Detection of Knee Osteoarthritis Using X-Ray

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Abstract: **We describe a method to detect osteoarthritis (OA) from knee X-ray images. The detection is based on the thickness of cartilage in knee bone, which correspond to possibility of osteoarthritis. Using our approach better diagnosis treatment can be applied to the patient since a computed automated measurements leads to accurate values so the image segmentation and mathematical morphological operation is applied to extract the border of cartilage by covering the boundary of cartilage. If cartilage thickness is lesser than 1.69 mm the patient has OA, otherwise not for this analysis we considered dataset of 100 X-ray image both with and without OA.**

Keywords: **Kellgren-Lawrence classification Osteoarthritis, image classification, thresholding, X-ray.**

I. INTRODUCTION

Human body has many bone joints which play a major role in physical working. Among them knee joint is one of the most important joints of our body, which allows the leg to bend, straighten, rotate and to carry the weight of body. In the stage infant stage of conventional knee cap is no well-developed. But as the human growing age the conventional knee cap developed with required cartilage. Knee is a complicated joint structure of lower leg with two important joints, one joint between femur and tibia and another joint is between femur and patella, as shown in fig 1.

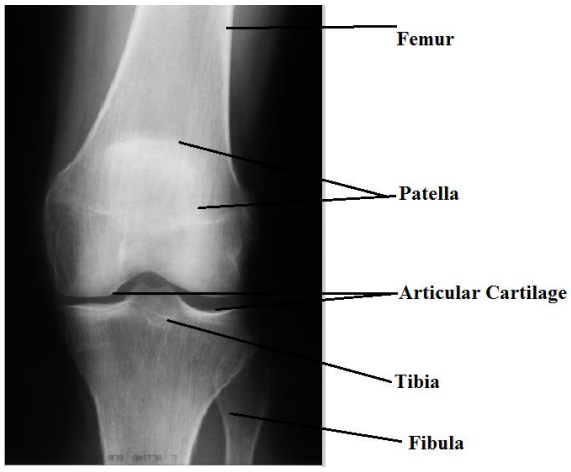


Fig1 Anatomy of Knee

Fig 2 shows knee X-rays, in fig 2(a) shows a normal healthy knee and fig 2(b) shows that there is OA since the gap in right side edge is less than the required measurement.

Fig 2 Comparison of radiograph before and after osteoarthritis

Osteoarthritis 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. As the cartilage become thin and gap between the bones become narrows. The main causes of osteoarthritis are greater than age of 40 years [1], overweight [1], previous joint injury and by genetic hereditary. Knee osteoarthritis can make sitting and walking extremely painful. Knee osteoarthritis also varies between male & female genders as per the survey shown by Arthritis Research UK Primary care Centre, Keele University[1],some of those result are shown in table1.The survey shows that female has higher ratio to get osteoarthritis.

TABLE I
Data is taken from Arthritis Research UK Primary care Centre, Keele University [1]

Total	Age	Male	Female
8121	45-64	1414(14%)	1542(15%)
	65-74	1970(20%)	2290(23%)
	75+	2313(24%)	2545(25)

In clinical diagnosis, for a human body X-ray imaging is best tool for detecting abnormalities in bone painful, and deformed areas of bone. MRI(Magnetic Resonance Imaging) and CT(Computed Tomography) will give more details compared to X-ray, to determine the exact location of injured bone. X-ray is relatively less expensive compared to MRI and CT and the cartilage can be clearly seen. X-Rays used to examine broken bones and detect diseased cartilage. In recent years, due to the rapid development of computer technology, computer vision, image processing and pattern recognition, the related technologies have become increasingly important in medical image analysis. To solve our problem, image processing tool is one of the best tool for the detecting the disease .We proposed an automated system for osteoarthritis assessment, which is applied on X-ray images for identifying the characteristics of osteoarthritis. Image segmentation and edge detection method are applied to determine the thickness of the joint space.

II. Related Work

In 1957 KELLGREN-LAWRENCE [2] proposed that every human knee joint has four grades as shown in the table 2.

TABLE II
KL GRADE DISTRIBUTION

KL grade	KL description
0	No Osteophytes
1	Doubtful narrowing, possible osteophytes
2	Minimal but definite osteophytes ,joint space
3	Definite and moderate osteophytes, joint space narrow, some subchondral sclerosis

Table 1 shows four knee X-rays of KL grades 0(normal), 1(doubtful) , 2(minimal) and 3(moderate).The KL method is is possible only when we have many X-ray image of knee of a patient with osteoarthritis and after. Unfortunately, this KL grade is not effective in the early period since X-rays show joint space narrowing. KL grade does not specify criteria for OA using cartilage thickness.

In 1995 J Christopher Buckland-Wright[3] et al. proposed a method of measurement of cartilage thickness using JSW (Joint Space Width) technique .This method used to approach such as plain film macro radiography and double contrast macroarthography for X-ray image generation then finally they compared with the sum of the tibial and femoral cartilage.For this analysis they used a hectic process is being done for osteoarthritis detection.

Philipp Peloschek[4] et al. given a RAQuantify software, this software use joint measurement in four steps and joint be selected at manually . This method that is measurement is based on web based technique ,for this they only measured the thickness with the RAQuantify and how to detection of knee osteoarthritis and how the identified this disease . Tati [5] et al.in 2005 proposed a technique to automatically determine the region of interest needed for knee osteoarthritis assessment to horizontal and vertical translation to place the axis and locate the joint. Boundary detection between femur and joint space, for some image boundary appears discontinuously.

Lior[6] et al. in 2008 developed an automated approach for the detection of OA according to Kellegren-Lawrence method which show the probability of OA in different stage i.e. KL grade 0,1,2,3 .Their work on 20 preselected image ,each image is a 150*150 window of center of joint, then these image downgraded by factor of 10 into 15*15 images.

Schmidt et al.[7] proposed a semi-automated method of JSW in knee X-ray that identifies the femoral and tibial edges by first adjusting the image intensity. Then use of canny edge detection algorithm determine the distal edge of the medial and lateral femoral condyles. Define the extent of the medial and lateral compartments by the user. The inner boundary was defined at that point where the slope of the tibial spine began to increase and the outer boundary was defined as the outer edge of the tibial plateau. The cortical bone interface of the tibia was found by determining the brightest pixels in each vertical scan line. This proposed method was replicated across the entire medial and lateral tibial compartment to detect femoral and tibial edges.

III. Dataset

The knee X-ray image are taken from Department of Medical Informatics, Aachen University of Technology, Germany entitled “10,000 IRMA images of 57 categories for Image CLEFmed 2005” that has been created by Dr. Thomas Deserno, Lehmann TM, Schubert H, Ott B and LeisenM.[11]

IV. Methodology

Thickness calculation measurement is used as major criterion in the diagnosis of osteoarthritis (OA) from radiographs and for monitoring of the disease. The proposed method has several steps.

Step 1: Map the intensity values in gray scale image to new values in such a way that few of data is saturated at low and high intensities of image. This increases the contrast of the output image.
Step 2: Threshold the image with its mean intensity value.
Step 3: Edge detection of the image
Step 4: Cropping the image
Step 5: Detecting the boundary of joint space
Step 6: Making the binary for cropped image
Step 7: Distance calculation

Fig 2 Algorithm

A. *Preprocessing*

Preprocessing works by first extracting the image features, which the most informative features. Before segmented, digital radiographs were preprocessed using maps the intensity values in gray scale image to new values in such that few of data is saturated at

low and high intensities of image. This increases the contrast of the output image. Fig 3 shows the result of preprocessing.[8][9]

Fig 3 Comparison of original radiograph and the result of preprocessing

The knee X-ray image is subjected to contrast enhancement for better view of anatomical boundaries. The contrast stretched image is then histogram equalized adaptively. The histogram is plotted to understand the gray level of the image. In the dark image, components of the histogram are concentrated on the low side of gray scale. The components of the histogram of the bright image are biased toward the high side of the gray scale. Fig 4(a) shows the histogram plot of image and fig 4(b) shows the histogram equalized image after contrast enhancement.

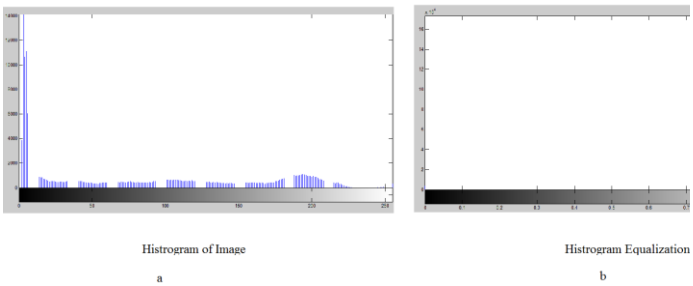


Fig 4 Comparison of histogram of image and after equalization of histogram

B: Thresholding

The first step of this process, as shown in fig is to threshold the image with its mean intensity. With help of this method minimize the variance of the black and white pixels.

Fig 5 Result of Thresholding

C: Edge Detection

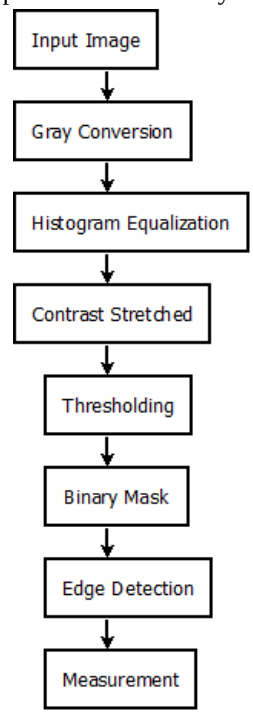
After all the process is completed, we may detect the boundary of femur and tibia. The algorithm used in this process is:

- Cropping the image
- Detecting the boundary between the bone and joint space.

Fig 6 Cropping the image and apply binary operation

D: Distance Calculation

Since the boundary of each bone has been known. We may determine the thickness for detecting osteoarthritis. Articular cartilage thickness represented by the distance between the articular surface, in the presence of a thin layer.



Algorithm for finding distance

V. EXPERIMENTAL RESULTS

The used method was tested using the dataset to perform automated segmentation and calculation of joint space

thickness needed in the detection of osteoarthritis. This method has been successfully implemented by using MATLAB R2013a.

The knee had mean cartilage thickness in the range 1.69 mm to 2.55 mm respectively [10]. If thickness is lesser 1.69mm then maximum possibility of osteoarthritis is possible.

TABLE III
X- RAY IMAGE IDENTIFIED BY THICKNESS(mm)

Case	Thickness	Status of Osteoarthritis
Case1	2.23	No
Case2	1.34	Yes
Case3	1.91	No
Case4	1.12	Yes
Case5	1.43	Yes
Case6	2.11	No
Case7	2.34	No
Case 8	1.19	Yes
Case 9	2.46	No
Case 10	1.10	Yes

JOINT SPACE THICKNESS MEASUREMENT RESULTS

Table 2 shows eight knee X-rays, in five image thickness is shown between 1.89 to 2.23, so in this X ray image not found OA. And remaining image thickness is between 1.12 to 1.46,these images are the case of OA.

VI. CONCLUSION

In this paper we described an automated method for the detection of OA using knee X-rays. In the absence of accurate method of OA diagnosis , use this method to diagnosis to OA and this is a data driven approach which is used on different data set to diagnosis the osteoarthritis. Experimental results suggest that more than 65% of OA cases are diagnosed.

In the future we find many more evidence of osteoarthritis which are noticeable by a human reader in X-ray image.

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