Dominant Temperature Extraction using MLX90640 as Far Infrared Thermal Sensor for Temperature Detection

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Abstract*— Temperature is a vital parameter of determining the status of both living and non-living things that emit infrared radiations. Far Infrared Sensors can detect temperatures without actually coming into contact with it. Unlike traditional temperature sensors such as thermistor, a far infrared sensor is capable of temperature measurements at short to far distances from the object depending on its resolution. This study aims to develop a far infrared sensor that will recognize a temperature of an object through the use of Melexis90640 and python programming. The temperature measurements will be taken on varying distances and will be compared to temperature readings from a touch tool which is a thermometer. As a result the MLX90640 proved to have 99.15% identical temperature reading to that of the thermometer. Reliable contactless temperature readings can be achieved through this study which is beneficial to various aspects that require temperature detection.

Keywords*— Thermograph, Far Infrared Sensor, Thermal Imaging

I. INTRODUCTION

Skin temperature is a valid and accurate measure for the reliable measurement of human sensations and homeostatic conditions due to the ambient temperature stresses [1]. This knowledge can be extracted from thermal images collected from far infrared imagery. Thermal detectors are considered necessary for a broad variety of essential measurement applications, including several non-contact temperature measurements, in-situ monitoring of semiconductor wafers during manufacturing, infrared spectroscopy and medical thermograph [2]. Because of this, certain physiological parameters from thermal imaging of the skin surface produced by far infrared (FIR) sensing may be observed non-invasively.

The device can log data such as temperature readings at short or long distances from the target, based on its resolution. Those also point to the possibility that the use of non-contact thermal sensors can aid early detection of outbreaks such as avian influenza by investigating temperature fluctuations as one of the symptoms of infected chickens shows a rise in temperature [3]. High temperatures, humidity, body weight and acclimation will influence the mortality rate of every chicken, which also correlates to the heat prostration [4]. The proposed system will help deter the spread of diseases by minimizing the user's interaction with the subject. Instead of utilizing conventional thermometers, which require a minute or two to calculate the temperature. The infrared sensors are a good substitute to contact sensors.

Most devices available today and in the current trend of technology can be programmed through python. This programming language has been essential to the development of automation technology and AI. Programming and hardware development are intertwined. Since competent technology involves pricing as a vital part. Developing low cost thermal sensors to compete with other commercially available sensors are a good market. The Melexis90640 can be utilized using python programming and develop a user friendly GUI to easily implement this low cost thermal sensor [6].

In the case of a pandemic, temperature sensors play a significant role in determining the health status of a person. This can help mitigate the spread of a virus as an increase above the threshold of human temperature is a sign that a person is carrying or suffering from a disease. This proves to be applicable in the field of biotechnology and human health care [5]. The immediate contrast of a person's temperature to its surroundings should also be taken into account when developing temperature sensing devices as this affects the reliability of the results [8].

II. RELATED STUDIES

Work carried out by F. N. Reece et al. suggest that ambient temperatures have a direct effect on the mortality rate of broiler chickens [4]. Thorough results regarding the impacts and relationships of acclimation, moisture and body weight is expected to be calculated in terms of mortality due to heat prostration of male broiler chickens. Tests were done using exposure to an ambient temperature of 40.6 ° C on the male broiler chickens. The humidity level has been found to have a significant effect on heat prostration.

To obtain a prototype that can capture infrared images in a cost-effective but also satisfactory way, G. Spasov et al. are using a new Melexis-generated infrared array sensor, MLX90640 [5]. In this paper, the Ambient Assisted Leaving (AAL) wireless thermal infrared sensor device is described in health care and in-home safety smart systems. Owing to a low current consumption of less than 23mA it is ideal for the

solution with battery power. The refresh rate between 0.5 and 64Hz makes it possible to track very fast moving objects.

The group of M. Vandersteegen et al. explored the prospect of creating a low-cost variant of an in-car human-machine interface for manipulating such a multimedia platform utilizing the low-cost Melexis MLX90640 thermal sensor [6]. Compared to the time-of - flight camera, the thermal camera does not depend on ambient illumination conditions and can reliably differentiate the background temperature from the foreground body temperature, making the thermal sensor a fascinating substitute for this reason. The researchers have collected a new collection of data of more than 1300 gesture videos with multiple cameras, two points of view, and which have been made public. A recognition algorithm is introduced that uses the 1D Temporal Convolution Network (TCN) on top of the CNN 2D Spatial Feature Extractor. TCN demonstrates better low latency owing to the mixture of causal and non-causal convolution layers.

To build a hand-waving gesture spotting device, the group of Y. Kawanishi et al. used a far-infrared sensor system that can run in an area where low ambient light is present instead of visible-light sensors since they do not perform effectively in the dark [7]. Because it is difficult to locate hand-waving movements with varying durations, a voting-based strategy is introduced. Dynamic Time Warping (DTW) dependent distance metric was used along with Spatial and Thermal Region of Interest (STRoI) to reliably detect differing durations of movements to overcome low-resolution and noisy efficiency.

Hedin et al. did another work that uses a far infrared that enables a rapid detection of the human being mainly attributable to a usually high temperature contrast between the person and the immediate surroundings [8]. This paper assesses the effectiveness of the use of remote infrared thermal cameras with a haptic layout to enable the rapid identification of people's existence and position compared to a blind user. The idea is to use a haptic display that evaluates the outcome of the infrared sensor. The pixel of the display consists of a binary up or down by matching the output of the IR camera to a level set at a temperature below the human skin.

III. METHODOLOGY

The aim of this paper is to establish a portable temperature detection device. The design of the temperature control method using MLX 90640 is key to this development.

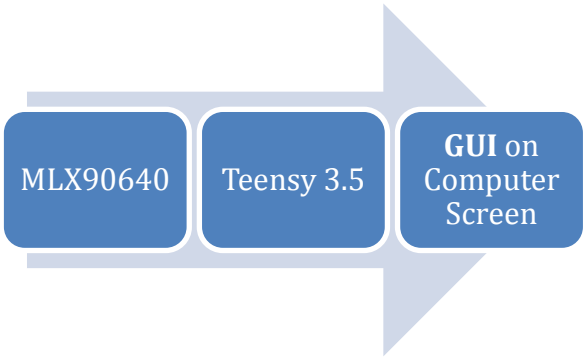

Figure 1. Data Processing

This figure shows the flow of data from the thermal sensor which is the melexis90640 going to the Teensy 3.5 which will contains the program for array arrangement of the temperature reading per pixel. The array of temperature readings will be mapped through python programming and the Graphical User Interface that will contain the thermograph will be developed using tkinter library of python.

A. Temperature Detection using MLX 90640

The temperature reading per pixel is arranged into arrays in which these arrays are then mapped into colors specifically RGB per pixel depending on the temperature reading. In the Thermal Cam interface in the figure below the colors and its respective temperature readings are displayed. The coding was done also through python with the help of the cv2 or computer vision library.

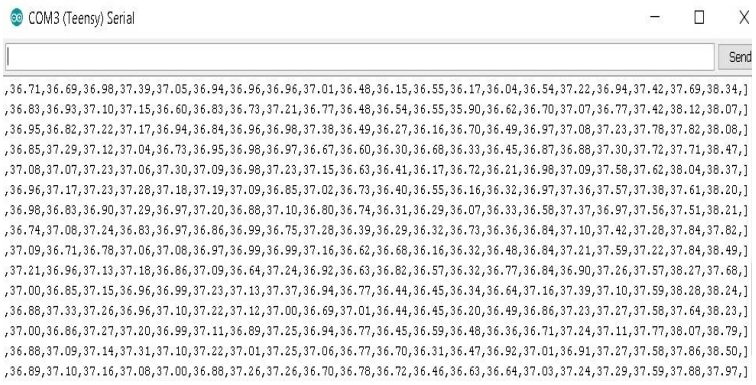

FIGURE 2. SERIAL MONITOR OF MLX90640

Figure 1 shows the serial port of the thermal camera which has an output of arrays of temperature readings per pixel. The array that the serial monitor produces will be used to plot the thermograph using Processing IDE. From there, the thermal image will be produced together with color combinations set to identify the temperature of the object the camera is pointed to. The proponents used a microcontroller compatible to the thermal camera which is the Teensy 3.5. The program for the serial monitor is uploaded to the Teensy 3.5.

B. Thermograph of MLX90640

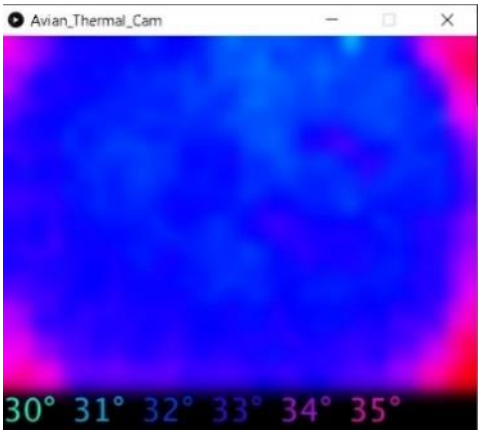

FIGURE 3. 32X24 PIXEL THERMOGRAPH

This figure shows the initial interface of the thermal imaging system, the numbers below are legends intended for color interpretation of the thermal image, this thermograph is plotted through the use of Processing IDE software which is the default library for the MLX90640 developed by the manufacturer.

C. *Flowchart of Temperature Reading to GUI*

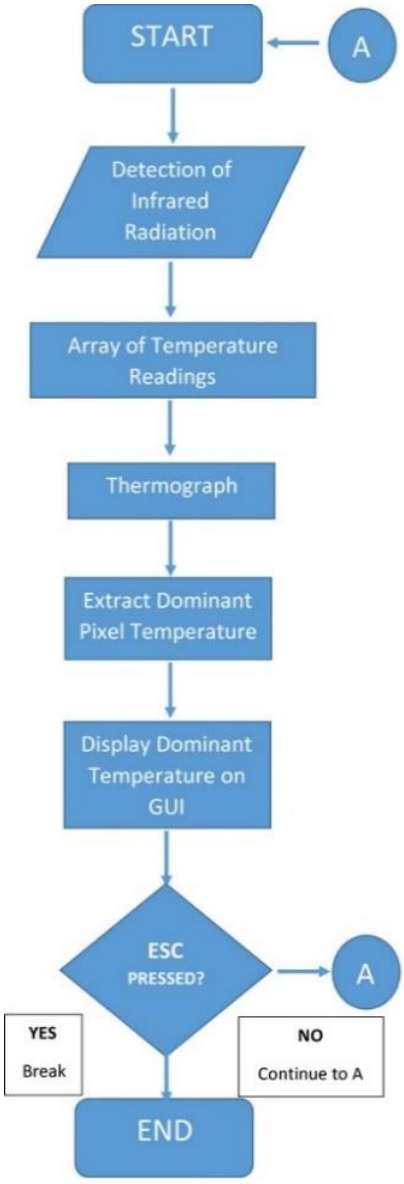

FIGURE 4. FLOWCHART OF TEMPERATURE EXTRACTION

This figure shows the temperature detection flow which starts when an infrared radiation has been sensed after turning on the melexis90640 thermal camera. The thermal camera will output an array of temperature readings which will be used to plot the thermograph. Using statistics mode in python, the dominant temperature can be extracted and then using tkinter library, the GUI will be displayed containing the thermograph and the dominant temperature. This process continues while the device is turned on.

D. *Thermograph Testing of MLX90640*

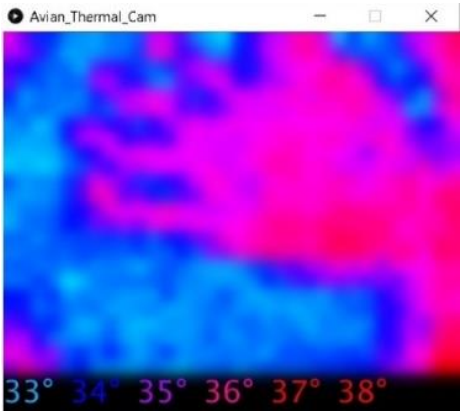

FIGURE 5. 32X24 PIXEL SAMPLE THERMOGRAPH

This figure shows a thermograph or a thermal image of a hand with an 8.4x7.8cm dimension and is 10cm away from the thermal camera. From the legend below the thermal image, it can be seen that the temperature can be interpreted to be between 36 to 37 degrees Celsius. This is a 32x24 pixel thermograph from the Melexis90640 which the proponents used as a thermal camera.

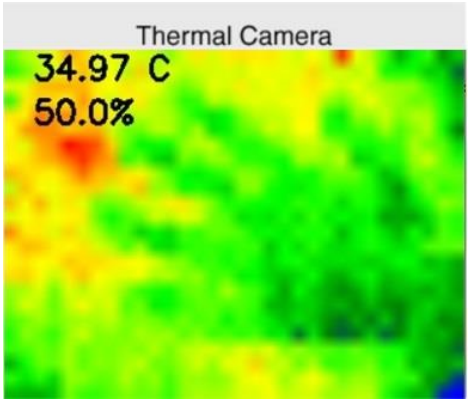

FIGURE 6. 32X24 PIXEL THERMOGRAPH USING DESIGNED GUI WITH TEMPERATURE EXTRACTION

This figure shows the designed GUI of the study for temperature extraction using the melexis90640. As observed, the default interface for the Melexis library coded in Arduino and output graph on Processing IDE only has legends to determine temperature whilst the interface designed in the study using python displays the temperature dominant from the pixels to be able to determine the object's temperature that is in the front of the thermal camera.

IV. RESULT AND DISCUSSION

The Melexis 90640 infrared camera module was used for temperature detection. It captures images based on the intensity of the infrared radiation being reflected. The photos taken in the camera are then converted to a grayscale in order to simplify the calculations, from which the device scaled the values that represent the image pixels from 0-255 to 0-100 as a temperature representation in Celsius for an optimum sensitivity that is good enough without needing too many

calculations. It should be noted that the distance of the target from the thermal camera is directly related to the accuracy and sensitivity of the temperature measurement performance.

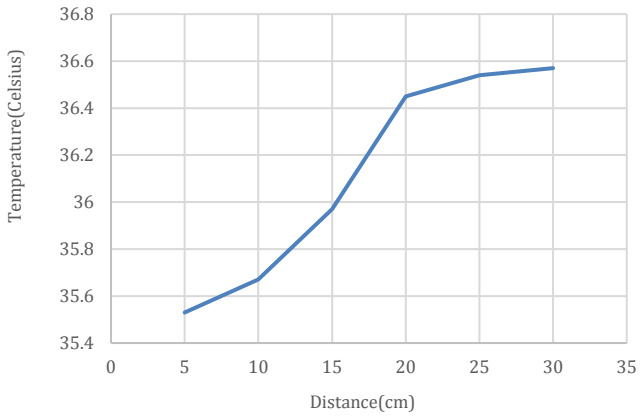

FIGURE 7. THERMAL CAMERA SENSITIVITY

The figure shows the temperature sensitivity of the thermal camera from the temperature vs. distance plot, which measures the temperature shift as the thermal camera moves farther away from the target. The absolute temperature used in the test was measured by a touch tool called a thermometer with a value of 35.2 degrees Celsius.

Distance(cm)	MLX90640 Temperature(°C)	Thermometer Temperature(°C)
5	35.53	35.2
10	35.67	35.2
15	35.97	35.2
20	36.45	35.2
25	36.54	35.2
30	36.57	35.2

Figure 8. Table for Distance vs. Temperature

This figure shows the tabular data for the different distances and its temperature reading. The thermometer is constant which is used as a comparison for contact and non-contact thermal sensors. It can be observed that the temperature reading increases as the distance of the MLX90640 from the object increases. This is because of the resolution of the thermal camera. Tabulating the data is important for future researchers to specifically identify where a certain data belongs to and evaluate data integrity from experiments conducted by the proponents of this study. This can also be used to compare to other contact and non - contact temperature sensors. All the temperature readings are subject to a 32°C surrounding temperature.

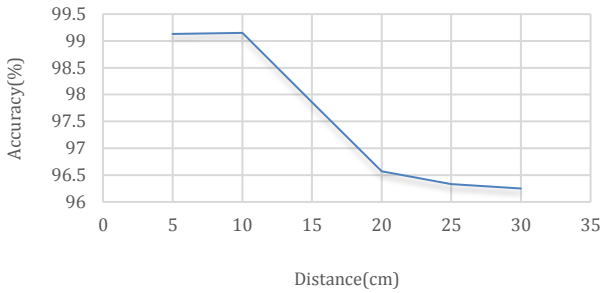

FIGURE 9. THERMAL CAMERA ACCURACY

As seen from the graph, the accuracy is at its best at a distance of 10 cm from the 8.5x7.8 cm object. This makes a distance of 10 cm the most effective. The sensitivity decreases slowly as the distance between the thermal camera and the target increases. The resolution of the thermal camera affects its accuracy at longer distances that is why implementing thermal cameras with a higher resolution will give much better results at longer distances but will also come at a higher cost. For its performance, the MLX90640 gives accurate results at shorter distances but this will also depend on the size of the object.

Distance(cm)	Accuracy MLX90640 (%)
5	99.13
10	99.15
15	97.86
20	96.57
25	96.33
30	96.25

Figure 10. Table for Distance vs. Accuracy

This figure shows the tabular data for the different distances and the corresponding accuracy of the temperature reading from the MLX90640 far infrared sensor. It can be seen that the relationship between the distance and accuracy is inversely proportional. This is because the resolution of the MLX90640 is 32x24 pixels. This means that the farther the object from the far infrared sensor, the lesser the accuracy of the temperature reading will be.

V. CONCLUSION

The Melexis90640 was used as a far infrared sensor that can sense temperature through infrared radiations from objects that emit heat to the surrounding. Using Melexis90640 as thermal camera, a Graphical User Interface was developed to output the thermograph which is a plot of arrays from the thermal camera. Using python the dominant temperature was extracted and used to measure the temperature of an 8.5x7.8cm object. The temperature measurements was compared to that of a touch tool temperature sensor called thermometer.

VI. Recommendations

The proponents recommend that the future works focus on a more updated far infrared sensor commercially available. The technology for far infrared detection is still in progress in developing cheaper and much more accurate solutions to contactless temperature detection. Higher resolution thermal cameras will give better results in terms of accuracy per distance.

ACKNOWLEDGMENT

The authors wish to convey their full appreciation and gratitude to BLI Farms and YCP Farms, Inc. for their time and consideration and to the Technological University of the Philippines-Manila for its important contribution to the project.

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