Blind Pixels Auto-Searching Algorithm for IRFPA based on Scene

Chen DaChuan[1]   He SiMing[1]   Zhao LiLi[1]   Chen Ding[2]

[1]Department of Electronic, Aviation University of Air Force, Changchun, China
[2]Design & Research Department, Shanxi Huang-he Group Co. ,Ltd.,Xi 'an Shanxi , China

Abstract. One of the important factors which influence the imaging of IRFPA array is the quantity and distribution of bad pixel. Based on the features of infrared image, response characteristics of IR FAP's bad pixel and the corelation of adjacency pixel, this paper put forward a new method to detect bad pixel .The experimental result has proved that this method not only can actualize the detection of IRFPA bad pixel, but has many advantages like real time bad pixel detection, low rate of miss detection and fast detection etc. Also this algorithm is easy to be implemented by hardware.

Introduction

Blind pixels, also termed invalid pixels, refers to over-responding detector unit and under-responding detector unit in IRFPA devices. In images, the gray values of those pixels change very slowly and therefore can't correctly reflect the change of scenes. Compared to other research on IRFPA correction methods, the current reported Blind Pixels Detection (BPD) has not been enoughly researched. This is especially so in our country. A very important reason is that it is only significant to conduct BPD on actual original data of IRFPA. Yet in the current reported research on IRFPA BPD, a lot of them are insufficient due to lack of necessary original data.

Based on the analysis on the characteristics of blind pixels, using digital image processing technology, the thesis has suggested a Blind Pixels Detection Algorithm with regard to the infrared image of scenes. The algorithm can effectively conduct automatic detection on blind pixels. It has significance on research of image blind pixels detection of IRFPA, on improving imaging quality and on development of infrared imaging technology.

The definition of blind pixels

The definition mainly considers the responding degree the device has on blackbody radiation as the quantitative indication. Three related definitions of IRFPA   parameters are firstly given.

A Pixel responsivity

Assumptions for the $M \times N$ detector of infrared focal plane arrays.Pixel responsivity $R(i, j)$ for the infrared focal-plane array in certain frame period and under the certainly dynamirange condition, the element exposes the output signal voltage which to each unit the power produces

$$R(i, j) = \frac{V_s(i, j)}{P}$$

The formula $i = 1 \sim M, j = 1 \sim N$, $V_s(i, j)$ is the (i, j) pixel corresponding to the response voltage of *P*'s radiation power, *P* is the (i, j) pixel of the radiation received power.

B mean response ratio

Mean response ratio is the mean value of each effective pixel response ratio in IRFPA

$$\bar{R} = \frac{1}{M \times N - (d + h)} \sum_{i=1}^{M} \sum_{j=1}^{N} R(i, j)$$

M and *N* respectively are representing Linage and Columnage of IRFPA pixels. d and h are dead pixels and over-heating pixels. In the actual measuring, d and h are obtained by iterative computations.

C blind pixel ratio

The percentage of blind pixels to total pixels in IRFPA is represented by the following formula:

$$N_b = \frac{d + h}{M \cdot N} \times 100\%$$

d and *h* respectively are dead pixels and over-heating pixels.

The causes for blind pixels

the causes for blind pixel have many similarities with the causes for Non-uniformity, but not identical. Research therefore is necessary. In the actual imaging system, the signal output of IRFPA is the combined results of optical system, units of detector, read-out circuit and signal processing circuit (such as amplification and A/D conversion). Therefore, it can be seen that the main causes for blind pixels are as follows:

a) The optical lens have flaws or are attached with stains. Those flaws or stains will alter radiant energy making the produced image apparently different from surrounding pixels and furthermore the signal is showing blind pixel characteristics.

b) The materials used to build the device are not completely the same. While IRFPA is being made, if there are any factors such as effective sensitivity surface and unequally adulterated materials leading to the inconsistency of characteristic-curves of photoelectricity conversion of each detector unit, blind pixels are formed.

c) Caused by excessive dark current. It is generally recognized that dark current is caused by the surface current of semiconductor. Some documents believe that dark current will deteriorate the capability of detector unit and thus blind pixels are formed.

d)Affected by readout of signal charge transfer. The channel obstacle of IRFPA detectors which adopt displacement readout will weaken related pixel signal and the pixels become blind.

e)Lead by working environment. The randomly changed temperature in the location of IRFPA detectors will affect pixel performance. In certain temperature, such as too high or too low, the performance of partial pixels will have a negative change. These pixels lose their ability of detection and become blind pixels.

f) Some detector units of IRFPA will be physically damaged and therefore become blind pixels

Automatic detection of blind pixels

It is found in the infrared image that normal detector pixels are very different from blind pixels in terms of the response characteristic. The temperature responding characteristic curve of normal detector units is linear within a certain dynamic range. Under a normal circumstance, the corresponding characteristic value of the curve raises with the increase of the temperature. However, the dynamic range of blind pixels is far away from that of normal detector units. This manifests on the curve as a relatively high or low variable slope.
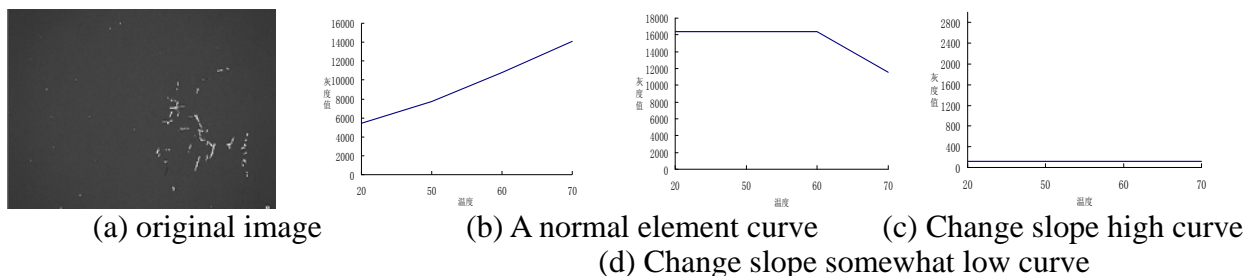

(a) original image   (b) A normal element curve   (c) Change slope high curve

(d) Change slope somewhat low curve

Figure 1 detector response characteristic diagram of curves

A the principle of scene-based blind pixel detection algorithm

blind pixel detection algorithm in the document is a comparatively mature algorithm with characteristics such as simple calculation and easily achieved hardware, but it is a detection of shooting infrared images under the supposed blackbody state. The actual infrared images with blind pixels all have scenes-that is destination (see the picture below). Therefore, it is not significant to have a scene-based blind pixel detection. Making use of threshold value + adjacent pixel algorithm to conduct the detection solves the scene-based detection problems.
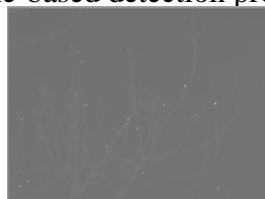

Figure 2 the blind pixel image based on scene

The principle for threshold value + adjacent pixel algorithm detection is that the blind pixels

and the adjacent responding ratio deviate more than 10% of the average responding ratio or less than 10% to determine the position of blind pixel in the infrared detector with the relative data. After threshold value detection, there are some scattered bind pixel points in the image. The gray values of those points which appear to be too bright or dark are beyond threshold value range. This condition cannot satisfy image processing. Therefore, we again use adjacent blind pixel detection to detect those points, which will have a better compensating effect to blind pixels. This kind of test works especially better when the gray values in the image are not changing too much.

B advantages of the algorithm

The adoption of threshold value + automatic detection of adjacent pixels has 5 reasons:

a) blind pixel detection can be conducted in scenes, which realizes the real-time nature of the detection.

b)in mean response ratio, the definition of R is the mean value of valid pixel response ratio. R cannot be calculated when blind pixels are absent.

c) from visual perspective, blind pixels have clear differences from adjacent pixels. In the whole image of scenes, their gray level is not sole and is not in the extreme gray level.

d) bind pixels draw distinctions in parts of the image.

e) after threshold value compensation, some pixels have response ratio over the deviation value and are shown as scattered bright points or dark points. Therefore, after threshold value compensation, the use of window response ratio test to realize another compensating will achieve better effect.

C detailed algorithm is as follows:

a) use an infrared detector to shoot an infrared image. Record every corresponding gray value by each detector and save them into a single dimension data group:

b)compute the R of every gray value in the image and save the result;

c) let the R respectively be divided by 10% or multiplied by 10%. Thus we get critical threshold value. Record pixels that are below the gray value of R×10% and over that of R/10% as blind pixels.

d)divide the radiation area of the infrared image as up and down part. Preset a threshold σ. Then go through pixels in the up area. The gray value of every pixel will subtract the gray values of the behind 5 pixels and down 5 pixels. If found subtracted value is bigger than σ, then the pixel is judged as a blind pixel. In a similar way, pixels in the up area are the same with that in the down area.

e) make a Boolean Array, put the results for blind pixels in the Array. In the Array, True means the corresponding pixels are blind pixels, while False not.

D analysis of the emulation result

The figures from different detection methods are shown in graph 1. Comparing the results with the original image and the collected data, we can see that threshold value method and adjacent pixel detection method have clearly misjudged
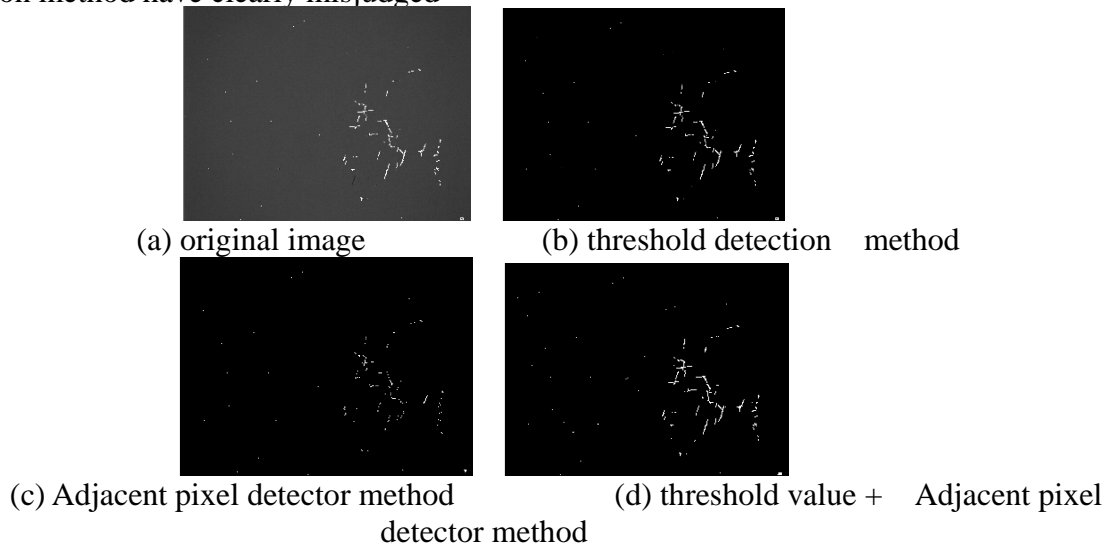

(a) original image   (b) threshold detection   method

(c) Adjacent pixel detector method   (d) threshold value +   Adjacent pixel detector method

Figure 3 under blackbody condition Blind Pixels test result chart

	Threshold detection method	Adjacent pixel detector method	Threshold value + Adjacent pixel detector method
numble of Blind Pixels	284	161	335
rate of Blind Pixels	0.3695%	0.2093%	0.4366%

Table 1 Blind Pixels test result statistics

The system the thesis has designed has achieved a better processing effect when applied in the real-time signal processing system of 320×240 IRFPA. Graphs 4 are two different infrared images after and prior the blind pixel detection. In graph 4(a), influenced by noises and invalid pixels, the image has shown clear blind pixel points. After the detection, it can be seen that the distribution of blind pixels in 4(b) is basically the same with that of 4(a).
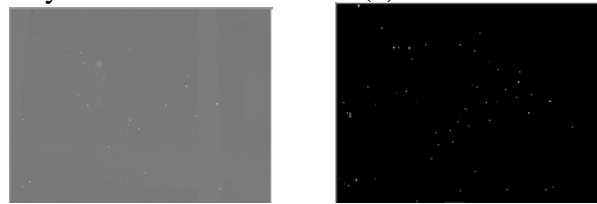
(a) Based on scene Blind Pixels image　　(b) Blind Pixels test result

Figure 4 based on scene Blind Pixels test result chart

Conclusion

Utilizing IRFPA, this paper research designed the thermal imagery blind pixel examination and in compensating system's process has studied one kind of threshold value + Adjacent pixel detector method, this system's blind pixel examination technology, might realize in based on the scene under the blind pixel automatic detection. May see this algorithm through the simulation experiment to search quickly, the examination rate is high. Definitely may adapt the production actual to apply.

References

[1]The technical norms for measurement and test of characteristic parameters of Infrared focal plane arrays. The national standard of China,GB/T17444-1998

[2]LAI Rui, LIU Shang-qian, ZHOU Hui-xin, SHEN Jian-hua，Blind-pixel Detection for Infrared Focal Plane Arrays[J]. Semiconductor Optoelectronics. 2005, 26(3):199-201.65

[3]FAN Sin Tian.Distortion Correction and Dead Pixels Compensation of Uncooled IRFPA[D].Changchun:Changchun Institute of optics,fine mechanics and physics,chinese academy of sciences.2005.

[4]Gonzalez. Digital Image Processing[M].Beijing:Publishing House Of Electronics Industry,2001:115-130.

[5]Dieickx B,Meynants G. Missing pixels correction algorithm forimager sensor[J].SPIE, 1998,3410:200-203.