IDENTIFICATION OF KNEE BONE ATTRITIONS IN A DICOM MRI USING HISTOGRAM ORIENTED GRADIENTS

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Abstract- Digital Imaging and Communications in Medicine (DICOM) is a standard and becoming popular in the digital medical imaging field. Several research works have been progressing in the DICOM medical image processing. In this article, a novel model for detection of knee bone attrition in the DICOM MRI image using Histogram Oriented Gradients is proposed. The Histogram Oriented Gradients has been proven as a superior feature extractor. In this proposed method, the medical practitioner receives a DICOM image with various knee bone attrition marked with Green color. The proposed model is simple and faster. The proposed novel model will assist the physician to diagnose arthritis disease and status of the arthritis disease using the marked regions of knee bone attritions for further investigations to recommend suitable medical procedures.

Keywords- DICOM MRI, Medical Imaging, Histogram Oriented Gradients, Feature Extraction, Pattern Recognition

I. INTRODUCTION

The diagnosis of a disease plays vital role in the medical field. The digital medical imaging such as X-Ray, CT, MRI, etc. is one of the tools used nowadays by the physicians for diagnosing myriad diseases. Numerous researchers have been developing various algorithms and models for analysing the digital medical imaging. The digital medical imaging analysis report prepared by the novel algorithms and model systems contribute for accurate diagnosis of the disease and stage. Arthritis is one of the common diseases among senior people aged above 50. More than 100 types of arthritis reported mostly due to bone joints of senior people due to overuse or injury. Common joint issues are swelling, stiffness, and pain and mostly of three different categories mild, moderate, and severe.

The magnetic resonance imaging (MRI) visualizes bone, cartilage, and soft tissues, assists the medical practitioner for the diagnosis of chronic and acute joint syndromes. The X-ray or ultrasound technology will not reveal subchondral bone marrow. But, MRI visualises subchondral bone marrow pathologies [8, 10]. Abuse or damage on arthritis of knee causes pain. The knee pain intensifies by age. Every year approximately 20 million public consulting therapeutic practitioners for arthritis knee pain in the United States. The knee pains are classified in to acute and chronic. The acute knee pain develops quickly and chronic knee pain develops

steadily over time. The largest joints in the body are knees. The knee joints are made with the bones of the lower end of the thighbone (femur), the upper end of the shinbone (tibia), and the knee cap (patella). Bands of tissue called ligaments connect the bones in the knee, which allows freedom of movement with certain limitations. The impacts are absorbed by cartilage in the knees cushioning the ends of the bones. In the recent years, pediatrics patients are reported with CNS tumors in the knee bone [10].

Arthritis generally refers to inflammation of the joints. Osteoarthritis (OA) is a deteriorating joint disease of the bone joints caused by repair and remodelling of concomitant cartilage, subchondral bone sclerosis (increased bone formation around the joint), and osteophyte and bone cyst formation [1]. Osteoarthritis causes due to wear and tear of cartilage in joints and happens in any joint of the body. The weight-bearing joints of the hips, knees, spine, and fingers, thumb, neck, and large toe are affected by osteoarthritis. Clinical signs and symptoms such as joint pain, effusion, movement limitation, and gait deviations are results of joint changes. These characteristics make OA a particularly weakening disease affected approximately 21 million adults in USA. In addition, fifty percent of Americans aged 65 and above (17 million) reported having OA in any one of the joint [2]. 250 million people approximately reported to have osteoarthritis in the knee in global [3]. These facts made OA a serious public health concern and identifying at early stage prevents major damages to the knee joints. Selected research works related to arthritis are discussed in the following section.

II. RECENT WORKS

Wouter Stomp et al. presented detailed research work on cartilaginous tumor around the knee [9]. Their research work named as "Netherlands Epidemiology of Obesity" (NEO) included 6,673 individuals were identified as obese and aged between 45 and 65. This study had been designed to find causes for the disease of those individuals. Persons aged from 45 to 65 years were residing in the Leiden and having body mass index (BMI) of 27kg/m^2 or higher were

considered for the NEO study. Further, the study included residents of Leiderdorp aged between 45 and 65 years. Among 1,285 participants forty-nine cartilaginous tumours were observed. The tumour diameter was ranging from 2mm to 31mm. Mean largest tumour diameter was 12mm. Eight participants were with a tumour larger than 20mm. These tumours with destructive features were ruled out low-grade chondrosarcoma. About 2.8% of incidental asymptomatic cartilaginous tumours around the knee cases were reported. The lesions less than 20mm in size were located within 2cm of the growth plate did not cause cortical abnormalities [9].

An algorithm developed to segment tumor regions biologically and measure different scales of heterogeneity [4]. The image of a tumor segmented recursively into several increasingly smaller regions. The line segregating two regions by maximizing signal intensity difference was chosen. This tumor divided repeatedly till it reaches single voxels. The tumor segmented at multiple scales. Segmented region is compared with the adjacent region for measuring heterogeneity values. Further, signal intensity histograms differences were calculated. The algorithm was robust to several tumor shapes and image structures. Moreover, heterogeneity of primary tumor scales was measured for 18 rhabdomyosarcoma patients using MRI. The algorithm produced segmented tumor regions and reported the quantity of heterogeneity at different distance scales.

Comparative study made on volumetric and semi-quantitative (SQ) measurements of subchondral bone marrow lesions (BMLs) on non-fat-suppressed (FS) T1-weighted (w), T1-w FS contrast enhanced (CE) and proton density (PD)-w FS images in order to define which sequence depicted the lesions to their maximum extent and if T1-w FS CE images and PD-w FS images may be used interchangeably to evaluate BMLs in a volumetric or SQ fashion. A standard 1.5 T MRI system used to scan thirty two patients with clinical knee osteoarthritis history. Identified 47 BMLs and on all three sequences these BMLs were segmented manually. Semi-quantitatively BMLs were assessed using the Whole Organ Magnetic Resonance Imaging Score (WORMS). The SQ and volumetric results were matched across the three imaging sequences by paired t-tests. Eighty-three percent of the lesions appeared largest on the PD-w FS sequence. Noteworthy changes were detected for volumetric measurements among all three structures. The mean volume difference between PD-w FS and T1-w FS CE was much smaller than for non-FS T1-w and PD-w FS/T1-w FS CE sequences. Significant differences in WORMS scores were noted between PD-w FS and non-FS T1-w images and between T1-w FS CE and non-FS T1-w images, but no significant difference was observed between PD-w FS and T1-w FS CE images. Their findings suggest that the T1-w FS CE and PD-w FS sequences may be interchangeably used for quantitative volumetric and SQ assessment of BMLs [5].

The researchers evaluated the longitudinal and cross-sectional association of BMLs with SBA in the same sub region of the knee [6]. The various causes for the attrition were unknown, but subsequent subchondral bone attrition (SBA) influenced by the remodelling processes. Longitudinal observational studies of individuals who have high risk of knee osteoarthritis were carried out by the Multicenter Osteoarthritis (MOST). Standard subjects were considered for the study for duration of 30-months with periodical MRI. Patients were excluded with initial stages of post-traumatic bone marrow changes. In a 10 tibiofemoral subregions the Subchondral BMLs and SBA scored semiquantitatively from 0 to 3. They calculated the relationship of dominant BMLs at baseline with the occurrence of dominant and incident SBA on a per-subregion basis using logistic regression. They evaluated cross-sectionally the relationship of BML grade severity and presence of baseline SBA. 1025 knees were included in the experiment. 8.9% of the examined knee subregions showed SBA present at baseline and 9.2% of subregions showed dominant subchondral BMLs. Greater BML size was is an indication of an increased risk of SBA. The regular medical follow-up study shows that 195 subregions exhibited incident SBA [6].

The researchers reported the instrument and its reliability for the magnetic resonance imaging (MRI) Osteoarthritis Knee Score (MOAKS) [7]. They identified issues in the presently available tools and evolved semi-quantitative scoring methods, integrated specialists knowledge with the published data and all available scoring tools compared with the different scoring systems. The MOAKS instrument improved new model for scoring bone marrow lesions (BMLs) and cartilage. Also, it improved the elements of meniscal morphology score. Two specialists studied MRIs of 20 knees individually after training and calibration session. Later on, after 4 weeks of time an expert studied the same 20 MRIs in random order for evaluating the intra-rater reliability. They analysed and reported the two intra- and inter-rater reliability. Kappa statistics were used for measuring reliability and results were very good except inter-rater reliability for tibial cartilage area and tibial osteophytes. The intra-rater reliability for Hoffa-synovitis, and inter-rater reliability for tibial and patellar osteophytes showed overall agreement < 75%. Experiment results show that the MOAKS scoring is excellent to very good reliability for the evaluated huge common features.

III. PROPOSED WORK

The knee bone attrition is major cause for several arthritis pains. Early diagnosis of knee bone attrition

may avoid further damages in the knee bone tissues. Thus, a simple and novel model proposed for detecting knee bone attritions in the MRI DICOM image. The proposed model has different phases starting from reading the DICOM image, enhancing contrast of the DICOM image, removing the noises using 2D median filter with 3 x 3 blocks and finally knee bone attrition is segmented using Histogram Oriented Gradients. HOG descriptor is performing better to extract desired features of face and human [11, 12] and proposed in this model to extract knee bone attritions. The following flowchart shows the various stages of the proposed novel model for segmenting knee bone attritions. The proposed model is implemented in MATLAB 2016a software and Windows 10 operating system.

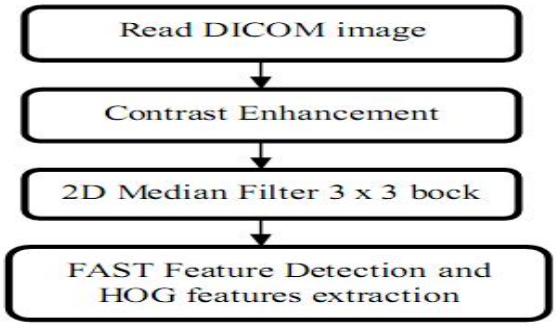


Fig. 1. Flowchart of Proposed Model

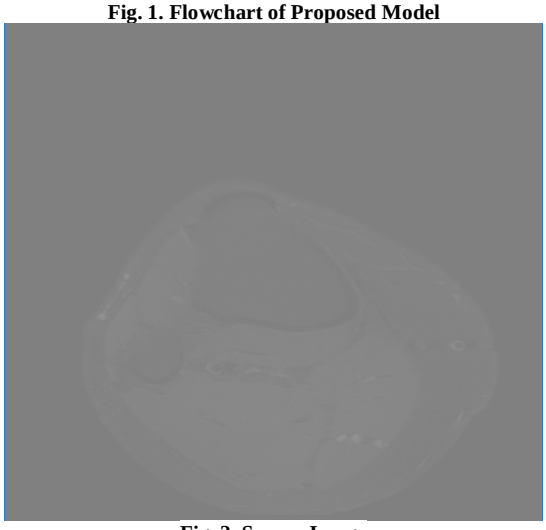


Fig. 2. Source Image

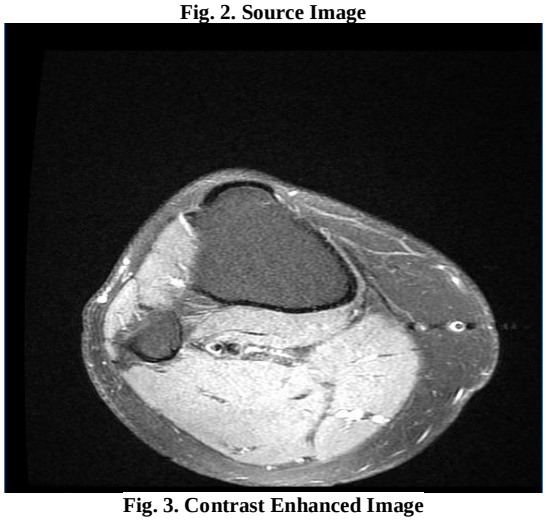


Fig. 3. Contrast Enhanced Image

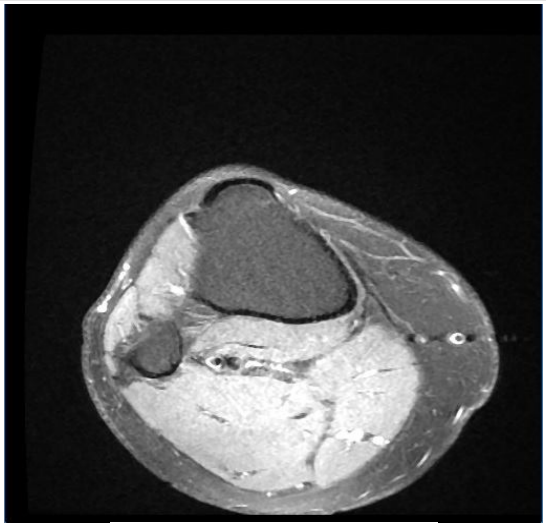


Fig. 4. Median Filter Applied Image

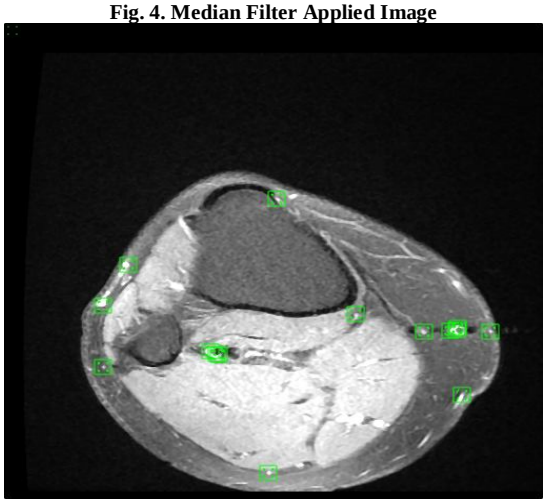


Fig. 5. Attritions Marked Image

CONCLUSION

Identification of knee bone attritions help to detect present stage of arthritis disease. A new model is proposed to identify the knee bone attritions, which highlights the knee bone attritions in green colour. The source DICOM image contrast is enhanced first. Further, median filter is applied to reduce noises. Finally, Histogram Oriented Gradients, proven as superior feature extractor applied for detecting the knee bone attritions. These highlighted knee bone attritions assist the medical practitioner to diagnose the status of the arthritis disease easily with higher accuracy. Future research will focus on quantifying the knee bone attritions and classifying different stages of arthritis disease based on the quantity values.

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