

Osteoarthritis Severity Determination using Self Organizing Map Based Gabor Kernel

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Abstract. The number of osteoarthritis patients in Indonesia is enormous, so early action is needed in order for this disease to be handled. The aim of this paper to determine osteoarthritis severity based on x-ray image template based on gabor kernel. This research is divided into 3 stages, the first step is image processing that is using gabor kernel. The second stage is the learning stage, and the third stage is the testing phase. The image processing stage is by normalizing the image dimension to be template to 50×200 image. Learning stage is done with parameters initial learning rate of 0.5 and the total number of iterations of 1000. The testing stage is performed using the weights generated at the learning stage. The testing phase has been done and the results were obtained. The result shows KL-Grade 0 has an accuracy of 36.21%, accuracy for KL-Grade 2 is 40.52%, while accuracy for KL-Grade 2 and KL-Grade 3 are 15.52%, and 25.86%. The implication of this research is expected that this research as decision support system for medical practitioners in determining KL-Grade on X-ray images of knee osteoarthritis.

1. Introduction

Approximately 13% of women and 10% of men at the age 60 years and older have symptomatic knee OA [1]. Based on data at the Ministry of Health of Indonesia, the number of patients with Osteoarthritis disease (OA) is quite high. From 1995 to 2007 the prevalence is 30 percent. So one of thirty Indonesians suffer osteoarthritis disease [2]. This is because the disease cannot be cured and the meet of tibia and femur bones causes pain for the sufferer. Knowing the status of the patient so it can be treated hopefully that the pain can be reduced [3-6]. Classification by Kellgren-Lawrence, based on the severity of osteoarthritis (normal, doubtful, minimal and moderate) [7].

X-rays, magnetic resonance imaging (MRI), osteo CT and arthroscopy are the usual methods used to determine the status of osteoarthritis [8, 9]. But in Indonesia has commonly used X-ray and Magnetic Resonance Imaging (MRI) to know the status of OA. Osteoarthritis has been studied by researchers all over the world. Research on the localization of the junction space area using delineation of cortical bone plates (active shape model) [10].

The classification using 20 pre-selected images of 150 × 150 is used as gold standard, to search for ROI done by scanning used euclidean distance to predict junction area, while to find the status of



osteoarthritis used fisher score from feature data [11], another research finding the distance between the femur and the tibia [12]. But the research that has been done is still difficult to classify KL-Grade 4. Another study is a novel hybrid of S2DPCA and SVM for knee osteoarthritis classification performed by Rima [13].

Some other studies are Osteoarthritis X-Ray Image Analysis Using Gray Level Co-occurrence Matrices Based Wavelet performed by Haryanto [14]. Automatic Segmentation of Impaired Joint Space Area for Osteoarthritis Knee on X-ray Image Using Gabor Filter Based Morphology Process [15]. Osteoarthritis Classification Using Self-Organizing Map Based on Gabor Kernel and Contrast-Limited Adaptive Histogram Equalization [16]. Research about performance evaluation of osteoarthritis X-ray image is investigated by Anifah [17].

The research that has been done above discussed ROI segmentation with various methods. Research that discussed the classification of osteoarthritis severity and classified image into KL-Grade 0, KL-Grade 1, KL-Grade 2, KL-Grade 3 and KL-Grade 4 but however the research is mostly texture feature-based. This research is done with feature-based template, hopefully this research can improve the result of previous research and become one of method to determine KL-Grade on x-ray image of knee osteoarthritis. The aim of this paper to determine osteoarthritis severity based on x-ray image template based on gabor kernel. This research is expected to contribute as decision support system for medical practitioners in determining KL-Grade on X-ray images of knee osteoarthritis. The novelty of this research is to determine KL-Grade based on template feature.

2. Methodology

2.1. Data

Please follow these instructions as carefully as possible so all articles within a conference have the same style to the title page. This paragraph follows a section title so it should not be indented. The data used in this research are 303 x-ray images, which consists of 25 data for training process and 258 data for testing. All data obtained from Osteoarthritis Initiative (OAI). The processed data is x-ray image of the knee fixed- flexion with 10° image capture angle [18].

2.2. Methods

The diagram block of this research is illustrated in Figure 1. This research is divided into 3 stages, the first step is image processing that is using gabor kernel. The second stage is the learning stage, and the third stage is the testing phase. The image processing stage is by normalizing the image dimension to be template to 50×200 image. Learning stage is done with parameters initial learning rate of 0.5 and the total number of iterations of 1000. The testing stage is performed using the weights generated at the learning stage.

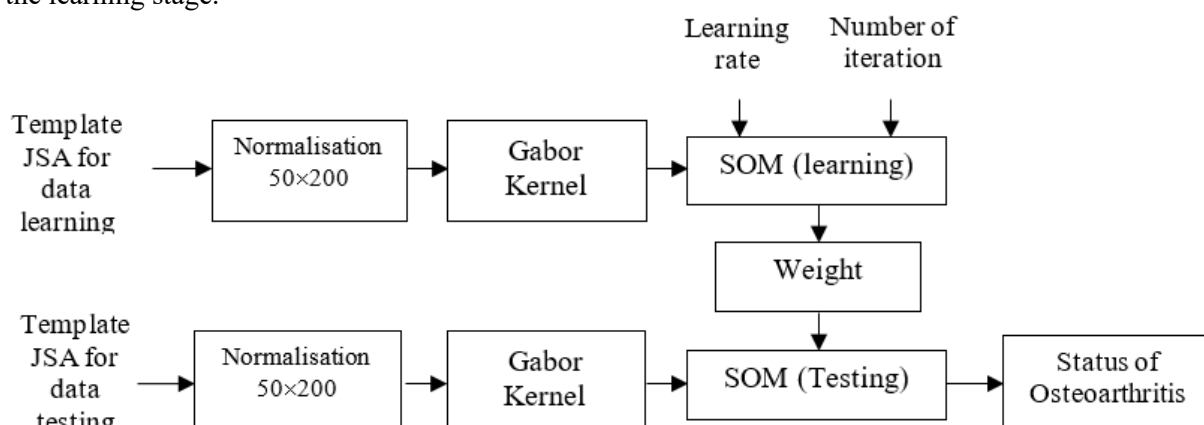


Figure 1. The diagram block of this research.

SOM algorithm used is illustrated in Figure 2. The learning step uses SOM with the following stages: initialization, determining the number of classes, setting up the learning rate parameters, determining the number of iterations and calculating the distance between the random data and the predetermined weights and obtaining the new weight (update weight). The purpose of using the gabor kernel here is to bring up the special features of x-ray images that have been convoluted to the gabor kernel. With the selection of the right parameters then get the typical image features.

The gabor complex formula is:

$$g(x, y) = s(x, y)w_r(x, y) \quad (1)$$

Where $s(x, y)$ is a complex sinusoid (carrier), and $w_r(x, y)$ a two-dimensional Gaussian-shaped function (envelope).

The sinusoid complex is defined as:

$$s(x, y) = \exp(j(2\pi(u_0x + v_0y) + P)) \quad (2)$$

Where (u_0, v_0) is defined as the spatial frequency and P as the phase of the sinusoid.

The real and imaginary part of the sinusoid is:

$$\begin{aligned} \Re(s(x, y)) &= \cos(2\pi(u_0x + v_0y) + P) \\ \Im(s(x, y)) &= \sin(2\pi(u_0x + v_0y) + P) \end{aligned} \quad (3)$$

Parameters u_0 and v_0 are defined in Cartesian coordinates. While spatial frequency is expressed in polar coordinates with peak F_0 and direction ω_0 as follows:

$$\begin{aligned} F_0 &= \sqrt{u_0^2 + v_0^2} \\ \omega_0 &= \arctan\left(\frac{v_0}{u_0}\right) \\ u_0 &= F_0 \cos(\omega_0) \\ v_0 &= F_0 \sin(\omega_0) \end{aligned} \quad (4)$$

Complex sinusoid becomes:

$$s(x, y) = \exp(j(2\pi F_0(x \cos \omega_0 + y \sin \omega_0) + P)) \quad (5)$$

And gaussian envelope expressed as,

$$w_r(x, y) = K \exp(j(-\Pi(a^2(x - x_0)_r^2 + b^2(y - y_0)_r^2))) \quad (6)$$

Where K is the magnitude of the gaussian envelope, (x_0, y_0) is the peak of the function, a and b are the scale parameters of the envelope gaussian, whereas r is denoted as the rotation operator [17]. So:

$$\begin{aligned} (x - x_0)_r &= (x - x_0) \cos(\theta) + (y - y_0) \sin(\theta) \\ (y - y_0)_r &= (x - x_0) \sin(\theta) + (y - y_0) \cos(\theta) \end{aligned} \quad (7)$$

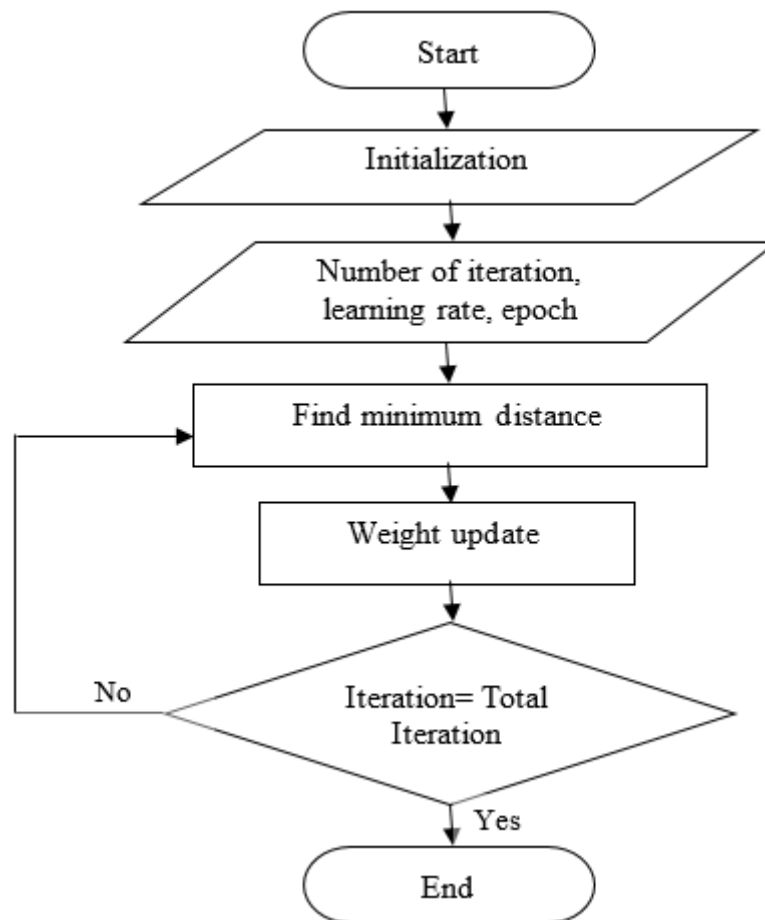


Figure 2. SOM algorithm used in this research.

3. Results and Discussion

Figure 3 is a template used in training process. Experimental results are strongly influenced by the intensity of the processed image, so that required normalization is not just normalization dimensions (size only). The first experiment using the image normalization of 10×40 is too small and possible the amount of missing image information, so image information has not been represented if using this normalization. The third experiment used templates based on gabor as a standardized gold standard to 50×200 and SOM parameters used initial learning rate 0,5 and total iteration 1000.

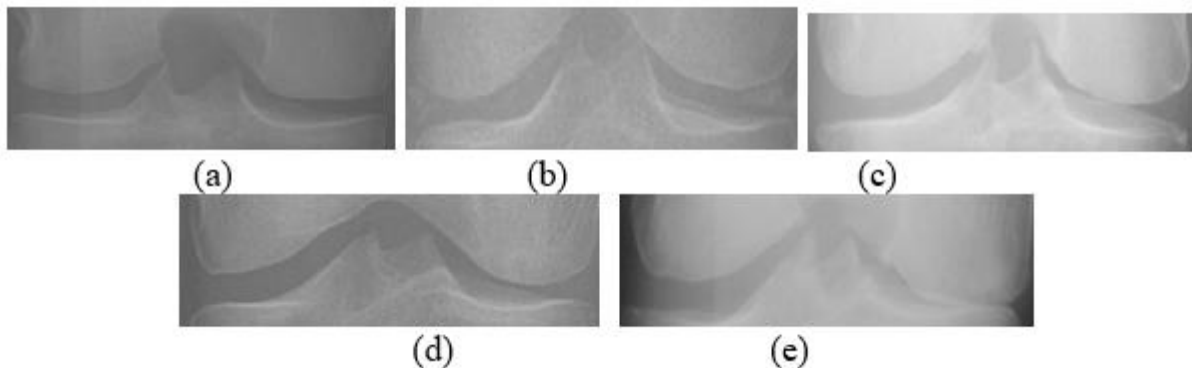


Figure 3. Template used in training process.

The experimental results still have not produced good results. Figure 4 is the result of the normalization of 50×200 previously edge detection using the Gabor Kernel, the five KL-Grades appear almost the same, allowing some information lost after the normalization process.

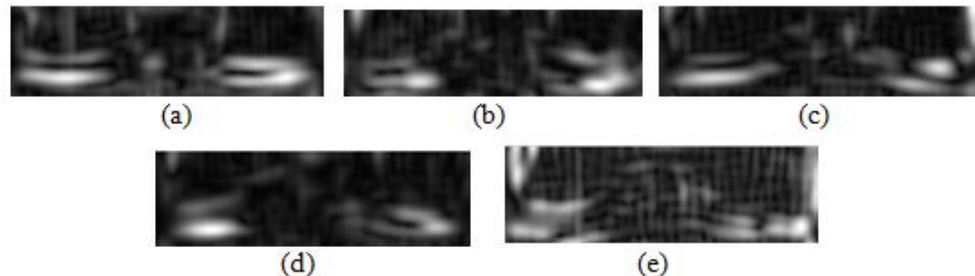


Figure 4. Result of 50×200 image using Gabor Kernel.

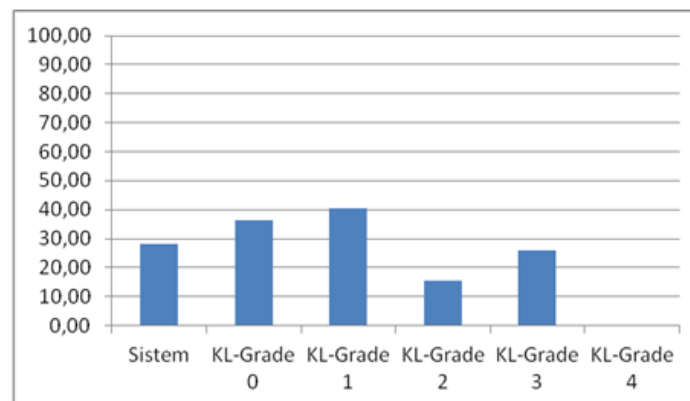


Figure 5. Accuracy of the system.

Figure 5 is illustrated of the system accuracy. KL-Grade 0 has an accuracy of 36.21% because 31.9% is classified as KL-Grade 1, 12.93% are classified as KL-Grade 2 and 18.97% as KL-Grade 3. Classified KL-Grade 1 as KL-Grade 0 is 14.66% while those read as KL-Grade 2 and KL-Grade 3 are 12.07% and 32.76% respectively. KL-Grade 2 which is read as KL-Grade 0 is 26.72%, and which is known as KL-Grade 1 is 44.83% and the remaining 12.93% is known as KL-Grade 3. KL-Grade 3 is recognized as KL-Grade 0, KL-Grade 1, and KL-Grade 2 were 14.66%, 44.83%, and 14.66%. While using this method has a weakness, it still cannot recognize KL-Grade 4, but KL-Grade 4 is known as KL-Grade 0 20%, known as KL-Grade 1 20% and is recognized as KL-Grade 3 32%. Some of the causes that cannot be detected correctly are some images of objects or medical instruments contained in the x-ray image, such as knee bond plate. This will affect the outcome of the kernel gabor process. This can be solved by re-checking the x-ray image before it is inserted into the system.

4. Conslusions

Osteoarthritis severity determination using Self Organizing Map based Gabor Kernel does not produce excellent results. KL-Grade 0 has an accuracy of 36.21%, accuracy for KL-Grade 2 is 40.52%, while accuracy for KL-Grade 2 and KL-Grade 3 are 15.52%, and 25.86%. The weakness of this system is still not able to classify KL-Grade 4. Based on this result, further research is needed to obtain higher accuracy.

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