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Determination of Exposure Factors And Interlock System Base on Fuzzy Logic In X-Ray Conventional Generator

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Abstract

One of the utilization of x-Ray on medical area is radiogram. Result of the radiogram can determine patient diagnosis of disease. More clearly the result of imaging, can bring pecise and accurate diagnosis. To solve that problem, we need to calculate distance between X-Ray tube and object, type of film, screen kaset, and also situation or condition of body weight either mature, child or infant to determine exposure factors. Exposure factors is kilovolt, miliampere and time. That exposure factors means electrical load toward X-Ray tube to produce radiant intensity. Interlock system is used to prevent useless generation of X-Ray and doesn't produce diagnostic value. In this research using fuzzy logic to determine exposure factors on thorax examination which is implemented in software by using pre-defined reference data. By input distance, body weight, body height in software will be obtained appropriate exposure factors setting for radiografer. By determining the focus distance of the appropriate (valid) film, then the fuzzy logic system can build an interlock system that will prevent the useless x-rays. The results showed that data taken from a radiographer in a local hospital in Semarang compared with the output of exposure factor software was appropriate and when interlock system is activated the fuzzy control system can prevent the generation of x-rays

Keyword:*x-ray, radiogram,exposure factor,interlock system, fuzzy logic*

1. Introduction

Radiology diagnostic examination in hospital used x-ray, which is pattern or image is producted due effect of attenuation on material or object when passed by x-ray radiation, is ability of the material to absorb the radiation that comes through or passing from the organ. The shadow pattern output from x-ray film is produced based on suitability of the exposure factor selected by a Radiographer with observing the patient's physical condition for the x-ray photograph. The exposure factor is selected base on type of examination, body weight, projection position, distance and the physical condition of patient. Exposure factor is an electrical load on the x-ray tube during x-ray generation. The exposure factor is determination of voltage, electric current, and times quantities to produce x-ray intensity. Previous research about use of x-rays in the medical field such as the research of the image plate as a detector, with the purpose to determine the effect of exposure factor on level sensitivity of image plate to x-rays [1], The study about implementation rule of the 15 percent to obtain the highest contrast on a radiograph of Computed Radiography, with Stepwedge as an object, Imaging Plate as a digital data storage device to be processed into image [2], Research about creating the Prototype of device micro controller x-ray, purpose of this research is innovating the device system of x-ray from conventional system become an automatic system [3], Research on the effect of scatter radiation on radiographic contrast because an effect of variations on object thickness and radiation field area in order to analyze the correlation between the effects of scattering radiation on density change and radiographic contrast caused by object thickness and changes in radiation field and to measure film density [4]. This research focused on the determination of exposure factor and interlock system by using fuzzy logic control based on ideal patient reference data in one of the hospitals.

Fuzzy logic is used to determine correction of exposure factors and interlock systems for patients with lean to fat conditions.

2. Methodology

X-rays are electromagnetic waves that have very short wavelengths, so that x-rays can penetrate the material. The caracteristic of x-rays such as can be absorbed by the material, can discolor the film paper, and cause biological hazard. Based on these effects, x-rays are used in the health field, both for diagnostic and treatment [7]

X-rays are protucted by x-ray device, right on an inherent x-ray tube. The x-ray tube consists of the cathode electrode and the anode electrode as the target. The filament cathode as an electron generator, when the cathode and anode are given high voltage, the electrons will move rapidly to collide with the target anode, due the collision is generated x-rays.

Figure 1. Indicates an inherent x-ray tube, shows the cathode and anode electrodes in the glass envelope

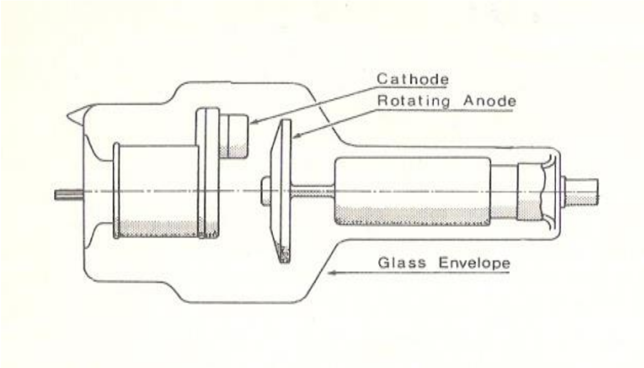

Figure 1. X-Ray Tube (inheret)

Voltage, electrical current and times is used to variable of radiation, this variable is an exposure factor that determines the amount of x-ray intensity while imaging. x-rays are directed precisely to the object. The strength of the radiation and the amount of radiation need to be adjusted to fit the size of the object.[5]

The Rays setting classified into three parts, such as :

(a) Focus Film distance (FFD)

Distance between ray source (focus) to Film should be adjusted on every imaging, because it will affect image quality, exposure factor and so on. Generally, FFD on Radiography imaging ranges from 70 – 150 cm, depend on type of examination.

(b) *Central Ray Setting* (CR)

Central Ray is the center of ray beam used in imaging. The central ray is a straight line in the middle of a ray beam that indicates the direction of the ray in Figure 2.

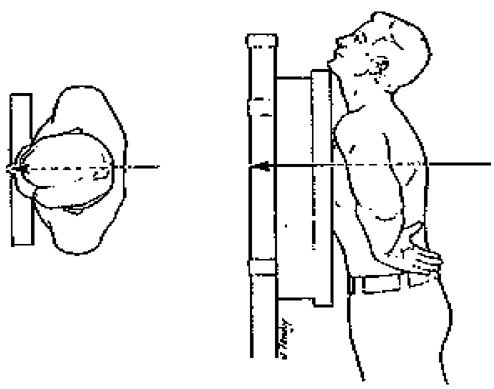

Figure.2. Direction of Posterior-Anterior Projection

(c) Exposure Factors (kV, mAS)

The exposure factor determines the value of electrical load in x-ray tube when emitting x-rays to determine the intensity of x-rays.

The determination of exposure factor can be corrected if there is a change [8], there are:

a. Correction focus distance to film
   Will affected to mAS value, for example on distances 70 cm, 100 cm, 120 cm, and 150 cm, we will had ratio of mAs each 1: 2: 3: 41/2. mAs are always larger when FFD distance is more far.
b. Correction Body Thickness
   The effect of object thickness on radiation value is very important. If estimate of object thickness are too low, it will cause poor radiation value. And If estimate of object thickness are too high, it will cause transcendence radiation value.
   The radiation data tabel is based on the "normal" condition of the object, which have proportional body height about 1.70 m and body weight about 70 kg. By using "normal" radiation price, should be applicable that variations when setting radiant strength when examination on thin patients or fat patients.

Rule of thumb for correction kV, every increasing 1 cm of the object's thickness requires increasing voltage about 5 %, and decreasing 1 cm of the object's thickness decreasing voltage about 5%.

Rule of thumb for mAs correction, every increasing 1 cm of the object's thickness requires increasing mAs about 25 %, and decreasing 1 cm of the object's thickness decreasing mAs about 25%.

Ideal Body Weight Using Body Index Calculation Method [17] like the equation below.

$$BBI = \frac{BB}{KTB} \quad (1)$$

where :

BBI = Body Mass Index (Kg / m)
BB = Body Weight (Kg)
KTB = Body Height in quadratic (m)

Tabel 1. Criteria of Body Mass Index

Body Mass Index	Characteristic
< 17	Underweight
17	Severely underweight
18,4 – 21	Medium weight
21,1 – 25	normal / ideal weight
25,1 – 27,5	Overweight level 1
27,6 – 30	Overweight level 2 / Obese

Computer radiography equipment is used for making up the image. The exposure index of CR tool is intensity value of x-ray produced, which is used for effective value required in image processing to produce the maximum image contrast that can be produced. The formula in calculating the Exposure Index :

$$EI = 1000 \log(E) + 2000 \quad (2)$$

For counts of data with linear regression formula

$$Y = a + b X1 + c X2 \quad (3)$$

where :

Y = *Index Exposure*
X1 = kilo Volt
X2 = mAS

The Research Method using fuzzy logic controller application to determine the extent exposure factor which using reference data of the X hospital exposure factor in Semarang. Literature study used to get reference about fuzzy logic application, exposure factor data, and GUI (graphic user interface) with visual basic programming.

This programming is used to simulate the result determination of exposure factor by using fuzzy logic, use correction of rule of thumb

Fuzzy Inference System (FIS), in forming FIS, the input distance data and body mass index, and output is exposure factor value, Kilo Volt, mA and Time.

Fuzzyfication

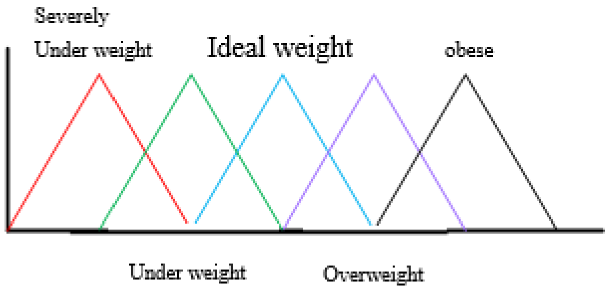

Figure 3. Body Mass Index Variable

where :

- Criteria of Body Mass Index (17 - 30)
- Severely underweight = Triangle (human index, 0, 17, 19.5)
- Under weight = Triangle (human index, 17, 19, 22)
- Ideal weight= Triangle (human index, 19, 21.5, 25)
- overweight = Triangle (human index, 21.5, 25, 28)
- obese = Triangle (human index, 24.5, 28, 31)

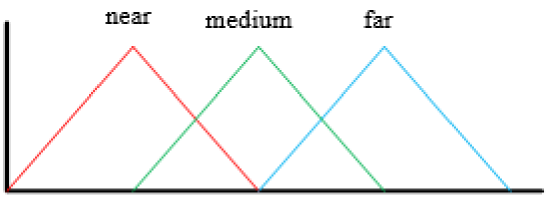

Figure 4. Distance Variable

Information :

- Criteria of Distance (0-150)
- Near = Triangle (Val(txt_distence), 70, 82.5, 95)
- Medium = Triangle (Val(txt_ distence), 90, 97.5, 116)
- Far = Triagle (Val(txt_ distence), 110, 130, 150)

a. Rule Base (Index vsdistance)

Table 2. Rule Base

Rule	Index vs distance
r (1)	Minimal (Severely underweight, Near) * Smaller
r(2)	Minimal (Severely underweight, moderate) * Smaller
r(3)	Minimal (Severely underweight, far) * Smaller
r(4)	Minimal (Underweight, near) * Smaller
r(5)	Minimal (Underweight, moderate) * Smaller
r(6)	Minimal (Underweight, far) * Small
r(7)	Minimal (Ideal weight, Near) * Smaller
r(8)	Minimal (Ideal weight, Moderate) * Small
r(9)	Minimal (Ideal weight, Far) * Small
r(10)	Minimal (Overweight, Near) * Small
r(11)	Minimal (Overweight, Moderate) * Moderate
r(12)	Minimal (Overweight, Far) * large
r(13)	Minimal (Obese, Near) * Smaller
r(14)	Minimal (Obese, Moderate) * large
r(15)	Minimal (Obese, Far) * larger

The Research Method using fuzzy logic application to process the exposure factor, then will be implemented through GUI (graphic user interface) with visual basic programming. This simulation illustrates the steps taken by a radiographer when performing X-ray shoot in a patient. Fig 5 shows the radiographer simulation step when making radiogram, that is:

1. Estimates the patient's body condition, by including patient's weight and patient's height to produce body mass index, condition of lean to fat patients is depicted in body mass index between 17 – 30
2. Enter the selection of organs to be examined, eg "Thorax"
3. Enter the projection option to be done "anterior posterior" or "posterior anterior"
4. Enter selection of focal distance - film, option 70 cm - 150 cm
5. Make a choice of "Interlock" or "No Interlock"
6. Pressing the "Exposure" Execution Button

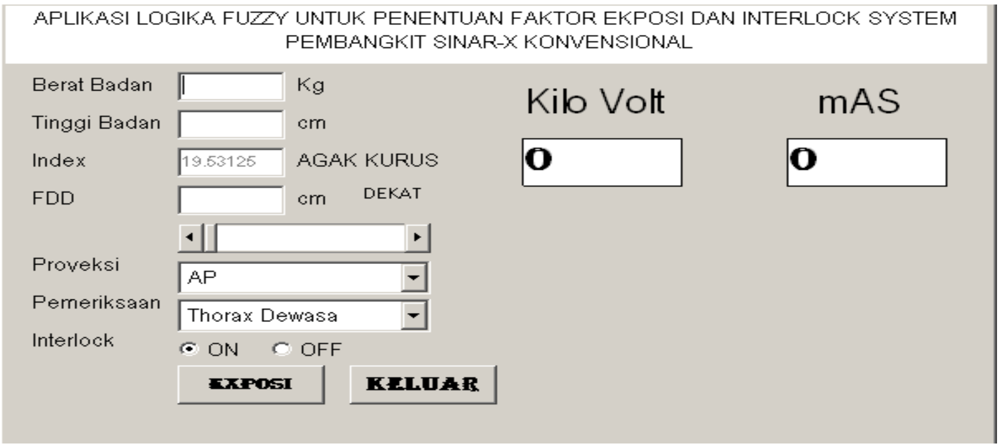

Figure 5. GUI Simulation Mode

Flow Chart

Describes the flow of exposure factor determination program

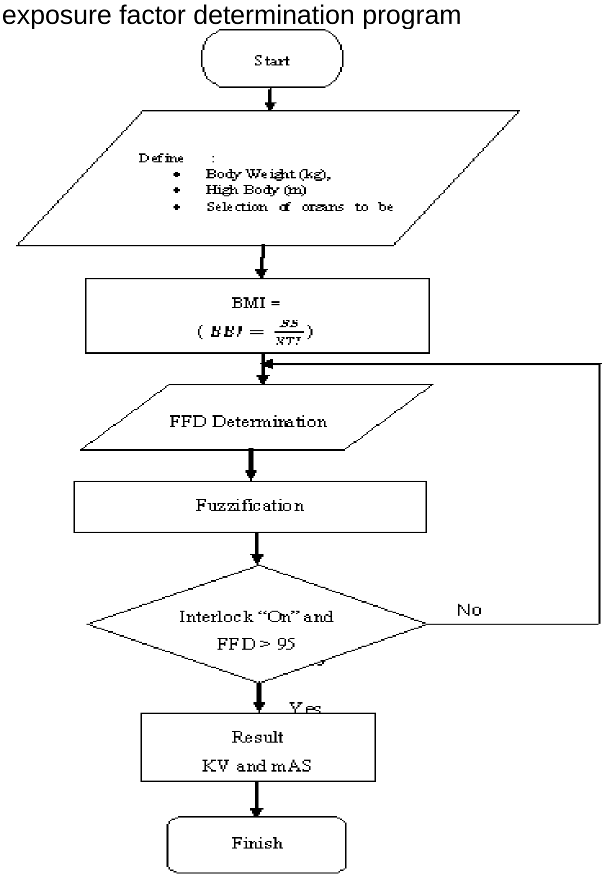

Figure 6. *Flow Chart* Research

3. Results and Discussion

The results is exemplified in obese patient examination, then the results eksposi factor as shown in Figure 7 :

1. Obese patient

Figure 7. Simulation of overweight patients

The study :

In Picture 7, Size of body mass index = 29.6 produced according to the formula above, then entered in category of obese conditions. By inserting an adult Thorax examination option on the posterior anterior projection (AP) option, as well as a choice of a distance of 140 cm, after execution is generated the output of the exposure factor:

X-ray tube voltage = 69 kV
X-ray tube current = 9,5 mAS

2. System Interlock "ON", if the focus distance - film <95 execution performed will not produce exposure factor output, because the distance is not appropriate, it cause the occurrence of radiogram that do not meet the requirements as shown in Figure 8.

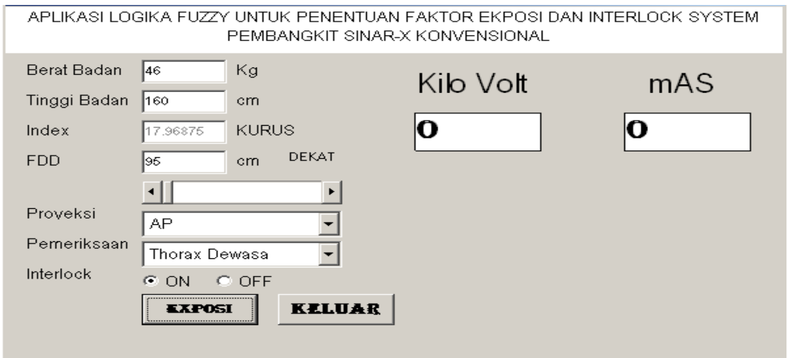

Figure 8. Interlock System Simulation

3. In Table 3. shows the simulations performed representing of underweight body index to overweight body index in produces an exposure and interlock factors that occur based on focus distance - the selected film. The table corresponds to simulation conditions performed in Figure 8

Table 3. The simulation result of Exposure Factor & Interlock System

Wight body (kg)	High body (Cm)	Index	Condition	Interlock	FFD (Cm)	Voltage (kilo Volt)	Second Flow (mAS)	Information.
48	168	17	Severely underweight	On	130	55	2,5	Valid
48	168	17	Severely underweight	On	95	0	0	Not
48	168	17	Severely underweight	Off	95	55	2,5	Valid
62	168	21,9	Under weight	On	120	61,3	5,1	Valid
62	168	21,9	Under weight	On	95	0	0	Not
62	168	21,9	Under weight	Off	95	61,3	5,1	Valid
65	162	24,7	Ideal weight	On	140	66,2	7,4	Valid
65	162	24,7	Ideal weight	Off	140	66,2	7,4	Valid
65	162	24,7	Ideal weight	Off	95	0	0	Not
75	170	25,9	Overweight	On	140	67,6	8,4	Valid
75	170	25,9	Overweight	Off	140	67,6	8,4	Valid
75	170	25,9	Overweight	Off	95	0	0	Not
75	170	25,9	Overweight	Off	95	64,9	6,5	Valid
85	172	28,7	Obese	On	140	69	9,5	Valid
85	172	28,7	Obese	Off	140	69	9,5	Valid
85	172	28,7	Obese	On	95	0	0	Not
85	172	28,7	Obese	Off	95	66	7,5	Valid

4. Analyze sample of thorax photo which is processed using SPSS on linear regression formula shown as table 4:

Table 4. Results of linear regression of SPSS

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	1172.527	424.787		2.760	.010
	kV	1.167	5.875	.031	.199	.844
	mAs	57.682	15.047	.594	3.833	.001

a. Dependent Variable: IE

The exposure factor analysis uses Kodak *Computer Radiography* system which requires exposure index range between 1700 - 2000, with the help of linear regression formula using SPSS result. the determination of exposure factor obtained decreased the exposure index of minimum exposure index requirement from minimum standart.

Tabel 5. IE Result by using SPSS

Kondisi Fisik	Indek Eksposi	Standar IE Kodak
Severely underweight	1423,3	1700 – 2000
Under weight	1513,5	1700 – 2000
Ideal weight	1609,4	1700 – 2000
Overweight	1705,2	1700 – 2000
Obese	1802,2	1700 – 2000

4. Conclusion

Results of the reseach is, fuzzy logic is used for determine of exposure factor and can built interlock system if the distance of focus-film is not appropriate.

The analysis using computer radiography and linear regression using SPSS is known that the referencing exposure factor should be evaluated and corrected again.

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