Application Report

PHYTEC Messtechnik GmbH

Robert-Koch-Str. 39, 55129 Mainz
Telefon: (06131) 9221-0
Telefax: (06131) 9221-33

Demo Systems for Contactless
Body Temperature Testing with Inexpensive
Thermal Imaging Sensors

Products:

- **phyCAM Thermal Imagers VM-050, VM-051**
- **Thermal Imaging Kit phyBOARD-Nunki (KPB-02301-Video-L03)**
- **7“ Display Kit (KPEB-AV-02)**

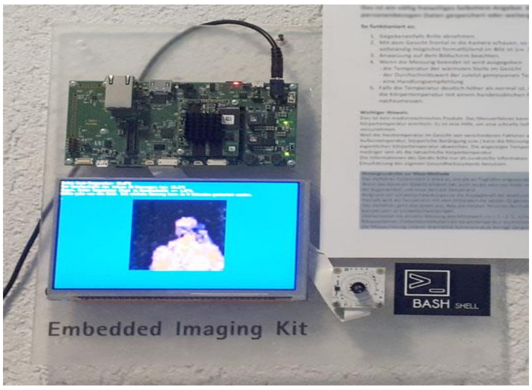
Related Material:

- **Demo-Package „Body Temperature Tester Demo“ Version A2**

Revision History

Version	Changes	Author	Date
A0	Initial	M. Klahr	10.04.2020

Introduction



As part of the health care sector, contactless health checks of passengers are carried out with thermal imaging cameras – for example at airports. Thermography is used to measure a passenger's temperature using the skin on their faces. Any passenger with a conspicuously high temperature can be specifically addressed and asked to undergo an more precise measurement of their body temperature.

A self-monitoring station can be very useful in sensitive areas of the health care sector. Examples include eldery people care and preventive measures / risk minimization at the workplace. People can reguraly check whether their body temperature is normal or abnormal.

This concept paper outlines a solution with low-cost components that could be used to install control stations in many areas.

Concept

The self-control station sketched here should have the following function: The system consists of a simple thermal imaging camera, an embedded computer, and a user display. The station is installed on a wall at around eye level. In order to make the applicaiton completely contactless, the system should automatically detect when a person steps in front of the camera and then measure the surface temperature of the face.

For self-checking, the display shows the user their temperature image as a false-color image and, after the meaurement is complete, displays the temperature value of the skin, a comparision value, and a recommendation for action.

The comparision value is useful because the absolute value of the skin temperature can deviate from the core body temperature depending on the situation and time of day. One possible solution to this is a sliding situational adjustment of the reference value by taking the statistical average of the last *n* measurements and comparing the current measured value with it. A temperature deviation of more than 1 or 2 °C upwards can then form a threshold for the output of a recommendation for action.

Of course, such a simply constructed system has its limits. For example, the falsificaiton of the reference value by incorrect measurements is conceivable and a basic requirement is that the majority of the people measured have inconspicuous temperature values. For this reason, the solution presented is to be understood as a concept study. For the development of market-ready solutions, statistical solutions including daily curves and limit values or AI-based approaches could be used.

Note:
The system presented in this application note has the status of a concept study and is not a medical device. It is not sufficiently verified to be used in the field in this form.

System Design

To keep the hardware costs of the system low, thermal imaging camera modules with relatively low image resolution are used. The phyCAM VM-050-050 thermal imaging module with a resolution of 32 x 32 pixels was used for the test setup. For a higher resolution image display, the VM-051-105 module with a resolution of 80 x 64 pixels can be connected to the application.

Both modules have an intergrated ISP (Image Signal Processor), which corrects the data of the thermal image sensor in such a way that the output pixel values can be directly interpreted as temperature values.

In addition, the ISP implements a number of special functions, which we will use in the following to make the application software particularly simple. A value of approx. f = 5 mm (VM-050-050) or f = 10.5 mm (VM-051-105) was chosen as the focal length for the germanium optics of the thermal image sensors. This allows the face of a person to be captured from a distance of approx. 40 cm in a relatively full format. The sensors have a temperature resolution of 0.3 K, which is fully sufficient for the application.

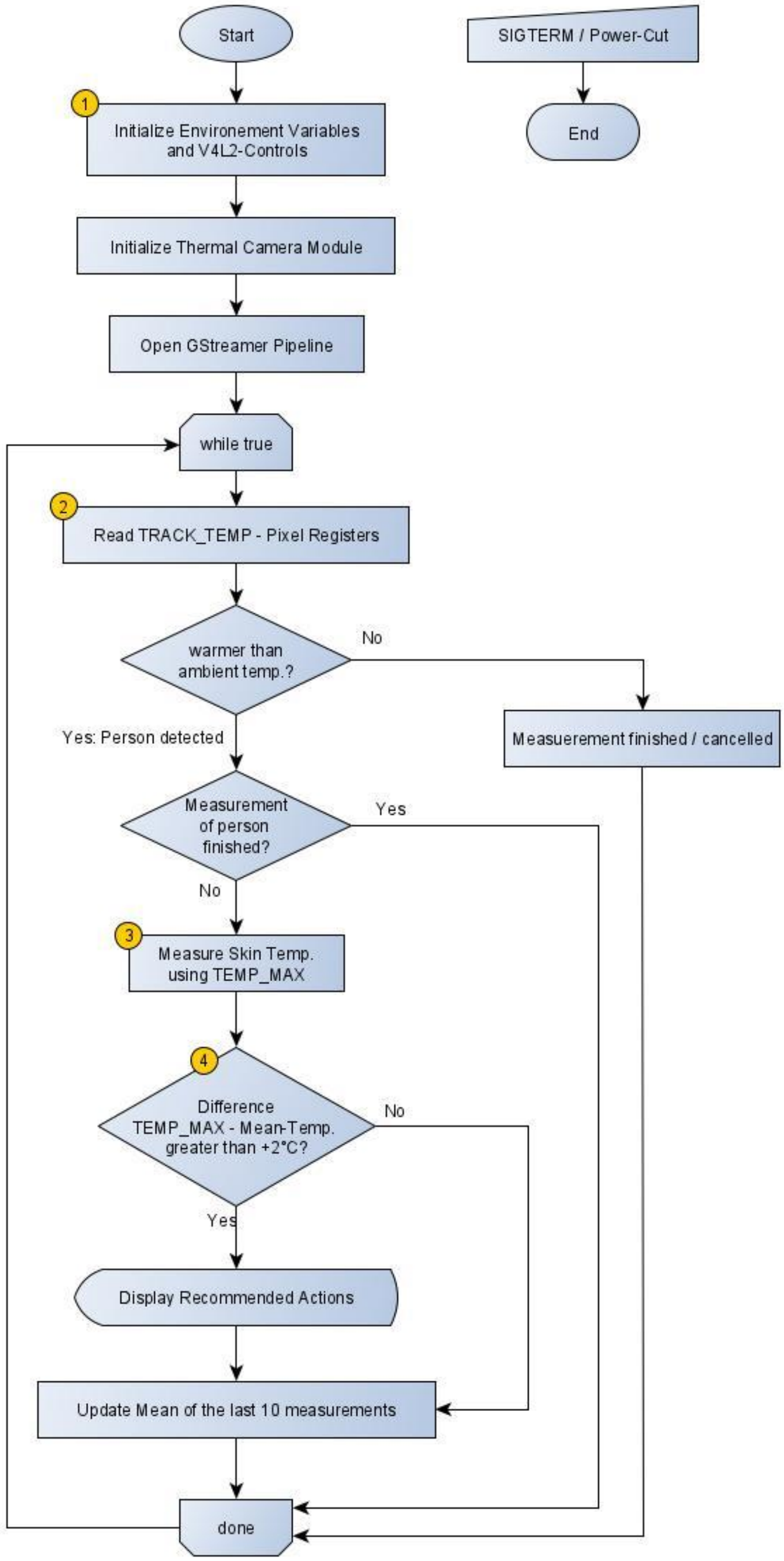
The Embedded Imaging Kit „phyBOARD-Nunki“ with NXP i.MX6 processor is ued to evaluate the image data. The kit has two phyCAM camera inputs where the VM-050 or VM-051 thermal imaging modules can be directly connected. For this demo, only the Camera Port 0 is required. The second input is not used. A camera module for the visable wavelength range (e.g. VM-010) could be connected in parallel in order to superimpose thermal and real images or to implement additional functions.

The kit's Linux BSP already contains the software drivers for the phyCAM thermal imaging cameras. These can be put into operation immediately.

Software Application

By using the analysis functions already intergrated in the ISP of the VM-050 / VM-051 thermal imaging camera modules, the application software setup for this demo is very easy. It is not necessary to program in C, the whole demo can be realized as a bash file with just 300 lines in Linux.

The following flow chart shows the basic structure of the application script:


Start
SIGTERM / Power-Cut
End
1
Initialize Environement Variables and V4L2-Controls
Initialize Thermal Camera Module
Open GStreamer Pipeline
while true
2
Read TRACK_TEMP - Pixel Registers
warmer than ambient temp.?
No
Measuerement finished / cancelled
Yes: Person detected
Measurement of person finished?
Yes
No
3
Measure Skin Temp. using TEMP_MAX
4
Difference TEMP_MAX - Mean-Temp. greater than +2°C?
No
Yes
Display Recommended Actions
Update Mean of the last 10 measurements
done

The application runs using the following steps:

1. Initialization and Configuration
   First, the thermal imaging camera is configured so that the temperature measurement window is placed around a fixed center value of 2969 dK (approx. 24 °C). in this mode, the image output of the camera module operates with the maximum possible resolution of 0.1 Kelvin.

   To reduce image noise, averaging values of 3 images is switched on in the ISP. In addition, the image output in the ISP is mirrored in order to create a familiar image display for the user. Using a Gstreamer pipeline, the thermal image is converted into a false color representation and continuously output on the display as a control image.

2. Person Recognition
   The start of the measurement should be contactless, i.e. the user should not have to touch a start button. This application example uses a simple method to do this: 3 measuring points are distributed in the center area of the image and continuously evaluate whether they are warmer then the ambient temperature. In order to make the system more robust against short-term disturbances, values averaged over 10 images are used.

   The position of the measuring points can be defined using the TRACK_TEMP function in the camera ISP. Afterwards, the measured values of these points are available in the camera registers and only need to be compared with the ambient temperature, which can also be read out of the camera as a register value.

   Note:
   This detection strategy is very simple and can easily lead to false detections. At this point, the introduction of a more robust strategy such as online recognition is useful and strongly recommended.

3. Skin Temperature Measurements
   As soon as a face is sufficiently in the field of view, the temperature measurement starts. The TEMP_MAX function of the camera module is used for this. This function outputs the highest temperature value in the image.

   Typically, this point is located in the area at the inner corners of the eyes. This requires any glasses be removed for correct measurements.

4. Evaluation
   As already mentioned, the absolute value of skin temperature is only conditionally suitable for classification because it is influenced by environmental conditions. Due to this, a reference value should be carried along and compared to the absolute value.

   In our example application, the reference value is generated from the arithmetic mean of the the last 10 plausible measurements.

   The current measured value, TEMP_MAX, is compared with the average of the last 10 and if there is a significant upward temperature deviation, a corresponding recommendation for action is issued. The first step, for example, can be to recheck after a short time in order to exclude incorrect measurements. If the measurement has a deviation of +2 Kelvin, the second step may be a recommendation to check the body temperature with a precise measuring method.

The evaluation includes a simple plausibility check. If the deviation is more then +4 Kelvin, the measurement is assumed to be from another object in the measuring field and the measurement is rejected.

The demo applicaiton includes a counting function for the number of measurements and the respective results. This makes a simple statistical evaluation possible.

Figure: Screenshot of the bash script after measurement

Conclusion

The example application demonstrates how easliy a cost-effective rapid test station for body temperature can be set up. Due to the inexpensive components, solutions can be realized in application areas of daily life for which the use of a classic thermal imaging camera is too cost-intensive and too complicated in terms of operability.

The built-in analysis functions of the phyCAM thernal imaging camera modules VM-050 / VM-051 simplify the evaluation of thernal image data.

The Linux-based embedded imaging system enables the development of more advanced, individual solutions. The platform's interfaces allow, for example, the connection of additional peripheral components.