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Radiometric Data Estimation using Thermogram and Comparison to the Data Provided by the Camera

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Abstract

Fire causes many casualties as well as material damage and thus prevention and early fire detection are important. There are many existing solutions that can detect anomalies after other visible symptoms which is already too late. By using infrared thermal (IRT) cameras anomalies can be detected in the early stage and thus potential catastrophe can be prevented. For successful development and implementation of the anomaly detection algorithm, detailed spatial radiometric data is necessary. Most IRT camera manufacturers provide full radiometric data through their software which is very limited. In this paper, we estimate radiometric data using only the pixel intensity of the thermogram and temperature boundaries. Estimated data is further compared to the data provided by the camera manufacturer to validate our findings.

1. Introduction

Fire is responsible for many casualties as well as billions of dollars in material damage, and thus prevention and early detection of fire is very important. There are many existing solutions for fire detection which include flame detectors, smoke detectors, chemical sensors, and many other hybrid systems. Most of them can detect anomalies only after the appearance of visible symptoms such as flame, spark, or smoke which is already too late. By using IR thermal cameras we can detect temperature increase over time which can be a sign of a potential problem. By recognizing that temperature increases, the problem can be addressed at an early stage and easily prevented. For that purpose, it is important to have correct radiometric data of the observed scene. Most of the camera manufacturers provide full radiometric data by using their specialized software which is, in the basic version, with limnited capabilities for detailed analysis. In addition, it can not be integrated as a part of some other custom software which makes it impossible to use for some automation tasks. On the other hand, many smaller and lesser-known manufacturers do not provide full radiometric data. They provide only a thermogram in selected color space along with the detected temperature boundaries. Using simple image processing techniques radiometric data can be estimated and then further used for anomaly detection.

In this paper, we demonstrate that radiometric data can be successfully estimated using pixel intensities of provided thermogram along with the detected temperature boundaries. In addition, we compared our estimated results with the data provided by the original software of the IR thermal camera manufacturer. The work conducted in this paper is a part of a larger project for developing a Firebot, an autonomous robot for fire prevention, early detection, and extinguishing.

2. Related work

There are many existing solutions that are using IRT cameras for fault detection. Authors in [1] investigated thermal imaging for early detection of fire outbreaks with the goal of a real-world application. They suggested a fuzzy modeling strategy based on IRT image attributes. The authors in [2] presented a method for identifying rotating machinery defects using IRT imagery paired with CNN to identify fault patterns. IRT images are used in [3] to detect faults in electrical facilities. As detection techniques, Fast Region-based CNN (Fast R-CNN), Faster R-CNN, and YOLOv3 were utilized.

All of the above-mentioned papers can address only a specific observed anomaly which makes them inadequate for other types of anomalies. In addition, they all use IRT images as an input which can be unreliable due to the different visualization of the observed scene when using automatic range mode or their inability to detect anomaly if inadequate fixed range mode is used. Instead, we propose using radiometric data as a better solution because all detected temperatures can be considered in an anomaly detection algorithm. In this paper, we demonstrate that radiometric data can be successfully estimated from IRT images by using pixel intensities and detected temperature boundaries.

3. Radiometric data estimation

For estimation of radiometric data, a white-hot IRT image was used as an input. Pixel values of the input image are then transferred to the array in which every element represents one pixel of the input image in a range of 0 to 255. Detected temperature boundaries are detected by the IRT camera and they will be referred as *lowTempBoudaryValue* and *highTempBoudaryValue*. By using simple linear conversion, radiometric data for every pixel is calculated with the following

Equation 1:

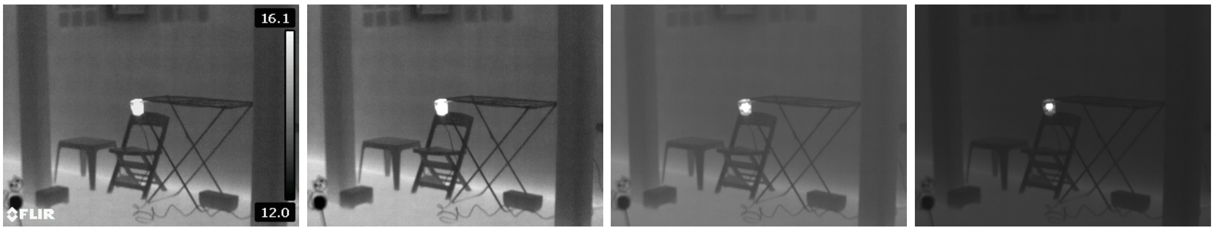
$$radiometricData = \frac{imagePixelValue}{maxImagePixelValue} * \frac{highTempBoudaryValue}{lowTempBoudaryValue} + lowTempBoudaryValue \tag{1}$$

where values represent the following: *imagePixelValue* - value (intesity) of current pixel; *maxImagePixelValue* - maximum possible value (intensity) of image pixels (in our case 255); *lowTempBoudaryValue* - detected lowest temperature boundary; *highTempBoudaryValue* - detected highest temperature boundary;

After the performed calculation, all values are stored in the *csv* file that represents the estimated radiometric data of the input IRT image. Estimated data can be further used in developing an algorithm for anomaly detection as well as visualization of the scene using the desired temperature boundaries as presented in the next section. An anomaly detection algorithm that uses estimated radiometric data is not in the scope of this paper.

4. Results

In this paper, we demonstrate that radiometric data can be successfully estimated from provided thermogram and detected temperature boundaries. Estimated values can be further used for visualizing the scene in desired temperature range as shown in Fig. 1 In our experiments, a Flir E60bx IRT camera was used with resolution of 320x240 pixels. The detailed analysis of estimated radiometric data will be presented in a full version of this paper.



(a) *Original IRT image* ***LB****: 12,* ***HB****:16*

(b) *Reconstructed image:* ***LB****: 12,* ***HB****:16*

(c) *Reconstructed image:* ***LB****: 10,* ***HB****:20*

(d) *Reconstructed image:* ***LB****: 10,* ***HB****:30*

Fig. 1. *Original IRT image (a) and IRT images reconstructed from estimated radiometric data (b-d).* ***LB*** *represents low temperature boundary,* ***HB*** *represents high temperature boundary*

5. Conclusion

IRT cameras can be used to detect anomalies before visible symptoms. For developing a general-purpose anomaly detection algorithm, radiometric data is necessary which can be estimated by using thermogram pixel intensities along with the detected temperature boundaries, thus, eliminating the need for expensive and complicated software provided by the camera manufacturer. In addition, an estimated thermogram can be used to visualize the scene in different temperature ranges.

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