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(54) Title of the invention IMAGE HIGHLIGHTING METHOD FOR IMAGE PROCESSING SYSTEM

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SPECIFICATION

TITLE OF THE INVENTION: Image highlighting method for image processing system

SCOPE OF PATENT CLAIMS

An image highlighting method for an image processing system in an image processing system consisting of an image input unit, an image data processing unit, and an image display unit, characterized in that an image is divided into partial images, the characteristics of each partial image are extracted, a relational expression is selected according to said extracted characteristics using preexisting known information, and highlighting processing is performed on each partial image using said selected relational expression.

DETAILED DESCRIPTION OF THE INVENTION

(FIELD OF USE OF THE INVENTION)

The present invention relates to image highlighting methods for image processing systems, and specifically to image highlighting methods ~~for images, etc.~~ in image processing systems *for images, etc.* taken by X-ray devices.

(BACKGROUND OF THE INVENTION)

Conventionally, since it is difficult to identify lesions in images taken using X-ray devices and the like (original images), filter processing is performed on the original image. If the original image is G and the image after filter processing is G′, this can be expressed in real space as

$$G' = F * G.$$

In this expression, F represents the filter function and * represents convolution.

Different filter functions F are used for high-pass highlighting, in-band highlighting, and low-pass highlighting.

Conventionally, when processing a single image, a filter function F with the same characteristics has been used. If processing is performed using a filter function F with the same characteristics as the single image as a whole, the following problem arises.

Figure 1 is a sketch of an X-ray image of the bones of the foot. In Figure 1, 11 through 13 represent bones. Moreover, region 14 is a smooth pattern and region 15 is a complex pattern with variations. Thus, for instance, if a high-pass highlighting filter is used to highlight the pattern of region 15, noise will generally become noticeable in region 14. Conversely, if an in-band emphasis filter is used to highlight region 14, the image will become blurred in region 15. Thus, it is not possible to effectively display the information contained in the image across the image as a whole.

To counteract this problem, Japanese Unexamined Patent Application Publication S55-87953 discloses non-sharp mask processing in order to improve the diagnostic capabilities of X-ray photographs.

If D′ is the reproduced image, D_{org} is the original image, D_{us} is the low-frequency highlighted image, and β is a constant, the reproduced image D′ can be expressed as

$$D' = D_{org} + \beta (D_{org} - D_{us}).$$

In this expression the constant β is varied, for instance, according to the density value of D_{us}. With this method, it is possible to vary the additive proportions of the original image D_{org} and the highlighted image $(D_{org} - D_{us})$ according to the density value of the image. With this method, it is possible to vary the degree of highlighting according to the density value of the image, but, as shown in the sketch of the X-ray image of foot bones in Figure 1, the problem remains that it is not possible to perform processing to select a filter function for highlighting according to the structural characteristics of each partial region.

(PURPOSE OF THE INVENTION)

The purpose of the present invention is to provide an image highlighting method for an image processing system that eliminates the problems described above and allows for effective image highlighting processing across an entire image.

(SUMMARY OF THE INVENTION)

The present invention, in order to achieve the purpose described above, is characterized in that, in an image processing system consisting of an image input unit, an image data processing unit, and an image display unit, a single image is divided into partial images, the characteristics of each partial image are extracted, and images with highlighting methods that differ depending on the diagnostic site, diagnostic purpose, etc. are obtained by picking filter functions, additive proportions for processed images, contrast conversion functions, etc. according to said extracted characteristics using preexisting known information.

(EXAMPLE OF EMBODIMENT OF THE INVENTION)

Below, an example of embodiment of the present invention will be described in detail using the drawings.

Figure 8 is a configuration drawing showing an example of an image processing system that is an example of embodiment of the present invention.

800 is an image processing unit that processes image data, 801 is a film reader that acts as an image input unit, 802 is a display with a keyboard or the like that acts as an image display unit, 803 is a film reader that acts as an image output unit, and 804 is an optical disk unit.

Moreover, Figure 9 is a functional block diagram of the image processing system of Figure 8.

The input X-ray image 900 is input into the image processing unit 800 by the film reader 801. In the image processing unit 800, processing is performed by the characteristic quantity extraction unit 902 to ascertain the characteristics, processing is performed by the similarity calculation unit 903 based on the characteristic quantities obtained, processing is performed by the selective filtering unit 904 to highlight specific frequency components based on the dialogue mode, and processing is performed by the contrast conversion unit 905 to further highlight density variation. The processing results from the image processing unit 800 are output by the film writer 803 as a processed X-ray image 920.

Figure 2 is an explanatory diagram showing an outline of pressing in the present invention. Small regions are set for each part of the original image data 21 input from the film writer 801 and characteristic extraction processing 22 is performed on each partial region to extract characteristics such as variance values, mean values, etc.

Next, according to these extracted characteristics, the optimal processing is selected from the following types of processing using preexisting known information 201, for instance, the diagnostic site, the diagnostic purpose, etc. Types of processing include filtering processing 23 to highlight specific frequency components, source image addition processing 25, and contrast conversion processing 27.

Also, using preexisting known information 201, filter function selection processing 24 of the filter to be used is performed for filtering processing 23, processed image addition factor setting processing 26 is performed for source image addition processing 25, and contrast conversion function selection processing 28 is performed for contrast conversion processing 27.

Figure 3 shows the characteristic value extraction methods for each partial region. Partial regions 31, 32, etc. are set for each pixel in source image 30 and the partial characteristics are extracted for each. For instance, if the size of partial region 31 is $l \times l$ and the pixel density value is g_{ij}, the variance value σ and the mean value $\overline{g}$ can be found.

[see source for formulae]

In these formulae, i and j denote the distance values in the x-axis direction and the y-axis direction, respectively, of the coordinates (x, y).

When setting regions, rather than rectangular regions, regions can also be set to be meaningful with regard to organs or the like.

Moreover, in addition to the previously mentioned statistical values, differential values, co-occurrence matrices, power spectra, etc. can of course also be used as characteristic values. In the following explanation, variance values and mean values are used as the characteristic values in order to simplify the discussion.

First, filter function selection processing 24 will be described based on Figure 4 (a), (b), and (c).

In figure 4, (a) shows filter functions, (b) shows correspondence functions between the filter functions and compound characteristic values, and (c) shows a sketch 49 of foot bones. In the filter functions in Figure 4 (a), the horizontal axis shows the cutoff frequencies f_c and the vertical axis shows strength S, with multiple examples are shown in advance. Characteristics can be set as desired, by in this example high-pass highlighting characteristics are shown as an example. As the filter function shifts from 44 to 41, the cutoff frequency f_c rises and so the strength S becomes greater, producing greater high-pass highlighting characteristics.

Moreover, in the correspondence function for the filter function and the characteristic values in Figure 4 (b), the horizontal axis shows the compound characteristic value Q and the vertical axis shows the number F of the filter function of Figure 4 (a), from 41 through 44, indicating the filter function.

The compound characteristic value Q can be found, for instance, as follows. If the variance value of the partial region 31 of the same size $l \times l$ into which the source image 30 is divided into by a mesh is σ_l, the maximum variance value of each partial ~~red example~~ *region* of the source image 30 is $\sigma_{\max}$, the minimum value is $\sigma_{\min}$, the mean value of the partial region of the source image 30 is similarly $\bar{g}_l$, the maximum mean value is $\bar{g}_{\max}$, and the minimum mean value is $\bar{g}_{\min}$, the normalized variance value σ_l' and mean value $\bar{g}_l'$ can be found as follows:

[see source for formulae]

Next, the normalized weights w_1 and w_2 ($w_1 + w_2 = 1$) are added to each characteristic, and the compound characteristic value Q becomes the cumulative value

$$Q = w_1\sigma_l' + w_2\,\bar{g}_l'.$$

The compound characteristic value Q found here takes the form of a value from 0 to 1. The correspondence function between this compound characteristic value Q and the number F of the filter function can also be set as desired, but generally it takes the form of an increasing function, as shown in the correspondence function for the filter function and characteristic values shown in Figure 4 (b).

The reason for this will be explained using the sketch 49 of foot bones. In the sketch 49 of foot bones, in regions with complex patterns like the bone trabecular area 401, since the compound characteristic value Q takes a high value, filter function 41 is applied, highlighting edges. Conversely, in regions with even patterns like area outside the bone (with low density) 402, the compound characteristic value Q takes a low value, so filter function 44 is applied, producing an image close to the source image.

With the processing described above, with the foot bone image shown in the sketch 49 of foot bones, it is possible to create an image in which the regions with the most complex patterns within the bone, such as the trabecular area 401 are highlighted most strongly, while the regions with even patterns like area outside the bone 402 vary hardly at all from the source image. Moreover, it is also possible to set the compound characteristic value Q to represent a single characteristic, for instance, by setting weight w_2 to zero.

Next, the processed image addition factor setting processing 26 will be described. Processed image addition factor setting processing 26 is generally performed to supplement images after filtering processing 23, since such images are considered poor in volume sensitivity. If the source image is G, the filter function is F (Q), and the image after filtering processing 23 is G′, the function is as follows:

$$G' = G * F(Q)$$

Furthermore, if the image after source image addition processing 25 is G″, G″ is found using the following:

$$G'' = G + \beta(Q) \cdot G'$$

In this expression, β (Q) is the highlighting factor, taking the previously described compound characteristic value Q as a variable, so, for instance, it can be set as shown in Figure 5, with Q on the horizontal axis and β (Q) on the vertical axis.

Figure 5 shows a case where the value of β (Q) increases along with an increase in the value of Q as 53, a case where it gradually increases as 52, and a case where it rapidly increases as 54. In regions with large compound characteristic values Q, i.e., in areas with edge highlighting, the G′ component is prominent in the image after source image addition processing 25, while the G component is more prominent in even areas, making it possible to obtain an image with sharp volume sensitivity.

Next, contrast conversion function selection processing 28 will be explained. In contrast conversion function selection processing 28, contrast conversion processing 27 is performed on the processed image G″ obtained as described above. Specifically, a conversion function taking the input density N and the output density K, as shown on the horizontal axis and vertical axis, respectively, in Figure 6, is used. For instance, differences in density in highlighted areas (areas with high densities) can be further highlighted by using the characteristics of 56.

In the processing described above, there are parameters that should be set for each type of processing, including the filter function in Figure 4(a), the correspondence function between the compound characteristic value Q and the filter function number F in Figure 4 (b), etc. Moreover, these parameters should be varied depending on the diagnostic site, the diagnostic purpose, etc.

These parameters are set using the preexisting known information 201 in Figure 2. Figure 7 shows an example of preexisting known information 201. In Figure 7, 61 shows a case where the site is the foot bones and the diagnostic purpose is periostitis. f_c indicates the filter cutoff frequency. In this example multiple high-pass filters (characteristics in Figure 4 (a)) are used within the f_c range 0.05 to 0.5 (cycles/mm), the characteristics of the highlighting factor β (Q) are set as shown in 53 in Figure 5, and highlight area highlighting is performed as shown in 56 in Figure 6 as contrast conversion. Moreover, 62 shows an example in the stomach area, where multiple high-pass filters are used within the f_c range 0.01 to 0.6 (cycles/mm), the characteristics of the highlighting factor β (Q) are set as shown in 52 or 54 in Figure 5, and highlight area highlighting is performed as shown in 56 in Figure 6 as contrast conversion.

This kind of preexisting known information 201 may be previously recorded or set in a dialogue format by the operator in order to reduce the parameter input workload of the operator.

(EFFECT OF THE INVENTION)

With the present invention, since optimal filters are selected for each partial region of the image and the processed image can be added in the desired proportion, it has the effect of making it possible to create images that are sharp and volume-sensitive, improving diagnostic precision.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a sketch of an X-ray image of a human foot bone area, Figure 2 is an explanatory diagram showing an outline of the processing of the present invention, Figure 3 is a diagram showing the characteristic extraction method for partial regions, Figure 4 is a diagram showing filter functions, Figure 5 is a diagram showing processed image addition factors, Figure 6 is a diagram showing contrast conversion functions, Figure 7 is a diagram showing examples of the designation of the preexisting known information, Figure 8 is a configuration diagram showing an example of an image processing system that is an example of embodiment of the present invention, and Figure 9 is a functional block diagram for the image processing system of Figure 8.

24 . . . Filter function selection processing, 26 . . . Processed image addition factor setting processing, 28 . . . Contrast conversion function selection processing, 201 . . . Preexisting known information

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[seal illegible]

FIGURE 1

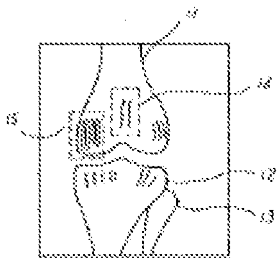


FIGURE 2

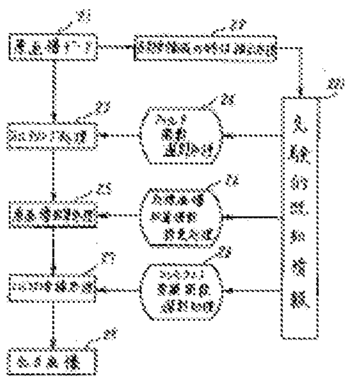


FIGURE 3

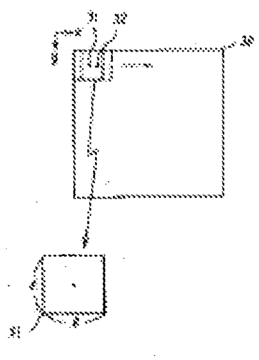
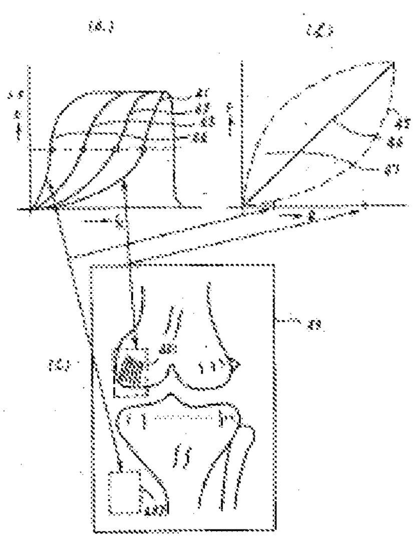


FIGURE 4



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