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DESIGN OF SMART TEMPERATURE MONITORING AND AUTOMATIC SANITIZER DISPENSER

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Abstract—During the COVID era, it has been challenging for organizations and public places to measure and keep records of body temperatures and sanitize people individually. At times, people responsible for these tasks may not perform them properly. This has led to increase in the number of COVID patients at the national level. The proposed device can be set up at entry

ways; it can adjust itself to the height of the person approaching, ensuring that the temperature sensor is exactly in front of the face. This will also encourage the person to bring their hands forward for sanitizing. The design was based on contemporary designs, but it uses an upgraded version of these technologies. It encourages individuals to put their hand forward for sanitization and restricts entry if their temperature is more than the specified temperature. The device can automatically measure the temperature and sanitize an individual passing through it. When the person approaches the device, the base sensor senses their presence; then, the belt and gear system gets activated and moves the sensore so that it is placed near the forehead. If the temperature is normal, then the device encourages the individual to put their hand forward for sanitizing.Simulation was done on Tinker CAD online software. The simulation diagram explains the working of the Smart Temperature Monitoring and Automatic Sanitizer Dispenser. The proposed design is efficient and can reduce human intervention. Our device can assist organizations in maintaining COVID protocols, thereby reducing the risk of spread of the virus.
Keywords—MLX90614, temperature sensing, distance measurement, Arduino UNO, HCSR-04, PIR sensor, IR sensor, DC motor, rack and pinion, gear and belt drive

I. INTRODUCTION

To mitigate the spread of the coronavirus in organizations and public places, social distancing, proper checking, and management are required. People have been advised to minimize social interactions. Since the lockdown has been released and organizations have resumed work, malls and restaurants are open, leading to higher chances of the virus spreading. Healthcare infrastructure is not equally distributed between rural and urban areas in India. According to an estimate by the World Bank, >65% of India's population resides in rural areas, while 65% of government hospital beds are in urban areas. With hordes of migrants returning to rural areas, the chances of spreading of COVID-19 doubled, thus worsening the socio-economic condition. Thus, screening at bus stands and stations is crucial. There are fewer testing and screening facilities in rural areas than in urban areas. The coronavirus is not airborne. It spreads via respiratory droplets that end up on our hands if we touch an infected person or surfaces that they may have touched or coughed on; thus, it is necessary to sanitize [1] and [2] our hands regularly, especially after coming from outside. The proposed device [3] can automate temperature checks and sanitization at offices, banks, and other places, eliminating the need for any human intervention. The device can be set up in front of entry ways; it uses a rack and pinion mechanism to adjust its height according to the individual approaching, such that the temperature sensor [4] to [6] is exactly in front of the face [7]. If the temperature is normal, a green light is shown, and the device encourages the individual to bring their hands forward for sanitizing. If the temperature is high, then a buzzer is sound and a red light is shown; the person is then not allowed to go and is required to test for COVID and seek medical aid as required.

As stated earlier, the person designated for the tracking of data may not always record these. The data are recorded manually on a register, which may be thrown when it is full. These data are crucial in this COVID-19 situation for organizations as well as for the country. We simulated the proposed design, and it achieved the required goal. All simulations were done on Tinker CAD. Our proposed design was for funding from IEEE.

II. LITERATURE REVIEW

In [1] and [2], an automatic sanitizer dispensing machine used an ultrasonic sensor to sense the hand placed near it. Our proposed design uses an IR sensor. The device also encourages an individual to put their hand forward for sanitizing. It restricts entry of the individual into the organization if sanitization is not done.

In [8] and [9], infrared image processing was used for fever detection; this is a complex and expensive design. Our proposed design uses an MLX 90614 IR temperature sensor that uses passive imagers that only sense heat difference in terms of black (which means cold) and white (means hot); the temperature is then displayed on a monitor. The MLX 90614 IR temperature sensor uses mid- or long-wavelength IR energy.

The sensor has a highly powerful digital signal processing (DSP) unit along with a 17-bit analog to digital converter (ADC), low noise amplifier, and IR sensitive thermopile detector chip, which is cost-effective and easy to install. The MLX90614 sensor measures the temperature of the surroundings, i.e., ambient as well as the temperature of the object. The temperature of the object is the body temperature that is in the field of view of the sensor.

In [10], a non-contact body temperature measurement system was designed for a smart campus, and this design had almost the same aim as our proposed design. Our design, however, has a smart temperature monitoring system as well as an automatic sanitizer dispenser, which is essential in this era of coronavirus; it also has an intelligent system that will restrict the entry of individuals—without human intervention—if the measured temperature is above the normal range.

III. CIRCUIT ARRANGEMENT

Table 1. Specifications of the component used

S.N.	Component	Specification	Qty.
1.	Arduino UNO	ATmega328p	1
2.	Ultrasonic Sensor	HCSR-04	2
3.	PIR/IR Sensor	-	1
4.	Motor Driver Module	L293D	1
5.	Peristaltic Pump	-	1
6.	DC Motor	12 V	1
7.	DC Geared Motor	300 rpm	1
8.	Push Buttons	Tactile	2
9.	Resistor	10 kΩ	2
10.	9 V Battery	-	1
11.	Battery Connector	-	1
12.	Jumper Wires	2.54 mm	As req.

Table 1 shows the specifications of the components used in the circuit. The connections shown in Fig. 1 and Fig. 2 are as follows:

1. A trig pin of the base HCSR-04 sensor is connected to pin 9 on Arduino UNO and Echo pin on pin 8 of Arduino UNO.
2. A trig pin of the height adjustment HCSR-04 sensor is connected to pin 11, and an echo pin is connected to pin 10 of Arduino UNO.
3. The PIR sensor is connected to pin 5 of Arduino UNO.
4. DC geared motor (height adjustment motor) is connected to the L293D motor driver IC, and the inputs of the IC are connected to pins 13 and 12 of Arduino UNO.
5. DC motor (sanitizer dispenser pump) is connected to L293d, and its input is connected to pins 7 and 6 of Arduino UNO.
6. Push/bump switches are connected to pins 4 and 3 of Arduino UNO. These switches are pulled down using an 11 kΩ resistor connected to the switch on one end; the other terminal is ground.

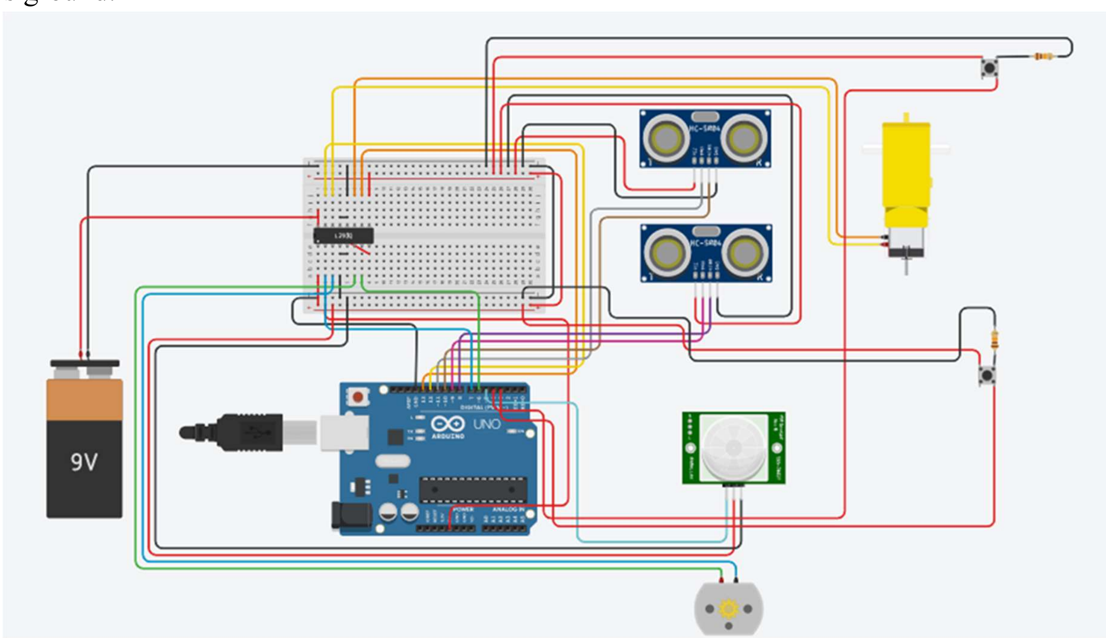

Fig. 1: Circuit arrangement

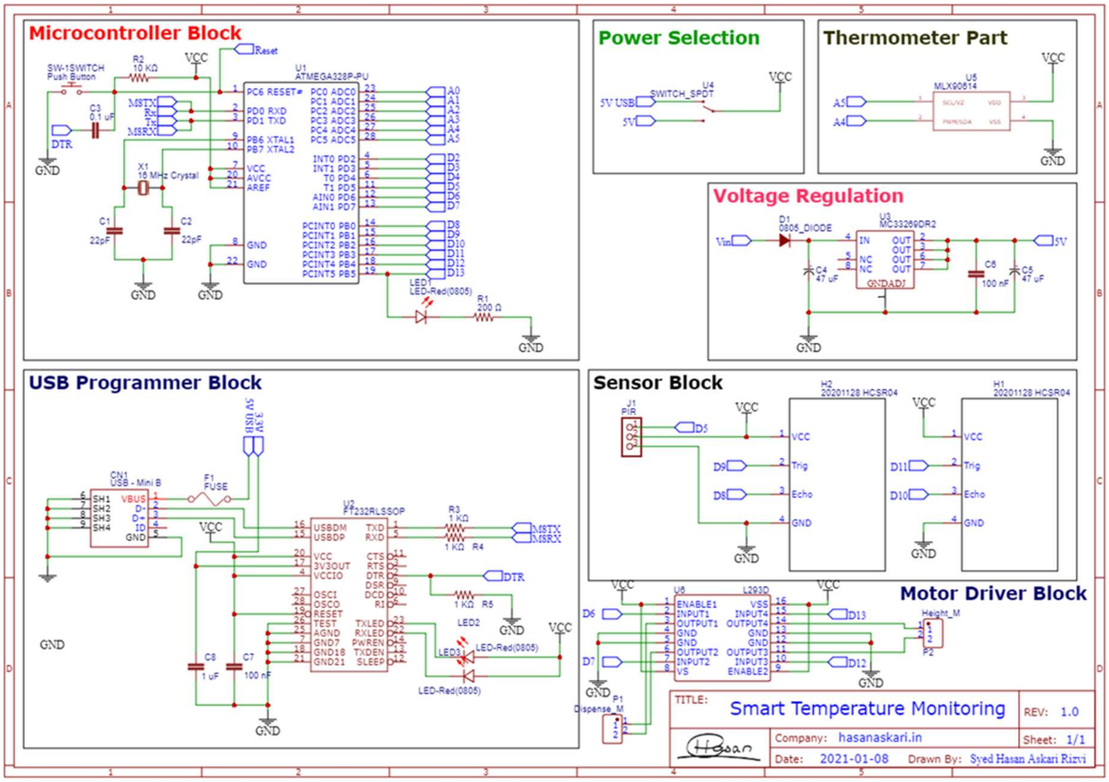

Fig. 2: Circuit schematic

IV. FLOWCHART AND BLOCK DIAGRAM

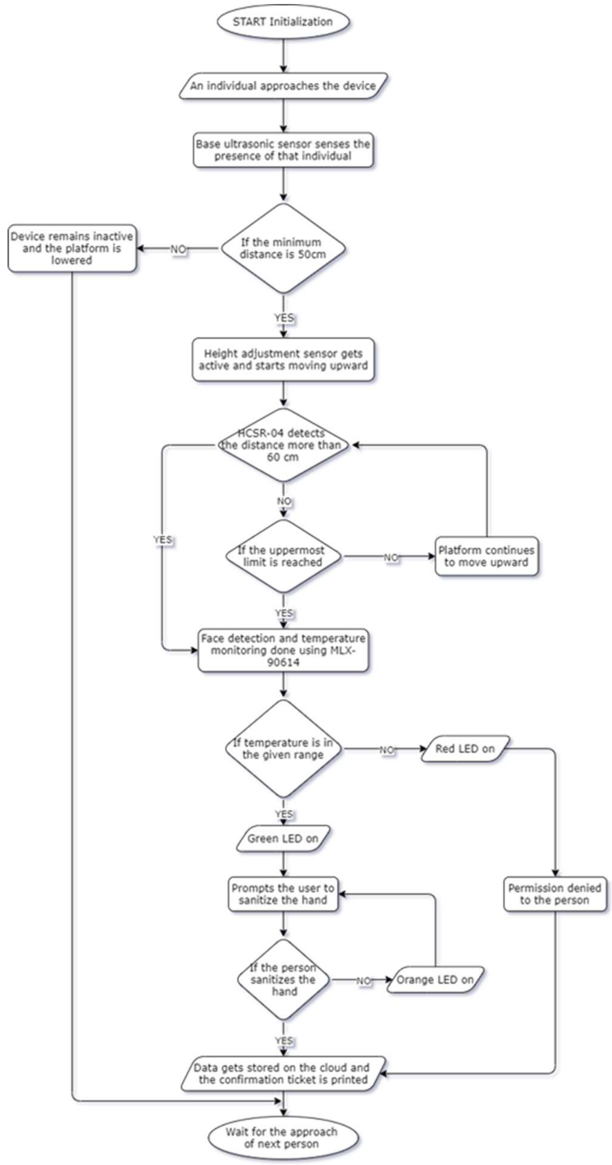

Fig. 3: Flowchart

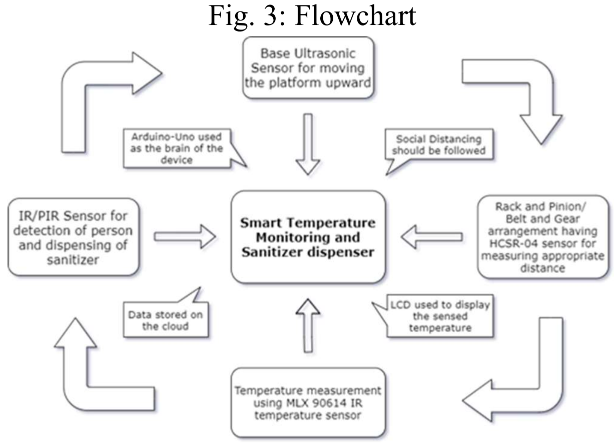

Fig. 4: Block diagram

V. WORKING OF THE PROPOSED DEVICE

The detailed workflow of the model is illustrated in Fig. 3, and the hardware and software components used to develop the model are shown in Fig 4. The working mechanism is as follows:

1. The smart temperature monitoring and sanitizer dispenser can automatically monitor the temperature and sanitize individuals passing through.
2. This device can be placed at entry ways of public places such as cinema halls, metros, railway stations, schools, and colleges.
3. It has an ultrasonic sensor (S1) placed at the base at the normal waist height; another sensor (S2) is installed on the rack and pinion/belt and gear system.
4. When no individual is present, only S1 is activated.
5. When a person approaches the device and the distance between the individual and the device is ≤50 cm, S1 activates S2.
6. When S2 gets activated, it starts moving upward till the HCSR-04 sensor on the rack and pinion/gear and belt system detects a distance of >60 cm or reaches the top.
7. While moving upward, S2 detects the face of the individual and then measures the temperature.
8. Temperature is measured using an MLX 90614 IR temperature sensor, and it is displayed on the liquid crystal display (LCD) screen attached to the device.
9. There are two bump switches, one at the top and the other at the base, which help in protecting the rack and pinion/belt and gear system from breaking by limiting its movement.
10. After temperature measurement, the device prompts the person to bring their hand below the sanitizing station, and when the IR/PIR sensor detects the hand, sanitizer is dispensed. The person is then allowed enter the area.
11. The data of users such as measured temperature and whether the user has been sanitized are recorded and stored on an SD card with a time stamp. Stored data are sent to cloud storage via the Wi-Fi module and stored on the cloud-like XXX used in [11] using smart microcontrollers such as lilypad, as in [12] and [13].

VI. NOVEL HEAD DETECTION ALGORITHM

As mentioned in steps 5 and 6 above, the novelty of our device is that it can detect the face without using a camera. The system relies entirely on data from two ultrasonic sensors. S1 first detects a human approaching, and when distance from the device is ≤50 cm, we can assume that a human has approached. This assumption is justified because the device is meant to be deployed on organizational premises, and the only duty of the person incharge is to ensure that humans approach the sensor.

Once the human is detected, as stated above, the rack and pinion mechanism is activated and S2 starts to move up (as initially, the sensor is low, at the chest level of a small kid of 10-12 years). The rack and pinion mechanism is activated only when the sensor on the head of the mechanism measures a value above a certain threshold (this value occurs only when the sensor reaches the top of the head and moves past it). Once it reaches the top of the platform where the bump switch is placed, the bump switch is activated; the mechanism then stops and state the end of the platform.

POSSIBLE DRAWBACKS AND FAIL POINTS

One of the drawbacks associated with the proposed system is that during the sensing, if the individual moves or fidgets, and if the ultrasonic sensor records a false value, then the system will measure the temperature at the wrong place. Chances of this happening can be drastically reduced by placing proper instructions at the installation site. While this drawback can be eliminated using a camera and image processing-based head detection algorithm, it will make the system expensive and thus not feasible for all organizations.

VII. BIO REFERENCES

Sanitization is a key measure for reducing the transmission of the coronavirus. However, not all sanitizers are suitable for this purpose. People working in an organization cannot use soap to wash their hands continuously because it is time consuming [14]. Soap needs water to wash off; an alcohol-based sanitizer vaporizes easily after use. Alcohol is also a better disinfectant than soaps. Alcohol-based sanitizers have been shown to be the most effective during COVID pandemic. However, we cannot use methanol because it has severe adverse effects on our health such as headache and nausea.

The World Health Organization has recommended the use of two alcohol-based formulations. One of them is ethanol (80% vol/vol), glycerol (1.45% vol/vol), and hydrogen peroxide (0.125% vol/vol). The other composition uses isopropyl alcohol (75% vol/vol) instead of ethanol. Researchers have shown that these formulations can successfully inactivate the virus. Some people directly use alcohol or spirit and rub it on their skin, which can cause skin inflammation and may be harmful to the skin. A recent study showed that iodine can kill the virus; however, even a single drop of iodine is injurious to health.

Fever is one of the most common symptoms of COVID-19. Therefore, accurate measurement of body temperature is crucial. The MLX 90614 IR temperature sensor used herein measures the temperature from the forehead of the person because forehead temperature has been proven to be the most accurate temperature than wrist or oral temperature [15]. Wrist temperature does not represent the actual body temperature, so it cannot be used for fever screening [15]. Forehead temperature has been proven to be more accurate, convenient, and fast. This is achieved by contactless distance measurement sensors, as stated in [16].

VIII. BASIC 3D MODEL OF PROJECT

The different variants of the model and their front and side views are discussed in Figs. 5–10. There are three variants of the model; type 1 (Figs. 5 and 6), which is a booth; type 2, which is wall-mounted (Figs. 7 and 8); and type 3, which is a wall-mounted booth (Figs. 9 and 10).

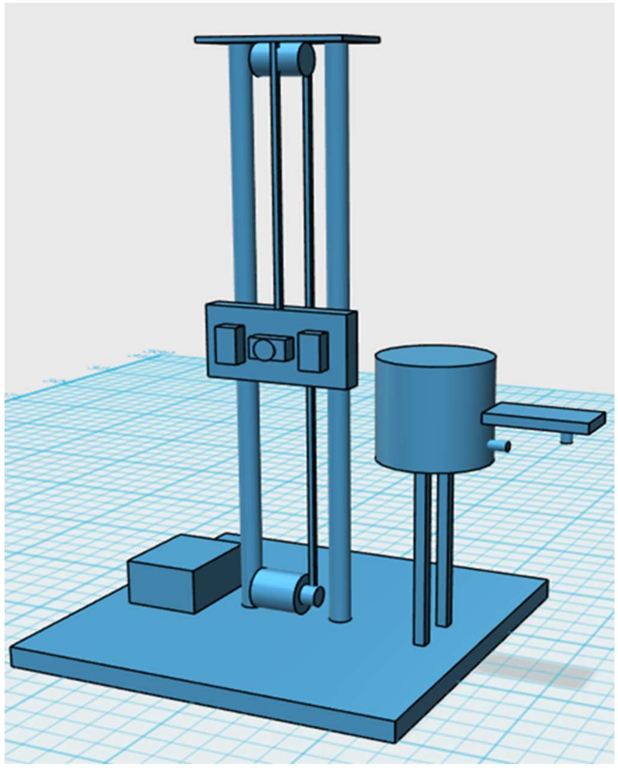

Fig 5: Type 1 (front view)

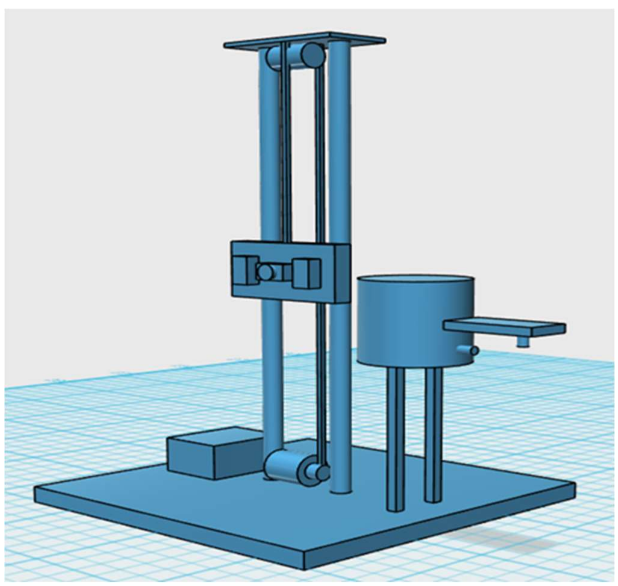

Fig 6: Type 1 (side view)

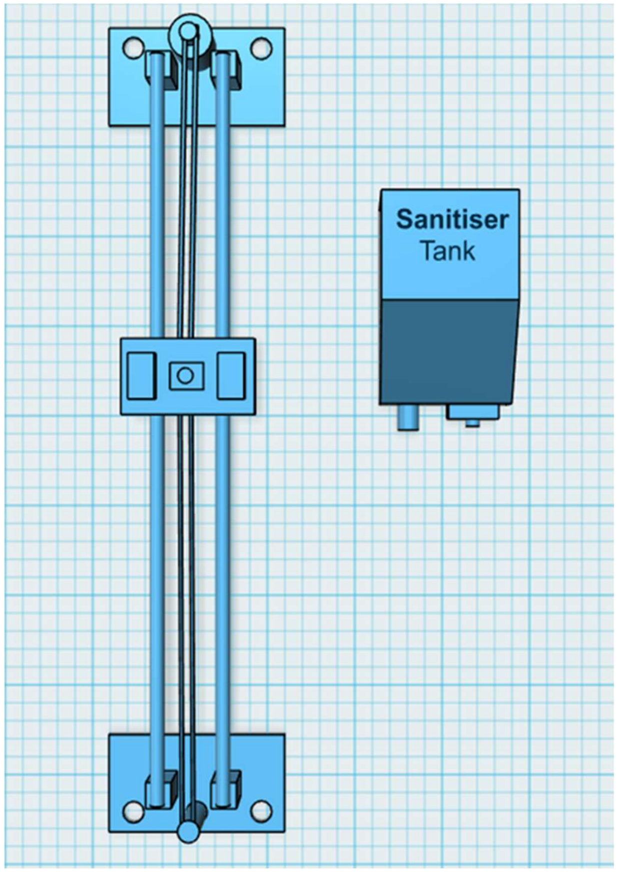

Fig 7: Type 2 (wall-mounted, front view)

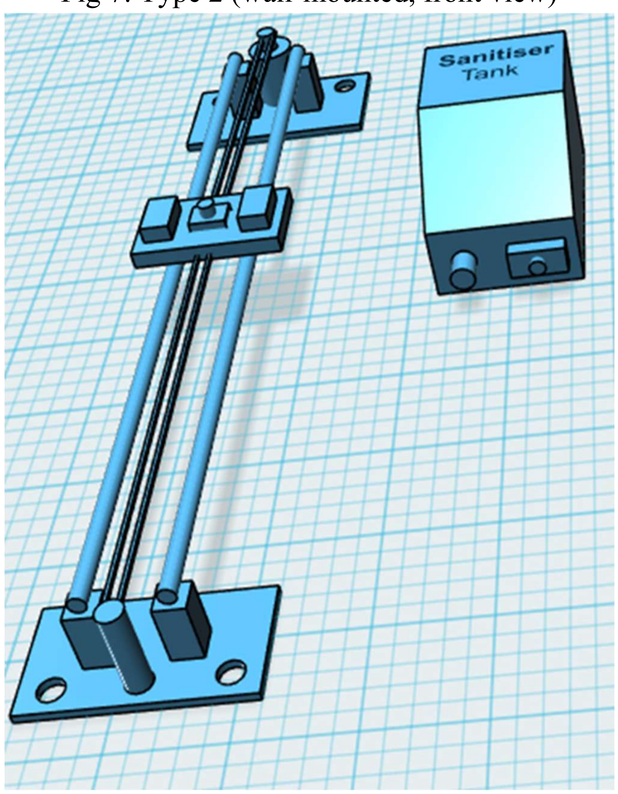

Fig 8: Type 2 (wall-mounted, side view)

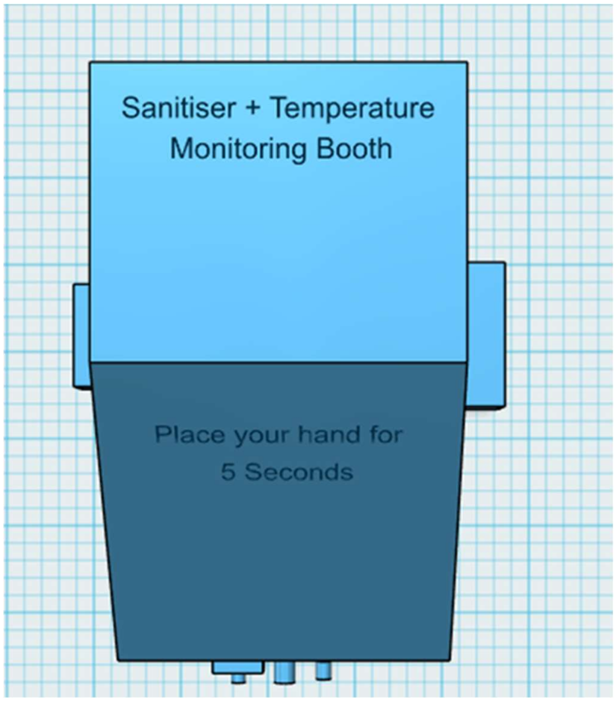

Fig 9: Type 3 (wall-mounted booth, front view)

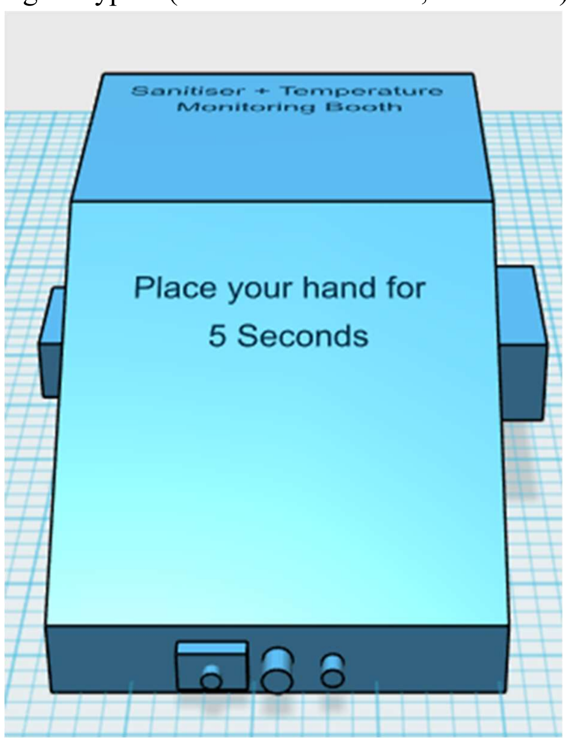

Fig 10: Type 3 (wall-mounted booth, side view)

IX. TECHNOLOGY USED

Our device used different sensors, modules, and other components, all of which have specific tasks. The brain of this design is Arduino (microcontroller), the sensors are the MLX-90614 temperature sensor, IR/PIR sensor, and ultrasonic distance sensor. The actuators in our project are DC motors and DC geared motor. The output device is an LCD screen.

a. Arduino UNO

Arduino is an ATmega328P-based microcontroller. All the processes, calculations, and decisions for our device are taken by this microcontroller. It has several pins that are known as general purpose input output (GPIO) pins or input/output (I/O) pins. There are 14 digital I/O pins, which can be set HIGH or LOW or sense HIGH or LOW signals. Six of these digital pins are capable of PWM functionality. The Arduino also has six analog pins, and these are capable of analog I/O. To power the device as well as the microcontroller, we use a Vin pin onboard or a power jack. We used a 9 V battery to power because it can accept any voltage between 6 and 20 V.

b. Liquid crystal display

LCD is used as the output component in our device, and it is used to display various instructions, calculations, measurements, and so on. It has 16 pins, with eight data pins for data/command and three control pins for controlling the functionality of the LCD. We can use all eight pins for the display (i.e., 8-bit mode), which is fast but occupied more pins on the microcontroller, which may be used for other sensors, actuators, and modules. To overcome this, we can use the four data pins in MSB mode (i.e., 4-bit mode); however, this too uses too many pins for the display. Instead, we use the I2C LCD module for our device. It uses I2C communication protocols, which means that we can use only two wires (on the same bus, obviously apart from power wires) for our device.

c. HCSR-04 ultrasonic sensor

The main sensor involved in height adjustment is the HCSR04 ultrasonic distance sensor, which has a range of 2 cm to >400 cm; this range is sufficient for our work. The working of the HCSR04 sensor is considerably simple because the distance between the object and sensor is calculated simply by recording the time required for the sound wave to leave the sensor, hit the object, and revert. This duration, which is recorded, can be converted to the distance by simple mathematical calculation and physics. This process is described as follows:

- When we activate the sensor, a HIGH pulse of at least 10 µs is triggered.
- Then, the module sends a sound wave of approximately 40 kHz toward the object and waits for it to return.
- If the signal returns, then the duration between after the pulse was emitted and returning time after hitting the object is recorded.
- This duration is used for calculating the distance by using the formula, distance = (HIGH time × velocity of the sound / 2); (velocity of sound = 340 m/s).

d. DC motor and DC geared motor

Motors or DC motors are typically used as actuators in our project. These DC motors use DC voltage for operation, and these can convert electrical energy to kinetic energy or rotational energy. We use one DC motor pump for dispensing sanitizer and one DC geared motor for height adjustment with the integrated rack and pinion or belt and gear mechanism.

Geared DC motors are the same as DC motors, except that they have a gear mechanism attached to the shaft. This arrangement increases either the speed of the motor or the torque. Increase in one is achieved by compromising the other. Our device requires torque more than speed, so we use a motor with sufficient speed (approximately 200-400 rpm) but a good amount of torque. The torque can ensure that the sensor, along with the rack and pinion or belt and gear mechanism, is lifted easily. Since the speed of motors is slow, this ensures stability to the system without requiring too much time for adjustment and temperature recording.

e. IR/PIR sensor

An IR sensor is used to sense the reflected IR waves from a white surface. A completely black surface absorbs the IR radiation, while a white surface light reflects it. The IR sensor cannot be precisely used for calculating the distance using the HC SR04 ultrasonic sensor, but it can be used for proximity detection. This IR sensor is installed below the sanitizer dispensing station. The IR module has two LEDs, one of which emits IR light and the other senses the reflected light. When the hand is brought close to the sensor, the IR module sends a HIGH pulse to the Arduino; upon receiving the HIGH pulse from the module, Arduino enables the sanitizer dispensing motor pump for the specified duration of time or till the hand is placed under the sensor. This enables dispensing of a specific amount of sanitizer without wastage. The PIR sensor also works on the same principle, and it can be used for the same purpose.

f. MLX 90614 IR temperature sensor

The MLX 90614 is a non-invasive, contactless, IR-based temperature measurement sensor. It has a powerful DSP unit along with a 17-bit ADC, low noise amplifier, and IR sensitive thermopile detector chip. This combination makes a powerful, highly accurate, and high-resolution thermometer that can be used from a distance, making it suitable in this COVID-19 situation when the use of digital or mercury-based thermometers is discouraged. This MLX 90614 sensor comes with a factory calibrated SM bus, measures the temperature with accuracy of 0.02°C. The temperature can be measured between -20°C and 120°C, with an accuracy of approximately 0.14°C. This is possible due to the 10-bit PWM, which is configured such that it continuously transmits the measured temperature in the above-stated range.

X. PCB DESIGNS

The model is developed on a PCB, whose blueprint is shown in Figs. 11 and 12. The front view and back view are shown in Figs. 13 and 14, respectively.

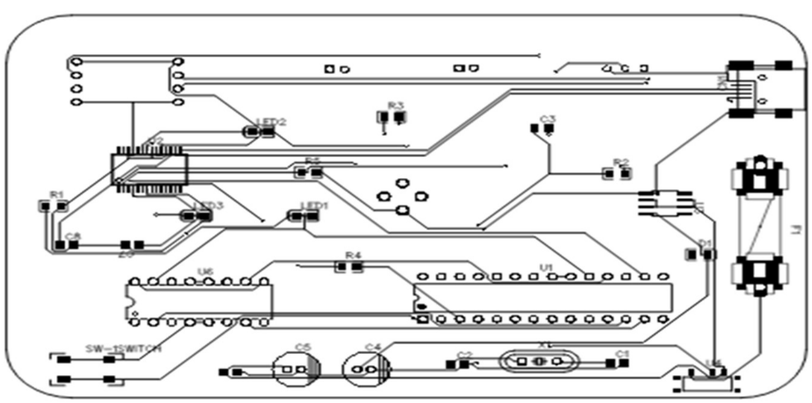

Fig. 11: PCB path tracing blueprint

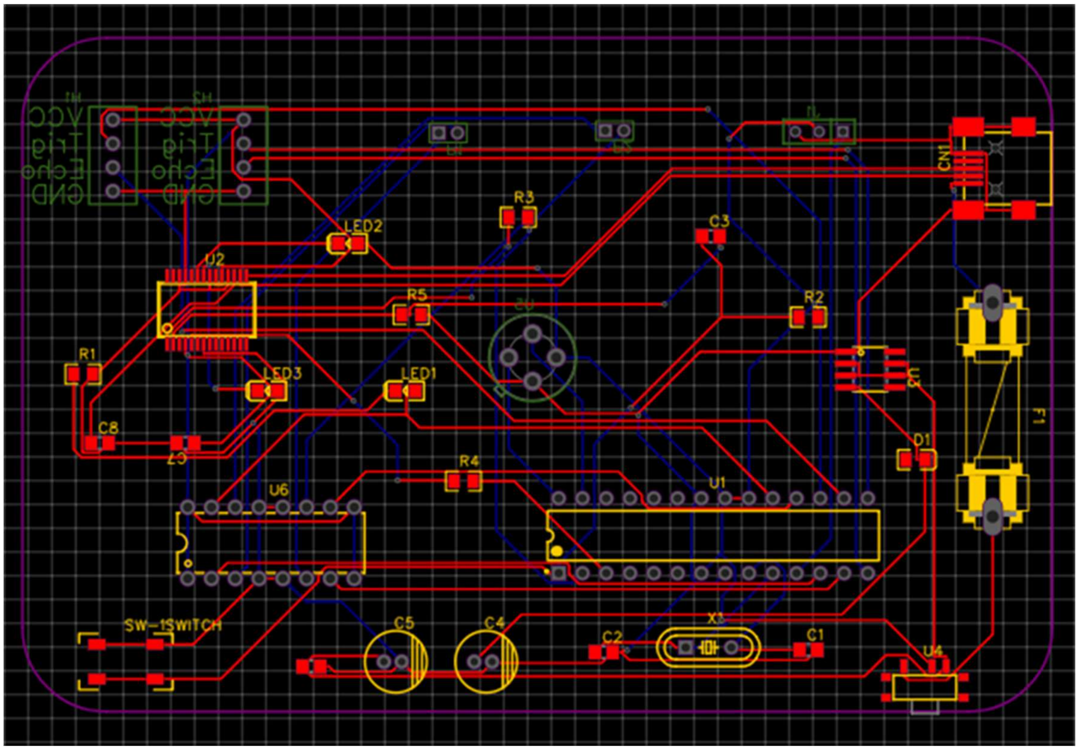

Fig. 12: PCB path tracing

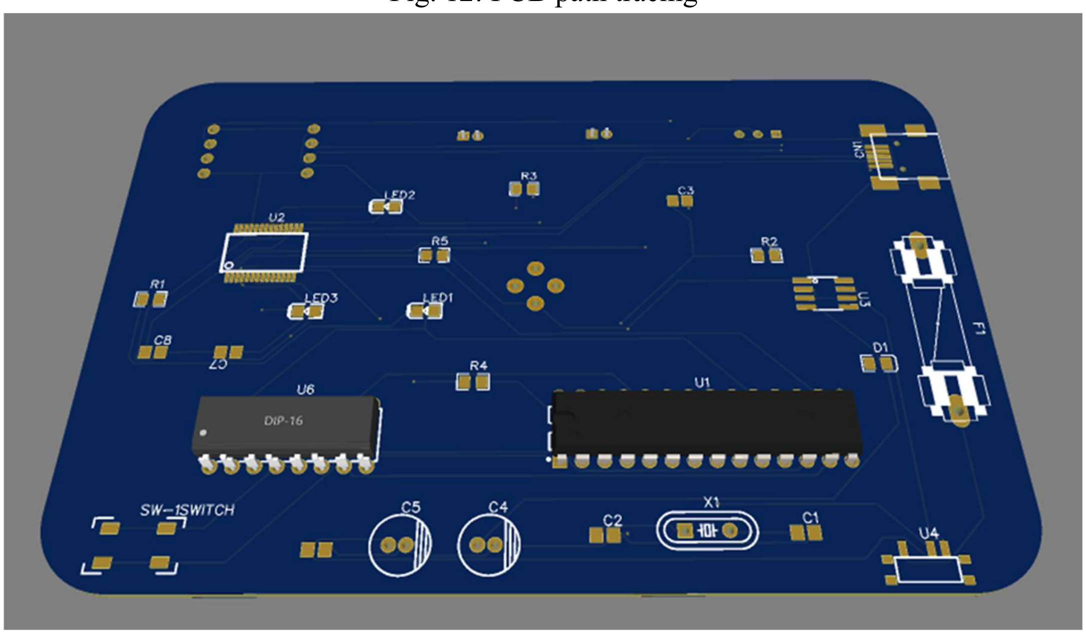

Fig. 13: PCB front side

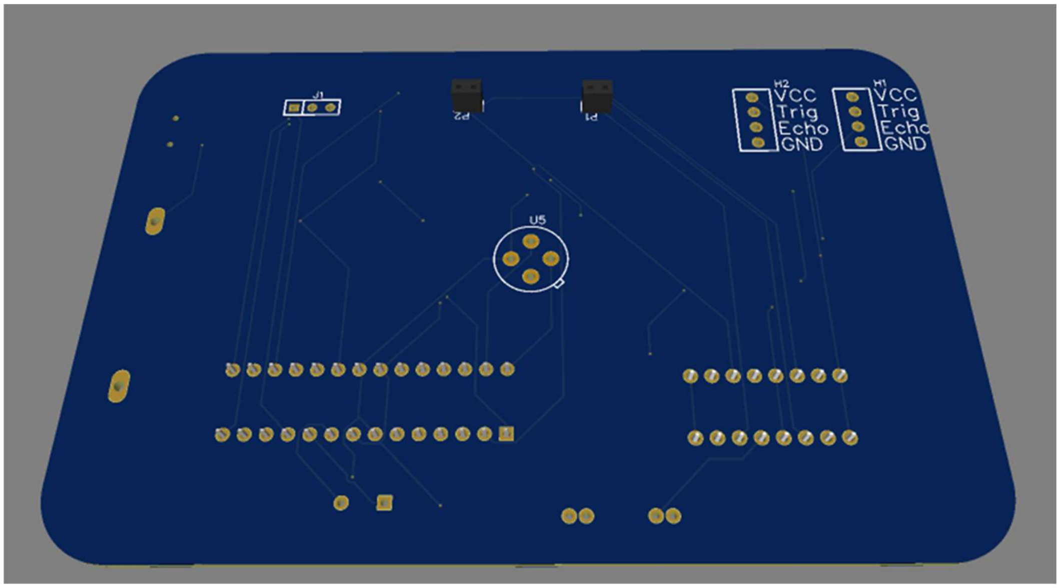

Fig. 14: PCB back side

XI. FUTURE SCOPE

A. App-based integration

When a person approaches the device, it prompts them to enter several details on APP [17]. The information is stored in the database along with the temperature, and the user is also asked to repeat this info. All these data are sent to an app via Bluetooth and stored in the database. Speech-to-Text Synthesis and Image capture technology is used here for gathering accurate information about an individual. Finally, if the vitals of the person's body match the required criteria, a pass ticket is generated, and it is printed using any Wi-Fi enabled printer mentioning the name and details of the person.

B. Hardware-based application

If the temperature of the person is above normal body temperature, then their vitals are monitored using the integrated hardware to predict the chances of COVID-19 even in asymptomatic patients. When the person enters (of course after sanitizing their hands), they place their palm on the device (MAX-30100), which records their heart rate, oxygen levels, and other pertinent information. If the measured oxygen level is low and the heart rate is high, then there is high probability (approximately 80-90%) that the person might be positive for COVID-19. Thereafter, concerned authorities will arrange the necessary medical care for this person.

C. Face mask detection

Wearing masks is the most important normal because it suppresses the transmission of the coronavirus. For detecting the face mask, we can integrate a face mask detection system [18]–[20] in our proposed design, which is used in all organizations that use CCTV cameras. A deep learning technique is used to detect a mask on a face, and IoT sensors are used to collect relevant data. The information is sent to the organization's network, and the entry of the person is restricted if they do not have a mask.

XII. RESULTS AND DISCUSSION

The simulation diagrams mentioned below explain the working of the design of the smart temperature monitoring and automatic sanitizer dispenser.

Fig. 15 shows that the device does not work if an individual is more than 50 cm away from the device. The base sensor is activated only when the distance between the person and the device is <50 cm. The motor continuously moves down till the individual comes in range or the moving platform touches the bump switch at the bottom, as shown in Fig. 16. When the individual comes close to the device, the height correction sensor gets activated, and the motor starts moving upward until the height correction sensor detects a distance of >50 cm or reaches the top bump switch, as shown in Fig 8. Once the head is located, the device measures the temperature and performs other tasks such as storing data on SD card and sending it to the cloud. Fig. 17 shows the activation of the PIR sensor when someone places their hands near the sanitizer dispensing station. When the sensor detects the hands of the person, a specified amount of sanitizer is dispensed.

Fig. 18 shows that the moving platform has reached the lowest limit and that the motor has been stopped to avoid damage to the device. The bump switch acts as a barrier and stops when the platform presses the switch; 0 rpm indicates that the motor has been stopped.

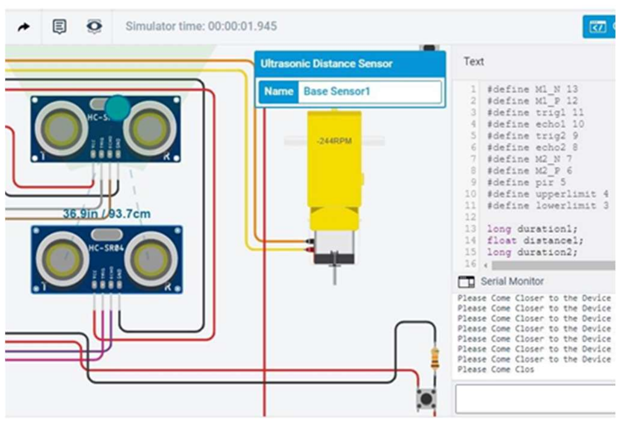

Fig. 15: Waiting for user to come closer

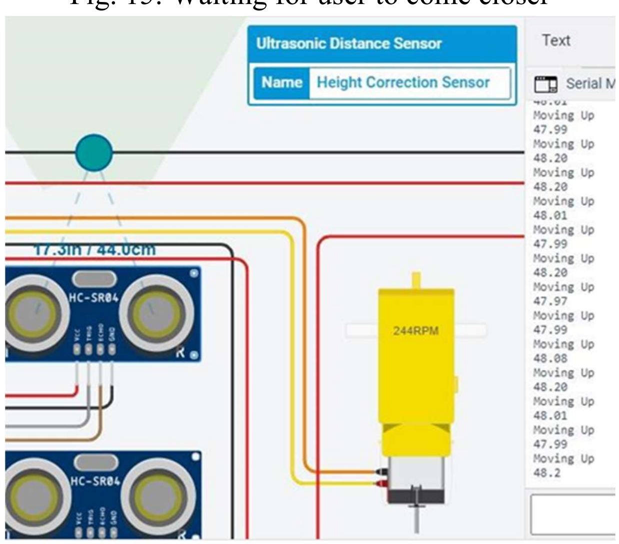

Fig. 16: User in range, detecting head edge

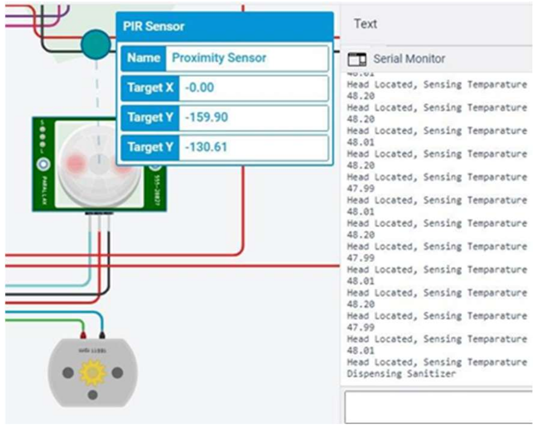

Fig. 17: Head located, sensing temperature and other tasks

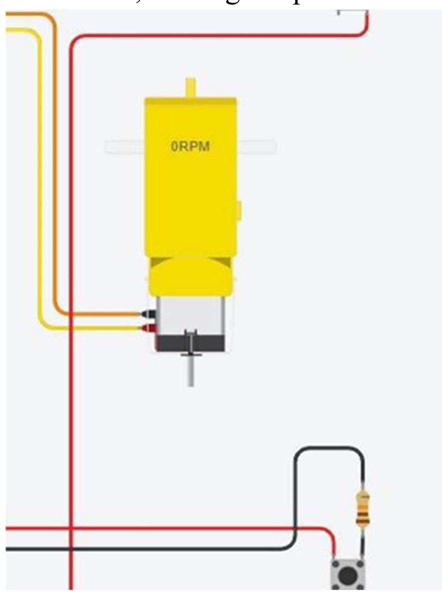

Fig. 18: Lower limit bump switch pressed and motor stopped

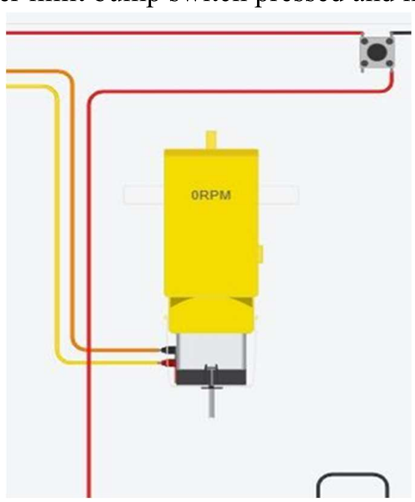

Fig. 19: Upper limit bump switch pressed and motor stopped

XIII. PICTORIAL REPRESENTATION OF THE SYSTEM IN ACTION

A pictorial representation of the complete system in action is shown in Fig. 20.

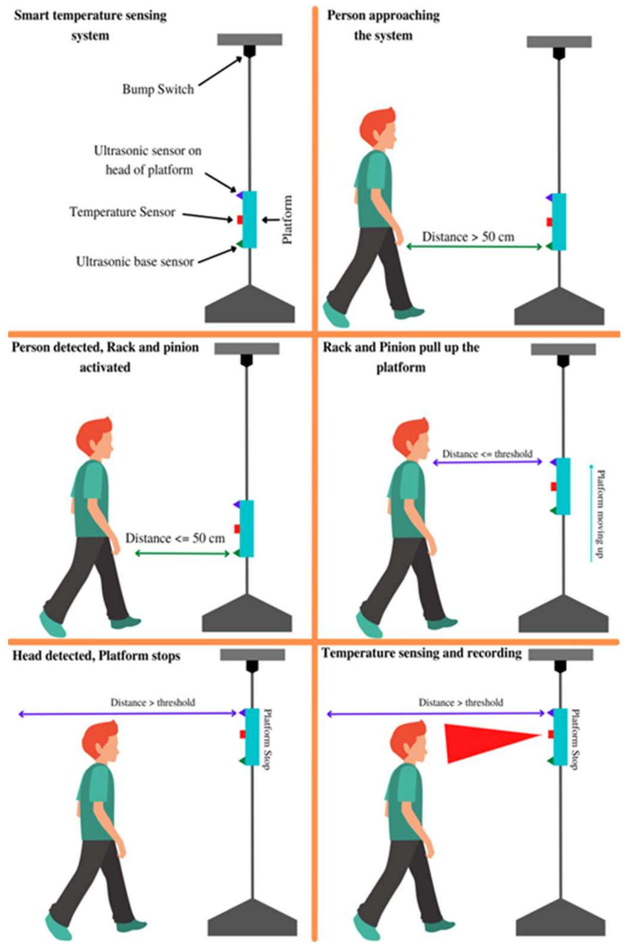

Fig. 20: Pictorial representation of the system in action

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