AUTOMATION OF SAMPLE HANDLING FOR COVID-19 TESTING PROCESS

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Dissertation submitted in partial fulfillment of the requirements for the degree of

BACHELOR OF ENGINEERING

Branch: ROBOTICS AND AUTOMATION

of Anna University

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DEPARTMENT OF ROBOTICS AND AUTOMATION ENGINEERING

PSG COLLEGE OF TECHNOLOGY

(Autonomous Institution)

COIMBATORE – 641 004

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Bona fide record of work done by

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To Whomsoever It may Concern.

This is to certify that **Ms. A. AARTHI**, a student of Bachelor of Engineering in Robotics and Automation bearing the **Register No – 18R201** at PSG College of Technology, Coimbatore has completed the internship at **AAtek Robo Private Limited**, Coimbatore from **February, 2022 to May, 2022**.

Involved in the following project:

Automation of Sample Handling for COVID 19 Testing Process.

During this period her performance and conduct was good.

We wish her the very best in all future endeavours.

For AATEK ROBO PVT LTD

Director

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Automation of Sample Handling for COVID 19 Testing Process.

During this period her performance and conduct was good.

We wish her the very best in all future endeavours.

For AATEK ROBO PVT LTD

Director

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We wish to express our sincere gratitude to **Dr. K. Prakasan**, Principal, PSG College of Technology for providing an opportunity and necessary facilities in carrying out this project.

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SYNOPSIS

Coronavirus disease (COVID-19) is a novel virus that causes an infectious disease. . Cough, fever, and more severe episodes of respiratory infection are common symptoms (flu-like).COVID-19 RT-PCR test, commonly known as a molecular test, detects virus genetic material using a lab technique called reverse transcription polymerase chain reaction (RT-PCR). A health care provider takes a fluid sample from the back of your nose by inserting a long nasal swab (nasopharyngeal swab) into your nostril. It's possible that he or she will be harmed as a result of the viral exposure in such circumstances of human intervention.

The main objective of the project is to develop an automation system to reduce human errors in the Covid-19 testing and provide accurate results. It must also enhance the level of traceability and produce high throughput. Moreover, the human exposure to hazardous viruses such as Covid-19 must be prevented by providing an easy handling experience. Being an automated process, it is possible to run 96 tests per hour, which is comparable to 2000 tests per day. Testing for new virus variants is possible with the right test kits, and the automated system could be used for alternative diagnostics like blood samples, urine samples, High-Throughput Screening, Molecular Diagnostics, Transplantation Diagnostics, Animal Laboratories, and more with minimal changes.

The internship was undertaken at AATek Robo Pvt. Ltd., Coimbatore, an emerging technological company that uses Industry 4.0 standards and Robotics to deliver Automation solutions and engineering services for Industrial and Medical fields. The startup receives engineering assistance from companies in Germany and Japan, two industry 4.0 and robotics technology powerhouses. Their goal is to provide self-regulating integrated automated solutions to enable their clients realize dependable operations that meet 6 sigma quality levels. This project has been successfully implemented with the support of AATek Robo Pvt. Ltd.,

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LIST OF ABBREVIATIONS

Sl No.	Symbol/Abbreviations	Abbreviated
1	RNA	Ribonucleic Acid
2	RT-PCR	Reverse Transcription Polymerase Chain
3	SARS	Severe Acute Respiratory Syndrome
4	RFID	Radio Frequency Identification
5	ISO	International Organizations Standardization
6	UL	Underwriter’s Laboratories
7	CCD	Charge-Coupled Device
8	SCARA	Selective Compliance Articulated Robot
9	PCS	Process Control System
10	DCS	Distributed Control System
11	HMI	Human Machine Interface
12	PLC	Programmable Logic Controller

CHAPTER 1

INTRODUCTION

Currently, the world is exposed to the outbreak of the dangerous Covid-19 disease, which makes it difficult for lab technicians to test the patients manually every day. The automation of sample handling for covid-19 testing process is employed to handle the covid-19 test samples by transferring them to an RNA extraction machine in an automated way. This automation system intends to provide effective diagnostics in laboratories without the need for human intervention. Automated handling also eliminates fatigue and continues the process with default efficiency.

1.1 OBJECTIVE OF THE PROJECT

The main objective of the project is to develop an automation system to reduce human errors in the Covid-19 testing and provide accurate results. It must also enhance the level of traceability and produce high throughput. Moreover, the human exposure to hazardous viruses such as Covid-19 must be prevented by providing an easy handling experience.

1.2 SCOPE OF THE PROJECT

This project focuses on shifting the samples and transferring them to a new tube which is then sent to diagnosis. Our scope is to achieve it in a quicker way, speeding up the total number of samples tested per day. With minimal human efforts, it serves as an effective application that eliminates human exposure to hazardous viruses. It can also be modified to handle other samples as well (e.g. Blood samples). While manual process can handle only 800 samples per day, the automated system is able to speed up the process by increasing the count to about 2000 samples.

1.3 ORGANISATION OF THE REPORT

- In Chapter 1, an overview of the project, problem definition and the objectives of the project are discussed.

- In Chapter 2, the existing techniques are summed up based on literature review.
- In Chapter 3, the methodology of the project is formulated.
- In Chapter 4, the process flowchart of the system is explained.
- In Chapter 5, the conceptual design of the system is discussed.
- In Chapter 6, the arm for the system is selected.
- In Chapter 7, the components used for the project is explained.
- In Chapter 8, the implementation and testing of the system is discussed.
- In Chapter 9, the conclusion of the project is discussed.

This chapter provided the outline of the project. The previous works done related to the robot are discussed in the upcoming chapter.

CHAPTER 2

LITERATURE SURVEY

In this chapter, the papers related to automation of samples handling for covid-19 process were analyzed. The results of the patent search and the outcome of the survey is presented.

2.1 LITERATURE REVIEW

Various literature papers published in the field were studied and the essence of the papers is given below for better understanding.

2.1.1 Implementation of an Open-Source Robotic Platform for SARS-Cov-2 Testing by Real-Time RT-PCR

José Luis et al. [1], aim to develop a repeatable system for real-time RT-PCR SARS-CoV-2 testing using open-source liquid-handling robots. They have developed a framework that contains a code template for building a range of stand-alone robotic stations that can follow specific protocols. Such stations can be used to establish a sophisticated multi-stage process by preparing samples using real-time RT-PCR.

Most laboratories and hospitals with experienced bioinformatics personnel can perform automated SARS-CoV-2 PCR testing due to the inexpensive cost of this technique. This platform is particularly adaptable because it is not dependent on any specific commercial kit, allowing it to swiftly adapt to protocol changes, reagent or consumable shortages.

2.1.2 Development of Flexible Laboratory Automation Platform Using Mobile Agents in the Clinical Laboratory

Byung June Choi et al. [3], describe a new robotic platform for clinical tests that is suitable for small or medium-sized laboratories that uses mobile robots in this study. Mobile Agent is a mobile robot that acts as a transfer system for blood samples, reagents and other devices, performing many tests at the same time thanks to its cooperative and distributed capabilities.

Patient information is recognized via an RFID technology. The Bio-Robot platform, which is built on mobile agents, may regulate throughput based on the number of tests. Additionally, because the system's components are easily changeable, the system's operation and maintenance can be improved. The system was produced and confirmed by preliminary experiments to determine the practicality of the Bio-Robot platform.

2.1.3 Smart Materials- Integrated Sensor Technologies for COVID-19 Diagnosis by Ozgecan

Erdam et al. [2], gives a thorough literature on smart materials (e.g., graphene, light sensitive, electrically sensitive, and wearable intelligent materials) and their biosensor integrations with instances of virus detection, including SARS-CoV-2, in this review.

The project's final goals are to build biosensor platforms for both point-of-care (POC) and clinical settings to speed up detection procedures, potentially allowing for the most cost-effective social and economic strategies to combat the disease.

2.1.4 Installation and Implementation of Automation and its Impact on Clinical Chemistry Laboratory Productivity

Sahar Iqbal et al. [4], states the influence of laboratory automation system on productivity with deployment of laboratory automation system in a clinical laboratory is explored, as described in the evaluation of cross-sectional study.

The laboratory automation adaptation process is explained in detail in this study, which will be useful for other clinical laboratories looking to deploy laboratory automation. By implementing automation, we discovered a reliable and effective way to manage high work flow. The study proved a productive and feasible strategy to handling high workload with laboratory automation without adding extra manpower.

2.1.5 Evaluation of Automated Molecular Tests for the Detection of SARS-Cov-2 in Pooled Nasopharyngeal and Saliva Specimens

Hamad Al-Hail et al. [5], stated pooling samples for SARS-CoV-2 testing in low-prevalence areas has shown to be a successful technique for increasing testing capacity and overcoming supply shortages. Two automated molecular test techniques for detecting SARS-CoV-2 RNA in pooled specimens are compared for cost savings and quality.

Pooled tests should be in 85% positive agreement with individual testing. Their findings showed that the Xpert tests can be successfully used for pooled testing with clinical sensitivity comparable to standard, resulting in cost savings and increased test capacity in new test facilities.

2.2 PATENT SEARCH

2.2.1 System and Method for Testing COVID-19

Richard A. Rothschild's patent focuses on a method for obtaining and transmitting biometric data (e.g., vital signs) from a user is disclosed, with the data being evaluated to identify whether the user is infected with a virus such as COVID-19. A pulse oximeter is used to obtain at least pulse and blood oxygen saturation percentages, which are then wirelessly transferred to a smartphone. An accelerometer in the smartphone measures movement of the smartphone and/or the user to guarantee that the data is accurate. Once reliable data has been collected, it is sent to the cloud (or host), where it is utilized to evaluate if the user is suffering from (or likely to suffer from) a viral infection such as Covid-19. Depending on the specific requirements, the data, changes thereto, and/or the determination can be used to alert medical staff and take corresponding actions.

2.3 OUTCOME OF THE LITERATURE SURVEY

Various outcomes derived from literature review are,

- The impact of a laboratory automation system on productivity as a result of its implementation.
- Mobile Agent used as a blood sample, reagent, and micro plate transfer system.
- Pooling of samples for SARS-CoV-2 testing in low-prevalence settings.
- The fundamental ideas of design calculations and component selection.

In this chapter, previous works done by various authors are reviewed. The next chapter deals with formulation of the methodology flowchart.

CHAPTER 3

METHODOLOGY

This chapter mainly focuses over the steps involved in development of the project. The methodology was formulated.

3.1 RT-PCR TEST

One of the most common COVID-19 testing is real-time reverse transcriptase-polymerase chain reaction (RT-PCR). A sample of the person's nose or throat swab is collected for the RT-PCR test, which analyses the virus's genetic pieces.

A major aspect of obtaining the RT-PCR test result is amplifying the genetic material in the collected sample; RNA must first be transformed into DNA, which is the only genetic material that can multiply. Reverse transcription is a process that converts RNA into DNA, which is subsequently amplified to a quantity that contains enough of the target portions of viral DNA to provide an appropriate RT-PCR test result.

A sample is taken from the bodily parts where the COVID-19 virus congregates, such as the nose or throat. Several chemical solutions are used to eliminate contaminants such as proteins and lipids from the sample, leaving just the RNA to be extracted. This RNA is a combination of the person's genetic material and, if present, the virus's RNA.

After that, the mixture is put into an RT–PCR machine. The machine alternates between heating and cooling the mixture, triggering chemical processes that produce new, identical copies of the viral DNA target portions. To keep duplicating the target portions of viral DNA, the cycle is performed over and over. Every cycle doubles the number before it: two copies become four, four copies become eight, and so on. A typical real-time RT–PCR setup runs through 35 cycles, which implies that each strand of virus in the sample generates roughly 35 billion new copies of viral DNA by the conclusion of the procedure.

The marker labels connect to the DNA strands when new copies of the viral DNA sections are made, releasing a fluorescent dye that is monitored by the machine's computer and displayed in real time on the screen. After each cycle, the computer records the quantity of fluorescence in the sample. When a specified amount of fluorescence is exceeded, the virus is confirmed to be present. Scientists also keep track of how many cycles it takes to reach this point in order to determine the intensity of the infection: the fewer cycles, the more serious the viral infection.

3.2 METHODOLOGY FOR SAMPLE HANDLING

First laboratory technician receives the sample, then they isolate genetic material from the rest of the materials in the samples. In our system robotic arm carries the sample. Next de-capping and Barcode Scanning takes place. Then Another arm will suck the samples in pipette tip Ejector and fill it in new tubes. Finally pipette tip Ejector is disposed to bio waste collector.

The system strives for Laboratories without any human interaction, offering effective Diagnostics without being exposed to any dangerous viruses. The project's major purpose is to eliminate human mistakes in normal testing.

3.3 COMPARISON WITH EXISTING SYSTEM

There are various laboratory automation systems that are available to diagnose different kinds of samples (like blood samples). However, the systems had minimal through-put. The automation of sample handling for Covid-19 testing process is exclusively designed for handling only Covid-19 samples without having its exposure to lab technicians, thereby reducing the human errors and improved safety. Moreover, this system provides an increased through-put and increased level of traceability.

3.4 METHODOLOGY FLOWCHART

Methodology is the study of research techniques, or, to put it another way, "a contextual framework for research, a coherent and logical scheme based on views, attitudes, and values that governs the decisions researchers make.

3.4.1 Methodology of the System

The flowchart depicts the step-by-step approach for achieving the main objective. The project's initial concept was developed. The approach was then developed by searching and studying numerous publications and patents related to the project. The various needs are recognized and a problem statement is framed as a result of the literature review. As the problem statement is stated, planning was completed and a process flowchart was created, which included all of the project's phases. The conceptual design was built with the help of the process flowchart. Further, the calculations for the required materials are done. After collecting the results, the most suitable materials were chosen based on the payload and the reach. Since all the requirements were met, the project is designed.

Further, all the components are assembled together at their particular stations. After completion of the mechanical part the coding for the movement of both the arms is done. The developed mechanical part and the software are interfaced and integrated. The movement of the arms and de-capping actions are checked for disputes. If there are any, the coding is revised. After checking for the movement of arms and the working of the de-capping station, the project is checked for errors and is ready for use. The formulated methodology is shown in Fig 3.1.

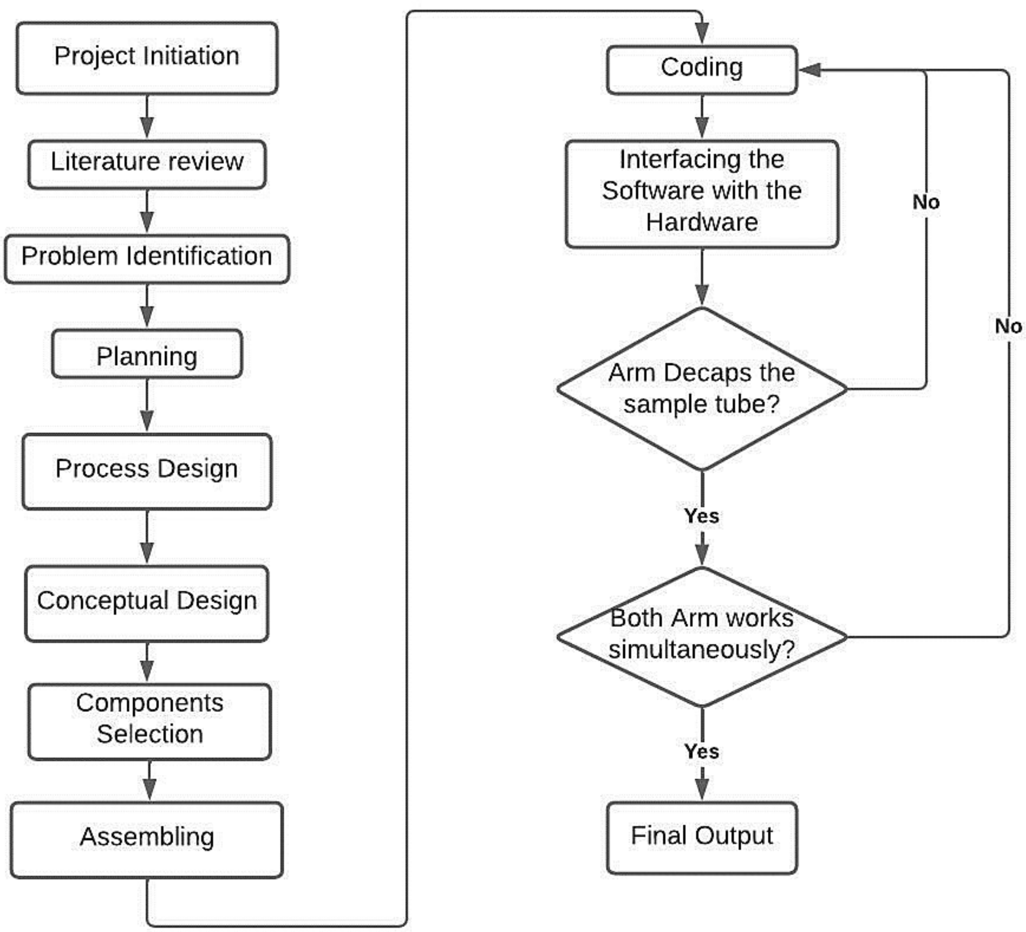

Fig 3.1 Methodology Flowchart

In this chapter the methodology for the Automation of Sample Handling for Covid-19 testing process is formulated. The process to be followed is discussed in the upcoming chapter.

CHAPTER 4

CONCEPTUAL DESIGN

This chapter gives a conceptual overview of the robotic arm and omnidirectional base along with the developed 3D Design.

4.1 SOFTWARE USED

Conceptual design is the initial stage for designing the mechanical structure of the prototype. It is developed based on the generated concept and it lacks technical specifications.

The software used to develop the conceptual design is Tinker CAD. Tinker CAD is a web-based 3D modeling program shown in Fig. 4.1 is developed by Autodesk and is completely free to use. It has become a popular platform for making models for 3D printing since its release.

Fig. 4.1 Tinker CAD Logo

(Source: www.tinkercad.com)

4.2 DESIGN

Conceptual Design is the framework for establishing the fundamental idea behind a design and a plan for how it will be expressed visually is conceptual design. It implies understanding what people want and how to address their requirements with products, services, and processes. Concept sketches and models are common artifacts of conceptual design. Initially, the conceptual overview of robot is generated.

4.2.1 Conceptual Overview

This is our conceptual design, which consists of two arms and five stations. Station 1 is the tray placement station. The tube is moved from this station to the barcode scanning station i.e., station 2 in the center by arm 1. This station holds the tube while arm 2 with the pipette tip ejector collects the sample and delivers it to the station 4 i.e., tube filling station.

At the same time, arm 1 caps the tube and take it from station 2 and place it at station 1. Now. The used pipette tip ejector in held by arm 2 is disposed of in the bio waste collector station say station 5. After which, The station 3 named pipette tip ejection station consists of a new pipette tip ejector, and arm 2 reloads the tip here to continue the loop.

4.2.2 3D Design

Based on the generated conceptual overview, the 3D design of the project which is shown in Fig 4.2 is developed.

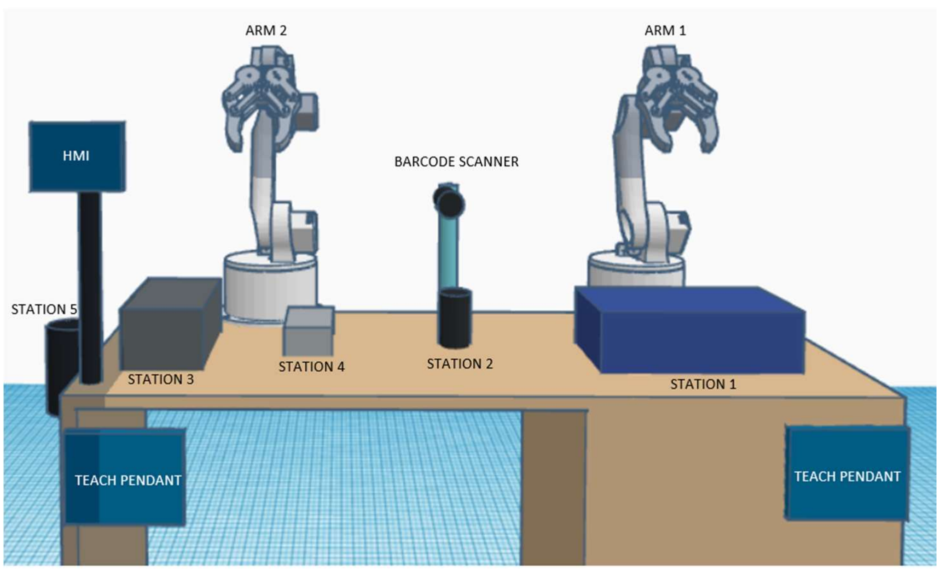

Fig 4.2 3D Design

In this chapter the conceptual design for the Automation of Sample Handling for Covid-19 is explained. The required arm for the system is selected in the upcoming chapters.

CHAPTER 5

PROCESS FLOWCHART

In this chapter, various steps involved in accomplishing the total automation process are discussed.

5.1 WORKFLOW

The system comprises of five different stations that are covered by two 4- axis robotic arms. The arms are placed at the correct position to reach the stations and complete the process without any intervention. The process flowchart is shown in Fig 5.1.

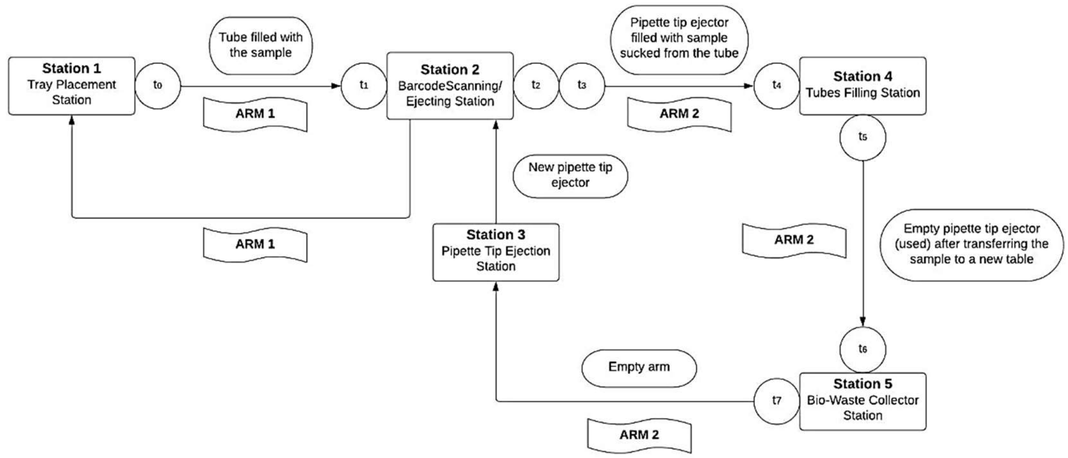

Fig 5.1 Process Flowchart

With the help of the timings the process can go with the flow without any collision. The following timings are

- T0 –T1 - Movement of Arm 1 from Station 1 to Station 2. Simultaneously, picking up of pipette tip ejector by Arm 2 from Station 3.

- T1 -T2 - Barcode scanning and de-capping. Simultaneously, movement of Arm 2 from Station 3 to Station 2.
- T2 –T3 - Sucking samples in pipette tip ejector.
- T3 –T4 - Movement of Arm 2 from Station 2 to Station 4. Simultaneously, movement of Arm 1 from Station 2 to Station 1 original position.
- T4 –T5 - Filling the tubes with samples.
- T5 – T6 - Movement of Arm 2 from Station 4 to Station 5.
- T2 – T3 - Disposal of pipette tip ejectors to Bio – waste collector.

5.1.1 Station 1

The first station is the tray placement station. In this station, as shown in Fig 5.2, the testing samples collected in tubes from the patients are placed in 96 well plates. The 96-well micro plates are a rectangular plate or block containing multiple small wells or cavities, used for analysis, clinical testing, or culture for antibiotic screens, cell-based assays and screening compounds. This tray placement station is a manual station involving no automation. The lab technician must place over all the swabs in the 96 well plate. The swabs are collected in tubes containing barcodes. The barcode contains the details of the patients which will be matched later with the final diagnostic results.

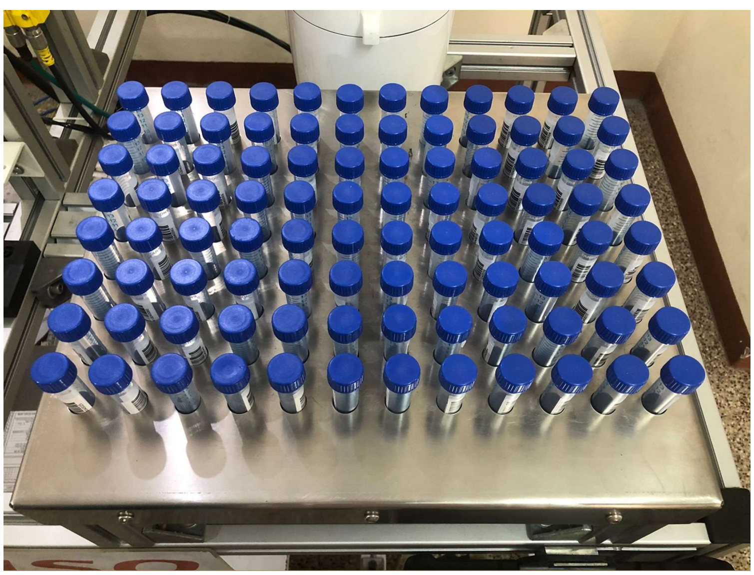

Fig 5.2 Station 1

5.1.2 Station 2

Station 2 is the Barcode Scanning or Ejecting Station. In Station 2, as shown in Fig 5.3, the collected samples tube are moved from station 1 to station 2 by arm 1 where the arm rotates the tube for scanning the barcode using the barcode scanner. A barcode scanner is a type of optical scanner that can read printed barcodes, decode the data contained within the barcode, and send the data to a computer. Here, the bar code scanner scans the details of the person and saves it to deliver the results. The tube is then placed in station 2 and the arm 1 de-caps the tube. The tube is de-capped so that the arm 2 along with the pipette collects the sample from the tube. After all process, the tube the station 2 is again capped by arm1 and moved back to its original position.

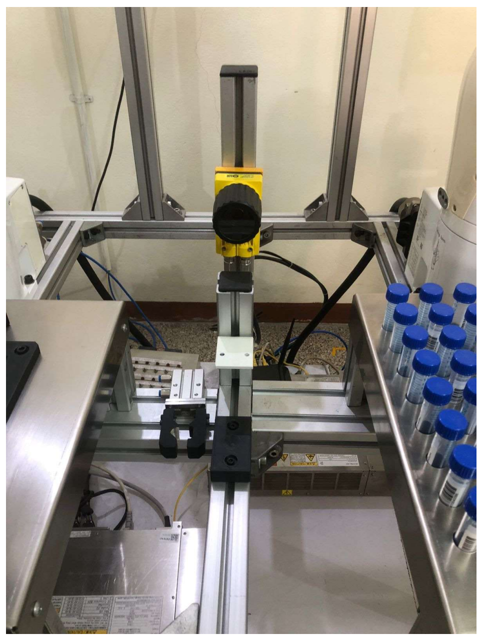

Fig 5.3 Station 2

5.1.3 Station 3

Pipette tip ejector station is the Station 3, where the new pipettes are placed in a tray as shown in Fig 5.4. Pipettes are used for collecting the samples from the swab tubes and transferring them to a new tube. A pipette is a tool used in laboratories for medical purposes to transfer a measured amount of liquid. Pipettes have different designs for variety of purposes. A pipette tip ejector is used. The pipette tip ejector is a push button actuated rod situated in a passage located in an upper part of the pipette's hand hold able housing. Using the pipette taken by arm 2, the sample is collected and moved to new tube which is then passed to RNA extraction machine.

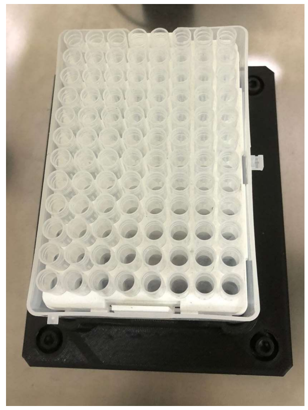

Fig 5.4 Station 3

5.1.4 Station 4

Station 4 is the tube filling station. In Station 4, as shown in Fig 5.5, the samples that are collected using pipette tip ejector by arm 2 are filled in the tray containing new tubes. The tube filling station contains tray with variety of new tubes that is passed on to the RNA extraction machine for further testing process. The tray contains 96 new tubes that need to fill to complete the set of process. This could be achieved within one hour.

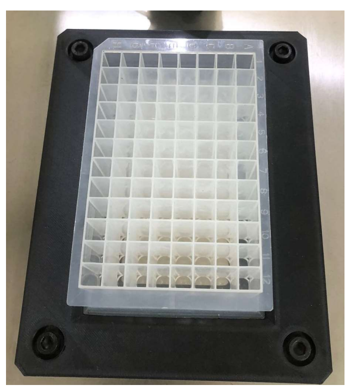

Fig 5.5 Station 4

5.1.5 Station 5

Station 5 is the bio-waste collector station. The bio waste collector is used to collect infectious biomedical waste or hospital waste. In Station 5, as shown in Fig 5.6, the Bio-waste collector is placed where the used pipette tip ejectors are disposed. The used pipette is not used again. Instead, the new ones are used in order to produce accurate results.

Fig 5.6 Station 5

5.1.6 Working

Utilizing this flowchart and the details of the stations and the timings, the working concept can be explained. The system comprises of five stations that are covered by two robotic arms. The tray placement station is the first station. This is where the collected test samples are kept in tubes. Arm 1 collects the tubes from station 1 at t0 and transports them to station 2 at t1.Station 2 is a barcode scanning and ejecting station. The barcode scanner now tracks the sample's state and saves it. The sample is then collected from tube 2 in station 2 by arm 2 using a pipette tip ejector at t2 and moved to station 4 at t4. This is the filling station for tubes. At time t5, arm 2 fills the tube in station 4 with the sample. At the same time, arm 1 cap the processed sample tube and takes it back from station 2 to station 1. Then, The empty pipette tip ejector handles by arm 2 is thrown at station 5's bio waste collector at t6. At t7, the empty arm 2 advances to station 3. The pipette ejector is located at Station 3. Then a new pipette tip ejector is installed in arm 2 at t1, and arm 2 is sent to station 2 to process the next sample. The process continues till the entire swabs are being shifted to new tubes which in turn are passed to RNA extraction machine.

In this chapter the process flowchart for the Automation of Sample Handling for Covid-19 testing process is formulated, various stations used is discussed and the working is explained. The next chapter describes the conceptual design of the system.

CHAPTER 6

ARM SELECTION

In this chapter, different types of DENSO arms are considered for selection and finally the correct fit robot is selected for operation.

6.1 TYPES OF ROBOTS

- 5- and 6-Axis Robots
- 4-Axis robots
- Collaborative robots

6.1.1 5- and 6-Axis Robots

6.1.1.1 VP-Series VP-5243 / 6242

It is very powerful for their small size. The VP-5243 / VP-6242 robot series is among the most compact of all DENSO robots and is perfect for installation where space is limited. The arm model is shown in Fig 6.1.

Fig 6.1 VP-5243/6242

Table 6.1 Specifications of VP-5243/6242

Maximum arm reach	430 / 432 mm
Maximum payload	3 1 / 2.5 2 kg
Position repeatability	±0.02 mm
Cycle time	0.99 sec (for 1 kg payload)
Options	Standard type

Table 6.1 shows the specification of the robotic arm.

6.1.1.2 VS Series VS-050 / 060

The compact body has outstanding power and speed. More speedy, more compact, and easier to use. Slim design robots featuring top-performing speed in its class with significantly-improved eases of use. The arm model is shown in Fig 6.2.

Fig 6.2 VS-050 / 060

Table 6.2 Spec of VS-050 / 060

Maximum arm reach	505 / 605 mm
Maximum payload	4 kg
Position repeatability	±0.02 mm
Cycle time	0.35 sec (for 1 kg payload)
Options	• Standard type • Protected type • Dust & splash proof type • Cleanroom type • UL specifications

Table 6.2 shows the specification of the robotic arm.

6.1.1.3 VM-6083 / 60B1

The robot series VM-6083 and VM-60B1 feature both the longest arm reach of all DENSO 5- and 6-axis robots and the highest maximum payload. The arm model is shown in Fig 6.3.

Fig 6.3 VM-6083 / 60B1

Table 6.3 Specifications of VM-6083 / 60B1

Maximum arm reach	1,021 / 1,298 mm
Maximum payload	13 kg 6
Position repeatability	±0.05 to ±0.07 mm
Cycle time	0.89 / 0.95 sec (for 5 kg payload)
Options	Standard type Dust & splash proof type (wrist: IP65, unit: IP54) Cleanroom type (Class 100)

Table 6.3 shows the specification of the robotic arm.

6.1.2 4-AXIS ROBOTS (HSR SERIES)

6.1.2.1 HSR® 048 / 055 / 065

Speedy start, speedy continuation of motion, and accurate stopping. In pursuit of the ultimate performance, the HSR Series features "true high speed," realizing a compact, space-saving, high-speed picking system to handle processes such as conventional components assembly, the packaging of food, pharmaceuticals, or cosmetics, etc. to innovate the work place. The arm model is shown in Fig 6.4.

Fig 6.4 HSR 048 / 055 / 065

Table 6.4 Specifications of HSR 048 / 055 / 065

Arm reach	480 / 550 / 650 mm
Vertical stroke	100 / 200 / 320 / 510 mm
Maximum payload	8 kg
Position repeatability	±0.01 to ±0.012 mm
Cycle time	0.28 - 0.31 sec (for 2 kg payload)
Options	● Standard type ● Bellows type ● Dust & splash proof type (IP65) ● Cleanroom type (ISO Class 3) 7 ● UL specifications ● Ceiling type ● H1 Grease type (IP65) ● Metal-detecting bellows type ● Dust and splash proof type

Table 6.4 shows the specification of the robotic arm.

6.1.2.2 HS-A1 Series HS-035A1 / 045A1 / 055A1

The HS-A1 Series of robots are next-generation SCARA robots that are faster and more accurate than the HS Series of robots while having inherited their advantages. It is suited to conveyance and assembly work. The arm model is shown in Fig 6.5.

Fig 6.5 HS-A1 Series HS-035A1 / 045A1 / 055A1

Table 6.5 Spec of HS-A1 Series HS-035A1 / 045A1 / 055A1

Arm reach	350 / 450 / 550 mm
Vertical stroke	100 / 150 / 200 / 320 mm
Maximum payload	5 kg
Position repeatability	±0.01 mm
Cycle time	0.29 sec (for 2 kg payload)
Options	Standard type Bellows type Dust & splash proof type (IP65) Cleanroom type (ISO Class 3) 7 UL specifications 7 Ceiling type

Table 6.5 shows the specification of the robotic arm.

6.1.2.3 HM Series HM-40＊＊＊ / 4A＊＊＊

The HM Series have the longest arm reach and carry the greatest payload among 4-axis (SCARA) robots. The arm model is shown in Fig 6.6.

Fig 6.6 HS-A1 Series HS-035A1 / 045A1 / 055A1

Table 6.6 Specifications of HS-A1 Series HS-035A1 / 045A1 / 055A1

Arm reach	600 / 700 / 850 / 1,000 mm
Vertical stroke	100 / 150 / 200 / 300 / 400 mm
Maximum payload	10 / 20 kg
Position repeatability	±0.02 to ±0.025 mm
Cycle time	0.29 - 0.31 sec (for 2 kg payload)
Options	● Standard type ● Dust & splash proof type (IP65) ● UL specifications 8 ● Ceiling type

Table 6.6 shows the specification of the robotic arm.

6.1.3 Collaborative Robots

Cobotta is a collaborative robot. The specifications of the robots discussed and checked for the suitability.

6.1.3.1 Cobotta (CVR038)

The Cobotta CVR038, from Denso Robotics, is a small, portable robot that can be easily taken anywhere to quickly automate work immediately. A robot that collaborates with everyone. It is a small portable body with a user-friendly form. The arm model is shown in Fig 6.7.

Fig 6.7 CVR038

Table 6.7 Specifications of CVR038

Total arm length	342.5 (165+177.5) mm
(No. 1 arm + No. 2 arm)	0.5 kg (0.7 kg within ±10 degrees
Rated payload	With the wrist angled downward)
(Maximum payload)	Without electric gripper
Position repeatability	±0.05 mm

Table 6.7 shows the specification of the robotic arm.

6.2 SELECTION OF ARM

The arms are checked for the requirement and among the various arms, one particular arm is selected based on the payload and reach.

6.2.1 Comparison Table

A comparison table is drafted and the most suitable type of arm is chosen.

Table 6.8 Comparison Table for Arm

Specifications	HSR	HS-A1	HM
Arm reach	480 / 550 / 650 mm	350 / 450 / 550 mm	600 / 700 / 850 / 1,000 mm
Vertical stroke	100 / 200 / 320 / 510 mm	100 / 150 / 200 / 320 mm	100 / 150 / 200 / 300 / 400 mm
Maximum payload	8 kg	5 kg	10 / 20 kg
Position repeatability	±0.01 to ±0.012 mm	±0.01 mm	±0.02 to ±0.025 mm

Based on the comparison table 6.8, HS-A1 Robot is the best suited robot as it satisfies all the necessary criteria.

6.2.2 HS-A1 Series HS-035A1 / 045A1 / 055A1

SCARA robots in the HS-A1 Series will be the next-generation SCARA robots, faster and more precise than the HS Series while keeping its benefits. This is high performance SCARA robot that specializes in high-speed movement in a small installation space and is suited to conveyance and assembly work.

6.2.2.1 Cycle Time

The time it takes the robot arm to travel up 1 inch, across 1 foot, down 1 inch, and back through the same path is referred to as the 'standard cycle time'. The cycle time is shown in Fig 6.8.

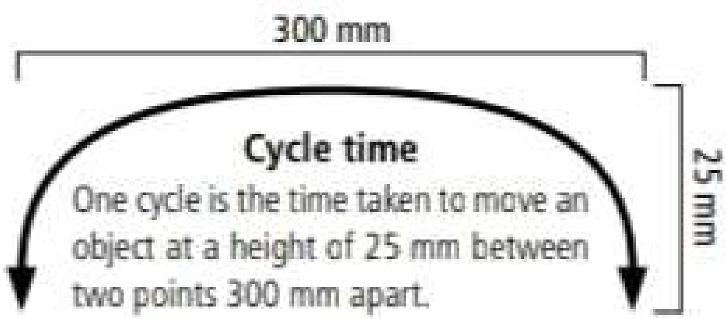

Fig 6.8 Cycle Time

6.2.2.2 Advantages of HS-A1 series arm

1) Very compact SCARA

- Small robot's base installation area:150x150mm
- Slim robot arm: width of 136 mm
- Flexible movement in a small space

2) Accurate

- Path accuracy
- Repeatability ±0.015/±0.02 mm
- Consistency in production

In this chapter the arm for the Automation of Sample Handling for Covid-19 testing process is selection. The required components is selected in the upcoming chapter.

CHAPTER 7

SELECTION OF COMPONENTS

This chapter gives an overview of the components used for the project. The system is designed by integrating the components together. A variety of components are chosen and used to accomplish this.

7.1. BARCODE SCANNER

Barcode scanners are used by businesses to record and read data from barcodes. A scanner is made up of a light source, a lens, and a light sensor that converts optical signals to electrical signals. A barcode scanner measures the quantity of light reflected after shining a beam of light across the barcode. The white areas between the dark bars on the barcode reflect less light than the dark bars themselves. The scanner then turns the light energy into electrical energy, which is converted into data by the decoder and sent to a computer. A typical barcode scanner is shown in Fig 7.1.

Fig 7.1 Barcode Scanner

7.1.1 Types of Barcode Scanner

There are basically five types of barcode scanners. They are:

- Pen wands.
- Slot scanners.
- Charge-coupled device (CCD) scanners.
- Image scanners.
- Laser scanners.

7.1.1.1 Pen Wands

The simplest and least expensive type of Barcode Scanner is the Pen and wand Barcode Scanner. Wand Barcode Scanners are the most durable type of barcode scanner due to its basic construction (no moving components), and may be tightly sealed against dust, filth, and other environmental threats. Wand Barcode Scanners are limited in their ability to read barcodes since they must come into direct contact with them. Wand Barcode Scanners are appropriate for portable (laptop) or extremely low volume scanning applications due to their tiny size and low weight. Fig 7.2 represents a typical Pen wand barcode scanner.

- Simplest and cheaper.
- Must remain in direct contact with the code.
- Must be held at a certain angle.

Fig 7.2 Pen Wands

7.1.1.2 Slot Scanner

The slot scanner is a stationary barcode scanner, and the item to be scanned is pulled through the barcode reader device's slot by hand. This sort of barcode reader is typically used to scan barcodes on identification cards and swiped cards. Fig 7.3 represents a slot barcode scanner.

- The item being scanned is pulled by hand to the scanner.
- Generally used on barcodes in ID cards.

Fig 7.3 Slot Scanner

7.1.1.3 Charge-coupled Device (CCD) Scanners

CCD (charge coupled device) barcode scanners/readers, as shown in Fig 7.4, are also known as linear image barcode scanners/readers. Tiny light sensors are stacked in a single file within the CCD scanner using this technology. These LEDs detect the ambient light emitted by the barcode (the dark versus the light in the code). These CCD barcode scanners are built to withstand the rigors of the job.

- Gun-type interface.
- Can only read barcodes that are the width of its face size.
- Used in retail sales.

Fig 7.4 Charge-coupled Device Scanner

7.1.1.4 Image Barcode Scanner

To obtain a picture of 1D and 2D barcodes, image-based barcode readers use an area array sensor similar to those found in digital cameras. The code is then located and decoded by a microprocessor running specific image-processing software before being distributed across a network. Fig 7.5 represents an image-based barcode scanner.

- Features a small camera that captures an image of barcode.
- Contains digital imaging processor that reads barcodes from as far as 9 inches.

Fig 7.5 Image Barcode Scanner

7.1.1.5 Laser Scanner

One of the most common types of proximity sensors is the photoelectric sensor. These sensors detect an object directly in front of it by detecting the light that reflects off the surface of the object and passes through the sensor. In a typical arrangement, both the transmitter and receiver are housed in the same unit, but not all photoelectric sensors are configured this way, as visualized in Fig 7.6.

- Uses mirrors and lenses to read barcodes from up to 24 inches.
- Can perform up to 500 scans per second.

Fig 7.6 Laser Barcode Scanner

7.1.2 Selection Parameters

The most suitable sensor must be selected on the basis of certain selection criteria.
They are:

- Way of scanning the objects (Solid/Liquid/Metallic)
- Type of the barcode to be scanned.
- Distance between scanner and barcode.
- Cost of the scanner.

From the data inferred from above, the options are narrowed down to Image-based scanners and Laser scanners.

7.1.2.1 Comparison Table

A comparison table is drafted and the most suitable type of scanner is chosen.

Table 7.1 Comparison Table for Barcode Scanner

Laser barcode scanner	**Image barcode scanner**
Low cost	High cost
Stable technology	Less standardization
Widely recognized	Better corrupted barcode scanning
Can scan only 1D codes	Scans for 1D and 2D

Based on the above furnished comparison table 7.1, it is concluded that the Laser barcode scanners are the best fit type of scanners for the project.

7.1.2.2 Features of Laser Barcode Scanner

- Error reduction

  Errors in transcription and recognition are eliminated. For every thousand keystrokes, manual entry using a keyboard, for example, produces ten mistakes. Only one error occurs in every 10,000 scans with optical barcode scanning.
- Improved productivity

  Barcode systems decrease human overhead and training time, resulting in increased productivity. They enable for the quick execution of any pricing adjustments made in a company's database.
- Asset Management

  At the heart of any effective asset management and theft prevention system are barcodes. They form the foundation for increased security and asset tracking across a wide range of businesses when properly installed and managed.
- Business Intelligence

  By incorporating barcode data into decision support and planning systems, managers can gain a better understanding of product availability and inventory movement.

In this chapter the barcode scanner for the Automation of Sample Handling for Covid-19 testing process is chosen. The next chapter discusses about the required sensors for the system.

7.2 PROXIMITY SENSOR

A proximity sensor detects the presence of nearby items without the need for physical touch. The proximity sensor often creates an electromagnetic field or a beam of electromagnetic radiation (infrared, for example) and monitors the field or return signal for changes. The proximity sensor's target is the thing that is being detected. Different sensors are required for different proximity sensor targets. In the project, it is used to ensure that the pipette tip ejector and the tube are picked up by the robotic arm from the station.

7.2.1 Types of Proximity Sensors

There are basically five types of proximity sensors. They are:

- Inductive proximity sensors
- Capacitive proximity sensors
- Magnetic proximity sensors
- Ultrasonic proximity sensors
- Photo-electric proximity sensors

7.2.1.1 Inductive Proximity Sensors

An inductive proximity sensor, as shown in Fig 7.7, is a sensing device that identifies metal targets without touching them using electromagnetic radiation. An inductive proximity sensor's sensing range varies depending on the type of metal detected. An inductive proximity sensor can work in wet or unclean conditions since non-metallic things like dirt and moisture do not interfere with detection.

Fig 7.7 Inductive Proximity Sensor

7.2.1.2 Capacitive Proximity Sensors

CPS (capacitive proximity sensors), as shown in Fig 7.8, is a type of sensor that can detect both metallic and nonmetallic targets. They can detect lightweight or small things that mechanical limit switches are unable to detect. Plastics and other nonmetallic targets, liquid level control, and sensing powdered or granular particles are also good candidates for CPS.

Fig 7.8 Capacitive Proximity Sensor

7.2.1.3 Magnetic Proximity Sensors

Magnetic proximity sensors, as shown in Fig 7.9, detect magnetic objects without requiring any interaction (e.g. permanent magnets). They detect a magnetic object's presence. Magnetic proximity sensors are used to detect non-contact position outside the range of inductive sensors. Magnetic sensors, when used in conjunction with a separate "damping" magnet, can detect magnets through non-ferrous metal, stainless steel, aluminum, plastic, or wood walls and have very extended sensing ranges from a tiny package size.

Fig 7.9 Magnetic proximity sensor

7.2.1.4 Ultrasonic Proximity Sensors

Ultrasonic proximity sensors, as shown in in Fig 7.10, are a popular form of proximity sensor that can be found in a wide range of manufacturing and automation applications. They're commonly utilized in food and beverage processing and numerous packaging applications, mostly for item identification and distance measurement. Ultrasonic sensors work by using sound frequencies that are higher above the human audible limit (about 20 kHz), often in the range of 25 to 50 kHz. The sensor gives out an ultrasonic pulse and gets a pulse back, which is the core physical concept of ultrasonic sensing. The distance to the object can be calculated using the time difference between the sent and received signals.

Fig 7.10 Ultrasonic Proximity Sensor

7.2.1.5 Photo-electric Proximity Sensors

One of the most common types of proximity sensors is the photoelectric sensor. These sensors, as shown in Fig 7.11, detect an object directly in front of it by detecting the light that reflects off the surface of the object and passes through the sensor. In a typical arrangement, both the transmitter and receiver are housed in the same unit, but not all photoelectric sensors are configured this way.

Fig 7.11 Photo-electric Proximity Sensor

7.2.2 Selection Parameters

The most suitable sensor must be selected on the basis of certain selection criteria. They are:

- Nature of the object to be detected (Solid/Liquid/Metallic)
- Distance between sensor and object.
- Shape of the object.

7.2.2.1 Comparison Table

A comparison table is drafted and the most suitable type of sensor is chosen.

Table 7.2 Comparison Table for Proximity Sensor

	Inductive	Capacitive	Magnetic	Ultrasonic	Photo-electric
Range	< 80 mm	< 60 mm	< 100 mm	<15 mm	< 200 mm
Detected materials	Metal parts	All materials	Magnetic parts	Any material in any form (Solid/liquid)	Parts with reflective property

Based on the comparison of the materials detected shown in table 7.2, Capacitive and Ultrasonic sensors can be considered. Considering the range and cost of the two sensors, the capacitive sensors costs around Rs.8,500, whereas the cost of ultrasonic sensors range from Rs.16,000 to Rs.85,000. Moreover, the range of capacitive sensors is greater when compared to the ultra-sonic type. Hence, the capacitive proximity sensors are chosen for the project.

7.2.2.2 Applications of Capacitive Proximity Sensor

- Final inspection on packaging lines.
- Measurements of filling level of liquids through walls of plastic or glass tanks.

7.3 SWAB SAMPLES WITH BARCODES

A viral test sample is taken from within the nose using a swab. The sample is typically taken at the nostrils' beginnings, but it can also be taken from the center or very back of the nose. The sample comes from the throat, the insides of the cheeks, and, less frequently, the gums or tongue. These samples are collected in tubes with barcodes. The swab samples are shown in Fig 7.12.

Fig 7.12 Swab Sample

7.4 96- WELL PLATES

For antibiotic screenings, cell-based assays, and screening chemicals, 96-well micro plates are a rectangular plate or block comprising several small wells or cavities used for analysis, clinical testing, or culture. This tray placement station is a non-automated manual station. In the 96-well plate, the lab worker must cover all of the swabs. The swabs are gathered in tubes with barcodes on them. The barcode contains patient information that will be matched with the final diagnostic results later. The 96 samples are shown in Fig 7.13.

Fig 7.13 96 Well Plates

7.5 BARCODE SCANNER

A scanner is made up of a light source, a lens, and a light sensor that converts optical signals to electrical signals. A barcode scanner measures the quantity of light reflected after shining a beam of light across the barcode. The white areas between the dark bars on the barcode reflect less light than the dark bars themselves. The scanner then turns the light energy into electrical energy, which is converted into data by the decoder and sent to a computer. A barcode scanner is an optical scanner that can read printed barcodes, decode the data within them, and communicate the information to a computer. It has light source, a lens, and a light sensor that converts optical impulses to electrical signals. Here the bar code scanner scans the details of the person and saves it to deliver the results. The barcode scanner is shown in Fig 7.14.

Fig 7.14 Barcode Scanner

7.6 PIPETTE TIP EJECTOR

The new pipettes are deposited in a tray by the pipette tip ejector. Pipettes are used to gather samples from swab tubes and transfer them to another tube. A pipette is a tool used in laboratories to transmit a precise volume of liquid for medical purposes. Pipettes come in a number of shapes and sizes to suit a variety of applications. The tip of a pipette is ejected using a pipette tip ejector. The pipette tip ejector is a push-button-operated rod that is located in a passage in the upper part of the pipette's hand-held housing. The material is collected and shifted to a new tube, which is then passed to the RNA extraction machine, using the pipette taken by arm. The pipette tip ejector is shown in Fig 7.15.

Fig 7.15 Pipette Tip Ejector

7.7 BIO-WASTE COLLECTOR

Any item that contains or has been polluted by a bio hazardous agent is considered biological waste. Petri dishes, surgical bandages, culture tubes, syringes, needles, blood vials, absorbent material, personal protective equipment, and pipette tips are examples of biological waste. Here the pipette tips are used to collect the samples from the swab tubes and transferring them to a new tube. The used pipette tips are thrown in the bio waste collector tray that is placed. The bio waste collector is shown in Fig 7.16.

Fig 7.16 Bio-Waste Collector

7.8 PROGRAMMABLE LOGIC CONTROLLER

A PLC is made up of a central processing unit (CPU) and input/output (I/O) modules. The majority of PLC designs are modular, which implies that numerous I/O modules may be stacked in a single PLC. The I/O modules can be installed in various physical places and linked together via data cables. PLC is required for interfacing with external devices such as HMI. The PLC used is Siemens starter kit S7-1200.

7.8.1 Siemens Starter Kit S7-1200

Siemens' SIMATIC S7-1200 controllers are the smart choice for compact automation solutions with advanced communication capabilities and integrated technology functionalities. They are available in two versions: standard and failsafe. When it comes to flexibly and efficiently completing automation tasks in the lower to medium performance range, SIMATIC S7-1200 controllers are the best choice. They have a wide range of technological capabilities and integrated communication, as well as a particularly compact and space-saving design. SIMATIC S7-1200 Starter Kits make it quick and easy to implement simple automation tasks. Fig 7.17 depicts the Siemens S7-1200 PLC.

Fig 7.17 Siemens S7-1200 Starter kit

Table 7.3 PLC Specification

Software	Hardware	Documentation
• SIMATIC CPU 1212C AC/DC /RLY • 8 position Digital Input Simulator • SIMATIC Industrial Ethernet TP Cord and more	SIMATIC STEP 7 Basic (TIA Portal)	SIMATIC S7-1200 Manual on CD

Table 7.3 shows the specification of the Siemens S7-1200 PLC.

7.9 TEACH PENDANT

A control box used to train a robot's movements. The robot is set to "learning" or "teach" mode, and the pendant is used to operate the robot step by step, sometimes known as a "teach box." Teach pendants are usually portable gadgets that can be corded or wireless. Teach pendants are used to program and control automated machines or robotics that execute demanding, hazardous, or repetitive activities in industrial applications. Industrial pendants are portable control devices that allow an operator to securely manipulate robotic machinery's movements. Automated or robotic machinery is often used for Material handling and assembly, Welding, Loading and unloading, Painting and coating tasks. Teach pendants are designed to control the robot using a teach-and-repeat technique, in which the operator programs the robot for a certain task, range of motion, or speed using the teach pendant. The robot pendant's controls are used by the operator to provide information to the robot concerning speed, delay times, and the execution of specific functions, as well as to establish the robot's physical interaction with any other apparatus participating in the operation. The teach pendant is shown in Fig 7.18.

Fig 7.18 Teach Pendant

7.10 SOFTWARE USED

This section deals with the software used to design the system. The software used are PCS, WINCAPS and IoT data server.

7.10.1 Process Control System

A Process Control System (PCS), whose logo is shown in Fig 7.19, is a Siemens-developed integrated DCS control system. It uses the hardware platform which is Siemens Simatic, while the software is TIA**.** PCS 7 contains an AS-OS engineering station, often known as a Simatic manager. This is a modified version of the step 7 application. The operator system client is a WinCC professional-based HMI program. It encompasses a wide range of software, including continuous and batch control, in addition to the engineering station. It also assists in controlling the flow of materials.

Fig 7.19 PCS Logo

7.10.2 WINCAPS

WINCAPS, whose logo is shown in Fig 7.20 is a software tool that handles all activities related to DENSO robots, from planning to maintenance. It aids users in the operation of DENSO robots by providing numerous services such as robot programming, controller data backup, and robot posture checking on a 3D screen. WINCAPS is simple operation and broad simulation functions allow customers to save time on robotics system design, manufacture, and maintenance.

Fig 7.20 WINCAPS Logo

7.10.3 IoT Data Server

IoT Data Server, whose logo is shown in Fig 7.21, is a Data Integration Controller that consists of high-reliability industrial computer and data integration software that does not require programming. It includes standard data management functions, such as data collecting, processing, saving, notification, and publishing. These functions will aid data management in a variety of scenarios, ranging from the production cell system to the factory and cloud system. In this three methods were used for total security they are Antivirus, Secure communication and Network monitoring.

Fig 7.21 IoT Data Server Logo

In this chapter, the components and the software used for the Automation of Sample Handling for Covid-19 testing process is discussed. The next chapter discusses about the implementation and testing of the system.

CHAPTER 8

IMPLEMENTATION AND TESTING

In this chapter, the step by step process of implementation and testing of the robot is discussed.

8.1 IMPLEMENTATION

The robot's implementation begins with the development of a process flow chart and designing the conceptual design. The size of various components is used to determine the position of it at the first stage. The Fig 8.1 illustrates the position of arm 1 and station1. The station 1 is placed in front of Arm 1.

Fig 8.1 Arm 1 and Station 1

In between Arm 1 and Arm 2, there is a center station named Barcode scanning or Ejecting Station where major processes takes place. The station 2 scans the barcode, de-capping takes place and the sample will be collected from here. The Fig 8.2 illustrates the location of Station 2.

Fig 8.2 Center Station

The left side of the system will cover arm 2 and 3 stations, i.e., the tube filling station, Pipette tip ejecting station and the bio-waste collector station. The station 2 and 3 is placed in front of Arm 2 and station 5 is placed at the left corner of Arm 2. The Fig 8.3 illustrates the position of arm 2 and stations 3, 4 and 5.

Fig 8.3 Arm 2 and Stations

The entire system is brought together and placed in their position to enable the arm to move freely and pick the objects to complete the action completely. The PLC is placed on the left corner of the system and two teach pendants are placed on both corners. Together a compact system is developed to handle set of samples and move to the next stage. Fig 8.4 and 8.5 illustrates the front view and side of the entire system respectively.

Fig 8.4 Front View of the System

Fig 8.5 Side View of the System

8.2 TESTING

After implementation, the automation process is ready and it is tested. The conditions to be met are discussed. The conditions to be fulfilled are discussed step by step.

Step 1: Initially, the barcode scanner is verified for its working. Only if the scanning is done properly, the system moves to the next step or it stops there and gives an alert message.

Step 2: The de-capping stage is checked and is found to be appropriate. If the arm does not decap properly, the arm 2 comes to the tube finds it to be capped and moves back to its place and gives an alert message.

Step 3: Finally, the movement of both the arms is monitored for its spontaneity. The movement of the arms is concentrated properly and is given perfect timings that both the arms does not meet and collide at the same time.

The implementation and the testing of the system is discussed in this chapter. The next chapter deals about the conclusion and future work.

CHAPTER 9

CONCLUSION

This chapter discusses the conclusion of the project and the further developments that can be done in the system.

Worldwide, the detection and monitoring of Covid-19 infection continues to be done based on results of the real-time reverse-transcription polymerase chain reaction (RT-PCR) test. The (RT-PCR) assay was developed to rapidly detect the Covid-19 infections in human. To enhance the rate of testing in the midst of the big rural population of India, Robotic automated medical testing solutions are formed. It's an automated procedure that can run at 96 tests per hour, which is comparable to 2000 tests per day. Testing for new virus variants is possible with the right test kits, and the automated system could be used for alternative diagnostics.

The project's main purpose is to eliminate human errors in normal testing. The research addresses the urgent need for diagnostics while also serving as a cornerstone to limiting the COVID pandemic. To protect laboratory technicians, it offers a higher throughput and is scalable for mass testing, such as at airports or railway stations, with accurate results sent in less time thanks to cloud-based technology. The automated system removes any bubbles or clots from the samples and carried the exact amount of sample required. The pre-analytical phase accounts for 60% of total laboratory hours and 75% of total errors, making it the most time-consuming and error-prone area. Approximately 13% of errors have the potential to harm a patient's health. The Automated system eliminates any such errors. With the help Automated system the diagnostic laboratories where able to produce higher accurate tests results on every day basis.

In manual testing the usual tiredness and fatigue reduces the test efficiency. Because most test procedures are repetitious, automated testing avoids tiredness and keeps the process running at its maximum efficiency. Automated testing provides a quick reaction time without the need for human interaction, 24 hours a day, 7 days a week, with maximum efficiency.

9.1 SCOPE FOR FUTURE WORK

The project's main purpose is to eliminate human errors in normal testing. The process can be extended to automate the diagnostic process as well. After the transfer of samples to the tube, the testing process can also be further automated that analyses and provides accurate results of the patients.

Furthermore, the entire system's aim is to make the entire automated device movable, allowing the test to be focused on the highest infection zone as rapidly as possible, and then moved to the next area for testing once the procedure is complete. We may also efficiently reach rural regions where accessibility is a concern using this method.

Also, with minimum modifications, this system can be transformed to handle clinical samples other than Covid-19 samples, which will be a greater help for the medical industry. For instance, blood testing process can be automated using this system, replacing the Covid-19 samples with the blood samples through application.

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