Chapter 71
Computer-Aided Diagnosis of Knee Osteoarthritis From Radiographic Images Using Random Forest Classifier

Pavithra D.
Avinashilingam Institute for Home Science and Higher Education for Women, India

Vanithamani R.
Avinashilingam Institute for Home Science and Higher Education for Women, India

Judith Justin
Avinashilingam Institute for Home Science and Higher Education for Women, India

ABSTRACT

Knee osteoarthritis (OA) is a degenerative joint disease that occurs due to wear down of cartilage. Early diagnosis has a pivotal role in providing effective treatment and in attenuating further effects. This chapter aims to grade the severity of knee OA into three classes, namely absence of OA, mild OA, and severe OA, from radiographic images. Pre-processing steps include CLAHE and anisotropic diffusion for contrast enhancement and noise reduction, respectively. Niblack thresholding algorithm is used to segment the cartilage region. GLCM features like contrast, correlation, energy, homogeneity, and cartilage features such as area, medial, and lateral thickness are extracted from the segmented region. These features are fed to random forest classifier to assess the severity of OA. Performance of random forest classifier is compared with ANFIS and Naïve Bayes classifier. The classifiers are trained with 120 images and tested with 45 images. Experimental results show that random forest classifier achieves a higher accuracy of 88.8% compared to ANFIS and Naïve Bayes classifier.

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INTRODUCTION

Knee Osteoarthritis (OA) is a chronic disease caused by the degeneration of cartilage, which leads to sclerosis and osteophytes. Cartilage helps the easy glide of bones and prevents them from rubbing against each other. In addition to the knee, osteoarthritis can occur in various parts of the body like toes, fingers, pelvis and even in the spine. The significant risk factors of osteoarthritis are ageing, obesity, decreased physical activity and injury. In primary stages, treating osteoarthritis includes non-surgical treatments such as medications, physiotherapy and lifestyle modification. If the disease is left untreated, it leads to the formation of bone spurs, deterioration of connective tissue that attaches muscle to bone and inflammation of joint lining. This adversely affects the individual's ability to move. Complete loss of cartilage characterized by bone-on-bone contact is an indication for end-stage OA. In such conditions, surgical treatments such as joint replacement surgeries, arthroscopy, osteotomy and arthroplasty are suggested. Several imaging methods include Magnetic Resonance Imaging (MRI), Computed Tomography (CT), and Ultrasound are used for diagnosis of augmented OA, however, X-rays are considered the gold standard.

According to National Health Interview Survey, arthritis which includes the knee OA, is expected to increase in the forthcoming years. By the year 2030, an estimated 67 million adults would have arthritis. Globally, OA ranks eighth in all diseases and has impact over 50% of population. In India, OA has a prevalence of 22% to 39% which is comparatively higher than in several countries. Data analytics and technology integration in healthcare improve population health and individual care outcomes. Data science application in medical imaging has caused tremendous impact and most significant potential for future development in healthcare. Hence, the development of expert systems for the diagnosis of knee osteoarthritis from medical images is in demand.

RELATED WORK

Machine intelligence models have received impressive results in various healthcare problems. This is attributed to the availability of data and advancements in algorithms. Several studies have been carried out on the diagnosis of knee osteoarthritis employing the computer-aided methods. Each study applied various segmentation techniques, feature extraction methods and classifiers to diagnose the knee OA. This section describes various researcher's works and studies of related research problems.

Brahim et al. (2019) applied circular Fourier filtering to retain necessary information related to tibial trabecular bone structure. Independent Component Analysis (ICA) was adopted for feature extraction and the first ten discriminant components were used for classification using Naive Bayes and Random Forest classifier. This method classified radiographic images with an accuracy of 82.98%, a sensitivity of 87.15%, and a specificity of 80.65%.

Thomson et al. (2015) developed an automated grading method by identifying the outlines of bones to standardise the measurement of OA features of the knee. The features derived from both bone shape and image texture in the tibia were given to Random Forest classifiers. The weighted sum of the outputs of two Random Forest classifiers improved the performance. Alternatively, the experimental results proved that Random Forest classifiers trained on simple pixel ratio features are as effective as the texture and shape features.

Anifah et al. (2013) employed Gabor kernel, template matching, row sum graph and gray level center of mass method for segmentation. A classic Self Organizing Map algorithm was trained with Gray