IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 6.252
Volume 2, Issue 3, January 2022

Article on Artificial Intelligence Infrared Wireless Thermometer (Temperature Monitoring)

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Abstract: *There are several approved procedures that have been created after years of study and development. The greatest precision is achieved by a form of physical touch between the estimating device and the patient. However, as recent events have demonstrated, there are some situations, such as viral pandemics, in which it is strongly advised to avoid direct contact with things that may be utilised by other people. The high viral contagion rate, such as the current COVID-19, can be best addressed by reaching the maximum level of prevention feasible. This work investigates infrared temperature measuring. We also suggest a simple arrangement based on infrared temperature sensors that might aid in the prediction of illness transmission in congested areas such as workplaces.*

Keywords: Infrared Sensors, Body Temperature, Health Care, Flu Prevention

I. INTRODUCTION

In our modern world, viral and bacterial infections are all too frequent. Almost everyone gets a cold or even the flu at least once a year, and despite decades of medical research, there has been little success in healing these illnesses. The existing treatment is largely effective at alleviating symptoms. The best recognised technique for dealing with highly contagious viruses like COVID-19 is for individuals to avoid contact with any potential viral carrier. Disease transmission is more likely in crowded environments (particularly closed ones). The identification of virus carriers in the early stages may be achieved by detecting the body temperature of each individual who enters a confined environment such as an office space. These procedures, however, are typically time demanding and talent dependent. Infrared temperature sensing may be the finest answer for our needs. The use of infrared is primarily based on the fact that the temperature of the human body is greater than absolute zero, a temperature value that is physically unattainable. The body emits radiation known as "thermal radiation" when it is heated. The mobility of atoms and molecules on the surface of objects with temperatures above absolute zero emits infrared light. Infrared radiation is really electromagnetic radiation with a lower recurrence than visible light. The emissivity of a body is defined as the ratio of brilliant energy produced by it to the amount of radiation discharged by a dark body at the same temperature. According to clinical experience, dry human skin is an excellent dark body, with the maximum emission frequency at roughly 9.3m. Planck's rule characterises the energy emitted by the dark body, and the Stefan Boltzmann law illustrates the otherworldly dazzling emittance of a certain frequency. The emissivity of dry human skin is around 0.98. There are several therapeutic applications that benefit from infrared thermography, including diabetes detection, joint discomfort, dermatitis, and concerns such as malignant development or cardiovascular diseases. A precision that would allow for the early detection of potentially contaminated persons. [2]

II. RELATED RESEARCH

With current global events, several research on viral transmission prevention are being conducted. Human body temperature monitoring is one of the most significant concerns. The tympanic temperature is unquestionably near to the core temperature of the human body. However, measuring tympanic temperature is a difficult operation since the probe must be fitted to the form of the ear canal. More importantly, in the scenario of a worldwide pandemic of a virus with a very high spread rate, this precise strategy is not a viable option. However, IRT devices have not been demonstrated to be reliable. Using a noncontact IRT, Ng et al. concluded that a temperature greater than 35.6 o C might be deemed fever. Another research determined a safe fever threshold of 35.5 o C by analysing the association between face skin temperature recorded with an IRT and a direct thermometer. In, two commercial and one industrial IRT are used to take a variety of measures. The measurement data is subjected to a statistical analysis. A BRAUN IRT-3020 thermometer was used to measure the tympanic temperature in the right and left ears, the forehead temperature, and the wrist temperature of 614 randomly selected people in one experiment. To assess the accuracy of the measurements, the coefficient of variation (CV) was determined. [4,5]

Table. 1. Statistical analysis over performed measurements in the experiment

	Forehead	Wrist	Ear avg.	Ear avg.- Forehead
Mean	34.714	34.164	36.911	2.196
Std dev	0.392	0.455	0.264	0.411
CV (%)	1.129	1.332		
Min	34.0	34.0	35.85	0.15
Max	37.3	36.1	37.7	3.4

Table 1 shows that there is a big gap of around 2.2 °C between ear temperature and forehead measurements on the same subject.

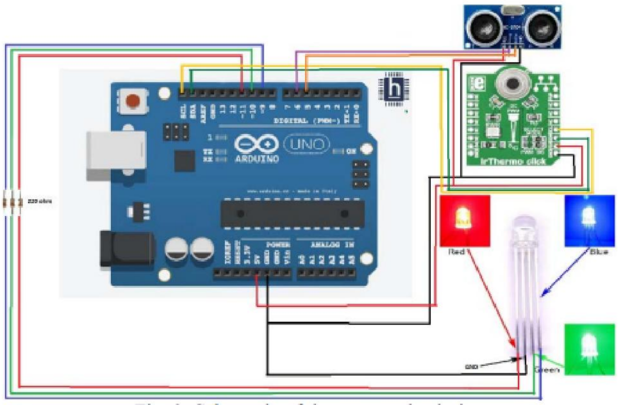

Fig. 1: Schematic of the proposed solution

In Fig. 2, it can be shown that the ambient temperature had little effect on the recorded temperature. The study concluded that there is measurement uncertainty when utilising IRT. However, forehead IRTs are well adapted for rapid screening, with a suggested threshold of roughly 36 o C. Our method is based on the use of one of the most widely used and least expensive infrared temperature sensors on the market, the MLX90614, which is intended to monitor skin temperature with an accuracy of +/- 0.5 o C in the 0-60 o C range.

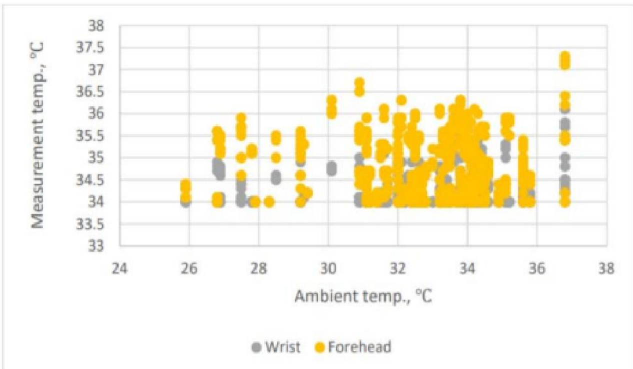

Fig. 2: Forehead and wrist temperature measurement

The following are the major components of the suggested strategy (Fig.3): • Arduino Uno board • infrared temperature sensor MLX90614 • ultrasonic distance sensor HC-SR04 • RGB led the total cost of components for this project was roughly $19, however it may be greatly lowered if purchases are done in bulk. The infrared temperature sensor sends data to the Arduino board through the I2C interface, with measurements taking place every 500ms and an output resolution of 0.14 o C.

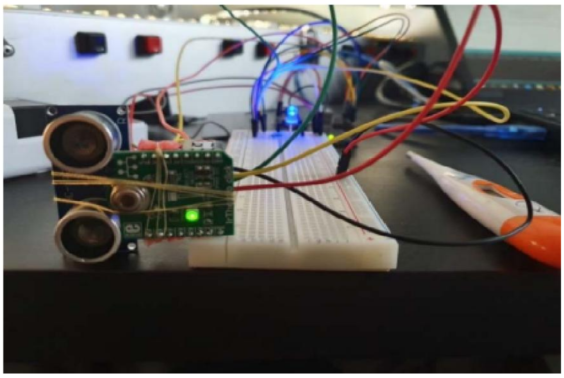

Fig. 3: Image of the system in action

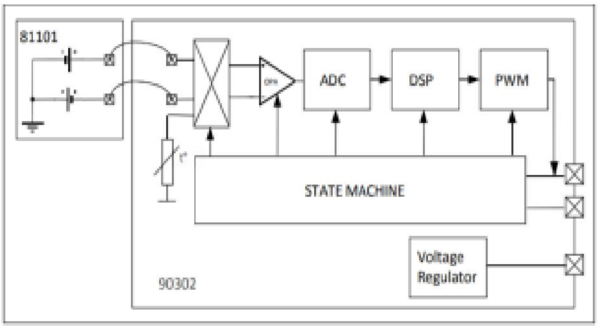

Fig.4: Block diagram of the sensor (MLX90614 datasheet)

III. SELECTING A TEMPLATE

The internal state system (Fig. 5) governs how ambient and object temperatures are measured and calculated. Some post-processing is also required to output the data over a Sambas compliant interface. The sensor has a factory calibrated emissivity of one. However, the emissivity of various materials varies. IR thermometers typically employ radiation flux between the sensor's sensitive element and the item of interest:

$$q = \varepsilon_1 * \alpha_1 * T_1^4 * \sigma * A_1 * F_{a-b} - \varepsilon_2 * T_2^4 * \sigma * A_2 \quad (1)$$

Where:

ε_1 and ε_2 are the emissivities of the two objects.

α_1 is the absorptivity of the sensor.

σ is the Stefan-Boltzmann constant.

A_1 and A_2 are the surface areas involved in the radiation heat transfer.

F_{a-b} is the shape factor.

T_1 and T_2 are the already known temperature of the sensor die (measured using integrated element) and the object temperature that is needed.

In reality, the total of Emissivity, Reflectivity, and Absorptivity for any given material equals exactly 1.00, therefore as long as there is a large difference in environment and object temperature at a particular reflectivity, there will also be a considerable measurement error. The field of view (FOV) of an infrared temperature measurement is also critical to its accuracy. We decided to calibrate the equipment for proper operation at predetermined distances (typically between 4 and 6 cm). Our method employs an ultrasonic distance sensor to determine the distance between the IR sensor and the target object:

Fig. 5: HC-SR04 - ultrasonic sensor

The concept is straightforward. The pulse duration is related to the time it takes to detect the broadcast signal. As a result, the distance is simply calculated:

$$d = 0.034\ cm/_{\mu s} * t\ \mu s \quad (2)$$

Where:

d – distance to object(cm)

$0.034\ cm/_{\mu s}$ – transformed speed of sound

t – time in μs (pulse width on the Echo pin)

To inform the user of the measurement result, the system employs an RGB led. There are four clearly defined states:

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- Distance is acceptable in the white state. Begin computing the average temperature.
- Red state: recorded average temperature exceeds predefined threshold (36 o C).
- Green - the recorded average temperature is less than the chosen threshold (36 o C).

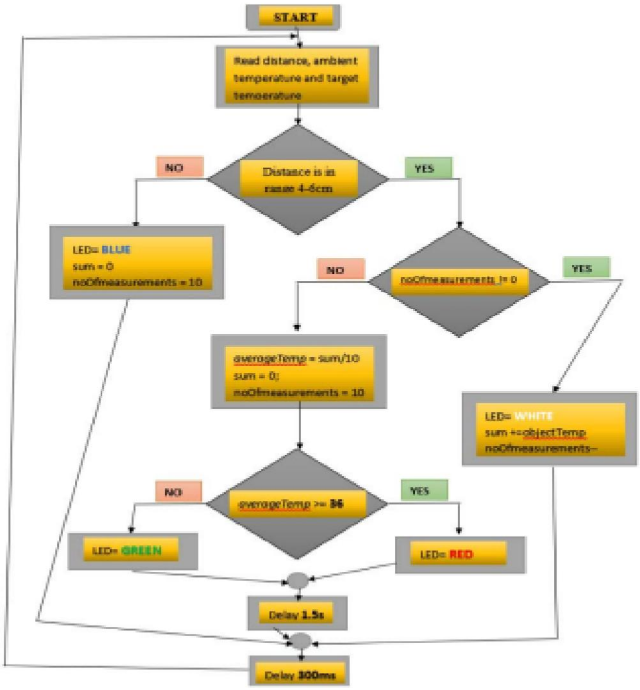

Fig. 6: Logical scheme of the IR temperature measurement system

To improve accuracy, the temperature value is calculated as the arithmetic mean of 10 consecutive readings (Fig.7). A whole measurement takes 3 seconds.

Fig. 7: Thermometer used for in-ear temperature checking [12]

In the first experiment, we measured the same person's forehead temperature 20 times in a row at room temperature. Previously, the in-ear temperature was measured to be 36.9 degrees Celsius.

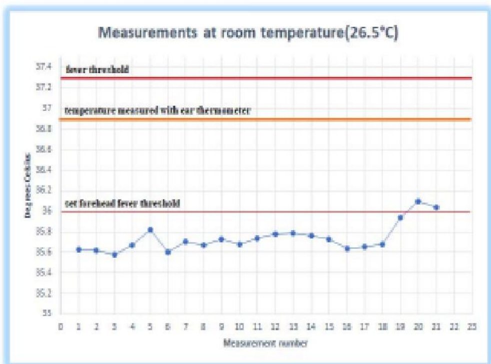

Fig. 8: First experiment. Room temperature measurements

As seen in the graph (Fig.9), two out of twenty-one measurements exceeded the established forehead fever threshold (36 o C), with the maximum recorded temperature being only 0.1 o C above the limit. However, recorded temperatures are typically 0.26 co. below threshold, which is close to the 0.4 co. difference between in-ear and the commonly recognised fever threshold of 37.3 co. (for contact-based measurements).

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2} \qquad (3)$$

Using formula in (3), we obtained the following results:

Mean	35.74
Standard Deviation	0.134
CV (%)	0.003
Min	35.58
Max	36.10

In the second experiment, we took the same series of measurements on the same person outside:

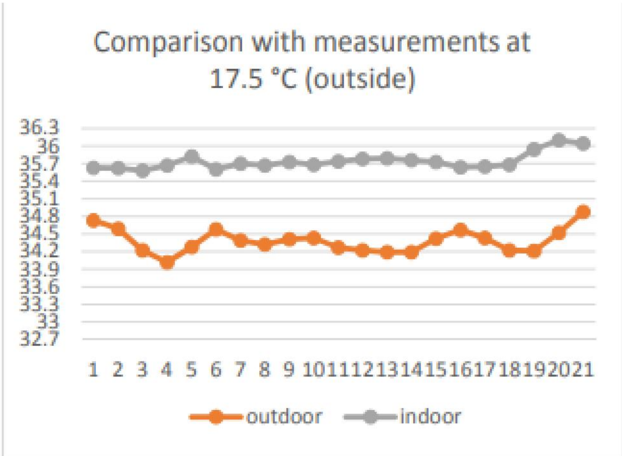

Fig. 9: Second experiment. Indoor vs. outdoor

The second experiment (Fig. 10) indicates, as predicted, that ambient temperature has a considerable impact on measurement accuracy. Our system has been tuned for indoor use (temperatures between 22 and 27 o C). Table 3 has statistical analysis.

Mean	34.385
Standard Deviation	0.201
CV (%)	0.005
Min	34.02
Max	34.88

Table. 3. Statistical analysis over outdoor measurements

IV. CONCLUSION

While infrared thermometers are a simple way to detect the surface temperature of any object, it is critical to choose the proper sort of device for your application to ensure accurate temperature readings. There are infrared thermometers designed specifically for long-range readings. Similarly, there are IR thermometers that are specifically designed for reading high temperatures from a short distance yet with greater precision.

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