Development of an Automatic Contactless Thermometer Alert System Based on GPS and Population Density

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Abstract-In today's out-breaking Covid-19 circumstance, treatments are preferred to be contactless. Social distancing has become a mandate in order to prevent disease spreading. In such a scenario, checking the body temperature is preferable to be made contactless because it helps the doctors and social workers to stay away from the symptomatic patients. Infrared (IR) contactless thermometers are employed in measuring the temperature while preventing direct contact with the body. Improved functionalities in the contactless thermometer can provide accurate precision in measurements and calculations. Technological advancement in pharmacy has cohesively improved over time. Coupling Machine Learning (CML) will revolutionize the process of testing. The demand for automated temperature test equipment is likely to grow at a significant pace, with the continuous advancements in technology and the adoption of ATE (Automated Test Equipment). The Global Positioning System (GPS) easy tracking and navigation can be used for easy tracking. Population density can be used to calculate the amount of population in a particular area. The proposed automatic contact-less thermometer system has the potential to replace the traditional temperature measuring techniques and safeguard from human-to-human transmission diseases.

Keywords-Covid-19; IR technology; ATE; GPS; population density

I. INTRODUCTION

The Global Positioning System (GPS) is used to determine locations using a satellite navigation process. It is well suited for different kinds of tracking applications [1] and is used for safety and security purposes. The main components of the GPS system are the space segment, control segment, and user segment. These segments collaborate with each other and process the signals received from the satellites and use them for further information processing like tracking, security in banking applications, automatic toll services, location identification, and navigation [2]. In our example, the idea is to develop an automatic contactless thermometer system based on GPS location (latitude-longitude) and population density. Population density is used to calculate the amount of population in a particular area. It is calculated as [3]:

$$Pd = \frac{Pn}{Ln} \quad (1)$$

where Pd is the population density, Pn is the total population, and Ln the total land area covered by the population. The calculation of population density varies depending on environmental (climate, resources) and human (economic and societal) factors [4]. Globally, millions of Covid-19 and temperature tests are conducted every day. Testing temperature for every person is very crucial: most enterprises, governments, and organizations are following very strict protocols in order to minimize the impact. Educational organizations are struggling to reopen schools, colleges, and research centers, mainly due to the lack of testing centers. Testing is time-consuming, and is conducted with low accuracy. The automatic contactless thermometer provides a solution. The contactless process is efficient and provides easy scalability among large groups. Automatic temperature test-centers will be the future regarding this matter. Public places, and the transportation sector need such technology during these hours.

In Figure 1, the details of the product development stages are presented. The first and second stages of the project are already completed, with stage three being our future plan. The increased adoption of smartphones brings a great opportunity to

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locate people affected with covid-19. Smartphones enable the governments to track and locate affected people and virtually fencing people is now possible. Technological advancement in pharmacy has improved with times. Coupling Machine Learning (CML) will revolutionize the way we test. The demand for automated temperature test equipment is likely to grow at a significant pace along with the continuous advancement in technology and the adoption of ATE (Automated Test Equipment). The increased adoption of smartphones brings great opportunity to locate Covid-19 affected people. Focusing on minimizing error in detection is a very important task. Using an automated contact-less thermometer and geolocation feature from a smartphone will help monitoring on a large scale. However, technology nowadays has become more sophisticated. For example, the number of available infrared (IR) detectors has highly increased, and thanks to their selective filtering capabilities, these detectors can promise more efficiency and speed.

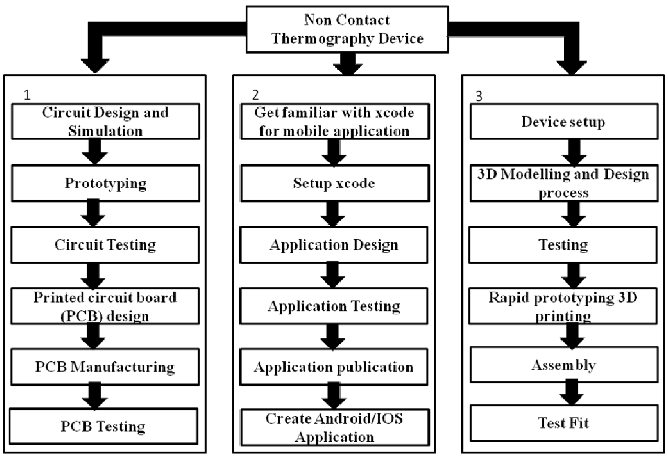

Fig. 1. Design and development steps of the complete product.

Minimizing error in detecting is a very important task. Public transportation is highly dynamic, testing the public in a fast phase and with high accuracy is essential. Non-contact temperature measurement is the preferred technique for monitoring [5]. During the Covid-19 pandemic, the bolometer IR sensor is commonly used, since it provides an IR based solution to measure the temperature and it is efficient with ~4% error rate. GPS provides satellite tracking that is very useful in many ways. The main objective of this research work is to develop and deploy an automatic alert system based on the IR thermometer. The two main parameters that are taken into consideration to fully automate the body temperature measurements are the population density and its accurate location identification. The hardware circuit diagram of the traditional non-contact IR thermometer is presented in Figure 2. In the proposed work, focus is given on developing the contact-less thermometer to work in a situation where there is a necessity to calculate the body temperature in mass gathering places.

The GPS tracking system in collaboration with the population density helps in identifying and locating densely populated areas. The aim is to develop an automatic contactless thermometer system to work in such an environment where the system can be deployed in identifying critically ill people. The proposed work is automated to initiate the functioning of the thermometer system by gathering the location identification of the densely populated area with the help of the GPS tracking system, and the IR signals of the contactless thermometer that provide an accurate measurement of the body temperature. As an outcome, the proposed system will help in identifying red alert areas, in which the population is affected with fever in order to isolate and prevent the general public from entering.

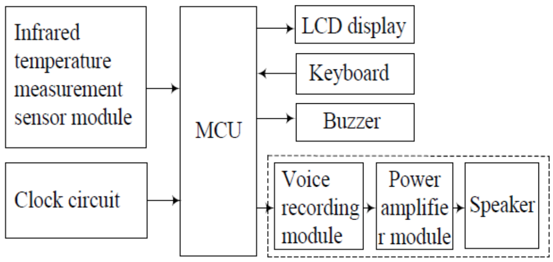

Fig. 2. The hardware circuit diagram of the non-contact IR thermometer.

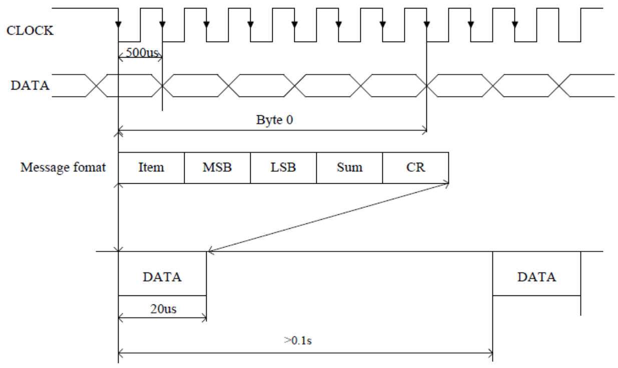

Fig. 3. The timing diagram of the IR temperature measurement module.

II. LITERATURE REVIEW

Globally, health centers have uploaded Covid-19 strains long ago and researchers and scientists are reverse-engineering the strains to find the solution [6]. Research institutions collect data regarding temperature, location, test results, and personal details to predict the future consequences using Machine Learning algorithms.

A. Smart IR Thermometers

Companies are focused on developing smart IoT thermometers. Real-time trackability is very crucial. To provide compliance with non-contact temperature measurements, it is necessary to calculate the effective efficiency of the black body and the difference in temperature between the workplace and the point or object in which the contact temperature is set [7]. Effective recreation can be calculated by applying the theory of evolution or by adjusting the temperature. The latter method seems to be difficult to use, as long as the black hole is cleaned.

B. Health-Internet of Things (H-IoT)

Considering the impact of the 2019 pandemic, it is natural that many contact tracing and self-assessment mobile applications have already been developed, such as the Aarogya Setu App1 of the Indian Government. Health organizations like Apollo have developed chatbots for analyzing the symptoms. Health IoT devices typically belong to two broad types, personal H-IoT devices and clinical H-IoT devices [8, 9].

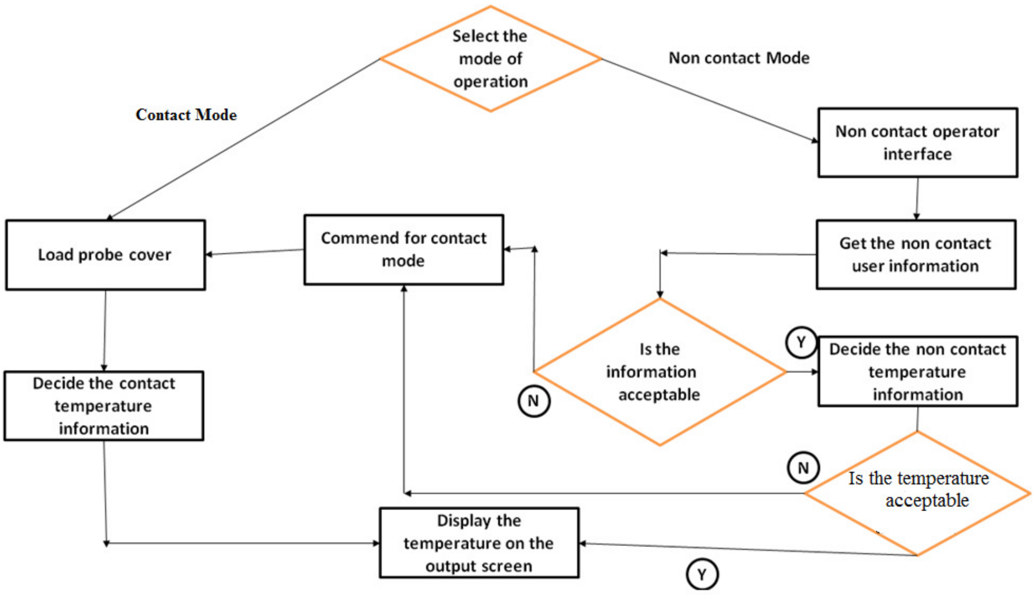

Fig. 4. Flow chart of the automatic test equipment.

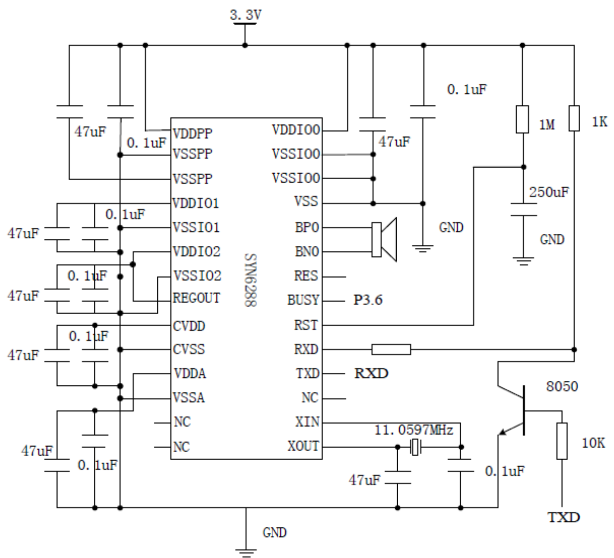

Fig. 5. The voice broadcast circuit.

III. METHODOLOGY

In Figure 4, the data flow between the modules of the proposed technique is presented. In the first step, the non-contact mode of operation is selected. In step two, we get the information from the source using sensors. If the reading received from the sensor is within the acceptable range, then the reading temperature is processed for future decision making. Else, the system is switched to contact mode to get the temperature, thus always making sure that acceptable accurate temperature is displayed on the display unit. Switching between the possible modes is only made based on the format of the data received from the sensor and the acceptable range of the received data. The circuit diagram is presented in Figure 5 with complete details.

IV. EXPERIMENTAL SETUP AND RESULTS

The circuit unit is simulated on the Proteus platform, where the PCB board is designed and built after simulation. The MCU download system and other components are mounted on the PCB board [9]. The temperature of the object is usually simultaneously measured by a mercury thermometer and with a non-contact IR thermometer, time is measured by the length of the clock, temperature is set at 25^{0}C to 48^{0}C. The results of the measurements are: Temperature error is less than 0.1^{0}C, measurement time is about 5s with an IR contact thermometer. The measurements are accompanied with a voice message transmission, and LCD display of temperature and time. In general, the measured data are very accurate. A screenshot of the experimental work is presented in Figure 6. The display unit IR with the VBC is presented in Figure 7. When a temperature of an object below 25^{0}C is detected with the IR contact thermometer, a buzzer alarm and a voice transmission take place. Object temperature at 25^{0}C ~ 48^{0}C is accompanied with voice transmission and LCD display of the temperature and time. Temperature above 48^{0}C is accompanied with a buzzer alarm, and a voice transmission. The data from the sensors are fed into the circuit and the outcome is obtained from the display component shown in Figure 7. To estimate the performance of the experimental setup, the collected data (temperature, GPS attributes) from the sensors are stored in an

Excel sheet. The corresponding output label (message to be displayed) for each input is included to establish the train data with the help of human radiologists for diagnosis. In order to test the experimental setup, new data instances are used (test data) and the output is stored in the same sheet. The Decision Tree model is constructed using the trained dataset [10]. The evaluation parameters used to estimate the performance of the model constructed are shown in Table I.

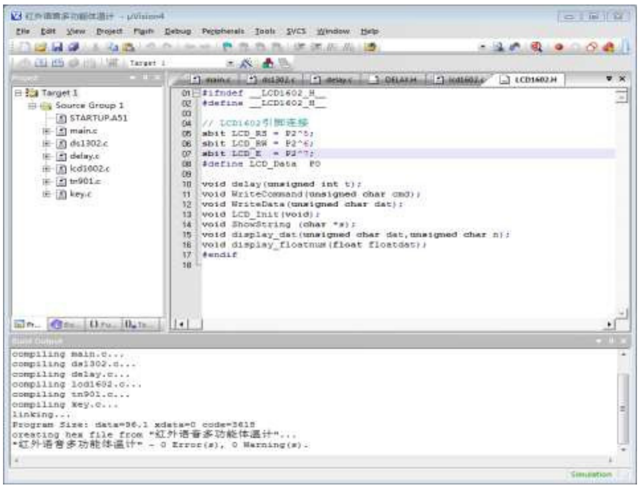

Fig. 6. Matlab experimental setup.

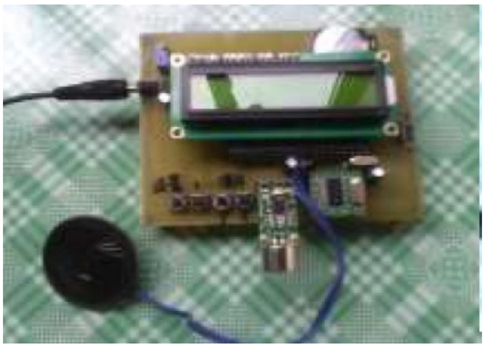

Fig. 7. Display unit interface.

TABLE I. EVALUATION PARAMETERS

Parameters	Formula
Accuracy (A)	$A=\frac{TP+TN}{Total}$
Misclassification Rate (MCR)	$MCR=\frac{FP+FN}{Total}$
Recall (R)	$R=\frac{TP}{Actual\ True}$
Precision (P)	$P=\frac{TP}{Predicted\ True}$
Prevalence (PV)	$PV=\frac{Actual\ True}{Total}$
F Score (FS)	$FS=2\times\frac{R\times P}{R+P}$

TP: true positive, TN: true negative, FP: false positive, FN: false negative

In Figure 8, the x-axis represents the evaluation metric used in estimating the performance of the experiment carried and in the y-axis the performance of the experiment is shown on a scale of 0 to 1. The experiment carried out in the present research work is reliable and proved to be robust with classification accuracy A=0.96. The present experimental setup and its performance are compared with the results of the similar research carried out in [12], in which, the recorded temperature is ±0.2°C accurate. The reason for achieving such accuracy is because of the metal cap attached to the thermopile sensor. The present circuit is designed to have ±0.5 trueness (P), which is better than the design of [11]. The provision of switching between contactless and contact modes allows much better precision in the current design. The GPS and population density values are used in identifying the crowded areas. The aim of the proposed work is to keep the average temperature 36.5-37.5°C in the tested locations. The latitude and longitude of the locations help to give alert messages to people in problematic areas in order to maintain their social distance.

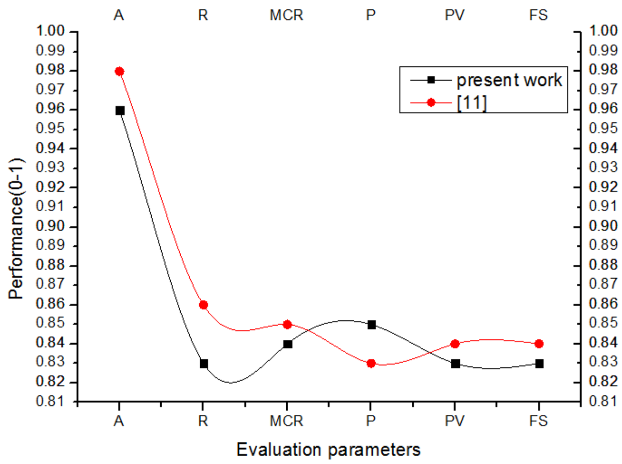

Fig. 8. Accuracy plot of the experimental work.

V. CONLCUSIONS AND FUTURE WORK

Advancement in technology and infrastructure will give us the cure to Covid-19 and its fellow strains. Automated testing and GPS-based geofencing will provide trackability on large scale. The GPS tracking system in collaboration with the population density help in identifying and locating the densely populated areas. The proposed system is aimed to develop an automatic contact-less thermometer system to work in such an environment where the system can be deployed in identifying critically ill people. The advantage of the proposed model is that it uses GPS coordinates and population density values towards identifying the most crowded areas. The aim of the proposed work is to keep the average temperature between 36.5 and 37.5°C in the tested locations. The latitude and longitude details of the locations allow sending alert messages in order to maintain social distance. The limitation of the product designed in the present research work is that its contactless mode has not been implemented yet. Regarding future work, we would like to extend our work in adding a metal cap to the thermopile sensor towards achieving better accuracy.

TABLE II. CHARACTERISTICS OF THE DATASET

Name of the area (India)	Latitude	Longitude	Density level	Population	Area (m^2)	Density value	Average temperature of the area (°C)	Alert message (text)
Coimbatore	11.0168	76.9558	Low	190	7516	0.0252	36.6	Temperature is normal
Coimbatore	11.0168	76.9558	Low	239	13,200	0.10176	36.6	Temperature is normal
Bangalore	12.9716	77.5946	Low	670	32,666	0.0205	36.7	Temperature is normal
Bangalore	12.9716	77.5946	Low	189	90,100	0.0012	37.4	Temperature is normal
Coimbatore	11.0168	76.9558	High	165	5501	0.03	37.4	Temperature is unusually high
Coimbatore	11.0168	76.9558	High	208	6890	0.0303	37.9	Temperature is unusually high
Coimbatore	11.0168	76.9558	High	260	9634	0.0304	38.2	Temperature is unusually high
Bangalore	12.9716	77.5946	High	259	6890	0.0303	38.3	Temperature is unusually high

ACKNOWLEDGMENT

This research has been funded by the Scientific Research Deanship of the University of Ha'il, project number COVID-1908.

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