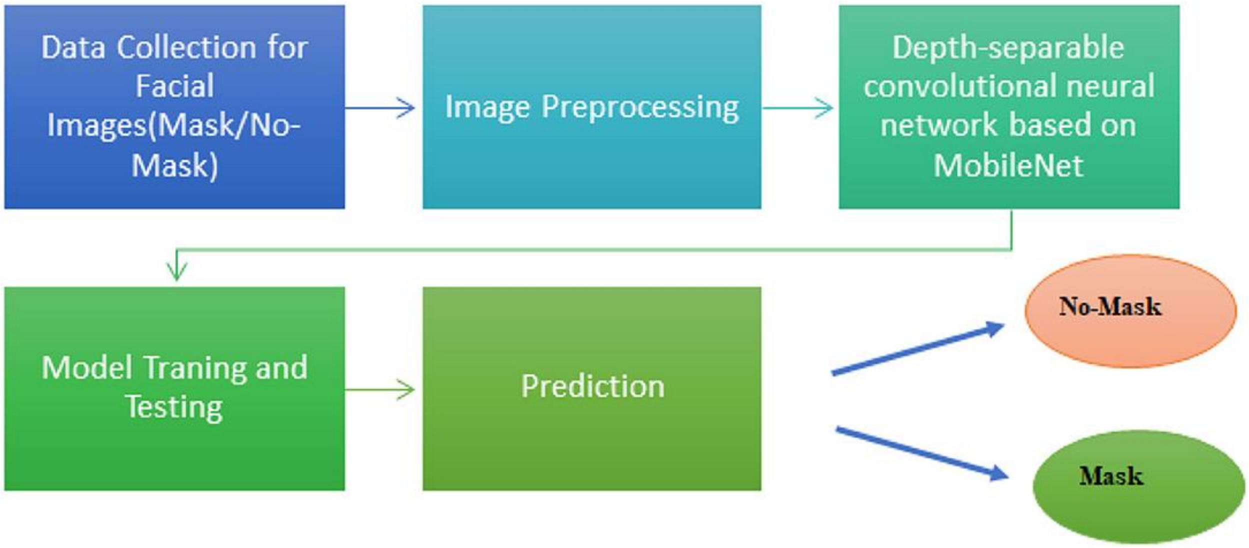

Figure 25: CNN model for face mask detection [32]

3.5 Mask and Sanitizer dispenser

1. **Mask Dispenser:**

The Nvidia nano jetson uses CNN and deep learning algorithms to detect face masks on people, as explained earlier. Whenever it detects that a person is without a mask, an alert is generated and a signal is sent to the arduino to generate a response for this alert. The arduino responds by sending a PWM pulse signal to the servo motor causing it to rotate which then opens the door of the mask dispenser. A message is also displayed on LCD to promote the person without the mask to take a mask and wear it.

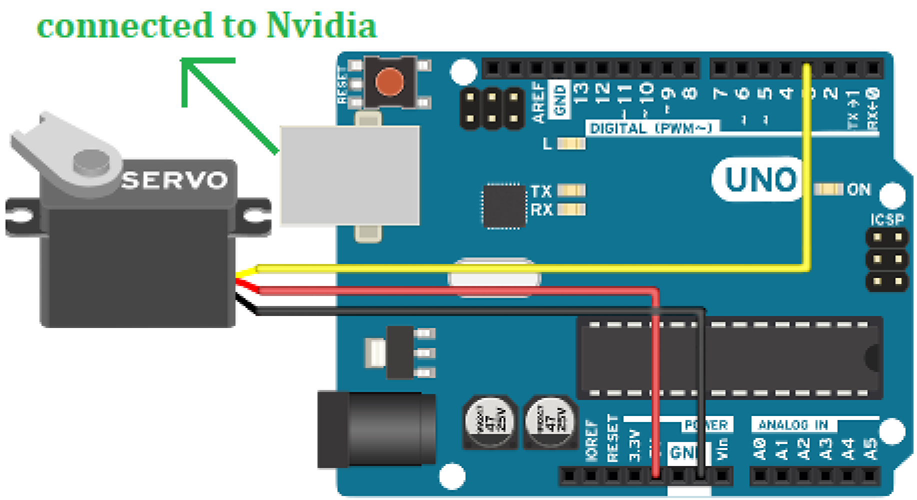

Fig 26: Interfacing Servo Motor with Arduino for automatic opening of Mask dispenser

2. **Hand Sanitizer:**

Since hand sanitizer is a must in times of COVID and especially in hospitals so this feature is also incorporated in our robot. This feature involves use of IR sensor, mini water pump and a 5V relay switch. The IR sensor controls the on and off state of the relay switch through an arduino board which in return controls the water pump.

When a person brings his hand near the IR sensor, the IR LED emits IR light which is reflected back by the hand and received by the photodiode. The received IR light changes the resistance of the IR sensor and causes output voltage of the sensor to increase. As a result, the relay switch is turned on and the water pump starts rotating. The rotation of the water pump enables the sanitizer to travel up along the tube and provides sanitizer to the person. The circuit diagram for sanitizer dispenser is shown in figure (27)

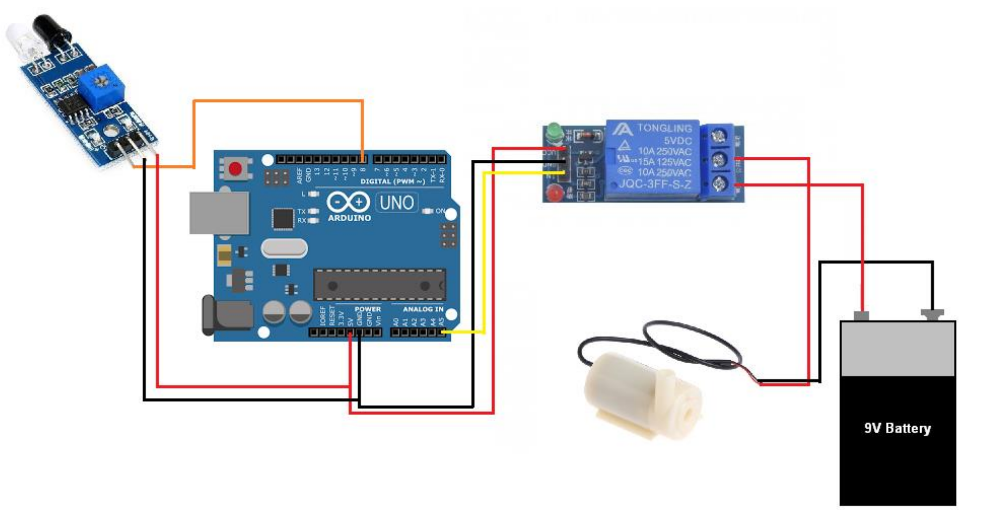

Fig 27: Circuit Diagram for Sanitizer Dispenser

3.6 Sanitization of surrounding

Cov'atch is not only capable of providing hand sanitizer but also sanitizes the environment. This process is almost similar to the process of Hand sanitization with the exception of the IR sensor. We connect the relay switch and the water pump with the arduino as shown in the figure (28). The arduino is used to provide a 5V output signal to the relay switch so that it can turn on the water pump. The rotation of the water pump which is connected to a long tube with nozzles attached to it then spray's the sanitizer in the surrounding area. This feature is very crucial in minimizing the spread of the virus in crowded and contaminated places like hospitals.

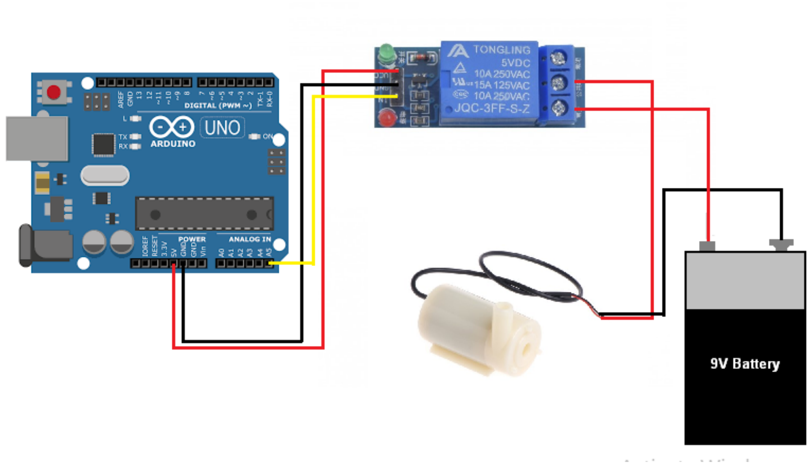

Fig 28: Circuit Diagram for Sanitization

3.7 Audio and Visual alerts

In case of violation of any SOPS, the robot will generate audio and visual alerts. In face mask detection, whenever a person is detected without a mask, the buzzer will be triggered and an audio alert will be generated. A visual alert will also be generated in the form of a message on the LCD to please take a mask from the mask dispenser and wear it. Similarly, when the threshold distance for social distancing is violated and two people are detected very close to each other, the buzzer will be triggered. A message will also be displayed on the LCD to maintain social distance. These audio and visual alerts will result in better compliance of SOPs.

3.8 Integration

For effective functioning of Cov'atch it was important to integrate all the processes that were previously implemented separately. For this purpose, we had to establish serial communication between the microprocessors.

We used a total of three microprocessors, one Nvidia Jetson nano and two Arduinos. Communication was required between both of the arduinos as well as the Nvidia and the Arduino. In the step wise description below Arduino 1 is referring to the arduino controlling movement of Cov'atch while the Arduino 2 is referring to the arduino controlling LCD,buzzer, servo motor and Sanitization circuit.

Step wise communication involved in functioning of Cov'atch:

1. Nvidia generates alert when it detects someone breaching SOPs
2. Nvidia sends a signal to Arduino 2 to trigger the buzzer and display a message on the LCD . In case of 'No Mask' alert arduino enables rotation of servo motors as well.
3. On the other hand, the IR sensor of the Sanitizer dispenser detects a person's hand.
4. Arduino 2 sends a signal to Arduino 1 to stop for a few seconds so a person can take the sanitizer.

3.9 Power Supply and Charging

1. Powering Cov'atch

Most simple robotic applications use Lithium-ion(Li-ion) batteries to power their controllers and the sensor circuits. These are high capacity rechargeable batteries easily available in the market. However, Lithium-polymer(Li-po) batteries are becoming more popular these days since they clearly have more advantages over the Li-ion batteries. Li-ion batteries are suitable to power low current electronics but are not recommended to power motors as they require relatively high current for their proper operation. On the other hand, Li-po batteries are designed to have higher discharge rates which make them more suitable to power the motors. Moreover, Li-po batteries are also easier to charge as compared to Li-ion batteries.

Considering the characteristics of both types of batteries, the Li-ion battery was a good option to power the Camera, LCD,sensors and other small electronic components of the circuits. However, they were not a compatible option to drive the DC gear motors of the project. Therefore, we opted for a li-po battery as the main power source for Cov'atch.

Li-po batteries are available in different sizes and voltage ratings. We can determine a suitable battery based on the specifications of motors and other electronic components that are to be powered from the battery. We used Li-po 4s 5200mah with maximum voltage of 14.8V to power 12V DC gear motors, two L298n motor drivers, two Arduino uno boards, LCD, sensors and a MG90S servo motor. All of these components were connected to suitable voltage regulators to ensure acceptable voltage is provided to each component depending on their respective requirements.

Along with the Li-po battery we also used a separate power bank to power the Nvidia jetson Nano and the camera attached to it.

2. Charging Cov’atch

In order to charge the li-po battery we used an iMAX B6-AC charger figure (29) which is able to charge, discharge and balance various types of batteries including Li-ion and Li-po batteries.

Fig 29: iMAX B6-AC charger

An additional feature that we incorporated in our project is charging indication. For this purpose we used 4s lithium battery capacity indicator module figure (30) which provides a quick visual display of charging status of the Li-po battery.

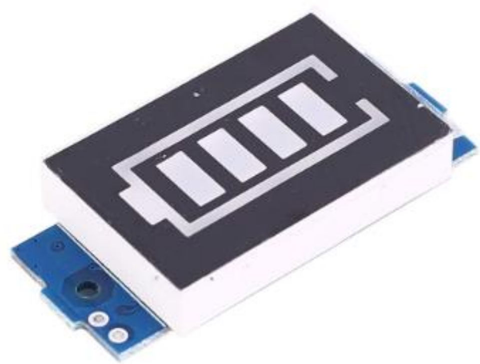

Fig 30: 4s lithium battery capacity indicator

Chapter 4: Future Work

Future Milestones that need to be achieved to commercialize this project are the following:

5.1 Improvement of autonomous movement in terms of accuracy

The autonomous movement can be improved by the implementation of navigation using ROS and LiDar. LiDar can convert the surrounding area into a map and can be used to estimate the position and location of the robot.

5.2 Separate Charging Dock

A separate charging dock is placed in a certain area, and the robot would automatically go to the charging station to charge itself when it has a battery lower than 10%.

5.3 Thermal Imaging

The robot would be able to sense and monitor the temperature of humans in its close proximity by thermal imaging and through a thermal camera.

Chapter 5: Conclusion

In this thesis we have discussed a smart autonomous robot that can not only help to control but also monitor contagious diseases like Covid-19 by having various features like sanitization, social distancing and mask detection .Overall, this project will be beneficial to the heath workers as it will reduce their workload. With the help of Cov’atch we will have a proper contactless surveillance system. It will reduce the risk of health care workers contracting the virus. Through the development of this project, implementation of COVID related rules will be more efficient and accurate, therefore minimizing the spread of virus.

Our proposed system, Cov'atch, is cost-effective as it is purely made for the core purpose of serving Pakistan, any system that could be beneficial to its citizens. Else, similar solutions provided by other countries are very costly. Moreover, Cov’atch provides an ease to adoption which can be adopted by beneficiaries, mass deployment can also be done and most importantly no product training is required.

References and Work Cited

1. Snyder H. Literature review as a research methodology: An overview and guidelines. *J. Busi. Res.104.* 2019:333–339

2. WHO . 1998. Safe Management of Wastes from Health-Care Activities. 2014.

3. Gopinath G. Limiting the economic fallout of the coronavirus with large targeted policies. *IMF*. 2020

4. Daszak P. Anatomy of a pandemic. *The Lancet.* 2012;380:1883–1884.

5. Ford T.E., Colwell R.R., Rose J.B., Morse S.S., Rogers D.J., Yates T.L. Using satellite images of environmental changes to predict infectious disease outbreaks. *Emerg. Infect. Dis.15.* 2009:1341.

6. Watts N., Amann M., Ayeb-Karlsson S., Belesova K., Bouley T., Boykoff M., Byass P., Cai W., Campbell-Lendrum D., Chambers J. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. *The Lancet.* 2018;391:581–630.

7. Javorcik B. Global supply chains will not be the same in the post-COVID-19 world. *COVID-19 and Trade Policy: Why Turning Inward Won't Work.* 2020

8. Javorcik B. Global supply chains will not be the same in the post-COVID-19 world. *COVID-19 and Trade Policy: Why Turning Inward Won't Work.* 2020

9. Sharma, Devansh, Ali Zaid Bin Nawab, and Mansaf Alam. "Integrating M-Health with IoMT to Counter COVID-19." *Computational Intelligence Methods in COVID-19: Surveillance, Prevention, Prediction and Diagnosis*. Springer, Singapore, 2021. 373-396.

10. Ethugala Pathiranage, Gehan Wishwajith Premathilake. *Value of Robots: A Literature Review*. MS thesis. 2020.

11. Ivanov, Stanislav Hristov. "Robonomics-principles, benefits, challenges, solutions." (2017).

12. Schaefer, Kristin E., et al. "Classification of robot form: Factors predicting perceived trustworthiness." *Proceedings of the human factors and ergonomics society annual meeting*. Vol. 56. No. 1. Sage CA: Los Angeles, CA: SAGE Publications, 2012.

13. Fong, Terrence, Illah Nourbakhsh, and Kerstin Dautenhahn. "A survey of socially interactive robots." *Robotics and autonomous systems* 42.3-4 (2003): 143-166.

14. Sathyamoorthy, Adarsh Jagan, et al. "COVID surveillance robot: Monitoring social distancing constraints in indoor scenarios." *Plos one* 16.12 (2021): e0259713.

15. Li, Shao-Qiang, et al. "Clinical application of an intelligent oropharyngeal swab robot: Implication for the COVID-19 pandemic." *European Respiratory Journal* 56.2 (2020).

16. Evans, Kevin D., et al. "Sonography of the lungs: diagnosis and surveillance of patients with COVID-19." *Journal of Diagnostic Medical Sonography* 36.4 (2020): 370-376.

17.Scott, Benjamin K., et al. "Advanced digital health technologies for COVID-19 and future emergencies." *Telemedicine and e-Health* 26.10 (2020): 1226-1233.

18. Zeng, Hui, et al. "The strategies of perioperative management in orthopedic department during the pandemic of COVID-19." *Journal of Orthopaedic Surgery and Research* 15.1 (2020): 1-9.

19. Khan, Zeashan Hameed, Afifa Siddique, and Chang Won Lee. "Robotics utilization for healthcare digitization in global COVID-19 management." *International journal of environmental research and public health* 17.11 (2020): 3819.

20.Mišeikis, Justinas, et al. "Lio-a personal robot assistant for human-robot interaction and care applications." *IEEE Robotics and Automation Letters* 5.4 (2020): 5339-5346.

21.Li, Zhi, et al. "Development of a tele-nursing mobile manipulator for remote care-giving in quarantine areas." *2017 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE, 2017.

22. Goel, Sachin S., et al. "Role of teleproctoring in challenging and innovative structural interventions amid the COVID-19 pandemic and beyond." *Cardiovascular Interventions* 13.16 (2020): 1945-1948.

23. Tsikala Vafea, Maria, et al. "Emerging technologies for use in the study, diagnosis, and treatment of patients with COVID-19." *Cellular and molecular bioengineering* 13.4 (2020): 249-257.

24. Tsikala Vafea, Maria, et al. "Emerging technologies for use in the study, diagnosis, and treatment of patients with COVID-19." *Cellular and molecular bioengineering* 13.4 (2020): 249-257.

25. S. Ahir, D. Telavane, R. Thomas. The impact of artificial intelligence, blockchain, Big data and evolving technologies in coronavirus disease-2019 (COVID-19) curtailment. Proc. - Int. Conf. Smart Electron. Commun. ICOSEC 2020, Vivekanand Education Society

26.“Servo Motor Control using Arduino Tutorial and Code”. *Mechatrofice*, 22 May 2022,www.mechatrofice.com/arduino/servo-motor

27. “Front and Back Movement Analysis of a Triangle-Structured Three-Wheeled Omnidirectional Mobile Robot by Varying the Angles between Two Selected Wheels”, *Hindawi*, 2016, www.hindawi.com/journals/tswj/2016/7612945/#references

28. Bhatt, Ashutosh. "Smartphone-Operated Omnidirectional Robot". *Engineers Garage*, 2022, www.engineersgarage.com/smartphone-operated-omnidirectional-robot/

29. Processing., What. "What Is Image Processing? Explain Fundamental Steps In Digital Image Processing.".*Ques10.Com*,2019, www.ques10.com/p/33595/what-is-image-processing-explain-fundamental-steps/

30. Aqeel Anwar., “Using Python to Monitor Social Distancing in a Public Area”, *Towardsdatascience,* 20 April 2020, www.towardsdatascience.com/monitoring-social-distancing-using-ai-c5b81da44c9f

31. "Logmask - Real Time Face Mask Detection, Capacity Control And EPI Detection. (COVID-19) Coronavirus Prevention Technology.". *Logmask.Com*, 2022, www.logmask.com/en

32. Asghar, Muhammad Zubair, et al. "Facial Mask Detection Using Depthwise Separable Convolutional Neural Network Model During COVID-19 Pandemic." *Frontiers in Public Health* 10 (2022).