Texture Analysis and Fracture Identification of Lower Extremity Bones X-Ray Images

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Abstract*—Lower limb bones or lower limb component related to the torso with pelvic ankle interference can be fractured. Fractures can be detected automatically take advantage x-ray images performed using feature extraction methods. Feature Extraction helpful to know existence and location of fracture with x-ray images. This research apply Gray Level Co-Occurrence Matrix (GLCM) and K-Means Clustering Algorithm to analyze texture of lower extremity bones or lower limb bones x-ray images especially on the lower leg bones (cruris) consisting of two long bones (tibia) and leg bone (fibula), as well as the kneecap bone (patella). The GLCM feature extraction process yields an image characteristic with four parameters, i.e. Contrast, Correlation, Energy, and Homogeneity done before clustering steps for identification of fractured or non-fractured (normal) bones. The results accuracy texture analysis of lower extremity bones x-ray images using GLCM Feature Extraction Method and K-Means Clustering Algorithm is 80 percent.** ***Keywords*—Fracture, X-Ray Images, Lower Extremity Bones or Lower Limb Bones, Feature Extraction, GLCM, K-Means Clustering.

I. INTRODUCTION

Every year, traumatic injuries contribute to cases of death and permanent disability. Patients with bone fractures who go into shock state have a mortality of 30-50%. When combined with other injuries in the body, for example, an abdominal injury, the chance of mortality rises even higher, approaching 100% in some cases. Traumatic injuries in this region can result in severe hemorrhage, multiple organ dysfunction syndromes (MODS), injury to the nerves, internal organ damage, thus resulting in a mortality rate from 8.6% to 50%. Automatic and accurate detection of fractures from segmented bones in traumatic injuries can help physicians detect the severity of injuries in patients [1]. Mechanism of injury due to many factors, including traffic accidents, falls from height, and so forth. Injuries to humans occurs in the musculoskeletal section.

Feature extraction is a general term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy. Texture tactile or visual characteristic of a surface. Texture analysis aims in finding a unique way of representing the underlying characteristics of textures and represent them in some simpler but unique form, so that they can be used for robust, accurate classification and segmentation of objects. Though texture plays a significant role in image analysis and pattern recognition, only a few architectures implement on-board textural feature extraction [2].

Clustering is a process of grouping data objects into disjointed clusters so that the data in the same cluster are similar, but data belonging to different cluster differ. A cluster is a collection of data object that are similar to one another are in same cluster and dissimilar to the objects are in other clusters. The demand for organizing the sharp increasing data and learning valuable information from data, which makes clustering techniques are widely applied in many application areas such as artificial intelligence, biology, customer relationship management, data compression, data mining, information retrieval, image processing, machine learning, marketing, medicine, pattern recognition, psychology, statistics and so on. Cluster analysis is a tool that is used to observe the characteristics of cluster and to focus on a particular cluster for further analysis [3]. In this paper, we use Gray Level Co-Occurrence Matrix (GLCM) method and K-Means Clustering Algorithm to analyze texture lower limb bones or lower extremity bones x-ray images, in particular tibia-fibula (cruris) bone and patella bone. Both methods area select based on the results literature review has been done. Feature extraction GLCM method is better than other methods. Meanwhile, K-Means algorithm is fast data clusters method.

II. LITERATURE REVIEW

A. Lower Extremity Bones

Bone is basically a connective tissue that is mineralized. The bone is coated with the vascular membrane (periosteum) which is the main source of blood flow to the bone. Periosteum helps when reducing the fracture, as it is often partially intact and can be used to unite fragmented fragments. Periosteum is also important in the healing of fractures, supplying cells that "organize" the hematoma around the site of the fracture [4]. The lower extremity bone or lower limb is attributed to the torso with the pelvic abrasion [5]. The figure of part lower extremity bones, as below [6] [7]:

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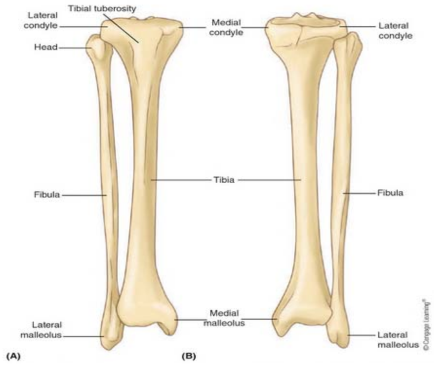


A) Anterior B) Posterior

Fig. 1. Tibia and Fibula Bones

Fig. 2. Patella Bone

B. *Gray Level Co-Occurrence Matrix (GLCM)*

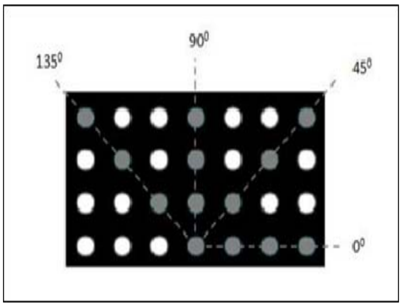


Fig. 3. Direction for GLCM

Gray Level Co-Occurence Matrix (GLCM) first suggested by Haralick on 1973 with 28 features to explain the spatial pattern [8]. In this paper, four parameter Contrast, Correlation, Energy, and Homogeneity are selected for texture analysis lower extremity bones x-ray images using tools MATLAB R2015b :

- Contrast :

$$\text{Kontras} = \sum_i^L \sum_j^L |i-j|^2 GLCM(i,j) \quad (1)$$

- Correlation :

$$\text{Korelasi} = \frac{\sum_{i=1}^L \sum_{j=1}^L (i-\mu i')(j-\mu j')(GLCM(i,j))}{\sigma_i' \, \sigma_j'} \quad (2)$$

- *Energy / Angular Second Moment* (ASM):

$$\text{ASM} = \sum_{i=1}^L \sum_{j=1}^L (\text{GLCM}(i,j))^2 \quad (3)$$

- *Homogeneity / Inverse Difference Moment* (IDM):

$$\text{IDM} = \sum_{i=1}^L \sum_{j=1}^L \frac{(\text{GLCM}(i,j))^2}{1+(i-j)^2} \quad (4)$$

C. *K-Means Algorithm*

The simplest K-Means algorithm is as follows [9] :

Input D = {d1, d2, d3, ... dn} // set n of number of data points

K // the number of the desired clusters

The Output: A set of cluster k

1. Select k points as initial centroid.
2. Repeat
3. From K cluster by assigning each data point to its nearest centroid.
4. Recompute the centroid for each cluster until centroid does not change.

III. RESEARCH METHODOLOGY

Methodology of research divided into two are:

A. *Data Collection*

We use some method to collect data and information related in this research. The method we use are literature review, observation, and interview. Literature review was doing by reading and studying books, papers, journals, proceedings, and also browsing information from internet.

We observed place which became an object of observation, namely at Army Central Hospital (RSPAD) Gatot Soebroto, Central Jakarta. The purpose of this observation we do to get data samples bone x-ray images that will become the primary data research.

We doing interviews with doctors. The purpose of this interview to obtain information about the fracture, cause fracture, managements fracture, checking procedures to patients with fracture, and how to read the results of the x-ray image.

B. *Simulation Method*

There are eight phases in simulation method, as mentioned below [10] :

1. Problem Formulation
   In this phase, we determining main problem with formulate problem research then search for problem solution.
2. Conceptual Model
   In this phase, we made conceptual model to described input, process, and output in diagram flow.
3. Collection of Data Input
   In this phase, we collect data input data to used in this research.

4. Modeling
   In this phase, we made modeling GLCM feature extraction method and K-Means clustering algorithm.
5. Simulation
   In this phase, we running simulation process based on conceptual model has been made.
6. Verification and Validation
   Verification and validation is testing phase.
7. Experimentation
   We do experiment phase based on previous using sample data that has been collected.
8. The Output Analysis
   We analyzing output analysis from test results that have been done. The results analysis is describing accuracy.

IV. RESULT AND DISCUSSION

A. Problem Formulation

The main problem of this research in accordance with the formulation problem is how to do texture analysis of lower extremity bones x-ray images using Gray Level Co-Occurrence Matrix (GLCM) and K-Means Clustering Algorithm.

B. Conceptual Model

The steps conceptual model, as below:

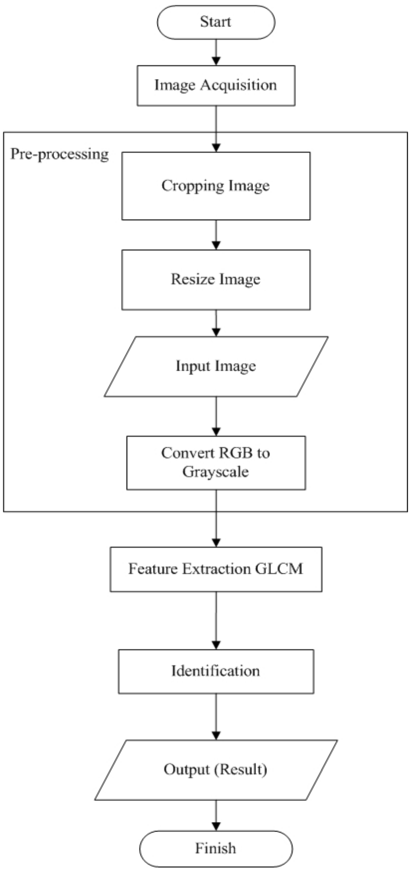


Fig. 4. Process texture analysis of lower extremity bones x-ray images.

C. Collection of Input Data

In this phase, we collected samples data as only 10 samples bone x-ray images consists of five fracture x-ray images and five non fracture (normal) images.

D. Modelling

- The modeling of GLCM [8] :
  1. Make the size of the work area matrix image
  2. Determine spatial relationship between the pixels
  3. Calculate the matrix co-occurrence
  4. Add the matrix co-occurrence
  5. Normalization matrix addition results
  6. Calculate the value of the GLCM feature extraction

- The modeling of K Means Algorithm [9] :

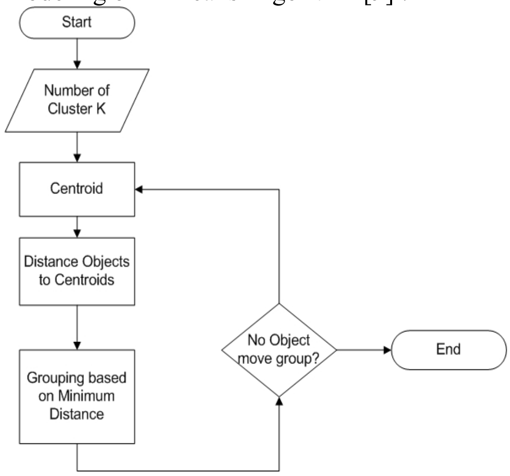


Fig. 5. Flowchart K-Means Algorithm

E. Simulation

Process simulation done based on conceptual model that has been created in the previous phase. There are some explanation simulation steps as follows:

1. Image Acquisition
   The step of image acquisition using x-ray, this research using dimension 100 x 400 pixel. e.g., x-ray image fracture tibia such as in the picture below:

Fig. 6. *X-ray* Image

2. Pre-processing
   Follows process of pre-processing such as in the picture below:

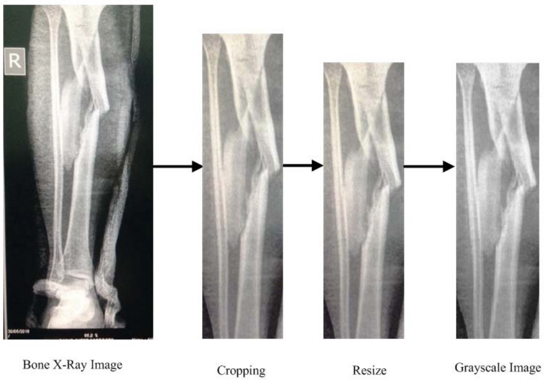


Fig. 7. Process of image pre-processing

3. Feature extraction using GLCM
   In this research, we only use four parameters of GLCM Method. Display output program feature extraction using GLCM in simulation as follows:

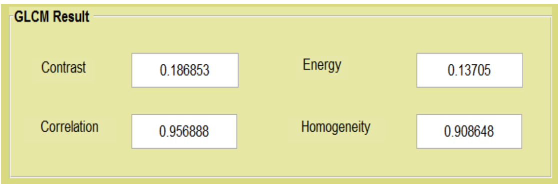


Fig. 8. Feature Extraction Result

4. Clustering using K-Means Algorithm
   Display output program clustering in simulation as follows:

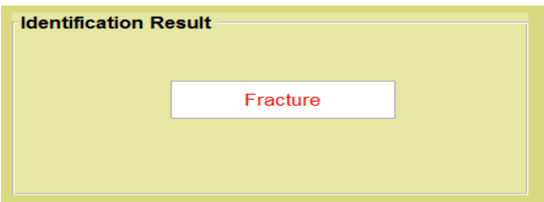


Fig. 9. Clustering Result

F. *Verification and Validation*

F.1 *Verification*

In this phase, verification conducted checking the suitability simulation process on the program by implementing GLCM Feature Extraction Method and K-Means Clustering Algorithm.

1. Interface View Image Grayscale Result

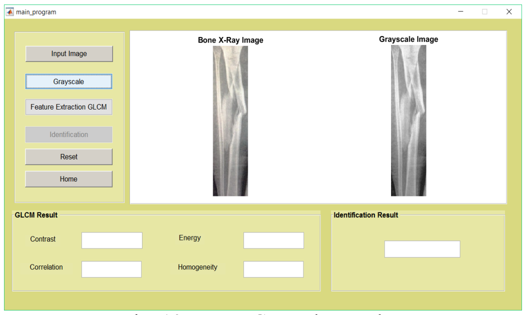


Fig. 10. Image Graycale Result

2. Interface view Feature Extraction GLCM Result

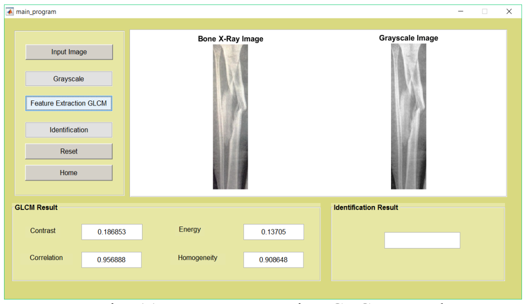


Fig. 11. Feature extraction GLCM Result

3. Interface View Identification Result

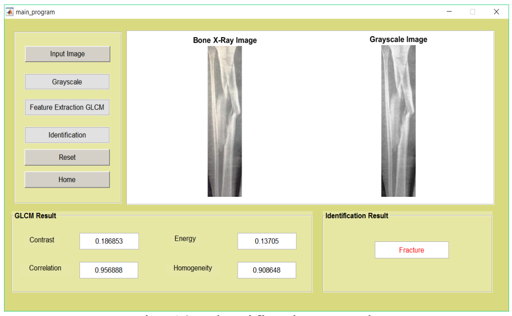


Fig. 12. Identification Result

F.2 *Validation*

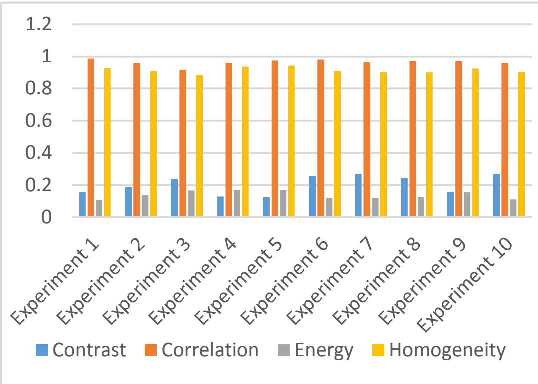
In this phase, validation is done by texture analysis x-ray images to ensure that the model and attributes characterize testing are valid with each object, namely lower extremity bones x-ray images.

Table I. Feature Extraction Results

Image No	The Average Value of each Parameter			
	Contrast	Correlation	Energy	Homogeneity
1	0.15695	0.98496	0.107461	0.925102
2	0.256502	0.979445	0.119273	0.907197
3	0.186853	0.956888	0.13705	0.908648
4	0.271115	0.964393	0.119314	0.902196
5	0.238627	0.916935	0.168171	0.885075
6	0.242761	0.971823	0.126215	0.899559
7	0.128562	0.96029	0.170939	0.935997
8	0.160635	0.9692	0.158417	0.924576
9	0.123061	0.972786	0.171636	0.942373
10	0.271254	0.957727	0.109735	0.90419

G. Experiment

We did an experiment using 10 samples *x-ray* images. The following is a table of the extraction of image features with pixel distance is 1 (d = 1) and orientation direction of all angles (00, 450, 900, and 1350) obtained from the application of the Gray Level Co-occurance Matrix (GLCM) feature extraction method. The parameters used are contrast, correlation, energy, and homogeneity by performing 10 experiments using x-ray image sample of lower extremity bone fracture consisting of fracture image and normal image (no fracture).



H. Output Analysis

Texture analysis of lower extremity bones x-ray images is obtained through the process of feature extraction using Gray Level Co-Occurence Matrix (GLCM) Method and K-Means Clustering Algorithm. In the process of feature extraction GLCM will be produced by value characteristics of the image with four parameters contrast, correlation, energy, and homogeneity. The parameters values from all the image that will determine the fracture or non fracture (normal) on x-ray image. Then the value of the characteristics all x-ray images will be processed as inputs for the process grouping of the image using K-Means Clustering algorithm with output in the form of identification. The following is a table of the *output* results image identification inputs in the form *x-ray* images fracture and non fracture (normal) that has been done by us:

Table II. Identification Results

Experiment	Input Image	Output	Result
1	Fracture1.jpg	Fracture	True
2	Normal1.jpg	Normal	True
3	Fracture2.jpg	Fracture	True
4	Normal2.jpg	Normal	True
5	Fracture3.jpg	Normal	False
6	Normal3.jpg	Normal	True
7	Fracture4.jpg	Fracture	True
8	Normal4.jpg	Fracture	False
9	Fracture5.jpg	Fracture	True
10	Normal5.jpg	Normal	True

The results of texture analysis value calculation accuracy x-ray images of lower extremity bones such as the following equation:

$$\text{Accuracy} = \frac{\text{Total Images True Identification}}{\text{Total Samples Images}} \quad (5)$$

$$\text{Accuracy} = \frac{8}{10} x100\% = 80\%$$

V. CONCLUSION

Based on the results, it can be concluded that From 10 experiments performed, 8 experiments yielded the correct identification output and 2 experiments yielded incorrect identification outputs, ie Fracture3.jpg and Normal4.jpg images.The Contrast feature parameter shows the difference between the adjacent and the adjacent pixels high value of the overall varied image samples, thus more affecting the image identification than the other features of Correlation, Energy, and Homogeneity features.Texture analysis on x-ray images of lower extremity bone fractures is represented using mathematical modeling by GLCM method as a feature extraction method and K-Means as Clustering algorithm yields an accuracy of 80%.GLCM Feature Extraction Method and K-Means Clustering Algorithm can be applied to texture analysis x-ray images lower extremity bones using GLCM feature extraction method gives result accuracy is 80 percent.

ACKNOWLEDGMENT

Many Thanks for all of people especially Mr. Baron, Mrs.Endah, and doctor Rizka at Army Central Hospital (RSPAD) Gatot Soebroto, Jakarta.

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