Analysis of Osteoarthritis in Knee X-Ray Image

[1]Shashikala R, [2]Divya.M.Shetty, [3]Anupa, [4]Deepikaraj Ballal, [5]Rakshitha

[1]Assistant Professor, [2,3,4,5]Student (BE)
Department of Electronics & Communication Engineering,
Shri Madhwa Vadiraja Institute of Technology &Management, Bantakal, Udupi, India

***Abstract*—Osteoarthritis (OA) is a common disease in human. Under various joints such as knee, hips, hand and wrist. It is the stage of human bone in which the joints of human body become damaged and stop moving freely which causes pain. Due to the increasing prevalence of knee Osteoarthritis and related effects on functional limitation, reduced health related quality of life, health care utilization and total joint arthroplasty, there is a growing need for clinical and scientific tools that can reliably detect knee OA early in its development. The scenario for the evaluation of Osteoarthritis includes clinical examination and various medical imaging techniques. We describe a method to detect Osteoarthritis from knee X-Ray images. The detection is based on the thickness of cartilage in knee bone, which corresponds to possibility of Osteoarthritis. Here we have used active contour segmentation technique to segment the part of the knee X-Ray image. The various features like Haralik, Statistical, First Four Moments, Texture and Shape Features are computed and classified. However, these are based on the presence or size of Osteophytes and the degree of joint space narrowing as assessed by human readers.**

***IndexTerms*—Osteoarthritis, X-ray images, Active contour segmentation, Feature Extraction, Classification.**

I. INTRODUCTION

The human body is held together by different types of joints. A joint is where two bones meet, held together with ligaments. Joints allow us to be flexible by lubricating our bones to provide movement without friction. These bones are constantly being used in everyday an activity, which makes them more prone to injuries and diseases. Most people face problems with joints as they get older. The bones start to get weaker making joint pain a common issue among the older generation. Although, most adults also face this issue from time to time. Especially for individuals who are physically active or have jobs that are labour intensive. Heavy lifting and strenuous exercise can have a debilitating effect on the joints. Injuries can also cause joint pain because the joints are all connected, a single fracture can cause strain on the joints. Diseases such as arthritis, bursitis and osteomyelitis can also cause extreme pain in the joints. Pain can be experienced anywhere in the body, most people experience pain in their wrists, knees, shoulders and back. These ligaments are constantly being used which can cause the joints to deteriorate much faster. One of the most common causes of joint pain is osteoarthritis. Osteoarthritis (OA) is a type of joint disease that results from breakdown of joint cartilage and underlying bone [2]. The most common symptoms are joint pain and stiffness. Initially, symptoms may occur only following exercise, but over time may become constant. Other symptoms may include joint swelling, decreased range of motion, and when the back is affected weakness or numbness of the arms and legs. The most commonly involved joints are those near the ends of the fingers, at the base of the thumb, neck, lower back, knee, and hips. Joints on one side of the body are often more affected than those on the other. Usually the symptoms come on over years.It can affect work and normal daily activities. Unlike other types of arthritis, only the joints are typically affected. Causes include previous joint injury, abnormal joint or limb development, and inherited factors. Risk is greater in those who are overweight, have one leg of a different length, and have jobs that result in high levels of joint stress. Osteoarthritis is believed to be caused by mechanical stress on the joint and low grade inflammatory processes. It develops as cartilage is lost and the underlying bone becomes affected [3]. As pain may make it difficult in medical imaging and other tests occasionally used to either support or rule out other problems. Osteoarthritis is the most common form of arthritis affecting about 237 million (3.3%) of the population. Among those over 60 years old, about 10% of males and 18% of females are affected. It is the cause of about 2% of years lived with disability. In Australia, about 1.9 million people are affected, and in the United States, 30 to 52.5 million people are affected. It becomes more common in both sexes as people become older. If the impact of symptoms of osteoarthritis on quality of life is significant and more conservative management is ineffective, joint replacement surgery or resurfacing may be recommended. Evidence supports joint replacement for both knees and hips as it is both clinically effective, and cost-effective. Surgery to transfer articular cartilage from a non-weight-bearing area to the damaged area is one possible procedure thathas some success, but there are problems getting the transferred cartilage to integrate well with the existing cartilage at the transfer site. Osteotomy may be useful in people with knee osteoarthritis, but has not been well studied. Arthroscopic surgery is largely not recommended, as it does not improve outcomes in knee osteoarthritis, and may result in harm. So we have introduced a semi-automated method that diagnosis the disease to some extent. This method includes segmentation and feature extraction for the classification of osteoarthritis based on knee X-ray imaging. The sample of normal and Osteoarthritis knee x-ray is show below in Fig. 1 and Fig. 2

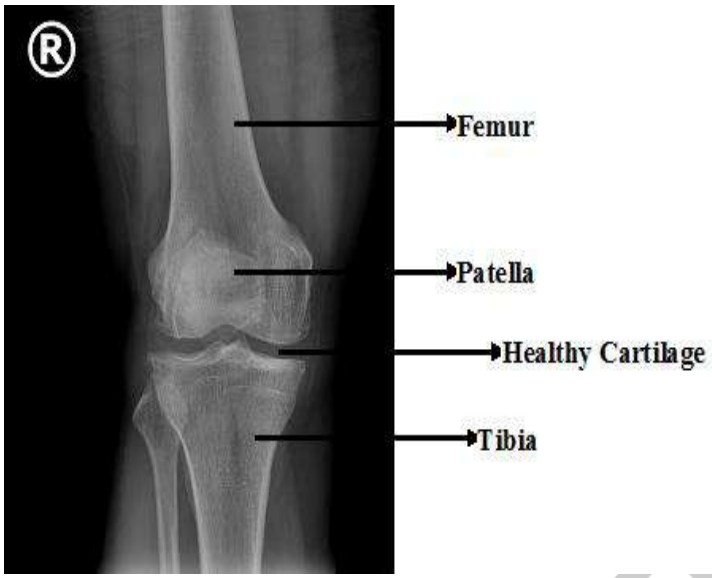

Fig. 1 Normal Knee X-ray Image

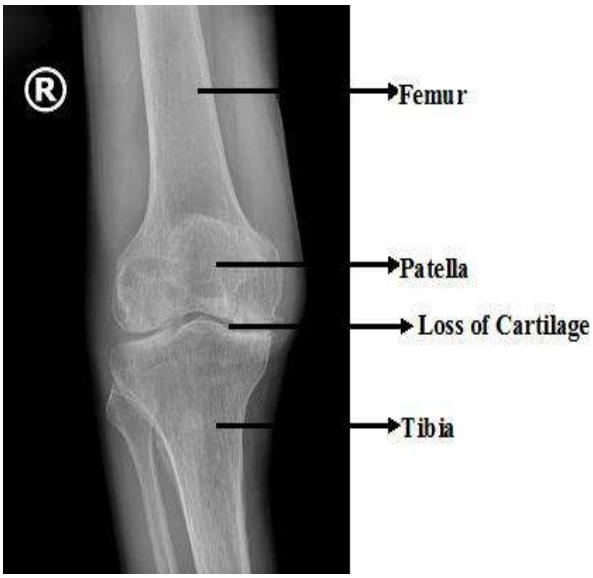

Fig. 2 Osteoarthritis Knee X-ray image

II. METHODOLOGY

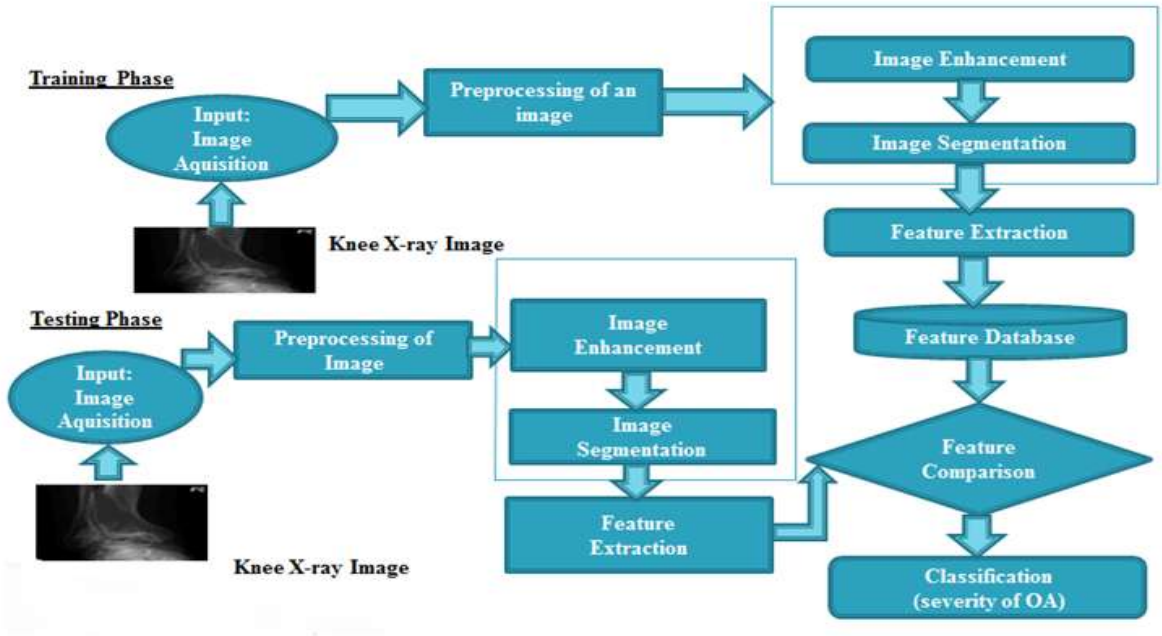

Fig. 3 Flowchart of the system.

The proposed methodology is categorised into 5 main steps,

A. Image Acquisition

Image acquisition can be defined as the action of retrieving an image from some source, usually hardware based source and then it is passed through whatever process need to occur afterwards [7].
Data Set: We have collected around 100 knee X-ray images from various hospitals and diagnostic centre. The images which were collected are based on different specifications.

B. Pre-processing

Pre-processing is carried out before image segmentation in order to extract the informative feature in an image. Pre-processing images commonly involves removing low-frequency background noise, normalizing the intensity of the individual particles images, removing reflections, and masking portions of images. Image Pre-processing is the technique of enhancing data images prior to computational processing [5]. Fig. 4 shows the image after Pre-processing.

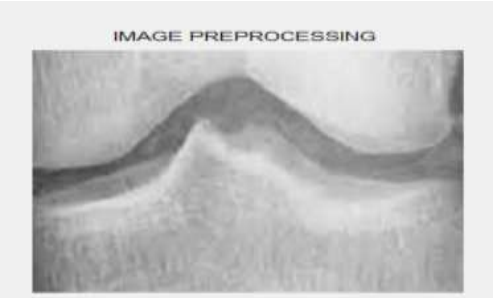

Fig. 4 Pre-processed image

The important steps in pre-processing is Image Enhancement. Image Enhancement is to improve the quality of image. It is a subjective process. The enhancement techniques for image includes noise removal, sharpening, or brightening an image, making it easier to identify key features. In our work after pre-processing the x-ray image is subjected to contrast enhancement in order to improve image quality. Fig. 5 shows the enhanced image after Pre-processing.

Fig. 5 Enhanced Image.

C. Image Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyse. Image segmentation is typically used to locate objects and boundaries. In the work image segmentation is carried out using Active contour [9]. Fig. 6 shows the segmented image after image enhancement.

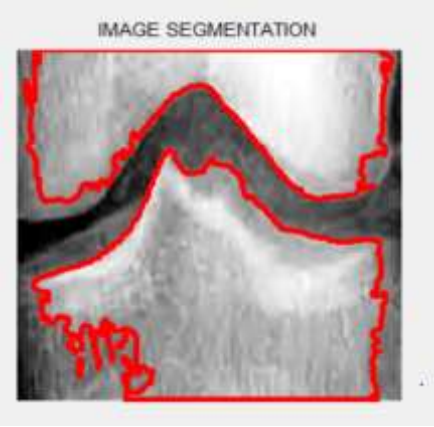

Fig. 6 Segmented Image.

D. Feature Extraction

Featureextraction is the process of transforming the input data into a set of featureswhich can very well represent the input data [8].This approach is useful when image sizes are large and a reduced feature representation is required to quickly complete tasks such as image matching and retrieval. In this stage different features of segmented images are computed using MATLAB. The computed features are First Four Moments that includes Skewness, Kurtosis, Variance and Standard Deviation. Second feature is

Shape features which are Mean and Entropy. Third feature is Statistical Features that includes Area, Major and Minor Axis length, Perimeter, Equiv diameter, Eccentricity and Euler Number. Fourth feature is Haralick features like Contrast, Correlation, Energy and Homogenity and the last feature is Texture analysis features. Fig.7 shows the image of feature extraction.

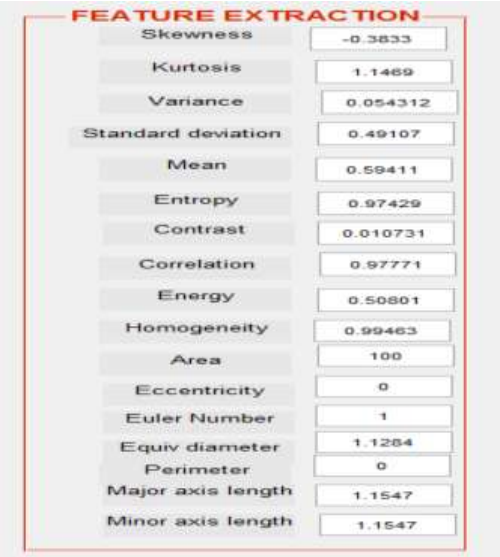

Fig. 7 Extracted Features.

E. Classification

Image classification analyses the numerical properties of various image features and organizes data into categories. Classification algorithms typically employ two phases of processing: training and testing. In the initial training phase, characteristic properties of typical image features are isolated and, based on these, a unique description of each classification category, i.e. training class, is created. In the subsequent testing phase, these feature-space partitions are used to classify image features. In this work the images are classified using different KL Grades.

III. RESULTS AND DISCUSSION

Kellgren-Lawrence (KL) system is validated method of classifying individual joints into 5 grades [1][4]. Table below shows thedifferent grades of OA disease.

TABLE 1
DIFFERENT GRADES OF OSTEOARTHRITIS

KL GRADES	OA ANALYSIS
Grade 0	No Radiographic features of OA present
Grade 1	Doubtful OA(narrowing of joint space)
Grade 2	Mild OA(definite narrowing of joint space)
Grade 3	Moderate OA(multiple osteophytes, sclerosis)
Grade 4	Severe OA(large osteophytes, severe sclerosis, bone deformity)

The results are as shown below

Fig. 8 Input Image

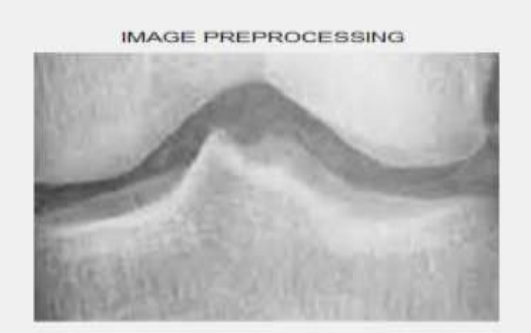

Fig. 9 Pre-processed Image

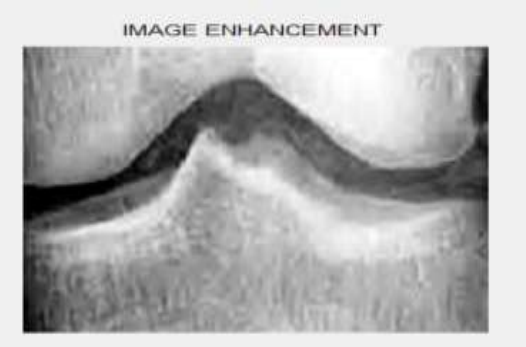

Fig. 10 Enhanced Image.

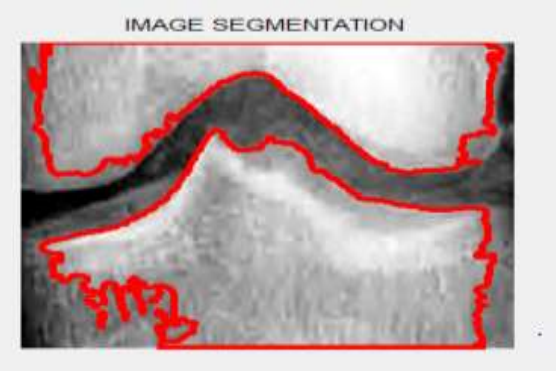

Fig. 11 Segmented Image

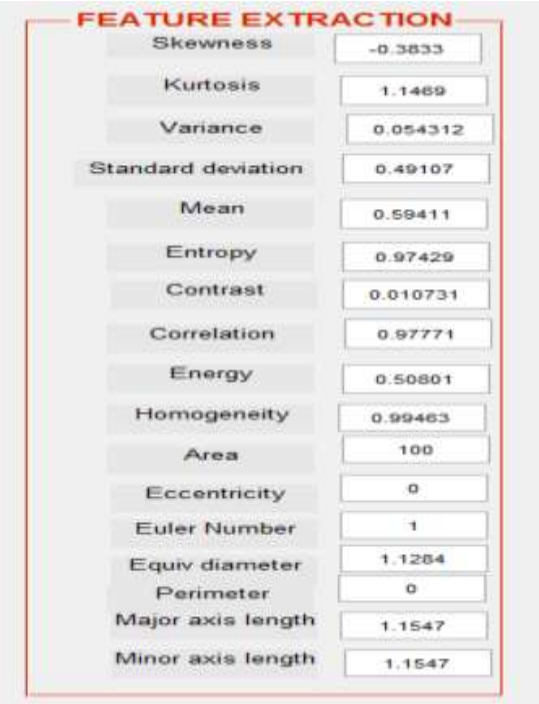

Fig.12 Feature Extracted Image

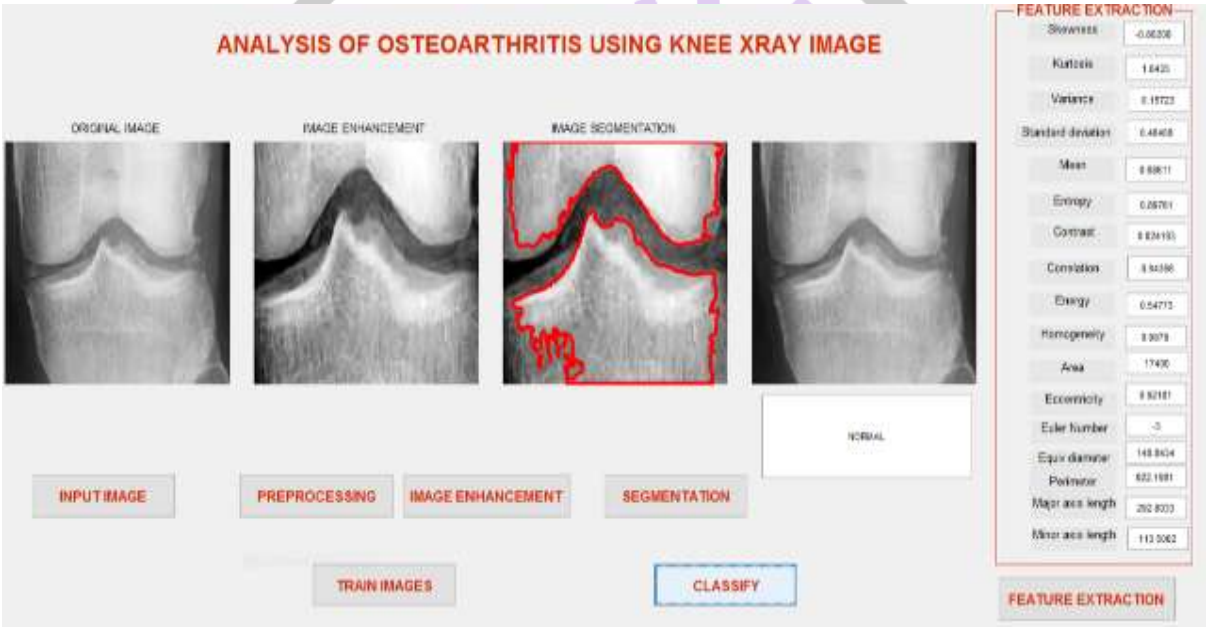

Fig. 13 Grade 0 i.e. Normal Knee X-ray

IV. CONCLUSION

Detailed examination of the of X-ray images is done manually by the physician that is time consuming, subjective & doubtful. The problems associated with the X-ray images make it complicate to analyse them in an effective way. A knee X-ray image may have unwanted distortions that cause problem in analysing the bone structures. To eliminate these problems, we have used semi-automated technique that gives a quick and efficient method to analyse the abnormalities & problems associated with the bone structures. In the work we have used Active contour algorithm to segment a knee x-ray image that undergoes various feature extraction techniques. In future the process need to be developed that is associated to Osteoarthritis pain and clinical symptoms.

V. ACKNOWLEDGMENT

We express our deepest gratitude and respect to our guide Mrs. Shashikala R, Assistant Professor, Department of Electronics and Communication Engineering, for her valuable guidance and encouragement while doing this project work. We also extend our heartfelt gratitude to Mr. Sachin Bhat, Assistant Professor, Department of Electronics and Communication Engineering, for his advice and suggestions at various stages of the work.

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