Grid-Eye Characteristics

Panasonic Automotive & Industrial Systems Europe
Typical measurement accuracy vs. ambient temperature & temperature of measurement object

Condition:
frame rate: 1fps
moving average: Yes
Characteristics after Calibration of the Pixels

Typical measurement accuracy vs. ambient temperature & temperature of measurement object after calibration of the pixels.

The calibration just can be done by customer. If customer adjust each pixel's output within the software the accuracy between the pixels can be increased like shown in the diagram.

Example:
All pixels does see a heat source of 35.0 °C. Customer can adjust the output to become 35.0 °C for all pixels.

Before
 Pixel 1 ; 34.5 °C
 Pixel 2 ; 35.25 °C
 Pixel 3 ; 36.75 °C ...

Adjustment by software
 Pixel 1 ; +0.5 °C
 Pixel 2 ; -0.25 °C
 Pixel 3 ; -1.75 °C ...

After
 Pixel 1 ; 35.0 °C
 Pixel 2 ; 35.0 °C
 Pixel 3 ; 35.0 °C
Measurement of a high temperature object

Standard type Grid-EYE (AMG8852, low gain type) saturates when object temperature exceeds 170 degreeC. By lowering gain amplification in IC, Grid-EYE (custom type) can detect the object which is higher than 200 degreeC. When gain amplification is set up low, a noise increases relatively, and the accuracy gets worse. The accuracy and object temperature range expansion have a relation of trade-off.

*Ambient temperature is 25 degC
Moving Average Register

Average Register
Register for setting moving average Output Mode.

bit5: MAMOD
1: Twice moving average Output Mode

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<th>register</th>
<th>R/W</th>
<th>bit7</th>
<th>bit6</th>
<th>bit5</th>
<th>bit4</th>
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Noise will decrease to $1/\sqrt{2}$ by using moving average function.

$$V_o(t) = \frac{\{V_{out}(t) + V_{out}(t-1)\}}{2}$$

$V_{out}(t)$  output data

$V_o(t-1)$  moving average data
How Moving Average Works

10f/s data

Moving average for 10 f/s

1f/s data

Moving average for 1 f/s
Characteristics

Example pixel size vs. distance vs. object size

Typ. viewing angle 7.5°
Pls refer to slide “Viewing Angle of Each Pixel”

3m
39cm

5m
65cm

7.5m
97.5cm

26cm

26cm

[1m]

[2m]

[3m]

[5m]

[7.5m]

The object size covers just 70% of the pixel

Ambient temperature = 25°C
Temperature of measurement object = 34°C
\( \Delta T \) = 9°C
\( \Delta T \times 70\% \) (@5m) = 6.3°C
→ Measured value = 25°C + 6.3°C = 31.3°C
Thermal Human Detection

Center of heat

Move or not?

Y
Detect as human

Detect as Object

N

Once it detects as Human, Even when he stops, it continues to detect as human
⇒Unmovable Detection possible

When the human moves,,,

“Heater” moves

Heater does not move

Continues to detect, even human does not move
Flowchart Human Detection with Background Subtraction

[Initial execution: Human detection / Getting background temperature] (Execute only when software booting up)

1. Calculate the difference btw. (B) and "average temperature of 64 pixels" – (C)
2. Compare (C) with 1.0°C threshold to judge a human presence

(C) >= +1.0°C
(C) < +1.0°C

[Update background data] (execute at every frame)

Pixel which is judged as "non-human pixel"

Use “current temperature value: (X)” for updating background data

Updating background data using data (X) by 1/128 %

Calculation Process
Previous background data × 127/128 + (X) × 1/128 = new background data

Pixel which is judged as "human pixel"

Calculate “average temperature value of all non-human pixels” (Y), and use it for updating background data

Updating background data using data (Y) by 1/128 %

Calculation Process
Previous background data × 127/128 + (Y) × 1/128 = new background data

Measure current temperature
20 frames - (A)

Calculate the mean of (A) for each pixel – (B)

[human detection judgment]

Result: Human is in the pixel
Get current temperature (10 fps) (D)

1. Calculation:
   (D) – (B): background temperature – (E)
2. Judgment:
   Compare (E) to 0.75 ºC
   (=threshold value to judge human presence)

(F) >= 0.75 ºC
(F) < 0.75 ºC

Result: Human is in the pixel
Go to ①
Count number of “Human pixel” by the 4-nearest neighbor algorithm

>= 2 pixels
< 2 pixels

Result: Human is in the pixel
Go to ①
Result: Human is NOT in the pixel
Go to ②

Result: Human is NOT in the pixel
Get current temperature (10 fps) (D)

1. Calculation:
   (D) – (B): background temperature – (G)
2. Judgment:
   Compare (G) to 1.0 ºC
   (=threshold value to judge human presence)

(G) >= 1.0 ºC
(G) < 1.0 ºC

Result: Human is in the pixel
Go to ①
Count number of “Human pixel” by the 4-nearest neighbor algorithm

>= 2 pixels
< 2 pixels

Result: Human is in the pixel
Go to ①
Result: Human is NOT in the pixel
Go to ②

Result: Human is NOT in the pixel
Go to ②
(3) Typical characteristics: Each pixel’s viewing central angle
* Regarding of Pixel Array, please refer to 4-7(1).

Sensor’s optical center (the origin of graph below) gap
: within Typ. ±5.6° (Both of horizontal and vertical directions)
Typical characteristics: Each pixel’s viewing angle (half angle)

Central 4 pixels (Pixel No. 28, 29, 36, 37) viewing angle (half angle):
- horizontal direction: Typ. 7.7°
- vertical direction: Typ. 8°

Each pixel’s horizontal viewing angle
Each pixel’s vertical viewing angle
## Detailed viewing angle data „Horizontal“

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Detailed viewing angle data "Horizontal"
Detailed viewing angle data „Vertical“

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![Graphs showing viewing angle data for different pixels](image)
Detailed viewing angle data „Vertical“

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Tolerance of FOV

=> Tolerance of FOV is approx. 3°. (Typ.60 ± 3°)

Detection area of each pixels (Typical data)

The case of narrow angle

The case of wide angle

(Typ.60°)

(Typ.57°)

(Typ.63°)
Optical center gap

=> Optical center gap is within typ.5.6°.

Detection area of each pixels (Typical data)
Field of view concept, if Grid-EYE is mounted like following.

→ No rectangular matrix

Result: Trapezoidal shape
• The *emissivity* of a material (usually written $\varepsilon$ or $e$) is the relative ability of its surface to emit energy by radiation.

• It is the ratio of energy radiated by a particular material to energy radiated by a black body at the same temperature.

• A true black body would have an $\varepsilon = 1$ while any real object would have $\varepsilon < 1$. Emissivity is a dimensionless quantity.

$\rightarrow$ Grid-EYE's is adjusted to an $\varepsilon \geq 0.93$
How to get data of 64 pixels

- Master (Micro, PC, etc.)
- Slave (Grid-EYE)

Diagram showing the process of data transmission, including sensor address, register address, data transfer, and stop conditions.
-1. Master send “Start condition” to Grid-EYE
   - SCL : High
   - SDA : Low

-2. Master send “Sensor address” and “Write” to Grid-EYE on SDA
   - SDA : 11010000 or 11010010
   - Sensor address Write Sensor address Write

-3. Master receive “ACK” from Grid-EYE on SDA

-4. Master send “Register address” to Grid-EYE on SDA
   - SDA : 0x80 ex. Lower Level Register of pixel 1

-5. Master receive “ACK” from Grid-EYE on SDA

-6. Master send “Start condition” to Grid-EYE on SDA
   - SCL : High
   - SDA : Low

-7. Master send “Sensor address” and “Read” to Grid-EYE on SDA
   - SDA : 11010001 or 11010011
   - Sensor address Read Sensor address Read

-8. Master receive “ACK” from Grid-EYE

-9. Master receive data of Lower Level Byte of pixel 1

-10. Master send “ACK” on SDA

-11. Master receive data of Upper Level Byte of pixel 1

-12. Master send “ACK” on SDA

   Repetition of 11, 12

-13. Master receive data of Upper Level Byte of pixel 64

-14. Master send “NOACK” on SDA

-15. Master send “Stop condition”
   - SCL : High
   - SDA : High
Is it possible to use an additional lens to increase the FOV?

An infrared image is formed on the sensor chip through the Silicon lens. In the case of Grid-EYE, sensor chip is placed on the focal point. So only parallel infrared beam can be formed.

If an additional lens is placed in front of the sensor, focal point is changed. Then infrared image is out of focus.
Wider viewing angle…..

The nearer focal point means wider viewing angle. In this case, Grid-EYE package height and lens shape need to be changed.

Is it possible to use an additional lens to increase the FOV?