Feasibility Study of the Implementation of IR Technology for the Recognition of Covid-19 Carriers in Public Places

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ABSTRACT

Identifying COVID-19 carriers has become the first need worldwide, especially in crowded airports, stores, etc. There are systems based on the infrared vision that can help recognize one of the most common symptoms of this pandemic disease: body temperature. The study presented here aims to analyze the feasibility of implementing infrared (IR) technology in public places to effectively and efficiently recognize people with symptoms of elevated temperature or fever. As a result, the best solution (IR) was obtained in terms of time, accuracy, and ergonomics, depending on the user. Sampling was also conducted to measure the feasibility, with a sample of approximately 400 users who visited the COVID-19 vaccination center, located at the Salesian University of Guayaquil-Ecuador. A percentage of time and error is presented, using 2 of the most used technologies in the technological market, thermographic technology, and thermopile, considering the proposal as very feasible.

Keywords: COVID-19, infrared technology, thermographic technology, thermopile.

INTRODUCTION

On November 17, 2019, the world first discovered covid-19 through a patient named O in Wuhan, China. Since those days, the world has changed from its controls at airports, shopping malls, factories, and everywhere where there are possible covid-19 infected people. Today, great technological advances have been made in medicine and other areas. Where temperatures are taken in most public places, and 70% alcohol is offered to disinfect hands, in addition to recommending social distancing to prevent the spread of the pandemic. Many countries have seen the need to rely on IR infrared radiation technology to recognize people with the more classic symptoms of covid-19, such as fever, and have implemented stringent controls at the entrance of such public places[1].

Today, many electronic devices use IR radiation technology supported by Artificial Intelligence (AI) algorithms to recognize body temperature. Thermographic technology is a technique that helps to monitor the temperature without physical contact through thermal cameras or thermovision, capturing infrared radiation from the electromagnetic spectrum of each person. [2].

The problem lies in the lack of precision and knowledge for the accuracy of taking the body temperature of the body. The person taking the temperature does not make the respective control and measurement of external factors, which may yield erroneous data.

Define what technology is recommended to be used in public places such as airports, shopping malls, or educational institutions, where it is difficult to place one person or guard to take the temperature 1 to 1 at the entrance, as it would cause too much congestion at the entrance of the mentioned places.

Thermography technology is a non-contact passive measurement method in which the temperature allocation at the surface is measured with a thermographic camera that allows measuring the long-wave infrared radiation that focused in the field of view and used these results to calculate the temperature of the focused object. [3]. These results are captured in a colored virtual image (dominated thermal image). Each pixel representing a thermal image will show a temperature point on the surface of the object.

The processing of the colored virtual image takes into account the emissivity (e) of the surface of the measured object and the reflected temperature. Both variables can be adjusted manually on the thermal imaging camera. Thermography is a state-of-the-art measurement technology in terms of image production [4].

A thermal imaging camera records the radiation intensities measured in the infrared region of the electromagnetic spectrum and converts them into a visible image. Any other type of electromagnetic radiation, such as infrared radiation, is invisible to the human eye, so those responsible for obtaining infrared temperature measurements are called microbolometers, designed to measure electromagnetic radiation and high-energy subatomic particles. They are especially effective for measurements in the spectral range between 200 micrometers and 1-millimeter wavelength [5].

Infrared lies midway between the visible spectrum and the microwaves of the electromagnetic spectrum, where heat, which is the main cause of infrared radiation, causes any object whose condition has a temperature above absolute zero (-273.15 degrees Celsius) to emit radiation in the infrared region. There are currently technological algorithms for body temperature recognition that can almost imperceptibly help the user recognize these sources of infection[6].

PREVIOUS BIBLIOGRAPHY

The key objective of the technologies applied to non-contact temperature detection (NCTD) is to use them to rapidly diagnose diseases or possible health anomalies and thus avoid future tragic consequences such as massive contagion in the case of a pandemic as we are currently experiencing. In addition, this non-contact temperature detection technology (NCTD).

This method of examination and diagnosis is generally very well received in the healthcare sector. It is also a non-invasive method, which does not cause pain to the patient and, above all, does not expose the patient to radiation.

In addition, thermopile-based infrared thermometers are widely used devices. However, this device can often be misused, as it usually depends on a person who knows how to use it correctly. In addition to this, people often find it uncomfortable to have such devices pointed at their face, forehead, or neck. In addition, the measurement is taken on the wrist or arm, giving false temperatures, allowing infected people to circulate freely, and infecting many more people[7].

MATERIALS AND METHODS

In physical and electrical terms, a thermopile is composed of several thermocouples connected in series. Together, they can generate a voltage proportional to the temperature difference between two points; this difference provides a relative temperature measurement[8].

A thermocouple is a sensor that will allow the temperature to be calculated and is made of two dissimilar metals joined at one end. When the connection of these two meta-les is heated or cooled, it produces a voltage that can be related to the temperature of the target to be measured. Thermocouple alloys are commonly manufactured in wire form[9].

A MEMS (Microelectromechanical Systems) thermopile sensor uses a thin, thermally insulated membrane. Since it contains a low thermal mass, it is rapidly heated by the incoming heat flux, thus creating a temperature differential that the thermopile can report as a temperature difference. In addition, by attaching a reference thermistor in the MEMS system, it will be able to generate an absolute temperature measurement [10].

The following materials were used to carry out the sampling for feasibility analysis:

- Thermometer (Thermopile technology) ROHS brand -model: DT-8826.with a commercial value of $35.00 plus VAT.
- Thermal camera (thermographic technology) Hikvision brand Model DS-2TD2617B-6/PA. With a commercial value of $2090.69 plus VAT.
- Special tripod for Hikvision thermal camera, Model DS-2907ZJ, with a retail value of $255.00 plus VAT.

This equipment was installed at the main entrance of the vaccination point located in the facilities of the Salesian University in the city of Guayaquil -Ecuador.

Temperature readings were taken from 400 people who entered on Tuesday, June 22, and Wednesday, June 23, 2021, for the anti-covid vaccine provided by the Ministry of Public Health of the National Government of Ecuador.

The readings were taken sequentially with the two technologies for each user. The survey variables are:

- No
- Thermographic camera
- Thermographic capture time
- Thermopile gun
- Thermopile capture time
- Age
- Sex
- Context
- When taking your temperature in a public place by pointing it at your forehead or hand, how comfortable do you feel?
- How necessary do you think it is to take each person's temperature at the entrance of a public place?

The questions asked were to evaluate the degree of user acceptance of the different technologies (Thermopile or Thermographic). In addition to this format, the average time per person it took to take the temperature in both technologies was validated[11][12].

The general hypothesis of the research is that the measurement by infrared camera technology is more reliable with respect to the measurement by Thermopile (Table 3).

The variables identified were as follows:

- Variable (X): Temperature is taken by heat gun.
- Variable (Y): Temperature is taken by infrared technology camera.

Data analysis is performed using the Python distribution for data science Anaconda to describe the behavior of both variables (descriptive statistics) and hypothesis testing (inferential statistics) using the Shapiro-Will test to demonstrate normality and the Wilcoxon test to show that significant differences exist [10][13][14] .

Figure 1. Shows how the thermographic camera sensor indicates when it detects people with high temperatures and displays the value taken.

RESULTS

Regarding questions 1 and 2 with the Likert scale, the results are analyzed, taking into account the users' satisfaction with each technology.

Table 1. Levels of satisfaction

Question 1	**Question 2**	**Likert Scale**	**Acceptance of the use of heat guns**	**Acceptance of temperature measurement**
Very uncomfortable	Much needed	0	22	92
Uncomfortable	Required	0	48	8
Indifferent	Indifferent	0	26	0
Comfortable	It is not necessary to	82	4	0
Very comfortable	Nothing necessary	221	0	0

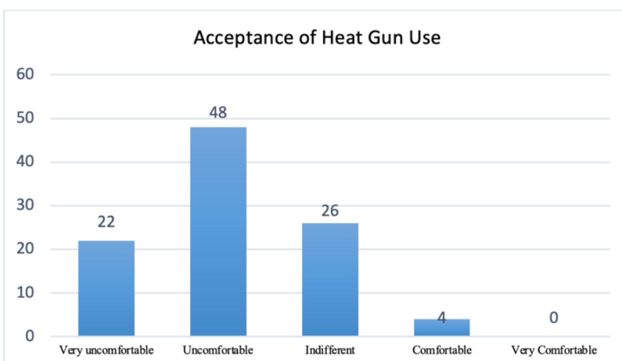

Fig. 2. Acceptance of the use of heat guns

Fig 2. Approximately 70% of the people surveyed in taking the temperature was 400 people. They find it very uncomfortable or inconvenient to take the temperature manually with a heat gun, mainly because it is pointed at each person's forehead.

Fig 3. This graph shows the importance of measuring the temperature of all people who need to enter a public place. More than 90% of the sample surveyed wanted this control to be maintained in places with a large influx of people.

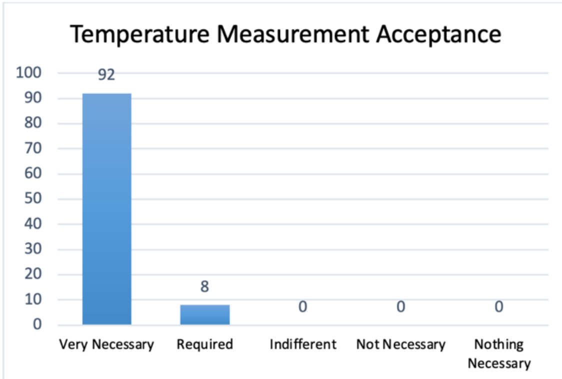

Figura 3. - Acceptance of temperature measurement

Based on the time of temperature data capture per user, we analyze the results in Table3.

Table 2. Temperature data capture by the user.

Capture time camera	**Number of thermographic persons**	**Number of people Thermopile**
1-2 seconds	395	0
3-4 seconds	5	0
5-6 seconds	0	0
7-10 seconds	0	82
11-14 seconds	0	221
From 15 onwards second	0	97

Fig 4. It is observed that the average time required to measure the temperature with thermographic technology is stable and remains almost unchanged (Blue Line). In contrast, the time required to measure temperature with thermopile technology is variable and much longer. These differentiating factors are associated with the predisposition of the persons to

be censored and the good application of this technology by the operator. Many times, the operator performs erroneous measurements.

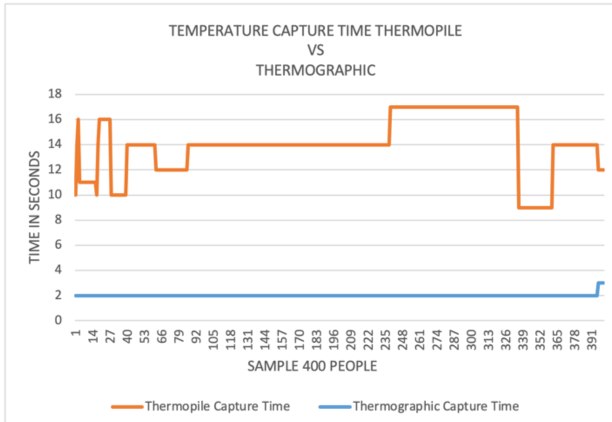

Figura 4. Temperature capture time vs. thermographic thermopile.

Fig 5. The graph shows and compares the times used to measure the temperature with both technologies. Less time used with thermographic technology (blue color), more time used with thermopile technology (orange color).

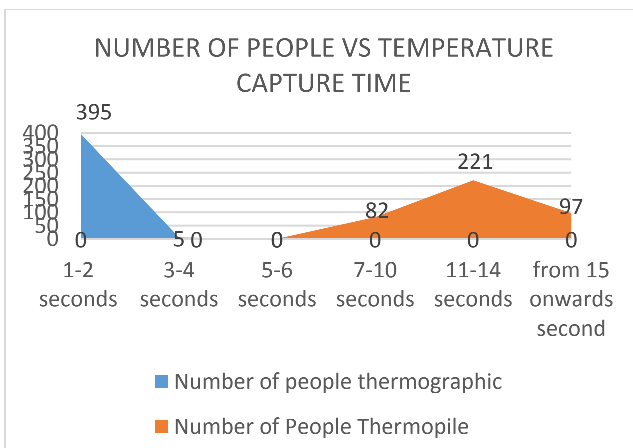

Figura 5. Thermopile vs. Thermographic Temperature Capture Time Distribution

HYPOTHESIS TESTING

To analyze the hypothesis, we took a confidence level of 95% and a significance level α = 5% = 0.05.

The decision rule in each case is to accept H0 if Sig. (p-value) ≥ α and reject H0 if Sig. (p-value) < α. For verification, working hypotheses are proposed in each case, wherein H1, the variables show significant differences, and, in H0, the variables do not show significant differences.

The application of the Wilcoxon test with a value of p=0.000, the preliminary test demonstrates the normality of the variables, accepts the researcher's hypothesis (H1), and rejects the null hypothesis (H0). The existence of significant differences between the variables was demonstrated, with thermopiles being the technology that did not present erroneous readings [10][15][16][17].

CONCLUSIONS

The analyzed results show that the analyzed thermographic technology has greater advantages than its thermopile counterpart for the following reasons:

Temperature readings are more reliable and faster since the distance between the equipment and the target to be inspected is 1.5 to 2.5 meters. This allows a sampling area of approximately 2 square meters and a capture rate of approximately 1 to 2 seconds, in addition to taking temperatures of up to 20 persons simultaneously, with video and photo recording. In addition to this, the advantage over thermopile technology is that people are not intimidated by placing the infrared thermometer on the forehead or hand at a distance of approximately 5 cm. This can also cause a false reading due to human failure. Since the thermometer operator could mistakenly point the thermometer at an inadequate distance or over accessories such as watches that users have on the wrists of the needles where they are censored. In addition to the inconvenience, normally, users in public places lose between 7 to 15 seconds of their time waiting for the temperature capture and can cause columns or rows of people to enter and accumulate in the public access, also losing the proper distance to avoid any type of contagion.

The error range according to the technical specifications of the equipment is ±0.3°C. in thermographic cameras and up to ±1 degrees in heat guns. In addition to this, infrared thermometers depend a lot on the operator to take the temperature on the forehead, and there can be a difference between the internal temperature of people and the forehead because environmental problems can alter it. That is why, in the attached table of temperature capture samples, we were able to observe captures of values that we consider erroneous (they are shaded with red color) of values below 35 degrees Celsius, which by medical standards would be considered hypothermia. Hypothermia occurs when body temperature drops below 95°F (35°C).

Artificial intelligence algorithms in thermal imaging cameras have now developed values in addition to temperature, such as distance. This is very useful for being able to control crowds in times of pandemics.

The application of the Wilcoxon test with a value of p=0.000, the previous test demonstrates the normality of the variables, accepts the researcher's hypothesis (H1), and rejects the null hypothesis (H0). Significant differences between the variables were demonstrated. The thermopile technology did not present erroneous readings.

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