INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	**Dhirendra Kumar Verma**
Roll Number	:	**176103116**
Programme of Study	:	**Ph.D.**

Thesis Title: **Development of Wearable Systems for the Detection and Classification of Knee Osteoarthritis and its Validation through Radiographic Images**

Name of Thesis Supervisor(s)	:	**Dr. Poonam Kumari & Dr. Subramani Kanagaraj**
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SHORT ABSTRACT

Knee osteoarthritis (OA) is a prevalent degenerative joint disorder characterized by a gradual degeneration of articular cartilage, leading to joint stiffness, discomfort, and restricted joint movements. The conventional diagnostic methods of knee OA include clinical assessments and radiographic imaging, often limited to early diagnosis, treatment cost, and sensitivity. The chronic condition of osteoarthritis may lead to total knee replacement surgeries. Early intervention in knee OA can prevent such painful surgeries and also saves on the cost of treatments. In recent decades, sensor-based disorder detection has received focused attention in OA identification. These procedures are non-invasive and very helpful in the early detection of OA. The primary objective of this research is to develop wearable systems for the detection of knee osteoarthritis and classification of it using acoustic emission technology and validate through radiographic images. In the present work, a total of two hundred ten human subjects from various places in the North-Eastern region of India have participated, and the acoustic waves generated from their knees during 0°-90° sit-stand-sit (S-T-S) activity are captured using AE sensors to diagnose different stages of OA. All subjects are examined through the digital goniometer and acoustic sensors placed at their medial tibiofemoral knee joint locations. Joint angle-based signal features are recorded for biomarker identification under the S-T-S data collection protocol. Joint space narrowing (JSN) of the knee for OA subjects is calculated through image processing of the knee X-ray, and the AE findings are validated from the obtained JSN and Kellgren-Lawrence (KL) grades. Results obtained from the study demonstrate distinct AE signal patterns in participants with knee osteoarthritis compared to healthy individuals. Moreover, a significant difference is observed among AE parameters in all OA grade participants, and the KL grades are classified through JSN obtained from radiographic findings. All signal parameters are acquired in increasing order with decreased JSN among the KL grades. The highest values of signal features like the number of acoustic hits 167±11, amplitude 76±1 (dB), signal duration 10±3 (ms), absolute energy 401±151 (fJ), and signal frequency 103±3 (kHz) are identified as per their dominance and suitability as a biomarker in the KL-4 grade group. The outcomes from two-dimensional Principal Component Analysis (PCA) analysis are evaluated for primary biomarker identification for OA detection, and it is revealed that sound amplitude (dB) is the most dominating

feature in the first principal component. In summary, the AE technology is successfully validated in a quantitative assessment of OA detection. The KL grade groups are distinguished successfully based on the obtained signal parameters and their validation through JSN confirmed the classification of grades among the groups. The study findings concluded that the AE is found to be a promising tool for the quantitative evaluation of knee OA using acoustic sensors and has proven efficacy in signal feature identification and differentiation among the KL grades. Further, sensor based wearable systems are successfully developed for knee joint OA detection. AE can be used as a non-invasive and non-radiographic tool for the progressive monitoring of knee osteoarthritis, which could be explored for the continual monitoring of cartilage degradation.