CRITIQUE ON PIXEL VALUES OF DIGITIZED RADIOGRAPHIC WELD IMAGES

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Abstract

Digital radiography consists of four major steps which include X-ray detection, digitization, image processing and display. During image processing the digital data is evaluated and manipulated before being displayed, and is used to construct the histogram, which is the graphic display of the distribution of pixel values. The digitization process varies from device to device and may suffer variations even when the same digital equipment is used throughout time. So it requires a high level emphasis to evaluate if a device used to capture an image can be trusted in subsequent digitization. A coefficient value relating the variability of pixel values given to the image throughout the digitization process was calculated and was called pixel value reproducibility (PVR) and a series of hypothetical tests were performed on calculated values and mean pixel values which throw light on digitizer characteristics.

Keywords: Digital Archival, Digital Radiography, Mean Pixel Values, T-Test, Image formats.

I. INTRODUCTION

In the past few years, a substantial increase in the number of radiographic film digitizers being used in radiological research industries throughout the world has been reported [1]. Basically, a film digitizer converts optical density information present in the radiographic image into pixel values, which are interpreted by the computer to create the digital image. Digital radiography consists of four major steps which include X-ray detection, digitization, image processing and display [2] – [6]. During image processing the digital data is evaluated and manipulated before being displayed, and is used to construct the histogram, which is the graphic display of the distribution of pixel values. The digitization process varies from device to device and can be evaluated using various methodologies and may suffer variations even when the same digital equipment is used throughout time [7, 8]. This domain increases the importance of digitized radiographic images being used for weld defect evaluation. So it requires a high level emphasis to evaluate if a device used to capture an image can be trusted in subsequent digitization or if the equipment is given the same pixel value information continuously throughout the captures. A coefficient value relating the variability of pixel values given to the image throughout the digitization process was calculated and was called pixel value reproducibility (PVR).

II. COURSE OF ACTION ADOPTED

The radiographic image of pipe weldment was digitized using two scanners viz., CYNOPTIX (CCD based scanner) with 570 dpi resolution and Laser scanner (LASER based scanner) with 50µm resolution which is equal to 508 dpi. The radiographic film was digitized repeatedly and consecutively with same capture parameters five times using both above said scanners and the images were stored in both BMP and TIFF format.

III. PIXEL VALUE REPRODUCABILITY COMPUTATION

The pixel values at distinct five locations were noted after each digitization and recorded for both scanners and image formats and also for the film using Iridium source (IR-192) and X-ray source. The pixel values were noted at penetrameter or IQI region (1) , then centre of the weld bead (2), left end of the weld (3),right end of the weld (4) and the parent metal PA metal (5).

The mean pixel values of same location for five digitizations were calculated [8]. The smallest and largest pixel values were obtained after five consecutive digitizations of the radiographic image. The pixel value reproducibility (PVR) was calculated as (Largest Difference / Mean pixel Value)*100.

$$PVR = \frac{L\arg estDifference}{MeanPixelValue} * 100 \quad (1)$$

The largest difference was chosen between the largest value obtained from the difference between mean pixel value of the five images minus the smallest pixel value of the five images and the largest pixel value of five images minus the mean of five images.

value of the five images and the largest pixel value of five images minus the mean of five images.

i.e., Largest Difference = max (A, B)

where A = M – S ; B = L – M.
M = Mean pixel values of Five Images.
S = Smallest Pixel value of Five Images.
L = Largest Pixel value of Five Images.

The above said calculations and pixel values for the set of images taken and recorded using two radiation sources IR-192 and X-ray and also recorded in two image formats viz., BMP and TIFF using Cynoptix (CCD based scanner) was tabulated in Table. A. and the same for LASER scanner was tabulated in Table. B as shown below. The corresponding performance charts based on comparison strategies taken in to account based on PVR values of the images acquired using both scanners were shown in Table 1 to 8.

TABULATIONS OF MEAN AND PVR PIXEL VALUES FOR CYNOPTIX SCANNER

Table 1. 8NB –SET1A-IR192-BMP

LOCATION	LOCATION IDENTITY	PV1	PV2	PV3	PV4	PV5	MEAN	PVR
IQI	1	83	84	86	85	87	85	2.35
WELD1	2	75	77	74	76	76	76	2.12
WELD2	3	152	153	151	155	154	153	1.31
WELD3	4	154	151	152	153	150	152	1.32
PA METAL	5	60	58	59	56	57	58	3.45

Table 2. 8NB –SET1A-IR192-TIFF

LOCATION	LOCATION IDENTITY	PV1	PV2	PV3	PV4	PV5	MEAN	PVR
IQI	1	76	75	77	79	78	77	2.60
WELD1	2	72	74	71	73	70	72	2.78
WELD2	3	88	89	91	90	92	90	2.22
WELD3	4	86	89	87	86	87	87	2.30
PA METAL	5	55	53	52	51	54	53	3.77

Table 3. 8NB –SET1A-X-RAY-BMP

LOCATION	LOCATION IDENTITY	PV1	PV2	PV3	PV4	PV5	MEAN	PVR
IQI	1	119	121	120	122	118	120	1.67
WELD1	2	112	114	111	113	115	113	1.77
WELD2	3	175	173	174	176	172	174	1.15
WELD3	4	182	183	184	185	181	183	1.09
PA METAL	5	69	72	71	73	70	71	2.82

Table 4. 8NB –SET1A-X-RAY-TIFF

LOCATION	LOCATION IDENTITY	PV1	PV2	PV3	PV4	PV5	MEAN	PVR
IQI	1	61	64	62	63	60	62	3.23
WELD1	2	56	57	58	60	59	57	3.45
WELD2	3	84	88	87	86	85	86	2.33
WELD3	4	100	99	98	102	101	100	2.00
PA METAL	5	36	35	37	38	34	36	5.56

PIXEL VALUES FOR IGCAR LASER SCANNER

Table 5. 8NB –SET1A-IR192-BMP

LOCATION	LOCATION IDENTITY	PV1	PV2	PV3	PV4	PV5	MEAN	PVR
IQI	1	69	71	68	70	72	70	2.86
WELD1	2	73	72	70	69	71	71	2.82
WELD2	3	116	114	115	112	113	114	1.75
WELD3	4	111	115	113	114	112	113	1.77
PA METAL	5	54	55	56	52	53	54	3.70

Table 6. 8NB –SET1A-IR192-TIFF

LOCATION	LOCATION IDENTITY	PV1	PV2	PV3	PV4	PV5	MEAN	PVR
IQI	1	72	68	70	69	71	70	2.86
WELD1	2	70	71	70	73	71	71	2.82
WELD2	3	115	117	114	116	118	116	1.72
WELD3	4	112	115	113	111	114	113	1.77
PA METAL	5	52	55	54	53	56	54	3.70

Table 7. 8NB –SET1A-X-RAY-BMP

LOCATION	LOCATION IDENTITY	PV1	PV2	PV3	PV4	PV5	MEAN	PVR
IQI	1	118	117	119	116	120	118	1.69
WELD1	2	113	109	112	111	110	111	1.80
WELD2	3	159	156	158	157	160	158	1.27
WELD3	4	170	169	172	170	169	170	1.18
PA METAL	5	79	82	80	79	80	80	2.50

Table 8. 8NB –SET1A-X-RAY-TIFF

LOCATION	LOCATION IDENTITY	PV1	PV2	PV3	PV4	PV5	MEAN	PVR
IQI	1	109	112	111	110	113	111	1.80
WELD1	2	116	113	112	114	115	114	1.75
WELD2	3	164	166	168	167	165	166	1.20
WELD3	4	153	154	156	157	155	155	1.29
PA METAL	5	81	80	78	79	77	79	2.53

IV. COMPARISON CAMPAIGN

The comparison was carried out based on two parameters namely, Pixel value Reproducibility (PVR) and mean pixel value (M).

The following figures 1 to 6 shows the comparison charts between variouse image formats.

Comparison Based on PVR:

A. Comparison between image formats i.e., BMP, TIFF.
B. Comparison between radiation sources i.e., IRAY, XRAY.
C. Comparison between scanners i.e., CYNOPTIX, IGCAR LASER.

Comparison charts between image formats based on PVR :

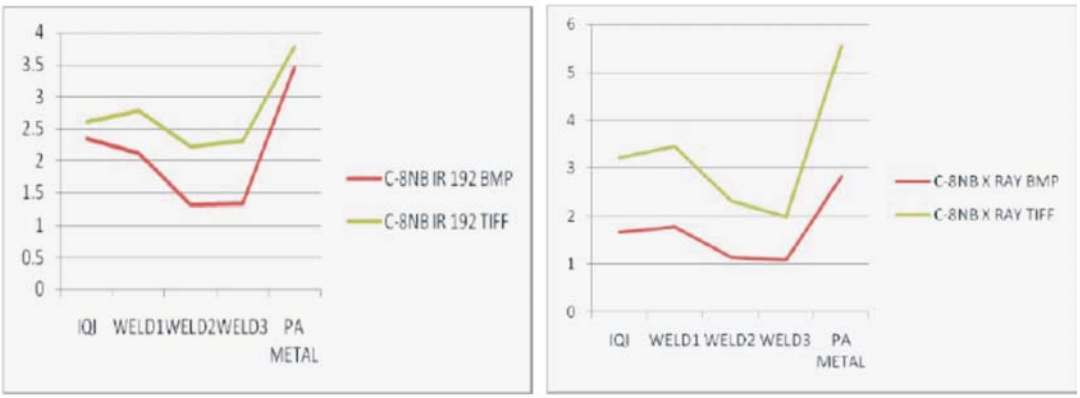

Fig. 1. PVR for CYNOPTIX scanners for IRAY & XRAY

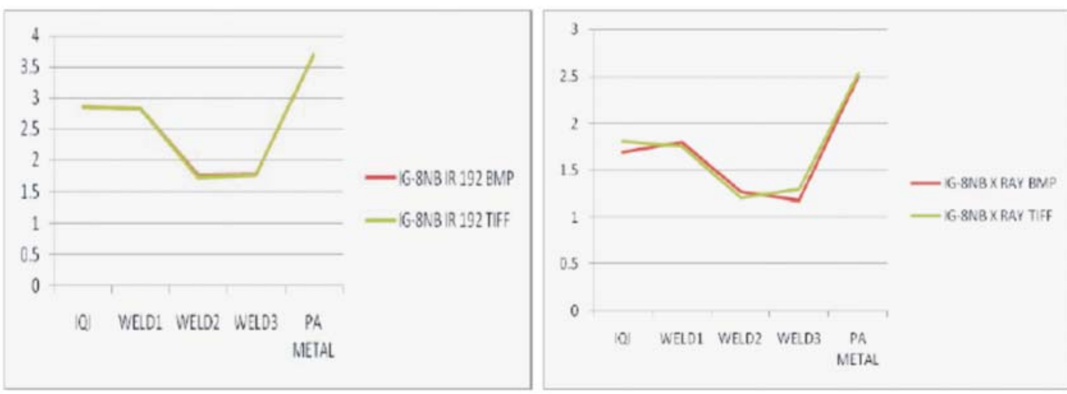

Fig. 2. PVR for IGCAR LASER scanners for IRAY & XRAY

Comparison Charts Between Radiation Sources Based on PVR:

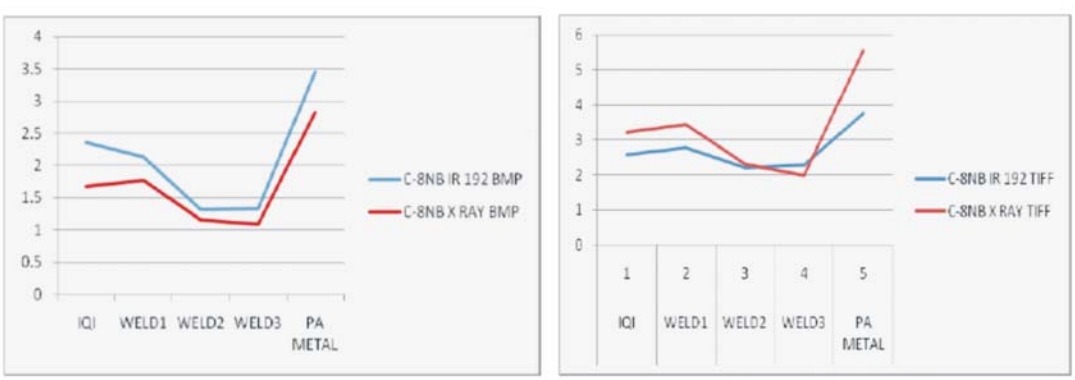

Fig. 3. PVR for CYNOPTIX scanners for BMP & TIFF

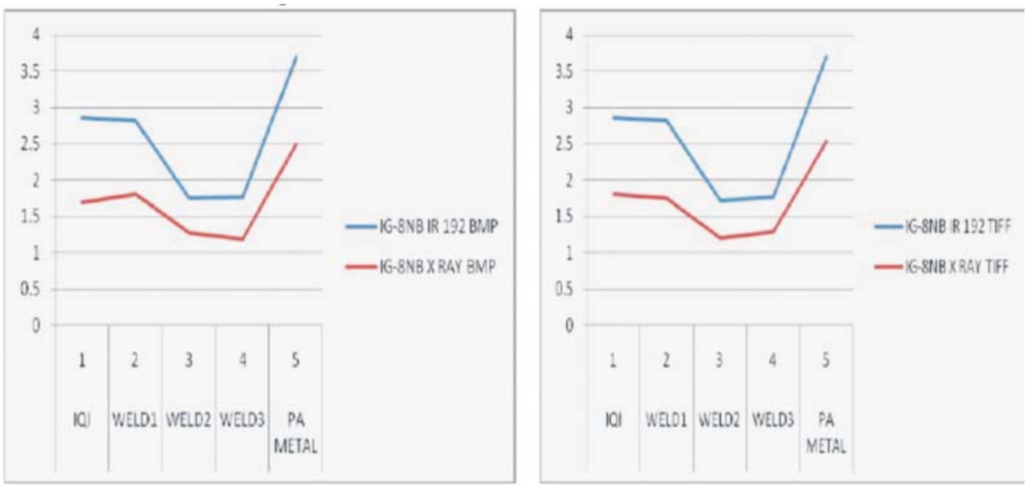

Fig. 4. PVR for IGCAR LASER scanners for BMP & TIFF

Comparison Charts Between Scanners Based on PVR:

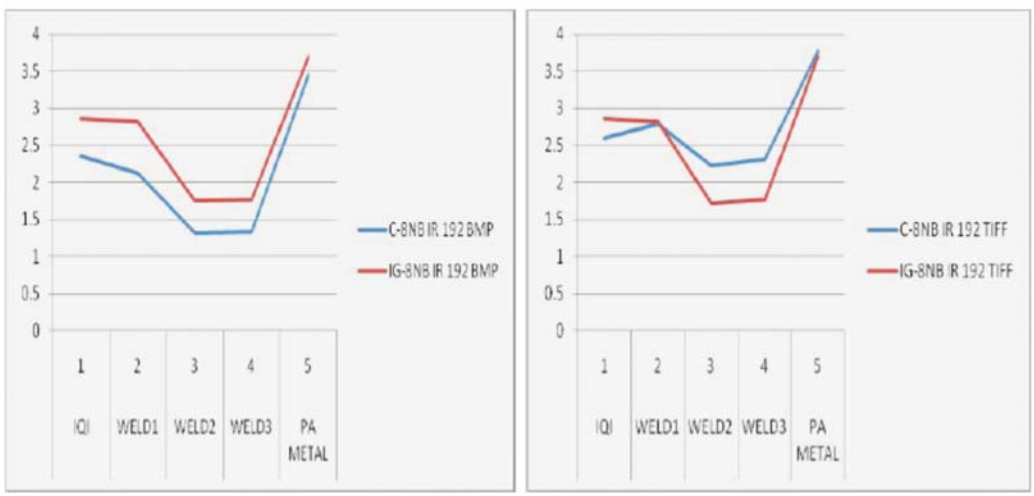

Fig. 5. PVR for IRAY Source for BMP & TIFF

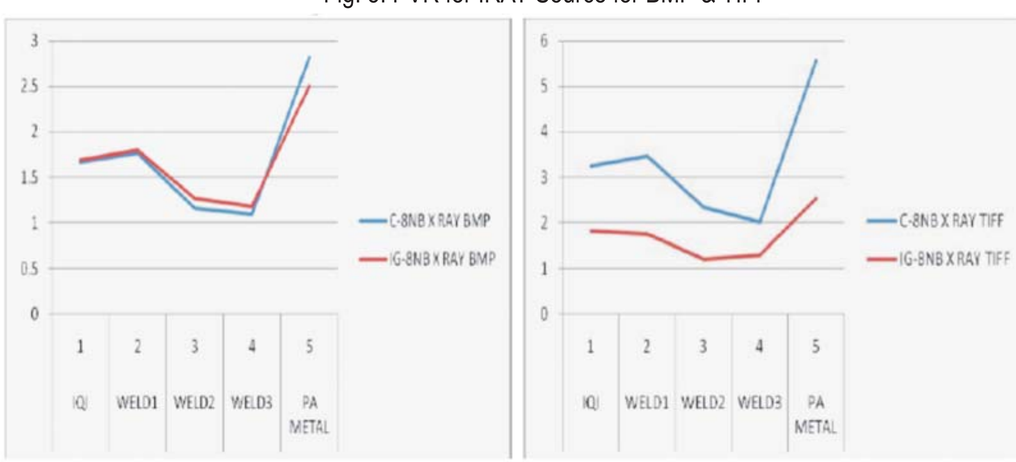

Fig. 6. PVR for XRAY Source for BMP & TIFF

V. COMPARISON BASED ON MEAN PIXEL VALUE (M)

The mean pixel value was compared for the same three categories i.e., With respect to image formats, With respect to radiation sources, With respect to scanners. The analysis was accomplished using statistics analytical tools. The mean pixel values of two sets to be compared were subjected to T-Test, which returns a hypothetical value or Probability value for the values submitted. From the values returned after the test, it I possible to decide that if any significant difference occurs or not occurs between the sets compared.

VI. CONCLUSION

On performing the hypothesis tests, the weld region presented a low PVR when compared with the PVR of IQI & Parent metal irrespective of the image formats, radiation sources, scanners compared. When the image formats are compared, the TIFF format presented a low PVR and BMP format presented a high PVR. When the PVR of radiation sources were compared, the IRAY source films produced high PVR whereas the XRAY source films produced low PVR, which concludes XRAY is best suited than IRAY films irrespective of image formats, scanners considered. When the PVR of the two scanners, viz., CYNOPTIX & IGCAR LASER scanners, the LASER scanner presented a low PVR and prints considerable difference in the pixel value reproducibility than CYNOPTIX-CCD based scanner.

On performing T-Test for the mean pixel values comparing the image formats resulted in a statistically significant difference ($p < 0.05$). When considered the radiation sources and scanners, the differences were again found to be statistically significant for all radiation sources and scanners ($p < 0.05$).

Usually, it could be assumed that a digital device should attribute the same pixel value as long as the image is kept same. But our results show that the above condition is not true. The variation in PVR may be due to the illumination source used in scanners, the type of radiation sources used, methods followed and temperature conditions in developing the sheets. It seems the digital device may suffer influences that modify pixel values for the same image in different digital captures. It is advisable to test the digitizers for pixel value reproducibility at same capture conditions prior to quantitative evaluation and analysis of dimensions of image features. The methods, comparison and tests performed provide a pragmatic approach in deciding the best digitizer giving true details of digitized radiographic image and present a method to find right image format and radiation source which can be realized by the results that plots the track for digital archiving of radiographic films.

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