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# Research on Fast Imaging Method of X - Ray Flat Panel Detector Based on Pre - Offset

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***Abstract*—In view of the problem that the X-ray flat panel detector products are slow from receiving X-Ray tube's exposure to generating the X-Ray medical image, it can not meet the time requirement of post-processing customers. It uses pre-offset calibration to reconstruct dark-field template based on the ck1417 flat panel detector. This series of templates can not only fit the dark-field map in different time window but could also calibrate the dark-field map influenced by different temperatures according to the circumstances that the flat panel detectors are easy to have error correction in different temperatures. This could effectively reduce the time to collect X-Ray Images and provide more time for X-Ray Image post-treatment manufacturer and let post-treatment more explicit and detailed.**

***Keywords-* *flat panel detector; offset template; dark-field calibration***

## I. INTRODUCTION

DR Imaging technology has become one of the main research direction of X ray detection. As the core equipment of DR Imaging system, flat plate detector determines the quality of output image by its manufacturing process and imaging performance. Detector calibration has important significance to improve the quality of the original image. The area array detector convert the received X-Ray energy to digital image. The flat panel detector consists of a direct conversion type X-ray detector with a direct conversion to charge, and an indirect conversion type flat-panel detector whose rays are firstly converted into visible light and then converted into charge. Among them, the direct conversion flat-panel detector refers to amorphous selenium coated on the pixel array of amorphous selenium flat-panel detector, while the indirect conversion type detector is mainly amorphous silicon flat-panel detector[1]. Although the image resolution of amorphous silicon flat panel detector is lower than that of amorphous selenium detector, it is widely used in nondestructive testing because of its good environmental adaptability.

For some reason about the manufacture, flat-panel detector inevitably have some flaws, such as white noise, pixel response nonuniformity and bad pixel[2]. The existence of these problems greatly reduces the quality of DR images. In order to improve the imaging efficiency and service life of the flat-panel detector, some related researches have been carried out both at home and abroad. The dark-field correction is simple in principle, Ho, Kyung, Kim and zhe, yin etc [3] have carried out a comprehensive exposition of this. And XIjun Jin investigate the effect of environmental temperature on the stability of the dark field detector. Klaus, Bavendiek etc [4] used the adaptive gain correction method to correct the image of the aluminum block and basically eliminate the structural noise. Zhenggan Zhou put forward a relatively complete calibration procedure to realize the overall correction of dark-field, gain and bad pixel.

In this paper, amorphous silicon flat panel detectors are provided from cooperative partner. Using the self-designed DR acquisition system, the performing parameters of the detector are deeply expounded in the laboratory environment, and the test result analysis are carried out for discussing the internal relations between them. This research is about the amorphous silicon flat-panel detector with different exposure time window and the different temperature field correction, it makes a imaging quality contrast between the template which use dark-field correction and the template which use post correction. So a series of pre-offset template is fitted to save imaging time. The research work in this paper can effectively improve the performance of flat panel detector imaging and provide important help to the practical application.

## II. USING DYNAMIC PRE-OFFSET TEMPLATE TO CALIBRATE THE IMAGE UNDER DIFFERENT EXPOSURE TIME WINDOW

The conception of this experiment is to design dynamic pre-offset template algorithm for calibrating the ck1417 detector when exposing the image at different exposure time windows from 1s to 30s so as to shorten the image time under the premise of ensuring the image quality.

### *A. Test Methods and Purpose*

- Without any calibration, by changing the size of the exposure window to obtain a series of dark-field images through overtime above, it is namely the dynamic pre-offset template. The experiment gained overall 20 template images which derives from 0.5s,1s,2s,3s,...10s,20s image

- Start the timing when getting the dynamic pre-offset template. In 10 minutes, collecting the original bright field plots of the three sets as follows:

TABLE I. THREE SETS OF TESTING SCHEME TABLE

| | | | | | | |
|---|---|---|---|---|---|---|
| Dose | 70Kv5mAs | | | | | |
| Exposure time | 2s | 3s | 6s | 10s | 20s | 30s |
| Dose | 65Kv5mAs | | | | | |
| Exposure time | 2s | 6s | 10s | 20s | 30s | |
| Dose | 60Kv5mAs | | | | | |
| Exposure time | 2s | 6s | 10s | 20s | 30s | |

- The gain_map template is generated form 70Kv5mAs bright-field image in 2s/3s exposure time window, 0.5s and 5s pre-offset template are used to do linear fitting and 3 suitable time interval pre-offset templates are used to do quadratic function[5]. This two type of functions are used to calibrate the original bright-field image.

### B. Design of Pre-offset Template

#### 1) Linear Fitting

0.5s and 5s exposure time's dark-field pre-offset template images are used to do linear fitting according to the equation as follows:

$$y = a * x + b \quad (1)$$

In equation 1, b is the fixed offset value caused by electronic circuit, ROIC, Gate IC and the pixel itself which is time independent. While k is the offset caused by leakage, which is proportional to delay time (x). It indicates the leakage current of each pixel in the image of unit time.

#### 2) Quadratic Fitting

Three suitable time interval pre-offset templates are used to do quadratic function. According to the equation as follows:

$$y = a * x^2 + b * x + c \quad (2)$$

In equation 2, with the increase of delay time, the dark-field image does not strictly increase the leakage current in a linear way, but it is a parabolic growth model. Therefore, quadratic function are used to approximately describe the increase leakage current in time unit.

### C. Experimental Test and Result

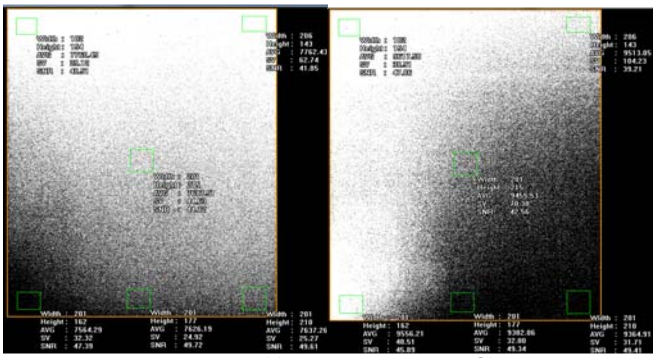
#### 1) Test results of linear fitting dark-field template

- 0.5s and 5s exposure time's dark-field pre-offset template images are used to do linear fitting according to the equation (1) and the delay time is 2s or 6s, the original bright-field image can be calibrated well.

(a) (b)

FIGURE I 0.5S&5S PRE-OFFSET TEMPLATE (A) 2S DELAY TIME 65KV5MAS, (B) 6S DELAY TIME 70KV5MAS

- 0.5s and 5s exposure time's dark-field pre-offset template images are used to do linear fitting according to the equation (1) and the delay time is 20s or 30s, the original bright-field image would have a certain degree of error-correction, oppositely, the corrected image also have increasing noise, the SV value is more than 40 and slight channel difference is found.



(a) (b)

FIGURE II 0.5S&5S PRE-OFFSET TEMPLATE (A) 20S DELAY TIME 65KV5MAS, (B) 30S DELAY TIME 70KV5MAS

- Gain_map was acquired at 70kv5mAs,therefore, dynamic pre-offset correction was done under different kV, it is valid when the delay time value is selected. The experimental observation shows that the dynamic pre-offset correction within time 10s is basically effective, and the corrected image is relatively uniform, SV value is between 20-30. (In the experiment, only the images of delay time 6s, 2s, 10s, 20s and 30s were collected) Table 1 make a result conclusion of civilizing 0.5s and 5s exposure time's dark-field pre-offset template images.

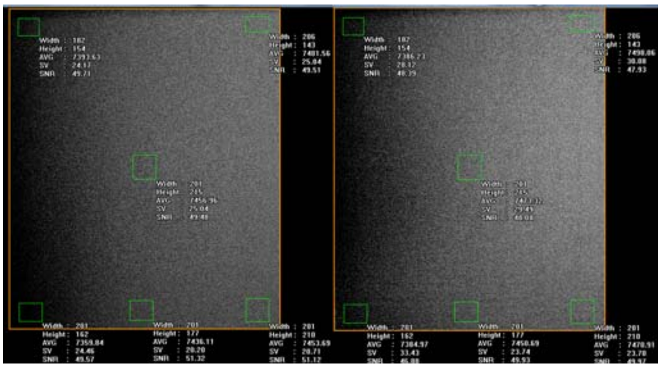
TABLE II. 0.5S&5S PRE-OFFSET TEST RESULT

| Dose | Delay time | Gain template | Level/window | sv |
|---|---|---|---|---|
| 65KV5mAs | 2s | 3s70KV5mAs | 7500/250 | 23 |
| 70KV5mAs | 2s | 3s70KV5mAs | 9200/250 | 27 |
| 65KV5mAs | 6s | 3s70KV5mAs | 7500/250 | 23 |
| 70Kv5mAS | 6s | 3s70Kv5mAs | 9200/250 | 28 |
| 65KV5mAs | 20s | 3s70Kv5mAs | 7650/100 | 37 |
| 70Kv5mAS | 20s | 3s70Kv5mAs | 9350/100 | 42 |
| 65Kv5mAS | 30s | 3s70Kv5mAs | 7650/100 | 39 |
| 70Kv5mAS | 30s | 3s70Kv5mAs | 9450/100 | 54 |

*2) Test results of quadratic fitting dark-field template*

- 2s,10s and 20s exposure time's dark-field pre-offset template images are used to do quadratic fitting according to the equation (2) and the delay time is from 1s to 30s, the original bright-field image can be calibrated well.

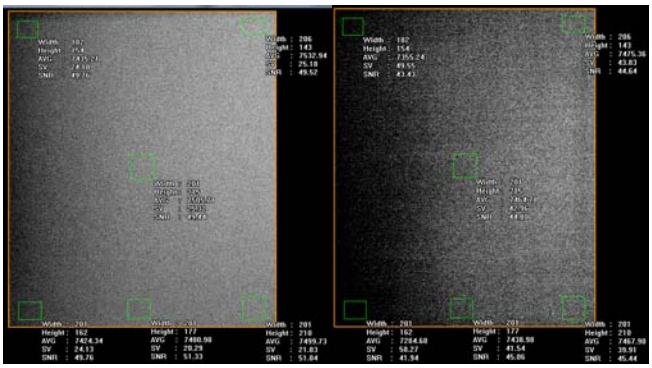
- When using 2s,10s,20s exposure time's dark-field pre-offset template, the delay time is 20s or 30s, there will be no channel differences after image correction, but the number of the needed templates is large and the total acquisition time is long.



(a) (b)

FIGURE III 2S&10S&20S PRE-OFFSET TEMPLATE (A) 2S DELAY TIME 65KV5MAS, (B) 30S DELAY TIME 65KV5MAS

- When using 2s,5s,10s exposure time's dark-field pre-offset template, though the overall sampling time is shorter, but the correction delay time is only from 1s~10s, the original bright-field image which delay time is 20s doesn't has good correction, the SV value is 45.



(a) (b)

FIGURE IV 2S&10S&20S PRE-OFFSET TEMPLATE (A) 2S DELAY TIME 65KV5MAS, (B) 30S DELAY TIME 65KV5MAS

- When using 1s,2s,5s exposure time's dark-field pre-offset template, its total acquisition time is shorter, but the image correction range is only from delay time 1s~6s, the original bright-field image which delay time is 10s doesn't has good correction, the SV value is 46.

- When using 1s,2s,3s exposure time's dark-field pre-offset template, basically the image correction of delay time only limits to 5s, the original bright-field image which delay time is 6s doesn't has good correction, the SV value is 60.

- Both linear fitting method and quadratic function method demonstrate that with the increasing of delay time, the offset induced by leakage has not strictly proportional to the delay time, and also not strictly increasing according to the form of quadratic function; But the offset caused by leakage increases as the delay time increases. Table 2 makes a conclusion of test results of quadratic fitting dark-field template.

TABLE III. TEST RESULTS OF USING QUADRATIC FITTING DARK-FIELD TEMPLATE

| Template | Dose | Level/windown | sv |
|---|---|---|---|
| 2s&10s&20s | 65Kv5mAs | 7500/250 | 23 |
| 2s&10s&20s | 65Kv5mAS | 7500/250 | 28 |
| 2s&5s&10s | 65Kv5mAS | 7500/250 | 23 |
| 2s&5s&10s | 65Kv5mAS | 7500/250 | 45 |
| 1s&2s&5s | 60Kv5mAS | 4500/370 | 21 |
| 1s&2s&5s | 60Kv5mAS | 4500/370 | 46 |
| 1s&2s&3s | 60Kv5mAS | 4500/370 | 19 |
| 1s&2s&3s | 60Kv5mAS | 4500/370 | 60 |

## III. DYNAMIC PRE-OFFSET TEMPLATE FOR CALIBRATING THE IMAGE UNDER DIFFERENT TEMPERATURE

### *A. Test Purpose and Method*

*1) Test Purpose*

0.5s&5s pre-offset template is tested about the temperature error correction range, the ideal is to ensure the rapid imaging and at the same time, the 0.5s&5s pre-offset template can be obtained in advance and call the corresponding template according to the actual detector temperature so that the dynamic template can be adjusted to static[6]. A preliminary determination is made on whether the template could become invalid after long time.

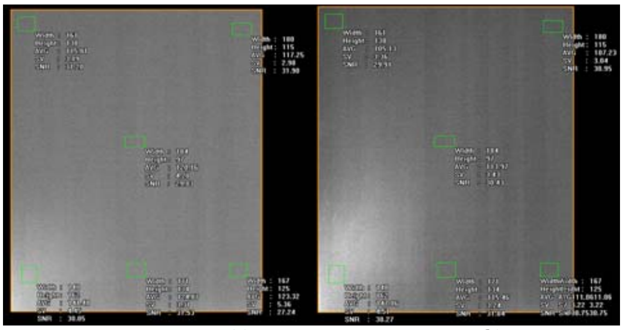
*2) Test Method*

- Without any calibration, in the temperature control laboratory, the temperature of the detector is 30℃,33℃,35℃,37℃,39℃,41℃,43℃,45℃, the delay time is 0.5s and 5s pre-offset template.

- The detector's initial temperature is 25℃, a group of original dark-field image is obtained under 30℃ while the delay time is 3s, 5s, 7s, 10s, finally, a template at a certain template is used to calibrate the original dark-field image around the temperature.

### *B. Experimental Test and Result*

- The range of temperature error correction to use 26℃ 0.5s&5s pre-offset template could see 26℃ template to 29℃ detector dark-field image's calibrating result is "left corner has slight bright shadow, good correction result". And utilizing 26℃ template to calibrate 32℃ detector dark-field image's calibration result is "left corner's bright shadow expands, bad correction result".



(a) (b)

FIGURE V (A) 26℃ TEMPLATE TO 29℃ DETECTOR DARK-FIELD CALIBRATION IMAGE. (B) 26℃ TEMPLATE TO 32℃ DETECTOR DARK-FIELD CALIBRATION IMAGE

- The range of temperature error correction to use 30℃ 0.5s&5s pre-offset template could see 30℃ template to 24.5℃ ~25.5℃ detector dark-field image's calibrating result is "left corner has obvious shadow, bad correction result". And utilizing 30℃ template to calibrate 26.5℃~27℃ detector dark-field image's calibration result is "left corner has slight shadow, good correction result" [7].

TABLE IV. TEST RESULT OF TEMPERATURE TEMPLATE TO DIFFERENT DETECTOR TEMPERATURE

| Template | Test | Test result |
|---|---|---|
| 26℃ | 29℃ | Good |
| 26℃ | 32.1℃ | Bad |
| 30℃ | 24.5℃-25.5℃ | Bad |
| 30℃ | 26.5℃-27℃,33.2℃ | Good |
| 30℃ | 34.1℃ | Bad |
| 35℃ | 32.1℃, 33.2℃ | Bad |
| 35℃ | 36.3℃ | Good |
| 35℃ | 37.3℃ | Bad |
| 39℃ | 36.3℃ | Bad |
| 39℃ | 37.3℃, 40.2℃ | Good |
| 39℃ | 41.1℃ | Bad |
| 43℃ | 41.1℃ | Bad |
| 43℃ | 42.1℃, 45.1℃ | Good |
| 43℃ | 46.1℃ | Bad |
| 45℃ | 42.2℃ | Bad |
| 45℃ | 43.4℃ | Good |

- By comparing and analyzing the correction results of the critical temperature images at different temperatures, the obtained range of temperature correction can be shown in the following table:

TABLE V. TEST RESULT OF TEMPERATURE TEMPLATE TO DIFFERENT DETECTOR TEMPERATURE

| Template | Correction range(temperature/℃) | |
|---|---|---|
| temperature/℃ | from/℃ | to/℃ |
| 30 | 25 | 32.5 |
| 35 | 32.5 | 37 |
| 39 | 37 | 41 |
| 43 | 41 | 45 |

### *C. Validity Determination to Use the Long-time Template*

#### *1) Experiment Method*

In the experimental test, a preliminary judgment is made on whether the template will fail after a long time. The basic way is using the temperature template obtained one day before to calibrate the original dark-field image obtained on present day, and the similar way is using the present day's temperature template to calibrate the dark-field image one day before at the same temperature range.

#### *2) Experiment Result*

- It makes 30℃ and 39℃ templates comparison, all the calibrated images have uniform calibration results, the images have even quality.
- Through the image calibration of 30℃ and 39℃, it could induce the calibration results of old template to real-time image, it has good calibration result.
- For the same detector, as long as the temperature is constant, the leakage current remains the same. Therefore, the extension of time will not change the leakage current distribution of the detector at a certain temperature.

## IV. CONCLUSION

According to the two-main problem "exposure time window" and "temperature" for flat panel detector using pre-offset imaging, linear fitting dynamic pre-offset template and quadratic fitting dynamic pre-offset template are utilized to fit the changing dark-field images with the variation of exposure time window so as to calibrate to the original bright-field image. The second research is that the 0.5s&5s pre-offset template is tested about the temperature error correction range and call the corresponding template according to the actual detector temperature in advance. The test results show that the proposed scheme can basically achieve the desired results, and the quality of DR images has been significantly improved. It shows that the detector image correction scheme established in this paper is reliable.

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