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Brightness and Contrast Enhancement of Medical Images (X-Ray and Fluoroscopy) and Quality measurement

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Abstract: The main objective of this study is to apply three cases of brightness and contrast on medical images. As for as measuring the quality of any digital image is of crucial importance for many image processing applications, this study would take this importance into consideration. Using various medical techniques, the medical images under study are taken X-ray and fluoroscopy. The purpose behind that is to ensure the enhancement of brightness and contrast. To achieve the objective of the study, a diagnosis for the medical images in the same part of the body is done by evaluating the quality of these images. A well-known set of quality metrics are applied such as Image Fidelity (IF), Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index (SSIM), Synthetic Content (SC), Average Difference (AD).

Key words: Quality image measurement, medical images, brightness and contrast, techniques, fluoroscopy, Iraq

INTRODUCTION

The tremendous developments in information technology has led to the increased use of digital images and the increased need for the development and introduction of many digital processing techniques. For the purpose of analyzing and extracting important information from images for use in different areas such as (military and industrial and agricultural). The picture usually sourced from ideal precisely for several reasons, including the limited visual system and lack of idealism and because of the presence of defects cannot be avoided in imaging systems as well as external influences of weather conditions or body movement or during the process of taking pictures imaging system. All these defects lead to reduce the resulting image quality of imaging systems.

So, it must address these distortions for new images can be analyzed and utilized. Has developed and introduced many of the removal of distortions techniques were also used many of the filtering techniques to remove the noise associated with digital images and reduce its impact but most of the processing is not free completely defects but improved in sometimes sites and other sites for the deformation suggested that many of the criteria to examine the quality of the image.

Digital image: It is representation through two values, these are the zero and one on the computer according to the bilateral measurement. In any digital image, pixels are considered the main components. On the computer, pixels ape the smallest units in the picture. Image, however is a matrix that contains of pixels which are distributed into rows and columns. The clearness is the image is characterized by the increase of the number of pixels. The higher is the number, the more clarity is the picture. Accounting for two-dimensional image function by a group of fragmented spatial variables and function numerical f(x, y) can be used to represent the light intensity in the spatial axes at the point (x, y) is positive (Sheikh *et al*., 2006).

In the vertical direction of the image, N refers to the number of elements. In the horizontal direction of it, M refers to the number of elements. Therefore, the digital image can be represented by the following matrix:

$$F(x,y) = \begin{bmatrix} f(0, 0) & f(0, 1), ..., & f(0, N\text{-}1) \\ f(1, 0) & f(1, 1), ..., & f(1, N\text{-}1) \\ F(M\text{-}1, 0) & f(M\text{-}1, 1), ..., & F(M\text{-}1, N\text{-}1) \end{bmatrix} \quad (1)$$

Here, will be f(x, y) sized Pictures (M N) where each element is considered a pixel and together those elements are shown in a specific form of integers characterized by a fixed range:

$$0 \le f(x, y) \le L_{max} \quad (2)$$

The highest level of intensity which is shown by white color is represented by L_{max} whereas the lowest level of intensity in the picture which is shown by black color

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is represented by 0. The period [0, L_{max}] is known as grayscale (the gray level). However, f(x, y) refers to the physical signal which reaches at a two Dimensional sensor (2-D sensor). These values are therefore representing a number of variables that including the depth of the body function (Z is the value of imaging color package, λ is the value of wavelength which represents the electromagnetic wave and the value of exposure sensing time-t as the time of fumbling exposure (Gonzalez and Woods, 2008).

Medical imaging: This term refers to all the procedures made in order to get particular images to all of the human body or part of it. Those procedures include the processes and techniques used for the purpose of human diagnosis and therapeutic as well as conducting a scientific research. The branches of the vital biological imaging (Bio biological Imaging) are involved heavily with radiology (Radiology) endoscopy (Internal fluoroscopy) and thermal imaging (James and Dasarathy, 2014).

Techniques of medical imaging

X-ray: X-ray technique that uses electromagnetic radiation to create a picture that is recorded on a thin plate (Thin plate) called “radial image” radiograph name. Body parts appear light or dark because of varying different tissue X-ray absorption rates (He *et al*., 2006).

Imaging devices for endoscopy (fluoroscopy): It is the technique that uses X-rays to be taken from a patient where it is signified by having the patient get a colored dye intravenously to identify the kidneys and urinary tract or to portray the veins. Adding to this by injecting pigment directly into the bladder or into the urinary tract, filming the bladder and the urinary system would be feasible (Hendee and Ritenour, 2002).

Brightness: Defined as the visual perception of self heavily on the light from the surface or from the source of the bullet. Also, it is known as a component of the sense of sight which seems to be a source radiates or reflects light. This means that the brightness is to recognize the existence of the source radiates light. It is measuring the reflected part of the beam falling on the white-colored material. The term brightness is used in the optical measurement as a synonym for the term illumination intensity (Luminance). Use as a mistake in the science of measurement of radiation as a synonym for the term radioactivity. So, you should use the term brightness (brightness) only refers to the sensation and perception of light. Brightness can be understood in the color space (Red Green Blue (RGB)) as the arithmetic mean (μ).

In order to make light look brighter, the coordination between the three colors red, green and blue with other three elements which can occurred automatically in some manifestation systems. This can be expressed by μ following relationship:

$$\mu = (R + G + B)/3 \quad (3)$$

As μ: the arithmetic average of the coordinates of the tricolor. R, G, B, coordinate the color red (Red) and green (Green) and blue (Blue), respectively (Miyahara *et al*., 1998).

Contrast: Contrast is the ratio between the body Lighting (Object) background lighting (Background) which is located by the objects. The contrast sensitivity depends on the spatial distribution of the bright areas (Mrak, 2004).

Image quality: The term image quality image quality refers to the degree visibility to see the picture and can be expressed analytical the image or the ability of analysis that can be defined as the viability of the optical system to separate objects converged and distinguish them or are smaller separation angle between the two bodies, the amount in order to keep each of them separately from the other in the visual system and can be defined as the amount of the quality of the image sharpness and contrast in the image details and there are several factors that affect the quality of the picture and the most important of these factors are (Zhang *et al*., 2011).

Image resolution: Defined as the ability of clarity imaging system to record the exact details by distinguishing between the two signals close to each other spatially or spectrally close to each other or in distress or tight timetable, describing the details carried by the digital image, the larger the high clarity the image more details (Sheikh and Bovik, 2006).

Contrast ratio: The contrast is one of the factors affecting the image quality and dynamic range is defined as the system show it is simply a way to express the degree of difference between the most viewer’s gradations or observers of the image (number of observer). As MOS consists of 5° to evaluate the image quality are (Zhang *et al*., 2010):

- Excellent quality
- Good quality
- Acceptable quality
- Poor quality
- Unacceptable quality

Objective quality metric: The objective standards to measure the quality of the image played important roles in various applications of image processing. The objective measure mathematical procedures that measure the amount of distortion in the image due to the lack of clarity and noise and pressure as well as the in efficiency of the sensor and any source can distort the picture. Image quality depends mainly on its own designs and traditional objectivity such as Square Error rate (MSE) which rarely works strictly in quality. Depending on prior information about the original image (Avcibas *et al*., 2002).

Objective quality metrics used in study: After application of the three cases to improve the brightness and contrast set forth in Table 1 on the image of the colon taken techniques (X-ray and fluoroscopy) was then applied the following standards to measure the quality of the image of the colon as follows (Sheikh and Bovik, 2006; Zhang *et al*., 2010; Avcibas *et al*., 2002; Eskicioglu and Fisher, 1995; Mrak *et al*., 2003; Kumar *et al*., 2012; Wang *et al*., 2002; ITU-T SG09, 2001; Damera-Venkata *et al*., 2000; Standard, 1996; Poynton, 1997):

Image Fidelity (IF): Image resolution refers to the ability of operations to restore the image accurately without distortion and clear or loss of information. There is a natural tendency to confuse the two terms image quality and image resolution but the two terms are used interchangeably (interchangeably) but different from one another. This is known as the scale according to the following Eq. 4:

$$IF = 1-\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j)-y(i,j)]^2}{\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j)]^2} \quad (4)$$

The Structural Similarity Index (SSIM): The more common standards in image quality with full reference are the two scales. First, the proportion of great signal to noise (PSNR), second, the Square Error Rate (MSE). Nevertheless, the big mistake difference in these meaures do not always lead to large structural distortions. Zhon Wang and Alan Bovik suggested the use of (SSIM) in order to assess the quality of image and to avoid the problem of measurements. The SSIM is based on a measure to evaluate the three different scales that are light intensity (luminance), contrast and finally structure. The equation below expresses the structural similarity index:

$$SSIM(x,y) = I(x,y).c(x,y).s(x,y) \quad (5)$$

Table 1: Cases change the brightness and image contrast

Cases	Image contrast ratio (Cont.) (%)	Image brightness ratio (Brit.) (%)
CB1	-20	-20
CB2	+20	0
CB3	0	+20

Feature Similarity Index By Using Riesz Transforms (RFSIM): This scale was based on a new property novel feature is based on a model to evaluate the Image Quality (IQA) is Rest Transfers (Riesz Transforms) based on the similarity who suggested the real basis that the Human Visual System characteristic scale (HVS) realizes's mainly according to the characteristics of low level. The (RFSIM) is calculated from the following Eq. 6:

$$RFSIM = \prod_{i=1}^{5}\frac{\sum\sum\frac{2x(i,j).y(i,j)+c}{x^2(i,j)+y^2(i,j)+c}.M(x,y)}{\sum\sum M(x,y)} \quad (6)$$

As the M(x, y): an on-site property Mask(i, j): c fixed be small value.

Spectral Residuals Based Similarity Index (SR-SIM): Defined as a rapid and high coefficient of performance in assessing the quality of the image based on the Remaining Spectrum (SR) Spectrum Residual. Where it was proposed fast and effective innovation labs evaluate the image quality is called the Remaining Spectrum (SR) Spectrum Residual based on Similarities (SR-SIM) as this measure is based on the importance visual Saliency Specific Model. Therefore (SR-SIM) between the original and enhanced images is known as in the following Eq. 7:

$$SR\text{-}SIM = \frac{\sum_{x\in\Omega} S_v(x)[S_G(x)]^{\alpha}.R_m(x)}{\sum_{x\in\Omega} R_m(x)} \quad (7)$$

Feature Similarity Index (FSIM): This measure is based on the theory that the human visual system (Human Vision System (HVS)) explains the image on the basis of low-level features such as edges. Uses the scale (FSIM) Fourier transform of the original image property and improved quality assessment. Is calculated scale ((FSIM to evaluate improved image quality for the original using the two features of the image are the consensus phase (Phase Congruency) (PC) and the amount of gradient (Gradient Magnitude) (GM). The calculated (FSIM) of Eq. 8 the following:

$$FSIM = \frac{\sum_{i=1}^{M}\sum_{i=1}^{N}(\text{Similarity image})}{\sum_{i=1}^{M}\sum_{j=1}^{N}(PC_m)} \quad (8)$$

Visual Information Fidelity (VIFp): The visual quality measurement is of fundamental importance in many image processing and video applications that have been proposed this tools to measure the accuracy of image information that determines the amount of the information contained in the original image and also determines the amount of reference information that can be derived from the distorted image. It is calculated from the following Eq. 9:

$$\text{VIFp} = \frac{(\sum_{(j\in \text{subbands})} I(\vec{C}^{(N,j)}; \vec{F}^{(N,j)} | \vec{S}^{(N,j)})}{\sum_{(j\in \text{subbands})} I(\vec{C}^{(N,j)}; \vec{E}^{(N,j)} | \vec{S}^{(N,j)})} \quad (9)$$

Mean Squared Error (MSE): Is the most basic standards for quality digital picture and is defined as a statistical measure that compares the pixels and pixel another on the basis of the intensity of illumination pattern (Luminance) between the original image and improved the image meaning it measures the difference between the pixels images and between (0-8) where the greatest value for (MSE) indicate that the picture has poor quality. It is calculated by the following Eq. 10:

$$\text{MSE} = \frac{1}{MN} \sum_{i=1}^{N} \sum_{j=1}^{M} [x(i, j)-y(i, j)]^2 \quad (10)$$

Where:

- $x(i, j)$ = An original image at the site (i, j)
- $y(i, j)$ = An improved image element (amended) required
- MSE = Account in the site (i, j)
- M, N = Number of items to square her error rate calculation or represent the image size or the size of a whole part of the picture

Root Mean Square Error (RMSE): Defined as the square root of the average square error (MSE) between the original images x(i, j) and improved y(i, j) as the lowest value for (RMSE) indicate that the picture has the best quality (better quality) is calculated from Eq. 11 following:

$$\text{RMSE} = \sqrt{\frac{1}{MN} \sum_{i=1}^{N} \sum_{j=1}^{M} [x(i, j)-y(i, j)]^2} \quad (11)$$

Peak Mean Square Error (PMSE): This is known as the scale according to the following Eq. 12:

$$\text{PSME} = \frac{1}{MN} \times \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} [x(i, j)-y(i, j)]^2}{[\text{MAX}(x(i, j))]} \quad (12)$$

Laplacian Mean Square Error (LMSE): This measure is based on the importance of measuring the edges (Edges Measurement). The greatest value of the Laplace Square Error rate (LMSE) between the two images indicate that the image has a poor quality (poor quality) defines this measure in accordance with the following Eq. 13:

$$\sum_{i=1}^{M} \sum_{i=1}^{N} [L(x(i, j)])^2 \quad (13)$$

As L (x (I, j)): an influential laplace.

Signal-to-Noise Ratio (SNR): It is defined as a relative measure of the ability reference unwanted noise and unwanted signal. Usually, expressed in (SNR) in the signal processing (signal processing) and (Decibel (dB)) as the ratio between the signal's ability (signal power) ability to noise (noise power) and is expressed in the following Eq. 14:

$$\text{SNR} = 10 * \log_{10} \log_{10} \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} [x(i, j)]^2}{\sum_{i=1}^{M} \sum_{j=1}^{N} [x(I, j)-y(I, j)]^2} \quad (14)$$

Visual Signal-to-Noise Ratio (VSNR): It is an effective measure to measure or to determine the visual precision of natural images based on the properties of human vision near the threshold limit ((near-threshold and above the threshold limit ((supra-threshold. The range VSNR values between (0-8). The calculated VSNR as in Eq. 15 following:

$$\text{VSNR} = 10 * \log_{10} \left[\frac{C^2(x)}{VD^2}\right] \quad (15)$$

Where:

- C(x) = A variation rate of the square root of the original image x
- (DV) = Distortion Visual

Peak Signal-to-Noise Ratio (PSNR): Defined as a statistical measure represents the ratio between the vast potential power of the signal and the ability of noise entering distorted by any pressure that measures the image resolution. And measured (PSNR) unit called decibels (decibel) and symbolized by the symbol (dB) as the ideal values have ranged between (30-50 dB) and greater value for (PSNR) indicate that the picture has the best quality (better quality) is calculated from the following Eq. 16:

$$\text{PSNR} = 10 * \log_{10} \left(\frac{(L-1)^2}{\text{MSE}}\right) \quad (16)$$

Since, L is the number of gray levels ranging from (0-255).

Normalized cross-correlation (NK): This measure is known according to the following Eq. 17:

$$NK = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}\left[x(I,j)\text{-}y(I,j)\right]}{\sum_{i=1}^{M}\sum_{j=1}^{N}\left[x(I,j)\text{-}y(I,j)\right]^2} \quad (17)$$

Structural Content (SC): The greatest value of the Compositional Content (SC) between the two images indicate that the image has a poor quality (poor quality). This is known as the scale according to the following Eq. 18:

$$SC = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}\left[x(I,j)\text{-}y(I,j)\right]^2}{\sum_{i=1}^{M}\sum_{j=1}^{N}\left[x(I,j)\right]^2} \quad (18)$$

Average Difference (AD): Rate represents the difference between the original image and the enhanced image. And according to the equation defines the following:

$$AD = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[x(I,j)\text{-}y(I,j)]^2 \quad (19)$$

As the largest value of contagious difference (AD) indicate that the image has a poor quality.

Maximum Difference (MD): It represents the greatest difference between the original and improved picture image. The greatest value to the greatest difference (MD) of the image indicates that the image has poor quality (poor quality) is defined by the following Eq. 20:

$$MD = MAX\left|x(I,j)\text{-}y(I,j)\right| \quad (20)$$

Normalized Absolute Error (NAE): The greatest value to calibrate the absolute error (NAE) between the two images indicate the image has a poor quality (poor quality). This is known as the scale according to the following Eq. 21:

$$NAE = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}\left|x(I,j)\text{-}y(I,j)\right|}{\sum_{i=1}^{M}\sum_{j=1}^{N}\left|x(I,j)\right|} \quad (21)$$

Mean Absolute Error (MAE): Mean Absolute Error (MAE) is used to measure of difference between two images. The mean absolute error is given by:

$$MAE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\left|x(I,j)\text{-}y(I,j)\right| \quad (22)$$

Correlation Quality (CQ): This measure is known by the following Eq. 23:

$$CQ = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}x(I,j)*y(I,j)}{\sum_{i=1}^{M}\sum_{j=1}^{N}x(I,j)} \quad (23)$$

Since, x(I, j) and y (I, j): represent the element of the original image and the enhanced on-site (I, j), respectively.

Universal Quality Index (UQI): This index is different from the traditional standards, it is used to calculate the error rate in the picture. Wang and Bovik out to the fact that the model of image processing is a mixture that consists of three factors. These are first the loss of the link, second the distortion of light and third contrast and distortion. This model is called the Comprehensive Quality Index (UQI). This measure is known by the following Eq. 24:

$$UQI = \frac{4\bar{x}\bar{y}\sigma_{xy}}{\left(\bar{x}^2+\bar{y}^2\right)\left(\sigma_x^2+\sigma_y^2\right)} \quad (24)$$

Where:

x and y = The original image and the processing rate, respectively

σ_x and σ_y = The standard deviation of the original image processing, respectively

σ_{xy} = Thecovariance

Personal Correlation Coefficient (PCC): This measure is known by the following Eq. 25:

$$PCC = \sum_{i=1}^{M}\sum_{j=1}^{N}\frac{x(I,j)*y(I,j)}{Std\left[x(I,j)\right]*Std\left[y(I,j)\right]} \quad (25)$$

Where:

Std. [x (I, j)] = The standard deviation of an original image on the site (I, j)

Std [y (I, j)] = The standard deviation of an improved image in the location (I, j)

MATERIALS AND METHODS

The practical side includes samples of the images used in the study as in Fig. 1. The proposed algorithm is also planned in the study. The algorithm reads the image from X-ray fluoroscopy by computer then application of the three cases to improve the brightness and image contrast is (CB1, CB2, CB3). After save the improved image the algorithm applies image quality measure (Fig. 2).

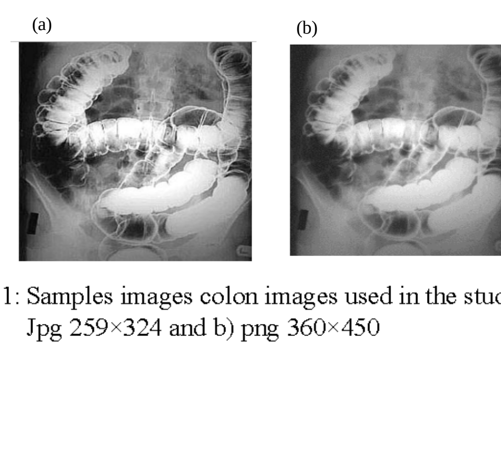


Fig. 1: Samples images colon images used in the study: a) Jpg 259×324 and b) png 360×450

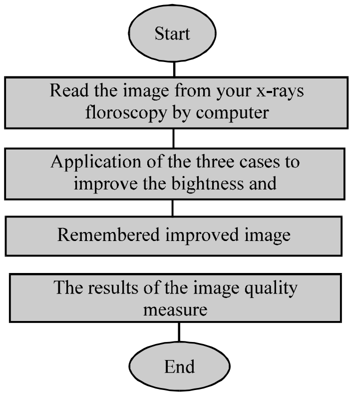


Fig. 2: Of the proposed algorithm in the study planned

RESULTS AND DISCUSSION

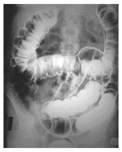
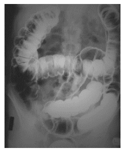
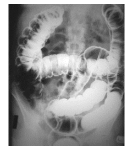
Table 2 shows the results of the application of the three cases to improve the brightness and contrast set forth in Table 1 on the image of the colon in Fig. 1 by MATLAB 2013 Software. And also, it shows the results of image quality standards colon taken medical imaging technology (X-ray and fluoroscopy) after improving brightness and contrast.

Table 2 has two parts the first improve the brightness and contrast of the image of the colon X-ray image and the second part is improved the brightness and contrast of the image of the colon fluoroscopy image. The result shows good quality measure in Table 2.

Table 2: The results of image quality standards colon (X-ray and fluoroscopy) after improving brightness and contrast

Case Original image	(Colon) Resulting (Processing) images		
X-ray	CB1	CB2	CB3
Cont. and Brit.	Cont.: -20%, Brit.: -20%	Cont.: +20%, Brit. : 0%	Cont.: 0%, Brit.: +20%
IF	0.9432	0.9967	0.9402
SSIM	0.9156	0.9663	0.8378
RFSIM	0.5497	0.7191	0.4908
SRSIM	0.9785	0.9908	0.9423
FSIM	0.9592	0.9833	0.9296
VIFp	0.8165	0.9615	0.8372
MSE	1232.301	72.3328	1304.401
RMSE	35.1047	8.5048	36.1161
PMSE	314611	179981	332001
LMSE	0.0941	0.0292	0.1496
SNR	12.4674	24.7813	12.2207
VSNR	13.1872	13.5732	10.4718
PSNR	17.2236	29.5374	16.9767
NK	0.7652	1.0188	1.212
SC	1.7042	0.9606	0.6747
AD	29.1313	3.6003	0.0174
MD	84	25 17	
NAE	0.2204	0.0556	0.2514
MAE	29.1667	7.2588	33.2956
CQ	125.5954	167.2354	198.7708
UQI	0.9473	0.9747	0.931
PCC	83685	83639	82234
Fluoroscopy	CB1	CB2	CB3
			
Cont. and Brit.	Cont.: -20%,Brit. : -20%	Cont. : +20%,Brit. : 0%	Cont. : 0%,Brit. : +20%
IF	0.9458	0.9958	0.9223
SSIM	0.9057	0.9704	0.8574
RFSIM	0.6656	0.7538	0.6748
SRSIM	0.9815	0.9919	0.9711

Table 2: Continue

Case Original image	(Colon) Resulting (Processing) images		
X-ray	CB1	CB2	CB3
			
FSIM	0.9636	0.9856	0.9542
VIFp	0.7901	1.0457	0.9587
MSE	1113.902	108.4920	1572.401
RMSE	33.3754	10.4161	39.6535
PMSE	278421	20852	396255
LMSE	0.0977	0.0594	0.1626
SNR	12.5616	22.6763	11.0649
VSNR	13.5257	13.7368	11.1703
PSNR	17.6623	27.7769	16.1653
NK	0.7692	1.0224	1.2641
SC	1.6847	0.9525	0.6227
AD	28.6328	3.8965	0
MD	86	46	22
NAE	0.2175	0.0683	0.2893
MAE	28.6328	8.1633	38.2897
CQ	116.8926	155.2806	192.0393
UQI	0.9471	0.9883	0.9265
PCC	161051	160901	159762

CONCLUSION

Results indicated shown in this study after application of three cases of improving the brightness and contrast of the image of the colon taken techniques (X-ray and fluoroscopy) is (CB1-CB3) the following conclusions.

In applying the first case (CB1): The image of the colon taken technology endoscopy (Fluoroscopy) gave a much better picture of the colon taken technology X-ray quality (X-ray) because the objective image quality parameters gave the best results for the image of the colon taken technology (Fluoroscopy).

When applying the second case and third (CB2 and CB3): The image of the colon taken technology X-ray (X-ray) gave a much better picture of the colon taken technology endoscopy quality (Fluoroscopy) because the objective image quality parameters gave the best results for the image of the colon derived technology (X-ray).

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