2023「中技社科技獎學金」

2023 CTCI Foundation Science and Technology Scholarship

創意獎學金

Innovation Scholarship

熱影智能-以樹莓派建立具人臉口罩識別與精準溫度校正之紅外線熱像儀系統

Infrared Thermal Imager System with Mask Recognition and Temperature Calibration built on Raspberry Pi

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Abstract

Measurement accuracy is important for thermal imaging technology take body temperature. Thermal imaging cameras on the market are generally expensive, and there are problems such as insufficient lens accuracy and limited measurement distance, which make it difficult to accurately take body temperature. This study thermal imaging system takes body temperature built on Raspberry Pi 4 and FLIR Lepton 3.5, and proposes calibration methods of reference temperature source calibration and compensate temperature with object detection model. After reference temperature source interpolation calibration, the accuracy of thermal imaging cameras from ±5°C to within ±0.5°C. In addition, after compensate temperature formula with object detection model, the rate of change can be kept within ±0.5°C with measurement range of 5 meters.

The object detection model Pi-fast run by the thermal imager is improved based on YOLO-Fastest as a reference framework. In terms of training set and test set performance, mAP are 99.64% and 93.18%, F1 score are 0.94 and 0.87, IoU are 78.07% and 65.98%. Thermal imaging system takes body temperature on the Raspberry Pi 4 with only 1.5GHz ARM CPU, it can operation stably at about 7.32FPS, which is 0.74FPS faster than YOLO-Fastest.

Innovation Focus

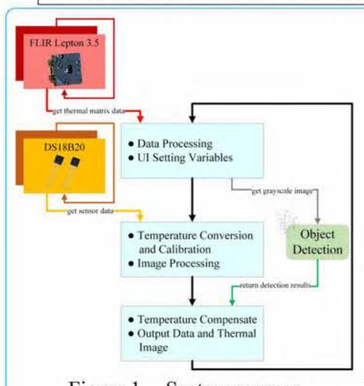


Figure 1. System process

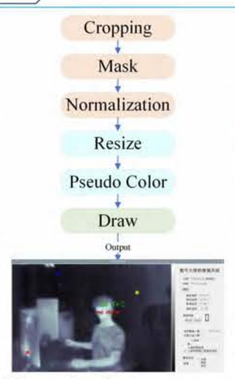


Figure 2. Image process

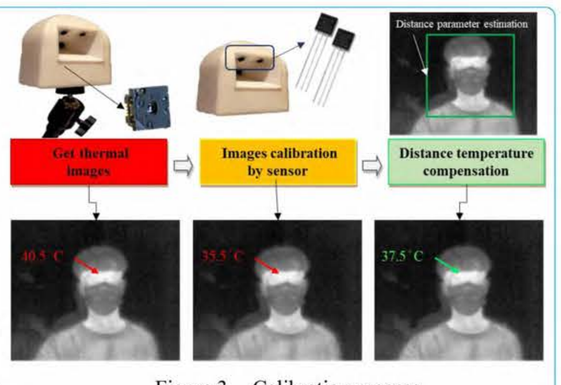


Figure 3. Calibration process

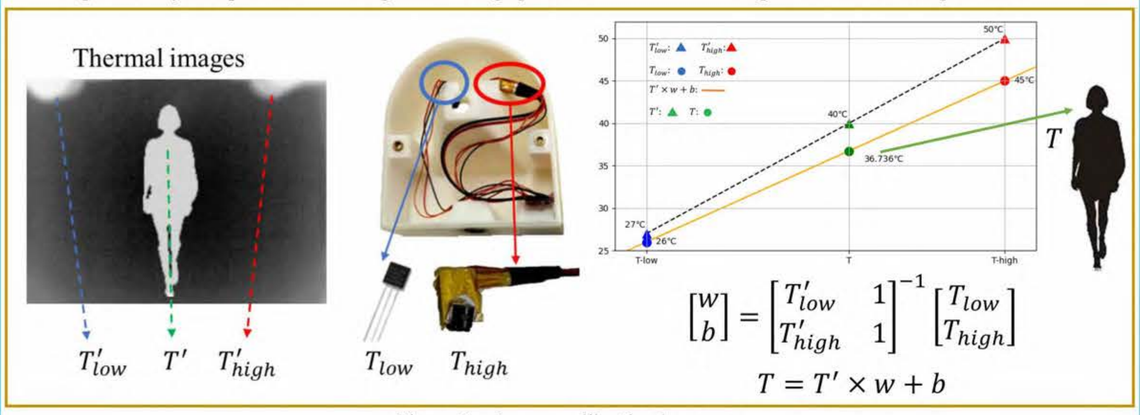
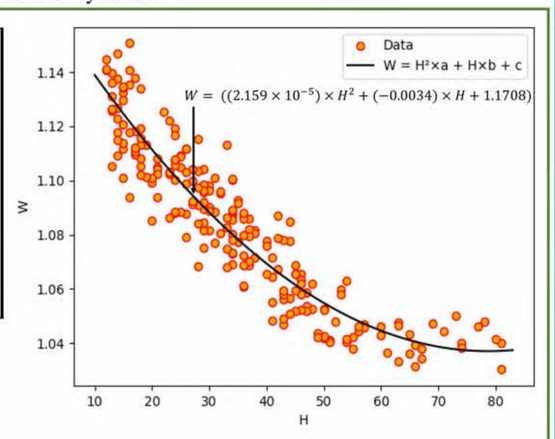


Figure 4. Images calibration by sensor

$$\begin{bmatrix} c \\ b \\ a \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^{220} 1 & \sum_{i=1}^{220} x_i & \sum_{i=1}^{220} x_i^2 \\ \sum_{i=1}^{220} x_i & \sum_{i=1}^{220} x_i^2 & \sum_{i=1}^{220} x_i^3 \\ \sum_{i=1}^{220} x_i^2 & \sum_{i=1}^{220} x_i^3 & \sum_{i=1}^{220} x_i^4 \end{bmatrix}^{-1} \begin{bmatrix} \sum_{i=1}^{220} (y_i) \\ \sum_{i=1}^{220} (y_i x_i) \\ \sum_{i=1}^{220} (y_i x_i^2) \end{bmatrix}$$

$$\begin{bmatrix} c \\ b \\ a \end{bmatrix} = \begin{bmatrix} 1.1708 \\ -0.0034 \\ 2.159 \times 10^{-5} \end{bmatrix}$$



compensate temperature: $T = T' \times W$

Figure 5. Distance temperature compensation

Innovation Results

Table 1. Performance comparison of YOLO-Fastest vs Pi-fast

Model	BFlops	FPS	Preson-AP	No_mask-AP	F1 score	IoU
YOLO-Fastest	0.368	6.58	99.88%	98.53%	0.92	74.28%
Pi-fast	0.351	7.32	99.99%	99.30%	0.94	78.07%

Table 2. Accuracy by distance temperature compensation

Test	Before	After
1	±1.31°C	±0.30°C
2	±1.10°C	±0.31°C
3	±0.96°C	±0.39°C
4	±1.35°C	±0.43°C
5	±1.08°C	±0.42°C
6	±1.14°C	±0.33°C
7	±1.37°C	±0.44°C
8	±2.25°C	±0.43°C

Figure 6. Effect of distance temperature compensation

Figure 7. System operation screen and detection results

Innovation Testimonials

Firstly, I would like to express my gratitude to CTCI Foundation for commending the student's research. This honor is a significant milestone for me, inspiring determination to move forward. I aspire to contribute to the advancement of technology in Taiwan in the future. The technology addresses critical issues in the thermal imager system market, with the anticipation that the research results will deliver substantial and positive impacts to society.