Smart Thermal Sensing Creates Machine Intelligent

PixArt is bringing Smart Thermal Sensing, an All-in-1 solution with low-power intelligent object detection capabilities fusion with the far infrared (FIR) and imaging sensor to create more machine intelligence. The far-infrared sensors can do more than just temperature sense when combined with the input from an image sensor for intelligent object detection processing to detect the presence and motion of people, animals, or objects that are stationary or moving. The intelligence on Smart Thermal Sensing in machines or gadgets is giving rise to a better home living experience and bringing the next revolution to various industries such as manufacturing, agriculture, construction, building management, etc.

PIXART'S FAR INFRARED PRODUCTS

Figure 1 shows the exceptional features of PixArt's Far Infrared series. PixArt's FIR SoC sensors not only detect heat radiation sources but can be customized to compensate for temperature variation according to the targeted application to boost accuracy. With the highly integrated SoC, PixArt's FIR product writes the calibrated temperature parameter value of the detected object into its memory, which can be directly read and converted to temperature for specific applications. Such a design is conducive to simplifying the subsequent MCU system polling process, offload the MCU resources for power saving.

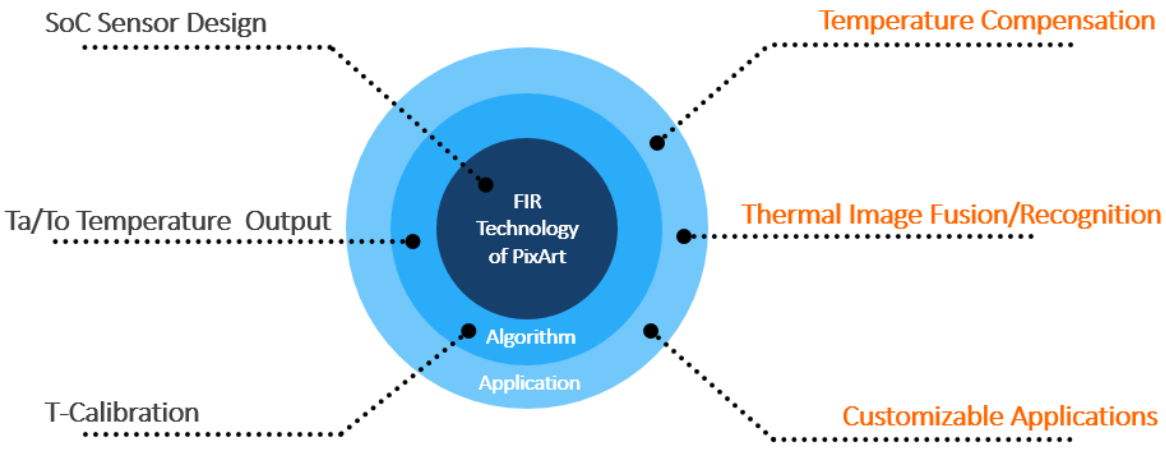

Figure 1. Features of PixArt's FIR Product Series

PixArt's FIR sensor product lineup includes the single-point FIR sensor and FIR sensor array to cater to diversified applications. These FIR sensors are great for non-contact sensing to directly output calibrated and readable temperature values with a faster thermal response (<0.5s) than the conventional thermocouple technology. PixArt is also taking its competencies in IC and package design for the scalability and reliability of SoC with low-power architecture to strengthen the values in the portable Smart system. Our FIR sensor products are in SMD-type CLCC package to facilitate the ease of integration into customer's system applications. Compared to the similar FIR sensors in the market, the current consumption of PixArt's FIR products is 50% less, thus well fit for battery-powered systems. The built-in self-calibrated algorithm supports immediate data processing to output digital temperature values via the I2C interface – all without an external high-end MCU.

23.65	23.07	24.06	24.19	24.97	25.03	24.54	23.59
23.52	24.24	24.32	24.58	25.18	24.64	25.06	23.81
24.47	24.62	24.75	28.32	30.37	26.69	25.15	24.69
23.45	23.53	24.65	29.27	29.48	26.38	24.95	26.67
23.8	22.9	24.1	28.23	28.04	24.5	21.77	23.49
24.83	25.28	25.76	29.95	30.28	25.52	23.16	23.37
24.58	28.28	28.27	28.45	30.05	28.3	28.37	23.52
30.96	30.56	28.43	29.04	27.45	27.51	27.95	30.64

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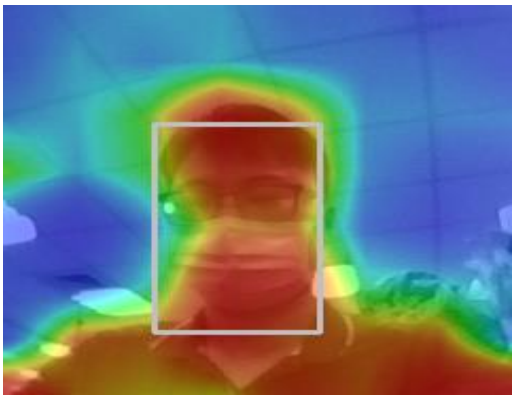
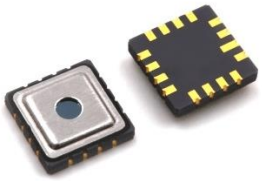


Figure 2. A low-resolution thermal image from the fusion of PAF9701C1 FIR Sensor with Imaging Sensor

Part Number	PAM9611CE	PAF9701C1
Package Size	CLCC : 6 x 6 x 1.75 mm^3 	CLCC : 8 x 8 x 3.75 mm^3 
Sensor Type	Single-Point FIR	64-pixel Sensor Array FIR
Purpose	Single temperature output	Array temperature sensing for sensing of motion and presence
Temperature Sensing Range	-20°C to 150°C	-20°C to 380°C
Accuracy	±0.5°C @ T_{object}/$T_{ambient}$: 10 to 45°C	±1°C @ T_{object}: 30 to 40°C ($T_{ambient}$: 15 to 40°C)
Interface	I2C	I2C
Operating Current	I60μA @ 3.3V	2.5mA @ 3.3V
Potential Application	▪ High accuracy temperature detection ▪ Short range (<100mm) sensing ▪ Personal temperature monitoring: 1. Forehead thermometer 2. Wearables	▪ Temperature distribution ▪ Long range and wide space sensing ▪ Smart home gadget: 1. Kitchen equipment 2. Presence/Motion sensing 3. Smart forehead thermal imaging

UNLEASHING THE SMARTY OF THERMAL IMAGING

1. Smart Forehead Temperature Sensing

The incidence of the COVID-19 pandemic has made a new norm in measuring the body or forehead temperature while entering indoor premises. A thermal detection device could be made smart with senses brought by PixArt's FIR sensor (PAF9701C1), a global shutter image sensor (PAG7920LT), and low-power intelligent object detection SoC (PAG7681LS) in a single system to monitor the body temperature of a person entering the indoor space. These senses empower the machine intelligence in the device.

- To quickly detect human presence and locate the face.
- Identify the forehead position to measure the temperature
- Automatically display and store the temperature reading

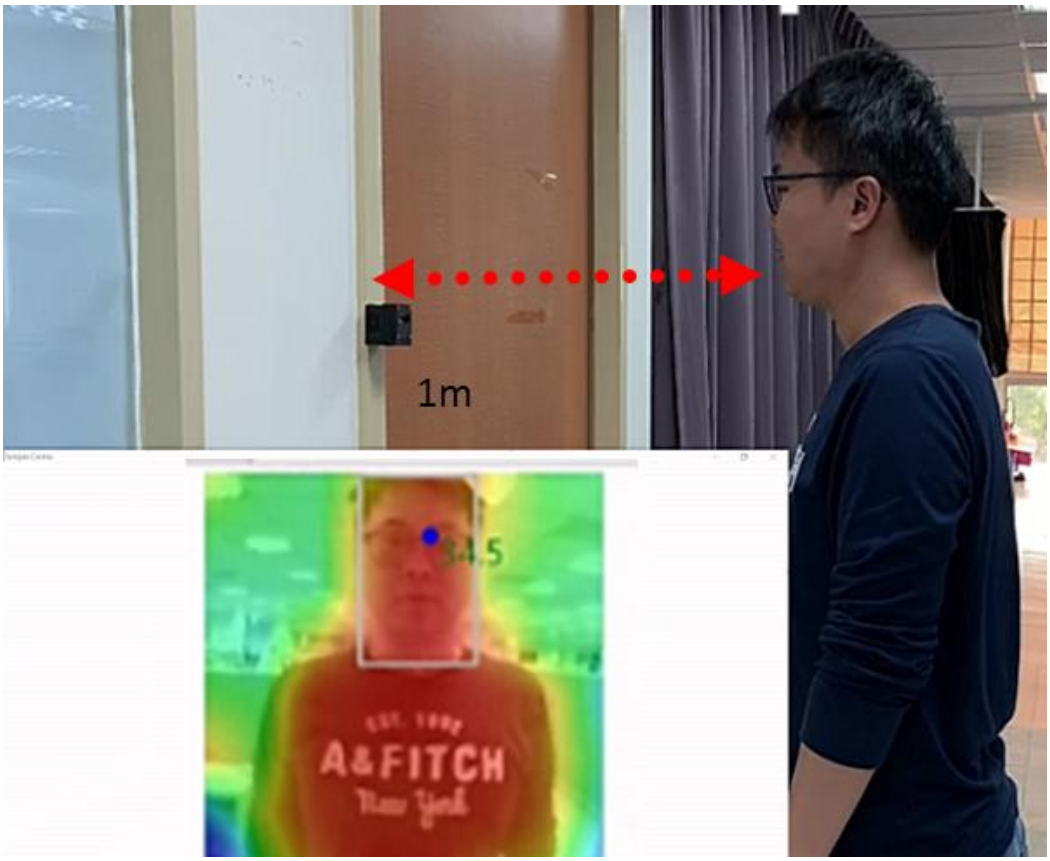


Figure 3. An Example of Smart Forehead Temperature Measurement

While PAG7920LT and PAG7681LS are the intelligent essences to the recognition of humans, faces, and other objects such as face masks, the Smart algorithm maps the identified face data points to the temperature distribution data detected by PAF9701C1 FIR Sensor Array to compute the compensated temperature values. Based on the test scenario under uniform background in the detection range of 50cm, the evaluation board of Smart Thermal Sensing can achieve high accuracy temperature sensing of ± 0.5°C at the human body temperature range from 36°C to 38°C. Note that the accuracy may be affected by factors such as forehead size, interference from hair, background condition, and sensing distance.

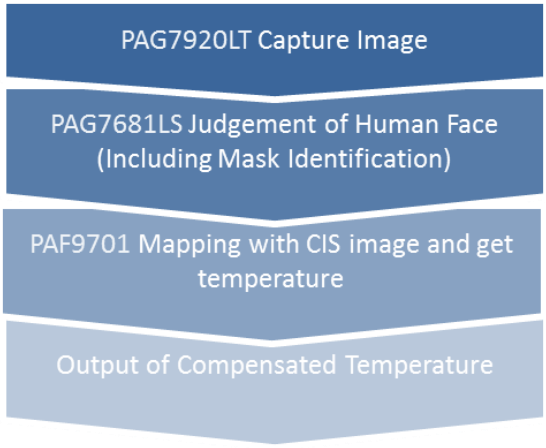


Figure 4. How a Smart Forehead Temperature Detection Works

2. Smart Cooking

Traditionally, if we want to know the temperature of cooking food or the cooking appliances, the contact-type of temperature sensors is most commonly used as a cooking thermometer. The knotty measurement set-up and slow temperature response in a couple of seconds make this kind of conventional cooking thermometer not easily mastered by an unexperienced cook. With the resolution of 64 pixels in the PixArt's FIR sensor array (PAF9701C1), the temperature distribution of the food in the frying pan, pot, or oven within the sensor's field of view is measured and directly outputs the calibrated temperature as a digital number accurately. Combining the temperature from PAF9701C1 and a low-resolution thermal image from an imaging sensor, the fusion output data can recognize the detected food object with the instant temperature reading to be further processed by the application firmware or software for the feedback control to automate the cooking power. This kind of intelligent temperature control method is also good for power or energy saving as well as reducing cooking time.

As illustrated in Figures 5, 6, and 7, the temperature of the respective hot pan, and uncooked or cooked food is clearly shown. One can easily make a judgement if the food is well cooked by knowing the overall temperature of the food, including the inner portion, which is not by the surface temperature of the food. Using this type of active detection method in food preparation, cooking recipes can be personalized to make the taste more personalized and delicious. This is the transformation of next-gen Smart and AIoT cooking appliances, with which dummies can cook like chefs.

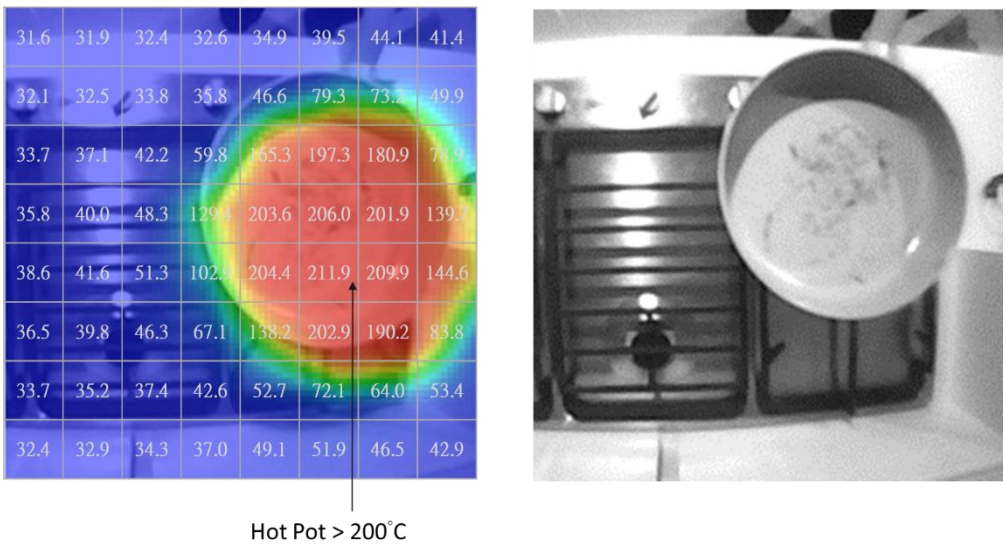


Figure 5. Smart Temperature Detection of a Hot Pan on the Stove

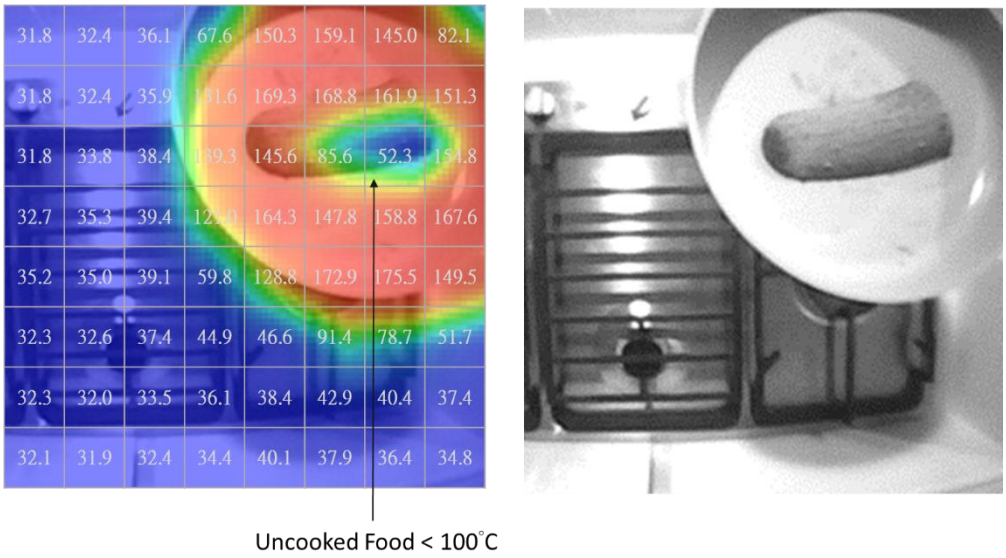


Figure 6. Low-temp Uncooked Food on a Hot Pan on the Stove

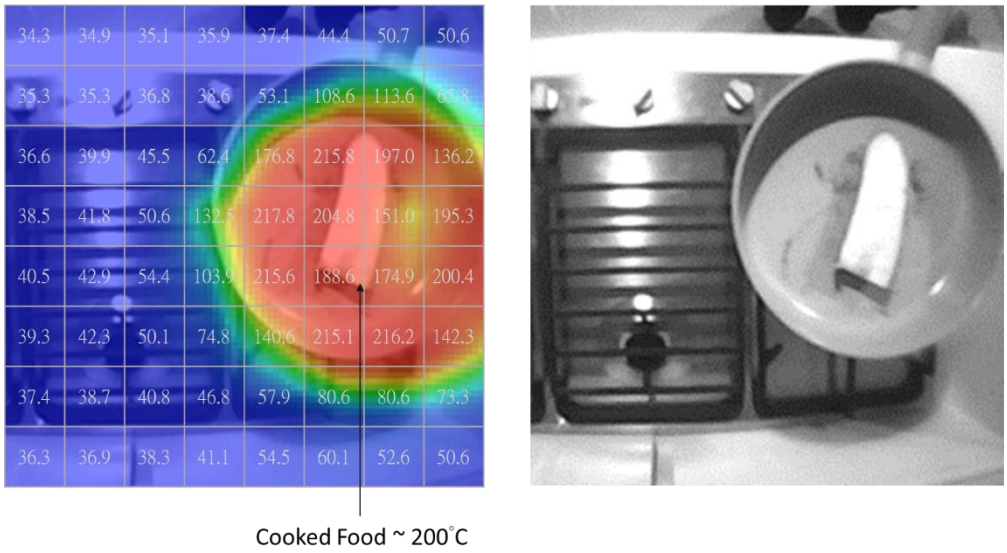


Figure 7. Cooked Food on a Hot Pan on the Stove

3. Indoor Occupancy Sensing for Human Detection

The call for indoor occupancy sensing is getting the heat along with the rapid growth of smart building facilities and management. The occupancy devices have been moving towards the trend of AIoT. A smart occupancy sensing system is not only for the detection of if space is occupied, but it can also detect the presence of humans providing convenience and potential security aid. When in the form of AIoT devices, the occupancy sensing system needs to detect any environmental changes and respond promptly. For example, the indoor human presence detection demand comes from private offices, conference rooms, classrooms, storage rooms, restaurants, homes, public building areas, etc. The device needs to detect whether anyone is in the room to automatically control the lighting, air-conditioner, audio/video conference system, or curtains.

In addition to the basics of human presence detection, a smarter system can know the crowd condition in a confined space to auto-regulate the air-conditioning by the temperature and airflow. The fusion of PixArt's FIR array sensor and CMOS image sensor with the intelligent object detection SoC is the perfect fit for an on-the-go smart occupancy system. The targeted object can be changed to human beings or any living creature that generates body heat by flashing the new pre-trained feature file in the simplified machine learning database. Based on the thermal information, it can differentiate a living person from a fake one (i.e. a humanoid stand or portrait on the wall, etc). Thanks to the human position information provided by PAG7681LS, it can accurately locate the human position and rule out other unwanted heat sources, such as heated windows, running machines, and lighting sources.

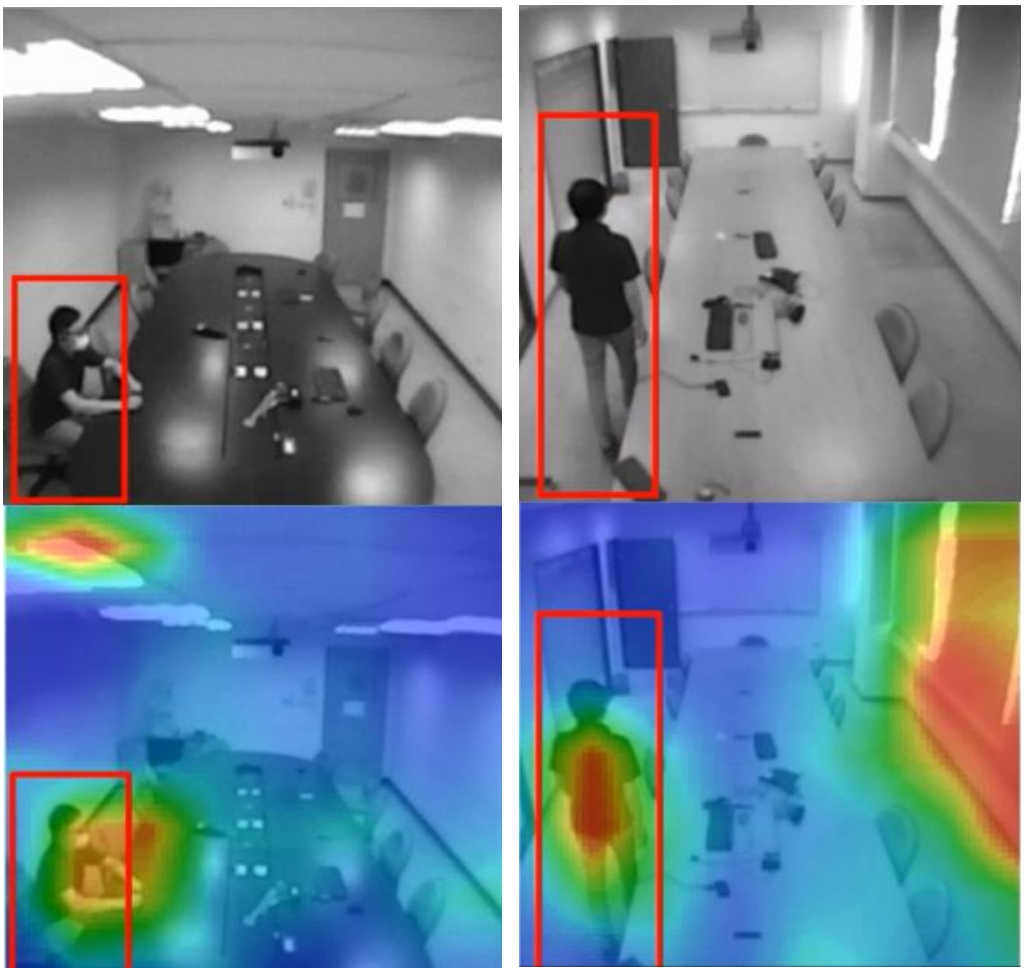


Figure 8. Fusion of FIR Sensor Array and Image Sensor in Occupancy Sensing for Human detection

DISCOVERIES WITH THE HIGHLY INTEGRATED EVALUATION BOARD

PixArt provides a highly integrated evaluation board (PAM9901) that is easy to integrate and offers fast verification and system prototype. A PAF9701 (FOV (H, V) = 60°), a PAG7920LT image sensor with lens set (FOV (H) = 72.5°), and a PAG7681LS SoC chip combine to provide 240 x 240 resolution to the smart thermal imaging applications such as face detection, temperature result computation, and control setup capabilities. For object detection other than human/face, you can update the pre-trained feature file of the targeted object in the flash memory. PixArt provides a complete reference design guide with software libraries for the evaluation board as design support tools.

Figure 9. PAM9901 Evaluation Board

a. PAF9701C1 FIR sensor with heat sink

b. FPC module of PAG7920LT Image Sensor

c. DSP chipset of PAG7681LS

d. External FLASH memory of PAG7681LS

e. 3.3V to 1.8V LDO

f. Reset button of PAG7681LS

g. 5-pin Reserved Host Control Interface

h. 30-pin Reserved Host Control Interface

BEYOND PARTNERSHIP WITH PIXART

The products' competitive advantages of low power consumption, small form factor, ease of fusion integration, and cost-effective architecture offered by PixArt's products and solutions are the catalyst for the innovation of more Smart Thermal Imaging devices to embrace the machine intelligent domain. Through PixArt's hardware IC design and strong built-in algorithms in SoC form, which are aimed at faster response time to AIoT devices, we are here to exclusively collaborate as partners, delivering a device with great user experience as well as making the design and development feel almost like a breeze.

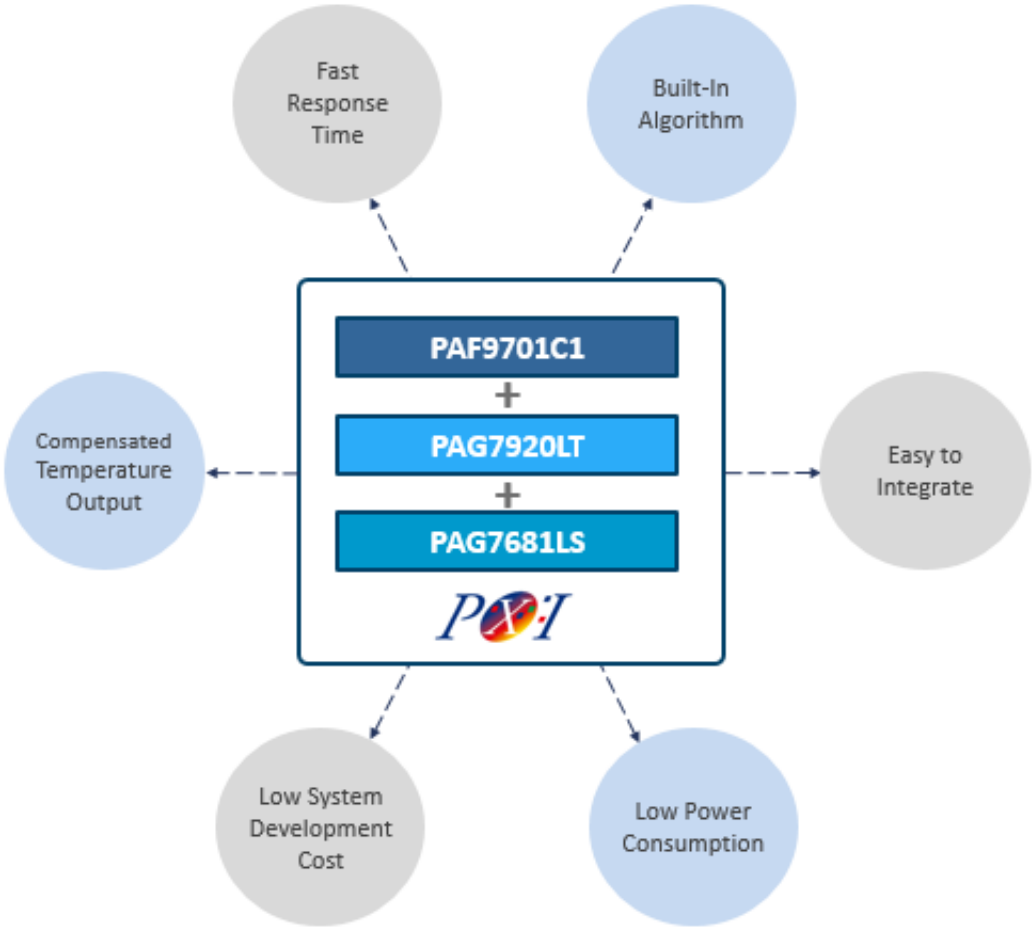


Figure 10. The Competitive Advantages of PixArt's Smart Thermal Imaging Solution

About PAG7920LT

PAG7920LT is an ultra-low power and monochrome QVGA Global Shutter image sensor for machine vision.

About PAG7681LS

This SoC is an ultra-low-power image processing chip with PixArt's proprietary algorithms and simplified machine learning for the detection of objects and motions. It can be applied to a variety of applications, including the detection of human faces and bodies, as well as report their positions.

Related articles: New thermal detection technology serves as a powerful, automated and full-integrated solution to a wide variety of applications

For more information, please get in touch with your PixArt local sales or contact us at https://www.pixart.com.

Ordering Information for Related Products

Part Number	Description
PAM9611CE	Single-Point Far Infrared Sensor
PAF9701C1	64-pixel Sensor Array Far Infrared Sensor
PAG7920LT	Global Shutter Image Sensor
PAG7681LS	Low-Power Intelligent Object Detection Processor

RoHS compliant