A Study on Image Output Method in the Radiography Training Simulator

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Abstract: Background/Objectives: A simulated training can be induced to suit the actual situation by outputting the changed image according to various exposure doses by applying image processing filter technique during the implementation phase of radiography training simulator. The purpose of this study is to present an image output method using image processing filter in radiography training simulator. Methods/Statistical analysis: The applied image processing filter adjusts the Window width of the original image by calculating the difference between the target tube voltage and the applied tube voltage(kVp) and adjusts the image contrast by weighting value. Next, the Window level is adjusted by calculating the difference between the applied tube current and the target tube current(mA) and the enhancement is adjusted according to the weighted value. Findings: Image with adjusted Window Width, Window Level, Contrast, and Enhancement according to the exposure dose by applying the developed image processing filter Improvements/Applications: In future studies, a method that can output the image by reflecting the region of interest (ROI) of the collimator will be proposed.

Keywords: radiography, training simulator, image processing, mock up, X-ray

I. INTRODUCTION

In order to take radiographic images using radiographic imaging devices and perform examinations, the training of professional workers who have acquired professional knowledge and experience is of utmost importance[1]. In addition, the medical radiography education to nurture such professional manpower should be accompanied by theoretical education to acquire the theoretical knowledge, and practical training for the improvement of practical ability and experience accumulation[2-4]. However, since there has been a problem of radiation exposure to the trainees participating in the practice in radiography and diagnostic device practice, there are many limitations due to the problem of prevention of risk[5]. In order to solve the problem of radiation exposure to the students, the role of the patient was performed by a manufactured human phantom without direct radiography[6], or practice was done through a simulator implemented on the image screen by software[7-12].

However, the method using the human phantom has a problem due to the limitation in reenacting the postures in radiological examinations requiring various patient postures according to the examination method. In other words, since radiographs are used for patients, practicing the patient's posture with the same object as the human body or human body can enhance the practical effect. However, since the phantom is a model only, it cannot take a variety of photographing positions, so it is very limited in practice. Although the whole-body phantom can have a somewhat different postures, it is expensive and heavy, so there are many limitations in realizing the photographing posture like the actual patient, and there is a problem that the practical effect is not great.

In addition, even though there is no direct radiation exposure to the trainee because it is a phantom, the problem of radiation exposure to the trainee participating in the operation of the radiation equipment still remains a problem because the equipment uses actual radiation. In addition, since it is the practice environment where actual radiation is used, in order to establish a safe environment, the radiation room should be designed and constructed so that the radiation room can be protected according to radiation safety management regulations, and trainees are required to wear a personal radiation detector and periodically measure and report it, as well as to report the installation to the administrative office and periodically inspect the installed radiological equipment. Therefore, financial burden and administrative burden have been major problems.

In order to acquire images using medical X-ray equipment, it is necessary to actually generate X-rays to irradiate the human body[13]. On the other hand, all the radiological examinations procedures of the educational radiological image simulator are the same as the actual X-ray examination, but similar situations can be realized without using X-rays. Since X-rays are not irradiated, it is possible to practice the patient's posture on the actual human body, and it is possible to increase its effects. The core of the simulator is to implement a visual recognition of changes in the image according to the exposure dose. Recently, the authors developed a radiation image simulator for education and implemented a method for image output according to exposure dose through a simulator program[14]. The purpose of this study is to propose a video output method applying image processing filter to realize change of exposure dose in educational radiological image simulator.

II. MATERIALS AND METHODS

As one step advanced image output method in the image output method by the stepwise image database according to the 10-step exposure dose proposed in the previous study, it is possible to express the contrast and brightness change which can occur according to

Revised Manuscript Received on January 03, 2019.

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the change of exposure dose by applying developed image processing filter to one original image saved by scenario. The applied image processing filter adjusts the window width of the original image by calculating the difference between the target tube voltage and the applied tube voltage (kVp) and adjusts the image contrast by the weighted value. Then the difference between the target tube current (mA) and the applied tube current is computed to adjust the Window level and adjust the enhancement by the weighted value.

For the method of processing the output image performed by the radiography simulation system including image data DB storing the radiographic image data for each photographing region by the photographing posture and the photographing angle, image conversion information DB storing image conversion information, model detector, model radiation generator, image conversion means, display means, and data input means, the design includes a photographing condition input step of inputting a photographing condition including a photographing part, a photographing posture, a photographing angle, a tube voltage and a tube current amount through the data inputting step; a model device adjusting step of receiving the adjustment completion signal through the data input means after receiving the positional adjustment of the model detector and the model radiation generating device; an image data selecting step of searching the image data DB according to the photographing part, the photographing posture and the photographing angle and selecting one of the radiological image data as a simulated photographing image; a standard information obtaining step of obtaining a standard tube voltage, a standard tube current amount, a standard window width, and a standard Window level for the simulation image from the image conversion information DB; a difference value calculation step of calculating a difference between the standard tube voltage and the tube voltage to obtain a voltage difference and calculating a difference value between the standard tube current amount and the tube current amount to obtain a current amount difference; a weight obtaining step of obtaining a 1st weight and a 2nd weight according to the voltage difference from the image conversion information DB and obtaining a third weight according to the difference in current amount; an adjustment value calculation step obtain a window width adjustment value where 1st weight is applied to the standard window width, and obtaining a window level adjustment value by applying a second weight value and a third weight value to the standard Window level; an image conversion step of applying the Window width adjustment value and the Window level adjustment value to the simulated image through the image conversion unit and converting the same into an output image; and a display step of displaying the image for output through the display means.

2.1. *Exposure Factor*

The radiographic imaging equipment produces a radiation image according to the amount of radiation detected by the detector portion. The radiation is generated in the radiation tube in the radiation generator, and the characteristics are different according to the tube voltage (kV) applied to the radiation tube and the amount of tube current (mAs, current amount x time). In radiographic imaging, the quality of the radiographic image depends on the characteristics of radiation. If each irradiation condition is given according to the set value, the image can be outputted.

2.2. *Window width and level*

If the window width is narrow, black and white can be distinguished clearly. If the window width is wide, the medium density of black and white is increased, so it is difficult to distinguish black and white clearly. And because the Window level is the center point, the higher the Window level is, the lower the brightness is displayed. Conversely, if the Window level is low, the brightness is displayed as low. Therefore, window width up/down can control contrast, and window level up/down can adjust brightness.

III. RESULTS AND DISCUSSION

The Flowchart of processing method of output image performed by radiography simulation system is as shown in (Figure 1).

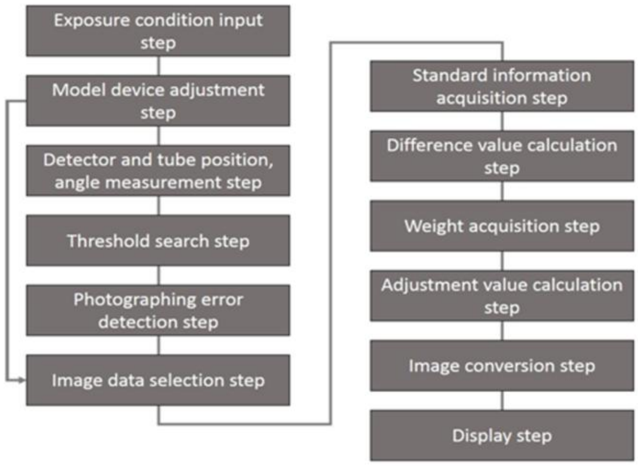

Figure 1. Flowchart of processing method of output image performed by radiography simulation system

The Example of image conversion information DB in processing method of output image performed by radiography simulation system is as shown in (Figure 2)

Image data identification code	Exposure area	Patient posture and direction	Standard tube voltage	Standard Window width	Standard Window widthl	Standard Window level	1st correction rate	2nd correction rate	3rd correction rate
A00001	Skull	AP	35	2.5	400	40	-0.02	0.003	-0.3
A00002	Skull	Right Latertal	35	2.5	400	40	-0.02	0.003	-0.3
A00003	Skull	Left Latertal	35	2.5	400	40	-0.02	0.003	-0.3
A00004	Skull	Town's	38	2.5	380	40	-0.02	0.003	-0.3
A00007	Skull	Lat	35	2.5	400	40	-0.02	0.003	-0.3
A00008	Skull	PNS	35	2.5	400	40	-0.02	0.003	-0.3
A00009	Skull	Cald well	35	2.5	400	40	-0.015	0.003	-0.2
A00011	Skull	Mandible series AP	37	2.8	400	40	-0.015	0.003	-0.2
A00017	Skull	Nasal bone Lat	38	2.5	380	40	-0.015	0.003	-0.2
A00018	Skull	T-M joint series	38	2.5	380	40	-0.015	0.003	-0.2
A00019	Skull	optic foramen	38	2.5	380	40	-0.015	0.003	-0.2
A00020	Skull	Zygomatic arch view	38	2.5	380	40	-0.015	0.003	-0.2
B00001	Pelvis &Hip	AP	40	5	350	35	-0.025	0.003	-0.2
B00002	Pelvis &Hip	Lateral	40	5	350	35	-0.025	0.003	-0.2
B00003	Pelvis &Hip	3/4view	40	5	350	35	-0.025	0.003	-0.2
B00004	Pelvis &Hip	Inlet view	40	5	350	35	-0.025	0.003	-0.2
B00005	Pelvis &Hip	Outlet view	40	5	350	35	-0.025	0.003	-0.2
B00006	Pelvis &Hip	S-I joint	40	5	350	35	-0.025	0.003	-0.18
B00007	Pelvis &Hip	Sacrum & Coccyx AP	38	5	380	38	-0.01	0.003	-0.18
B00008	Pelvis &Hip	Sacrum & Coccyx Lateral	38	5	380	38	-0.01	0.003	-0.18
B00009	Pelvis &Hip	Hip AP	38	3.5	380	38	-0.01	0.003	-0.18
B00010	Pelvis &Hip	Hip Frog-leg	38	3.5	380	38	-0.01	0.003	-0.18
B00011	Pelvis &Hip	Hip lateral	38	3.5	380	38	-0.01	0.003	-0.18
B00012	Pelvis &Hip	Hip axial -Translateal	38	3.5	380	38	-0.01	0.003	-0.18

Figure 2. Example of image conversion information DB in processing method of output image performed by radiography simulation system

The setting of exposure dose according to various test sites and body type is as shown in (Figure 3).

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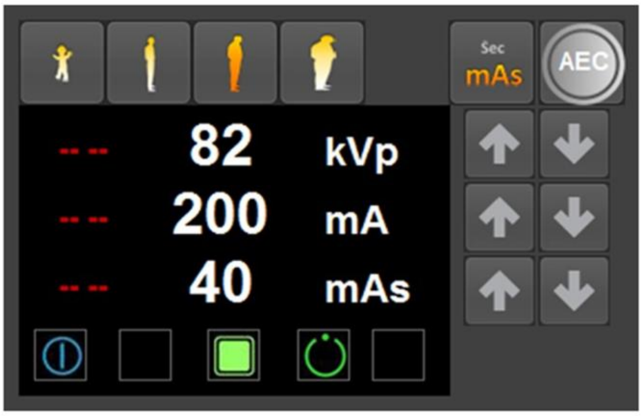

Figure 3. Setting window of exposure dose value

The method of outputting the image by calculating the target tube voltage, the applied tube voltage, the difference between the target tube current and the applied tube current by applying the developed image processing filter is as shown in (Figure 4) and Step 1, 2.

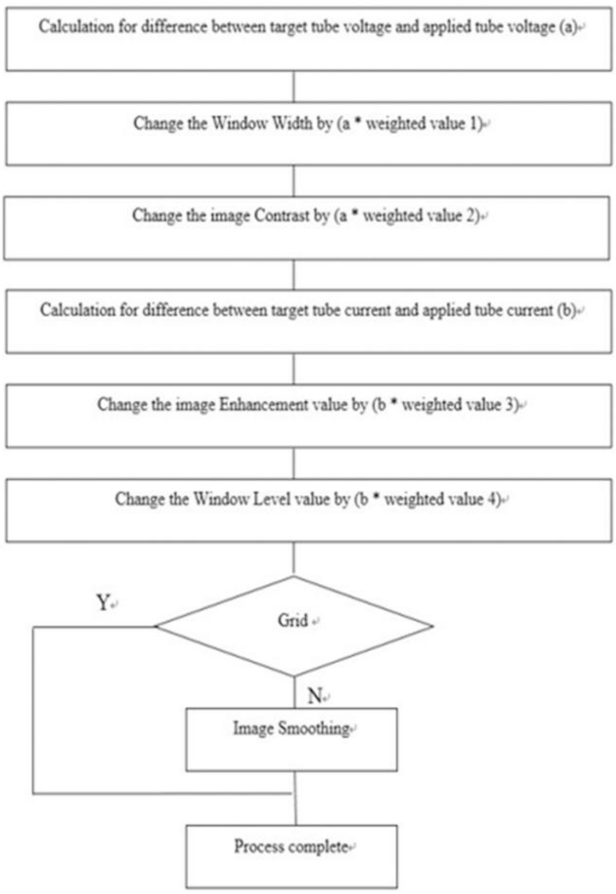

Figure 4. Flowchart for applying the image adjustment filter

Step 1: It is preferable that the correction rate includes 1st correction rate, 2nd correction rate), and 3rd correction rate. The 1st correction factor is a value for obtaining a 1st weight, and the 1st weight is a value for obtaining a window width adjustment value by applying the standard window width. The 1st weight is obtained by multiplying the voltage difference by the 1st correction factor (1st weight = voltage difference × 1st correction factor), The window width adjustment value is obtained by applying the 1st weight to the standard window width. The window width adjustment value is obtained as follows.

Window width adjustment value = (1 + 1st weight) × standard Window width = (1 + (voltage difference × 1st correction rate)) × standard Window width (1)

Step 2: The 2nd weight and the 3rd weight are values for adjusting the Window level by applying the standard Window level. Also, the 2nd weight is obtained by multiplying the voltage difference by the 2nd correction factor (2nd weight = voltage difference × 2nd correction ratio), and the 3rd weight is obtained by multiplying the current amount difference by the 3rd correction ratio (3rd weight = current amount difference × 3rd correction ratio). In addition, the Window level adjustment value is obtained by adding the 1st weight value and the 2nd weight value and applying the sum to the standard Window level. The equation for obtaining the Window level adjustment value is as follows.

Window level adjustment value = (1 + (2nd weight + 3rd weight))×Standard Window level = (1 + ((voltage difference×2nd correction ratio) + (current amount difference × 3rd correction ratio))) × standard Window level (2)

The image with Window Width, Window Level, Contrast, and Enhancement adjusted according to the exposure dose by applying the developed image processing filter is as shown in (Figure 5,6).

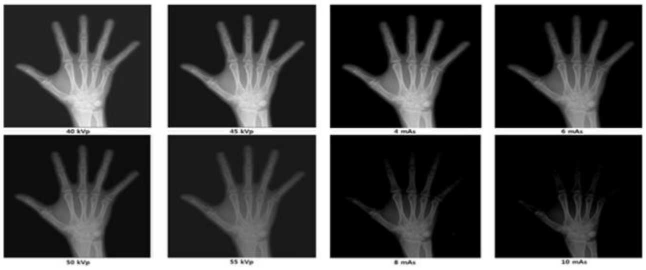

Figure 5. Example showing the contrast and brightness changes of radiographs according to tube voltage and current

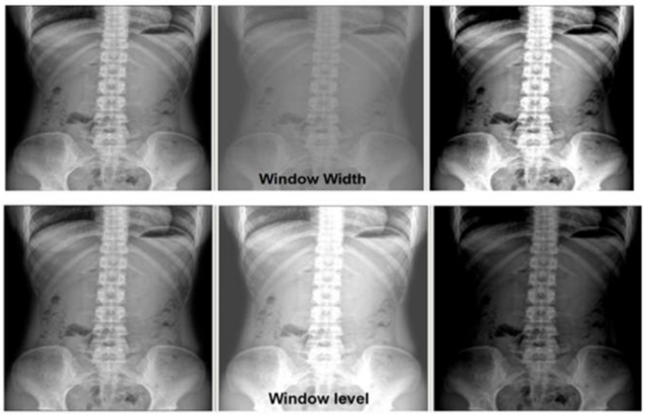

Figure 6. Example showing the change in contrast and brightness when the window width and level changes in radiograph

The processing method of the output image performed by the radiographing simulation system has the same effect as that of training with the radiographing apparatus by operating the actual radiographing apparatus even in the radiation simulation system in which the actual radiation is not emitted. Particularly, since radiation is not used at all, it is advantageous that all the persons involved in the operation such as the patient

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operator, the equipment operator operating the apparatus, and the trainee can receive the training without the risk of radiation exposure. In addition, the existing image data is stored in the image data DB according to the exposure posture/direction, the exposure angle, and the trainee participating in the exercise finds the image data matching the inputted photographing condition, that is, the photographing part, the photographing posture/direction, the photographing angle, etc., and displays it as a simulated photographing image on the display means, and in the case of students, it is advantageous since it maximizes the effect of the practical training by giving the same effect as seeing an image actually taken by the students. In addition, since the output image for which the window width and the window level are adjusted according to the tube voltage and the tube current input by the trainee for the simulation image to be produced and displayed on the display means, when the tube voltage or the tube current is insufficient or too large, the contrast or brightness is displayed to be inadequate (excessive or insufficient) in the simulated image, and this makes it possible for the trainee to know immediately whether the tube voltage and the tube current set by are appropriate or incorrect, and as a result, it is possible to obtain the same effect as actual radiography, and the effect of the practice can be maximized.

IV. CONCLUSION

In radiographing practice, not only is it possible to search for image data that match the radiographing area, radiographing position and radiographing angle in the image database storing the existing radiographs according to the radiographing conditions inputted by the trainees, since the image data is transformed according to the input conditions such as tube voltage, tube current, etc., it is possible to perform the same practice as the actual radiograph without danger or concern that the participant participating in the practice is exposed to radiation. It can realize images according to various exposure dose that can occur during video output. In addition, the radiographic image data of each photographing part, photographing posture, and photographing angle stored in the image data DB stores only one image data normally photographed, and if the input value for radiography is set correctly, it is displayed as it is, and if the input value setting is wrong, the image is modified to fit the input value, so there is no need to secure an image for all cases in which the input value is set incorrectly and there is an advantage that it is easy to construct the image data DB since only one image data normally photographed is taken for each photographing site, photographing posture and photographing angle. Future research is expected to provide a method of outputting the image by reflecting the region of interest (ROI) of the collimator.

ACKNOWLEDGMENT

This work was supported by the Far East University Research Grant(FEU 2018S05)

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