SCENE BASED TWO-POINT NON-UNIFORMITY CORRECTION of THERMAL IMAGES

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Abstract

Infrared imaging is a branch of technology that uses Infrared radiation to create an image. Night vision image equipment which uses infrared radiation play an important role for military and civilian applications, and the key kernel is no-light-level image processing system The presence of non-uniformities in the resultant image is a severe problem. . In this paper, we present a scene based two point non-uniformity correction method to improve its vision quality. Gain and Offsets are calculated for a particular frame and the analysis is done based on the corresponding gain and offset coefficients. The non-uniformities are removed and bad pixels can be replaced.

Keywords: Infrared Radiation, non-uniformities, Infrared detector.

I.INTRODUCTION

Thermal imaging system (thermography) is a non-invasive imaging procedure used to record the thermal patterns using Infrared (IR) camera [1]. Traditionally infrared thermal imaging system, also called as FLIR, refers to such equipment as thermovisions, which obtain two dimensional infrared radiation images with optomechanic scanning and quantum detectors. It was, originally, a non-real time auto-temperature distribution recorder [2]. Thermal imaging is a process of capturing the infrared radiation from a particular surface above zero degrees centigrade and converts that radiation into a temperature pattern**.** This Infrared Imaging is a non-contact sampling and these images are unique for each object. Infrared imagers can see almost all objects because all the objects that do not radiate visible energy can radiate Infrared energy. Infrared energy is also called as heat energy. This heat energy is produced by the motion of molecules. Heat can be transferred from one place to another when there is a temperature difference .Heat is a form of energy obtained because of continuous motion of molecules.

II. TYPES OF THERMAL IMAGERS

Thermal Imagers use infrared detectors for converting the infrared rays into electrical signals. These Thermal imagers based on infrared detectors can be classified as:-

2.1 Cooled or photon detectors

2.2 Uncooled or thermal detectors

Uncooled Thermal imager: It is the basic type of thermal imager. It operates at room temperature. It is simple to design and easy to use. It activates immediately and has built-in-battery**.**

Cooled thermal imager: In this type, the detector elements are placed inside a container which operates at below zero degrees centigrade. It increases sensitivity. The majority of the infrared imaging sensors are based on the Infrared Focal Plane Array (IRFPA) technology [3] [4].

III. INSTRUMENTATION

3.1 Infrared Detectors:

The detector is the most important component of the IR imaging system. Detectors can be characterized by their optical configuration or by the energy-matter interaction process. There are two types of optical configurations—elemental and imaging.

•Elemental Detectors:

Elemental detectors average the portion of the image of the outside scene falling on the detector into a single signal. The elemental detector requires time to develop the image because the entire scene must be scanned.

•Imaging Detectors:

Imaging detectors yield the image directly. An imaging detector is considered a myriad of point detectors. Therefore, the imaging detector produces the entire image instantaneously. The new generation of infrared cameras is based upon a different kind of detector technology, the FPA or Focal Plane Array.

•FPA (Focal Plane Array) Detector:

FPAs are made up of a multitude of detector elements, where each individual detector has different gain and offset that change with time, due to detector-to-detector variability in the FPA fabrication process [5].

IR cameras have become much smaller, lighter and more power efficient. Since the scanning technology is no longer required to provide both horizontal and vertical plane sweeps, the cameras themselves can have inherent improvements in reliability. Today, there are two types of IR FPAs: Monolithic and Hybrid. Monolithic FPAs have both the IR sensitive material and the signal transmission paths on the same layer. Monolithic FPAs have the benefit of typically being easier and less expensive to manufacture, since fewer steps are required in the process. On the other hand, Monolithic FPAs are typically considered to have lower performance than their Hybrid counterparts because Indium they have a significantly lower fill factor (-55%). Bumps Monolithic FPAs have a lower fill factor because both Readout The IR sensitive detector material and signal pathways are on the same level. In order to combine the advantages of volume, cost and technical simplicity an IR camera2 has been developed based on IR FPA technology. This incorporates a single 120 element FPA that is horizontally scanned to provide a thermal digital still camera image.

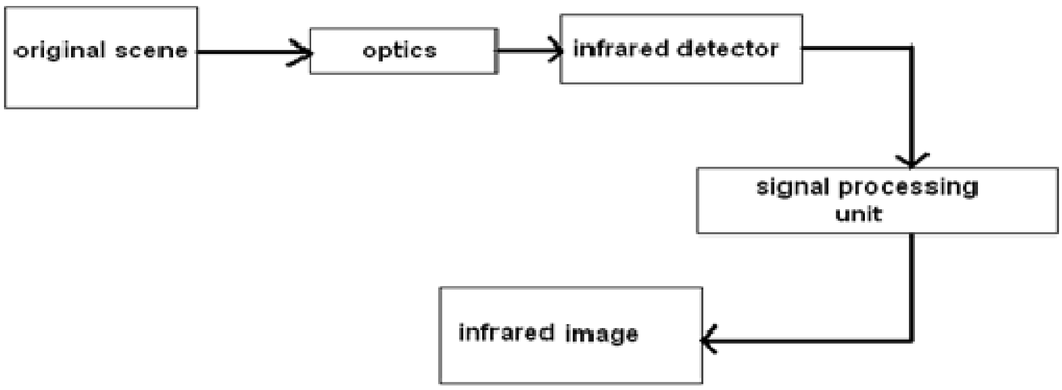

Figure1: Block diagram of Infrared Imaging camera

IV. THERMAL IMAGING SYSTEM WORKING.

1.The optical lens is responsible for collecting the energy from the target and focuses that energy on the surface of the infrared detector. The Infrared detector in Thermal imager is considered as collection of detectors which is called as Focal plane array (FPA). It is not a single detector. The scanned image is focused on Focal plane array which is the optical focusing point. In FPA, only some particular regions of FPA surface are sensitive to Infrared energy. The inactive regions can be used as pathways for electronic signals. The inactive regions are called as Read-out-integrated circuits (ROIC). The ROIC can also sequentially address the electrical signals. The phased array of Infrared detector elements is responsible for scanning the focused light. A very detailed temperature pattern is created by the detector elements called as Thermogram. The time taken for the detector elements to obtain the information of temperature and to create it as thermogram is one-thirtieth of a second. Thermograms obtained directly from a detector, without any correction, are almost unusable [8]. The thermogram is translated into electrical impulses by detector elements. These impulses are sent to a signal-processing board through interfacing board. A signal-processing board consists of a dedicated chip that translates the information from the elements into data for the display. The signal-processing unit sends the information to the display, where it appears as various colors depending on the intensity of the infrared emission. The combination of all the impulses from all of the elements creates an image.

Non-uniformity (NU) of sensor response leads to a structured noise resulting in a row or line pattern in the images. This “noise” is sometimes called fixed pattern noise, or non-uniformity (NU) noise. It is a serious practical limitation to both civilian and military applications - as it severely degrades image quality [6]. A good NU algorithmic correction is a key factor in ensuring the best image quality and the robustness of the downstream applications.

Non-uniformity is defined as the difference in element responsivity function. These non-uniformities cannot be calibrated during manufacturing of FPA detector as there exist some drifts in non-uniformity values. The calibration values change with time and between consecutive operations. As a result most detectors need to be calibrated on a regular basis. The time period between calibrations varies from a few minutes to a few hours [7].

V. NON-UNIFORMITY CORRECTION

Every detector in the array has unequal responses under the same stimulus, which leads to the presence of a fixed-pattern noise on the resultant images [9]. One of the effects that also necessitate the NUC is the Narcissus effect. The Narcissus effect occurs when an infrared detector, through unintended reflections off internal lens surfaces, sees sources at temperatures other than the background ambient; these sources are usually reflections of the detector itself [10]. To compensate for fixed pattern noise, non-uniformity correction must be applied to images acquired by infrared focal plane arrays. Several methods exist for non-uniformity correction- one point non-uniformity correction, two point calibration methods. To overcome the disadvantages associated with those methods, two point scene based technique is proposed.

Two point Gain Correction and Offset Correction against two different target temperatures (10 degrees and 40 degrees centigrade) are computed. We consider two frames: One frame at 10degrees centigrade and another frame at 40 degrees centigrade. Compute median of first frame. Call it as ‘x’. Similarly compute median for the frame at 40 degrees centigrade. Call it as ‘y’. Then Gain can be calculated as:

$$\text{Gain coefficient} = \{[x - y] / [(\text{Frame 1}) - (\text{Frame 2})]\} * 2 \quad (1)$$

Offset correction:

Offset correction is also considered as two-point non-uniformity correction. This Offset correction is applied on Gain corrected data to improve the quality and clarity of the image. The need for Non-Uniformity Correction or offset correction of thermal imaging cameras using staring detector arrays is a serious practical limitation to the military. The processes considered here operate pixel-wise or only employ neighborhood interconnections and do not require global or whole image transformations or manipulations. This constrains the project so that the function of the processes aligns with the proposal aim of emulating the human observer.

$$\text{Offset coefficient} = (\text{Gain corrected frame}) - (\text{Median of (Gain corrected frame)}) \quad (2)$$

$$\text{Resultant frame} = (\text{Gain coefficient} * \text{frame 2}) - (\text{offset coefficient}) \quad (3)$$

4.1 Non-uniformity correction algorithm:

1. Start.
2. Obtain the image from an object through the optical lens of a thermal imager at ten degrees centigrade.
3. Obtain the same image at forty degrees centigrade.
4. Calculate the median of two frames separately.
5. Then calculate the difference of median between two frames.
6. Similarly calculate the pixel difference of two frames: One at ten degrees centigrade and another at forty degrees centigrade.
7. Based on median difference and pixel difference, calculate the gain by taking division of both differences.
8. Limit the gain to some predefined value so that the entire frame acquires uniformity.
9. Gain corrected frame is obtained by multiplying the image with gain.
10. Offset is calculated by finding Median of the Gain corrected frame.
11. The obtained Median is subtracted from Gain corrected frame.
12. This Offset value is applied on Gain corrected frame.
13. If the obtained Offset coefficient is negative, take modulus to it.
14. Resultant image is obtained by multiplying the raw image with gain coefficient and then subtracting the offset coefficient.
15. Display the Raw image, Gain corrected image, Gain and Offset Corrected image which are obtained by applying proper MATLAB techniques to this algorithm.
16. End.

VI. Results and Discussion

Table I: Differentiating the output images:

s.no	Output image	gain	Offset
1.	Raw data	Not uniform	Exists
2.	Gain corrected image	Uniform (g=2)	Exists
3.	Gain and offset corrected image	Uniform (g=2)	Not exists

Pattern Figures:

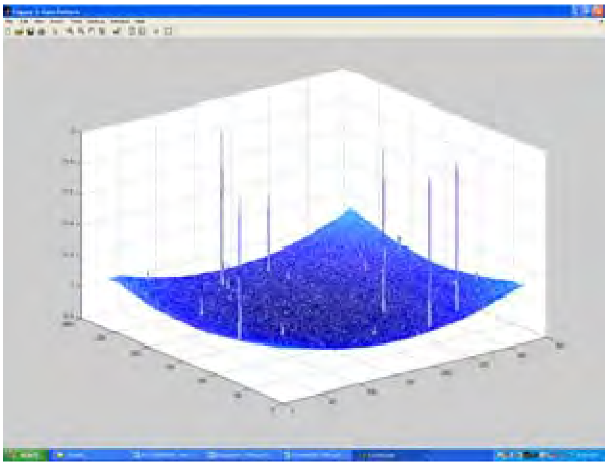

Figure 2: Gain pattern

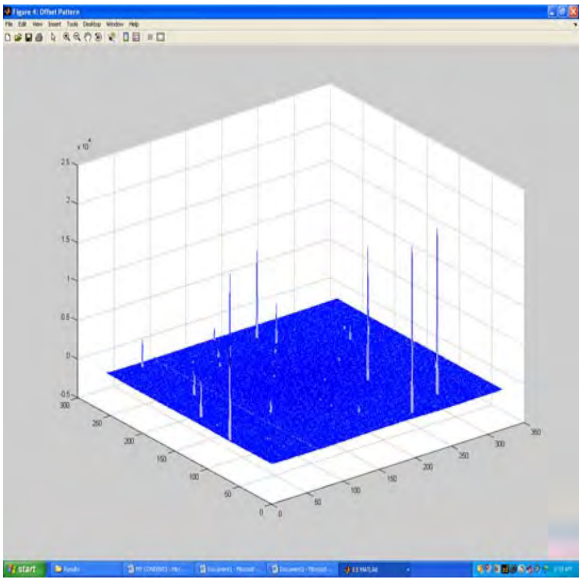

Figure 3:OffsetPattern

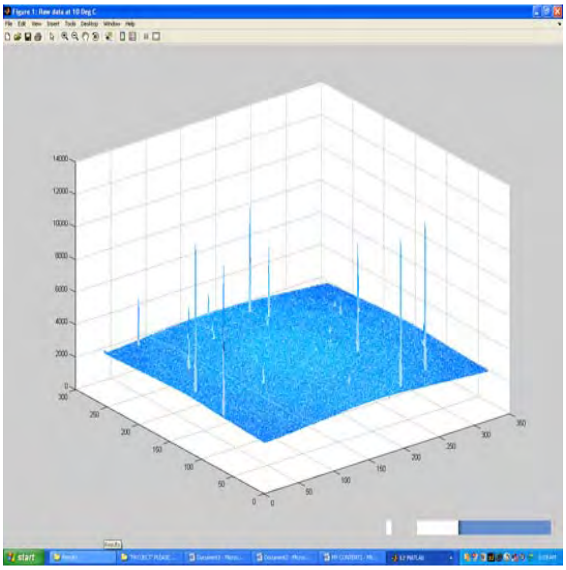

Figure 5: Raw data at 10 degrees centigrade

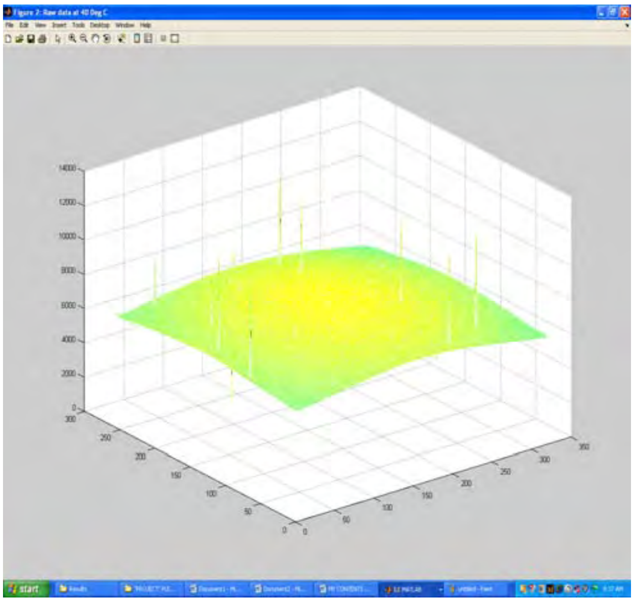

Figure 4: Raw data at 40 degrees centigrade

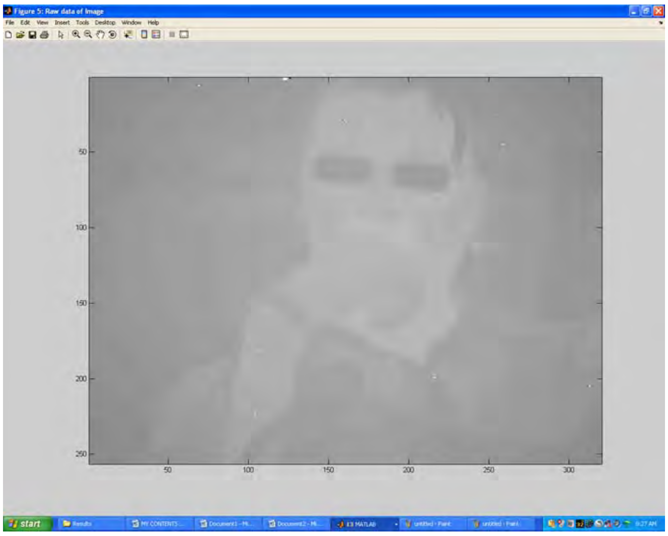

Figure 6: Raw data of an image

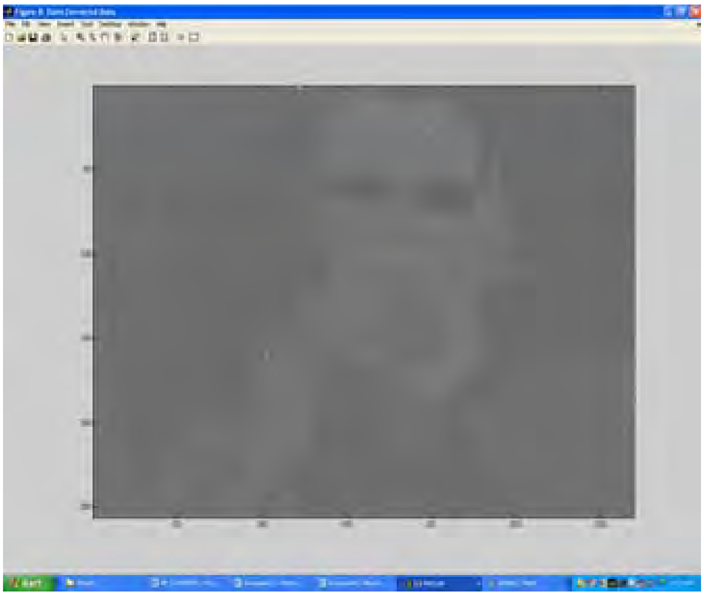

Figure 7: Gain corrected data

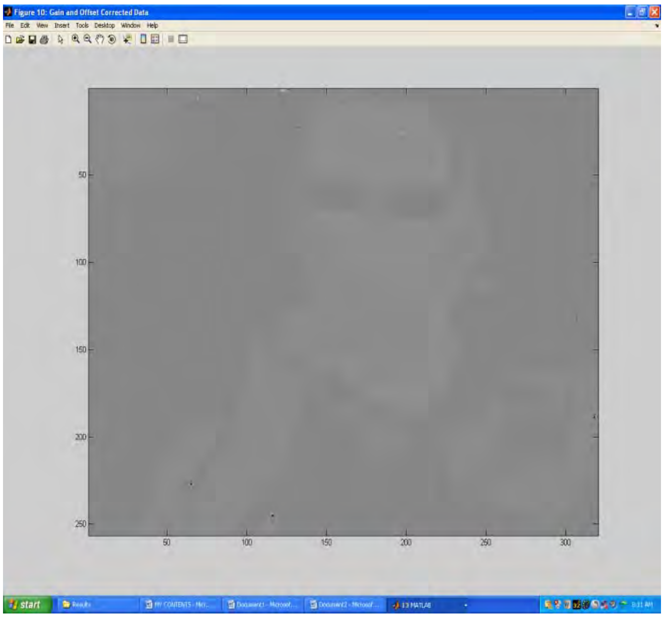

Figure 8: Gain and offset corrected data

VII.CONCLUSION

Thermal imaging find applications in many fields like Night vision, maintenance of machines in companies, finding human body anomalies, finding hidden objects. Hence the image quality is required to be high. Hence with proposed algorithm, non-uniformities are nullified to improve the vision quality using matlab software.

ACKNOWLEDGMENT

We are grateful to the management of the KL University for providing the necessary facilities. We received continual encouragement from Prof.Dr.Shree Hari Rao, Vice Chancellor of the KL University. We extend our thanks toProf.Habibulla Khan,HOD,ECE and Prof.N.Venkatram, Dean of Electrical Sciences of, KL University for thier continual encouragement on the research work .

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