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DETECTION OF OSTEOPOROSIS IN PANORAMIC IMAGE RADIOGRAPH AREA OF MANDIBLE BONE USING HARRIS CORNER DETECTION

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ABSTRACT

Every human will grow older. The aging process in a person is characterized by osteoporosis. Osteoporosis is a person's bone condition becomes porous and fragile. Marked by a decrease in bone tissue that is easily fragile or broken, a bent back and a shorter body. Alternative detection of osteoporosis can be done by X-ray image of the jaw bone from dental panoramic which analyzed the texture using machine learning and image processing techniques. Harris Corner Detection is a corner detection system that is often used because it is able to produce consistent values in images that experience rotation, scaling, variations in lighting and having lots of noise. Angular detection using the Harris method is based on variations in signal intensity. A large variation in intensity indicates the angle of the image. In a study conducted by Eduard Royce Siswanto in 2013, regarding the advantages of the Harris corner detection method, it was stated that the Harris corner detection method had an advantage of 77.5% compared to other methods for detecting smiles on the human face. In the research I will be doing, I will use the Harris Corner Detection method as a tool for detecting osteoporosis in panoramic images of the human mandible. In the process of osteoporosis detection system using image processing, it is started from preprocessing, processing and final results. The data used in the study were 152 data, with 3 stages of classification, namely: 3-20 years old, 20-40 years old and 40-71 years old group. Based on the expert validation calculation that has been done, the percentage of suitability of the 3-20 years old group is 100%, group 20-40 years old is 98.78%, age group 40-71 years old is 76.47%.

Keyword: Image Processing, Harris Corner Detection, Osteoporosis

INTRODUCTION

This osteoporosis is in dire need of serious attention because the disease can cause fractures, disability, complications or death. This disease can occur at any age, so it becomes a threat to human life. Judging from the statistical data in 2009, of the 200 million people with osteoporosis worldwide, it is estimated that 6.3 million people in 2050 will experience hip fractures each year, of which more than half are in Asia. Not only that, the disease is a type of disease that is difficult to know by the naked eye (silent disease) and is progressive which means that the disease is difficult to know until the fracture (fracture) [1].

Based on the data and information center of the Indonesian Ministry of Health, the factors that cause osteoporosis in Asia are divided into 2 factors, namely factors that can be changed and factors that cannot be changed. Factors that can be changed include lack of physical activity, low calcium intake, protein deficiency, vitamin D deficiency, smoking habits, drinking alcohol. while the factors that cannot be changed include family history, female gender, age and menopause.

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Alternative detection of osteoporosis can be done with jaw bone X-ray images from dental panoramic which analyzed the texture. Panoramic radiograph is a type of extraoral image that dentists often use before taking action. The Dental Panoramic Radiograph is often taken for dental and jaw examinations in dental practice throughout the world, because the results provide valuable information about the nasal region, maxillary sinus, tooth and gum position and bone deviation. This examination is also used to plan treatment for full and partial dentures, braces, extractions and implants [1-2].

Image processing is a process that is carried out on an image to get an image that has a better quality than the original image. Image processing in the radiography process is very important for diagnosing disease conditions without having to perform surgery and is also the next step of treatment planning. [3-4]. Harris or ordinary angle detection, which is called Harris Corner Detection, is one of the methods in image processing, where the angle is defined as the meeting of two sides. Research conducted by Eduard Royce Siswanto in 2013 to detect smiles on human faces resulted in high sigma values, thus slowing down computation time. While the current research, the data used is panoramic radiographic image data in the mandibular bone area, using the Harris corner detection method for osteoporosis detection [5-6].

METHODOLOGY

The input image used in this study is a panoramic radiograph of the mandibular bone area. The panoramic radiographic image is a grayscale image, so the image processing process does not need to be converted into a grayscale image [7-9]. As a result of system validation in this study, using direct validation from dentist Vicasari Dyah Anggraeni, SIP 440/1147/DG/405.09/2016. Then it will be known how many research results are appropriate or not. The images used are in Figure 1.

Figure 1. Panoramic radiograph image

In the harris corner detection, calculate the value of the variation in the intensity of an image in a binary window that will be shifted towards a particular axis (x, y). [10] In this equation, use a 3 × 3 binary window that will be shifted towards (1.0), (1.1), (0.1), or (-1,1) with the equation (1).

$$E_{x,y} = \sum_{u,v} w_b\,(u,v)\ [\ I_{x+u,y+v} - I_{u,v}]^{\,2} \qquad (1)$$

when:

Ex,y = variation in image intensity shifted towards (x, y)

$wb\ (u, v)$ = binary window, worth 1 in all windows and 0 outside the window

Ix+u,+v = the intensity of the image shifted towards (1.0), (1.1), (0.1), or (-1,1)

Iu,v = image intensity in position (u, v)

$$E_{1,0} = \sum_{i=1}^{3} \sum_{j=1}^{3} (\mathrm{A}_{i,j+1} - \mathrm{A}_{i,j})^2 \approx \sum_{k=1}^{9} (\frac{\partial Im}{\partial x})^2 \quad (2)$$

$$E_{0,1} = \sum_{i=1}^{3} \sum_{j=1}^{3} (\mathrm{A}_{i,j+1} - \mathrm{A}_{i,j})^2 \approx \sum_{m=1}^{9} (\frac{\partial Im}{\partial y})^2 \quad (3)$$

$$E_{x,y} = \sum_{u,v} w_{u,v}\,(\ \mathrm{x}\,(\frac{\partial \mathrm{I}}{\partial \mathrm{x}}) + \mathrm{y}\,(\frac{\partial \mathrm{I}}{\partial \mathrm{y}}))^{\,2} \qquad (4)$$

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$$= \sum_{u,v} w_{u,v} \left(x^2 \left(\frac{\partial I}{\partial x}\right)^2 + 2xy \frac{\partial I}{\partial x}\frac{\partial I}{\partial y} + y^2 \left(\frac{\partial I}{\partial x}\right)^2 \right) \quad (5)$$

The equation shows the process of multiplying the gradient of an image with a window that is shifted to all parts of the image. This process is like convolution in images, so that it can be defined:

$$A = \left(\frac{\partial I}{\partial x}\right)^2 * w$$

$$D = \left(\frac{\partial I}{\partial y}\right)^2 * w$$

$$C = \left(\frac{\partial I}{\partial x}\frac{\partial I}{\partial y}\right) * w \quad (6)$$

$$E_{x,y} = Ax^2 + 2Cxy + Dy^2 \quad (7)$$

$$E_{x,y} = [x\ y]\ M \begin{bmatrix} x \\ y \end{bmatrix} \quad (8)$$

$$M = \begin{bmatrix} A & C \\ C & D \end{bmatrix} \quad (9)$$

Equation (8) is unique because it contains all differential equations. Harris uses this equation to find the Harris detector response equation that is used to determine whether or not a point is an angle. The equation of the Harris detector response can be obtained by reducing the determinant of M with a sensitivity constant multiplied by the trace M. as shown in equation (10).

$$R_H = \det(M) - k * \mathrm{trace}^2(M) \quad (10)$$

Information:
R_H = Harris image detector response value
K = sensitivity constant of Harris corner detection
trace = diagonal summation of the matrix between the top left and the bottom right.

If the RH value> 0 indicates that the point on the image is an angle, the Rh value <0 indicates that the point in the image is an edge. The value of k in the calculation of this angle value is a sensitivity constant whose amount can change. Based on the research and experiments conducted by Neil Bruce and Pierre Kornprobost, the k values that gave good results ranged from 0.04 - 0.15. [10]

The angle detection of the Harris method replaces the binary window used by Moravec with the Gaussian window that smoothes the results of the square of the intensity difference obtained from the above equation. Mathematically, the application of a Gaussian window to an image is the same as multiplying that image with a 2 dimensional Gaussian function.

$$w_g(u,v) = e^{\frac{u^2+v^2}{2a^2}} \quad (11)$$

With,
wg = the value of each element of the Gaussian window in position (u, v)
Σ = standard Gaussian distribution deviation (sigma)

1. Preprocessing

In the pre-processing process, all data were 152 data for women and men aged 3-71 years which were divided into three classifications, namely ages 3-20 years, 20-40 years, and 40-71 years. This classification is grouped based on small age, young/middle age and old age. Then the process of cropping and resizing each image.

a. Cropping

The cropping process is carried out to obtain cortical bone found in the mandibular bone area.

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Figure 2. The cropping process

b. Resize

After the cortical bone cropping process, resize each image by 35x35 pixels, so that the following results are obtained:


Figure 3. The result of cropping and resizing the image

2. Processing

After the pre-processing process, proceed with processing, which is the grayscale input image and the convolution angle detection of all data is performed. Image convolution is a technique to refine an image or clarify an image by replacing pixel values with a number of pixel values by switching to the filter matrix. The calculation of the convolution is as follows:

a. Detection of normal bones (Aden, 3 years old)

1) Original image Ix value =

Table 1. Pixel the Ig image as the original image

86	86	86	84	82
100	101	101	101	100
98	99	101	101	102
98	101	103	104	105
89	92	95	96	98

2) To find the convolution, Ig is multiplied by convolution filter dx, Ix = Igconv2 (Ig, dx)

Table 2. dx filter value

-1	0	1
-1	0	1
-1	0	1

then the result

Table 3. Ix pixel value

4	0	-4
9	5	2
14	9	6

for Ix^2, the following results are obtained:

Table 4. Ix^2 pixel value

-40	-36	-40
109	43	-14
221	99	-2

Then look for the Iy value, the original pixel is multiplied by the dy filter, as follows

Table 5. dy filter value

-1	-1	-1
0	0	0
1	1	1

Then the result of Iy = Igconv2 (Ig, dy) is:

Table 6. Iy pixel value

40	45	52
0	5	10

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-22	-18	-15

for Iy^2, the following result are obtained :

Table 7. Iy^2 pixel value

456	1089	1750
-220	-155	-100
-550	-810	-1099

Then Ixy pixel values are searched, Ix pixels multiplied by Iy pixels, as follows:

Table 8. Ixy pixel value

248	252	268
316	394	488
428	567	728

The Gaussian filter is a linear filter with a weighting value for each member chosen based on the form of a Gaussian function. The Gaussian filter is selected as a smoothing filter because the Gaussian filter has a kernel center. The Gaussian filter is a good filter for removing noise that is of a normal distribution, which is often found in the distribution of the image from the digitization process using a camera because it is a natural phenomenon due to the reflecting nature of light. The following is a Gaussian filter calculation with a sigma value σ = 1.

$$w_g(u,v) = e^{\frac{u^2+v^2}{2a^2}}$$

$$w_g(-1,-1) = e^{\frac{-1^2+(-1)^2}{2a^2}} = 1{,}718$$

$$w_g(-1,0) = e^{\frac{-1^2+(0)^2}{2a^2}} = 2{,}218$$

$$w_g(-1,1) = e^{\frac{-1^2+(1)^2}{2a^2}} = 1$$

$$w_g(0,-1) = e^{\frac{0^2+(-1)^2}{2a^2}} = 2{,}218$$

$$w_g(0,0) = e^{\frac{0^2+(0)^2}{2a^2}} = 1$$

$$w_g(0,1) = e^{\frac{0^2+(1)^2}{2a^2}} = 1{,}649$$

$$w_g(1,-1) = e^{\frac{1^2+(-1)^2}{2a^2}} = 1$$

$$w_g(1,0) = e^{\frac{1^2+(0)^2}{2a^2}} = 1.649$$

$$w_g(1,1) = e^{\frac{1^2+(1)^2}{2a^2}} = 2{,}718$$

So the Gaussian filter is as follows:

Table 9. Gaussian Filter

1,718	2,218	1
2,218	1	1,649
1	1,649	2,718

Harris uses this equation to look for the Harris detector response equation, which is used to determine whether or not a point is an angle.

$$M = \begin{bmatrix} A & C \\ C & D \end{bmatrix}$$

Where value A is obtained by multiplying $Ix^2$with a Gaussian filter, while D is obtained by multiplying Iy^2 with a Gaussian filter, while C is obtained by multiplying Ixy by a Gaussian filter,

Then the value A = 451,923

Value D = -731,822

Value C = 6494,287

The equation of the Harris detector response can be obtained by reducing the determinant of M with a sensitivity constant multiplied by the trace M.

R_H = det (M) – k * trace^2 (M)

if, Det(M) = AD-CC, Trace(M) = A+D

$trace^2(M) = (A + D)^2$

k = 0,04

then : $\det(M)$ = 42506490,832075

$trace^2(M)$ = 78343,450201

then R_H = -42509624,578

If the RH value> 0 indicates that the point on the image is an angle, the RH value <0 indicates that the point in the image is an edge. So in the osteoporosis detection system, the Rh calculation is finally negative, it is considered 0, which means that the classification of cortical bone from Aden, 7 years old, is a normal bone.

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Figure 4. The angle detected in the image of Aden's bone

b. Bone is detected osteoporosis (Endang 71 years old)

The original Ix image value =

Table 10. Pixel the Ig image as the original image

112	110	108	108	110
114	112	109	108	108
113	112	109	106	104
110	110	108	106	105
106	108	109	109	110

To find the convolution, Ig multiplied by convolution filter dx, Ix = Igconv2 (Ig, dx).

Table 11. dx filter

-1	0	1
-1	0	1
-1	0	1

The result

Table 12 Ix pixel value

-13	-12	-4
-11	-14	-9
-3	-9	-7

for Ix^2, the following results are obtained:

Table 13. Ix^2 pixel value

313	360	188
324	409	233
159	225	142

Then look for the Iy value, the original pixel multiplied by the dy filter, as follows:

Table 14. dy filter value

-1	-1	-1
0	0	0
1	1	1

Then the result from $Iy = Igconv2(Ig, dy)$ is

Table 15. Iy pixel value

4	1	-7
-7	-5	-6
-11	-1	9

for Iy^2, the following results are obtained:

Table 16. Iy^2 pixel value

86	6	-97
73	24	25
-136	-15	164

Then Ixy pixel values are searched, Ix pixels multiplied by Iy pixels, as follows:

Table 17. Ixy pixel value

76	51	127
153	68	80
128	49	12

The Gaussian filter is a linear filter with a weighting value for each member chosen based on the form of a Gaussian function. The Gaussian filter is selected as a smoothing filter because the Gaussian filter has a kernel center. The Gaussian filter is a good filter for removing noise that is of a normal distribution, which is often found in the distribution of the image from the digitization process using a camera because it is a natural phenomenon due to the reflecting nature of light. The following is a Gaussian filter calculation with a sigma value σ = 1.

$$w_g(u, v) = e^{\frac{u^2+v^2}{2a^2}}$$

$$w_g(-1, -1) = e^{\frac{-1^2+(-1)^2}{2a^2}} = 1{,}718$$

$$w_g(-1,0) = e^{\frac{-1^2+(0)^2}{2a^2}} = 2{,}218$$

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$$w_g(-1,1) = e^{\frac{-1^2+(1)^2}{2a^2}} = 1$$

$$w_g(0,-1) = e^{\frac{0^2+(-1)^2}{2a^2}} = 2{,}218$$

$$w_g(0,0) = e^{\frac{0^2+(0)^2}{2a^2}} = 1$$

$$w_g(0,1) = e^{\frac{0^2+(1)^2}{2a^2}} = 1{,}649$$

$$w_g(1,-1) = e^{\frac{1^2+(-1)^2}{2a^2}} = 1$$

$$w_g(1,0) = e^{\frac{1^2+(0)^2}{2a^2}} = 1.649$$

$$w_g(1,1) = e^{\frac{1^2+(1)^2}{2a^2}} = 2{,}718$$

So the Gaussian filter is as follows:

Table 18. Gaussian Filter

1,718	2,218	1
2,218	1	1,649
1	1,649	2,718

Harris uses this equation to look for the Harris detector response equation, which is used to determine whether or not a point is an angle.

$$M = \begin{bmatrix} A & C \\ C & D \end{bmatrix}$$

Where value A is obtained by multiplying Ix^2 with a Gaussian filter, while D is obtained by multiplying $Iy^2$with a Gaussian filter, while C is obtained by multiplying Ixy by a Gaussian filter,

Then the value of A = 3952,044

Value D = 576,212

Value C = 1151,377

The equation of the Harris detector response can be obtained by reducing the determinant of M with a sensitivity constant multiplied by the trace M.

$R_H = \det(M) - k * \mathrm{trace}^2(M)$

if, Det(M) = AD-CC, Trace(M) = A+D

$trace^2(M) = (A + D)^2$

k = 0,04

then : $\det(M) = 951546{,}181199$

$trace^2(M) = 20505102{,}401536$

then $R_H = 131342{,}0851$

If the RH value > 0 indicates that the point on the image is an angle, the RH value <0 indicates that the point in the image is an edge. So in the osteoporosis detection system, the calculation of Rh is finally positive, it is considered 1, which means that the classification of cortical bone from 71 years old Endang detected osteoporosis. Besides the angle of the image is detected as many as 7 pieces, as seen in the picture 5.

Figure 5. The angle detected in the image of Aden's bone

RESULT AND ANALYSIS

Based on the calculations that have been carried out on the three age classifications, the following results were obtained and expert validation obtained directly from the dentist Vicasari Dyah Anggraeni, SIP 440/1147/DG/405.09/2016.

1. Groups of 3-20 years old.

Table 19. Results of Angle Detection, Calculation and Expert Validation 3-20 years old

Num	Name	Age	Real Image	Corner Detection	Rh	*N/O	Expert validation

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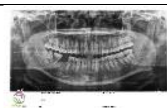
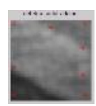
1	Aden	7			-42509624,57	N	Valid
2	Ahmad	20			-22939875,03	N	Valid
…	…	…	…	…	…	…	…
33	Zen	19			-32183592,06	N	Valid
34	Zhakila	4			-14007,444	N	Valid

*N/O is Normal or Osteoporosis

34 data of 3-20 years old samples, osteoporosis was not detected, all data entered into the normal bone category, because Rh produced R <0.

2. Group of 20-40 years

Table 20. Results of Angle Detection, Calculation and Expert Validation 20-40 years old

Num	Name	Age	Real Image	Corner Detection	Rh	*N/O	Expert Validation
1	Abdul	33			-230315989,1	N	Valid
2	Addian	23			-92071734,56	N	Valid
…	…	…	…	…	…	…	…
79	Yatmi	37			1693571,594	O	Valid
80	Zahrotun	30			-54187400,13	N	Valid
81	Zulfika	21			-82066745,73	N	Valid
82	Zuliatun	37			61172459,17	O	Not Valid

*N/O is Normal or Osteoporosis

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A total of 82 data aged 20-40 years old, a small proportion detected osteoporosis, there is 1 image that has a value of Rh> 0, then fall into the category of detected osteoporosis but the results, according to expert are invalid, because overall bone mass still looks good and homogeneous.

3. Group of 40-71 years old

Table 21. Results of Angle Detection, Calculation and Expert Validation 40-71 years old

Num	Name	Age	Real Image	Corner Detection	Rh	*N/O	Expert Validation
1	Achadiyah	50			-102735209,9	N	Valid
2	Ambarwati	55			-39276403,61	N	Not Valid
3	Andreas	53			-13511113,66	N	Valid
4	Ayik	56			-3268707,235	N	Valid
5	Chamdanah	52			-250057919,2	N	Valid

N/O is Normal or Osteoporosis

Patients aged 40-71 years who detected osteoporosis according to expert validation were 8 patients, 5 of them were female, Endang was 71 years old, Nur Afifah was 51 years old, Sarpi was 48 years old, Tri Endang was 61 years old and Zibdah was 49 years old. While the other 3 patients were male, including Nur Agung 51 years old, Roch Haryadi 62 years old and Wahyudi 64 years old. Sex factors also affect osteoporosis. Women have higher rates of osteoporosis than men because menstruation, childbirth and breastfeeding lead to reduced bone density in female patients. This is based on the Journal of Infodatin ISSN 2442/7659, about the factors that cause osteoporosis.

Based on the analysis of the three age groups, the majority of osteoporosis occurred in the age group of patients over 40 years. This is because the older a person is, then the density of bone mass will decrease, besides it is also influenced by gender and lifestyle factors. There is one data patient in the age group of 20-40 years who detected osteoporosis, this is caused by several factors, including lifestyle, low calcium intake, hormone-related diseases, use of certain drugs and other causative factors, such as families with a history osteoporosis. This is based on the Journal of Infodatin ISSN 2442/7659, about the factors that cause osteoporosis.

4. Accuracy

Calculation of accuracy:

$$\frac{\sum bone\ data\ tested - \sum invalid\ bone\ data}{\sum bone\ data\ tested} x100\% \qquad (12)$$

After calculating and validating 152 data, the percentage of suitability in the 3-20 year age group was 100%, the age group 20-40 years was 98.78% and the age group 40-71 years was 76.47%

CONCLUSION

Parameters used to detect osteoporosis in the mandibular bone area using panoramic radiograph images are patient age, gender and convolution angle detection (Rh) calculation. The Harris Corner Detection method that has been carried out 152 data on panoramic radiograph images of mandibular bone area of patients group of 3-20

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years has an accuracy of suitability with expert detection of 100%, age group 20-40 years at 98.78% and age group 40 -71 years at 76.47%. From patients in the 40-71 year age group, there were 35 data consisting of 21 women and 14 men. The results obtained are 16 valid data for women with osteoporosis and 10 valid men with osteoporosis. So these results are in accordance with the journal infodatin that women tend to be at higher risk of osteoporosis than men.

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