ABSTRAK

Nyeri leher kronis (*Chronic Neck Pain*, CNP) merupakan gangguan muskulosketal yang umum dan berdampak signifikan terhadap kualitas hidup. Salah satu pendekatan non-invasif yang potensial untuk menganalisis kondisi ini dalah *electromyography* (EMG), namun kompleksitas sinyal EMG menuntut metode analisis yang mampu menangkap pola secara efektif. Penelitian ini bertujuan untuk membandingkan model klasifikasi CNP berbasis sinyal EMG menggunakan pendekatan *hybrid machine learning* dan *deep learning*.

Dataset yang digunakan berasal dari 40 subjek (20 CNP dan 20 *Healthy*) dengan sinyal EMG multikanal yang direkam selama beraktivitas berjalan *curvilinear* dan *rectilinear*. CNN digunakan sebagai *feature extractor*, kemudian dikombinasikan dengan algoritma klasifikasi SVM, KNN, LDA, serta model rekuren LSTM, RNN, GRU. Evaluasi performa dilakukan menggunakan *stratified 5-fold cross-validation* dengan metrik *accuracy, sensitivity, specificity,* dan AUC. Analisis statistik dilakukan menggunakan uji Shapiro Wilk, Friedman Test, serta post-hoc Nemenyi serta analisis Fitness Function.

Hasil penelitian menunjukkan bahwa model *hybrid* CNN dengan *machine learning* (SVM, KNN, dan LDA) meningkatkan performa klasifikasi dibandingkan metode konvensional. Metode dengan hasil performa tertinggi dan stabilitas metrik terbaik diraih oleh metode CNN+SVM. Selain itu, analisis statistik mengonfrimasi adanya perbedaan performa yang signifikan antar model terutama antara *hybrid* CNN dengan *machine learning* dan *deep learning*.

Kata kunci— *Electromyography (EMG), Chronic Neck Pain*, *Hybrid* CNN, *Machine Learning*

ABSTRACT

Chronic neck pain (CNP) is a common musculoskeletal disorder that has a significant impact on quality of life. One potential non-invasive approach to analyze this condition is electromyography (EMG), but the complexity of EMG signals requires analytical methods capable of capturing patterns effectively. This study aims to compare CNP welding models based on EMG signals using hybrid machine learning and deep learning approaches.

The data set used was obtained from 40 subjects (20 CNP and 20 Healthy) with multi-channel EMG signals recorded during curved and straight walking activities. CNN is used as a feature extractor, then combined with the SVM, KNN, LDA welding algorithms, as well as recurrent LSTM, RNN and GRU models. Performance assessments were conducted using stratified 5-fold cross-validation with precision, sensitivity, specificity and AUC metrics. Statistical analysis was performed using the Shapiro-Wilk test, Friedman test, Nemenyi post-hoc test and fitness function analysis.

Results show that hybrid CNN models with machine learning (SVM, KNN and LDA) improve welding performance compared to conventional methods. The CNN+SVM method achieves the highest performance and the best metric stability. Additionally, statistical analysis confirms significant performance differences between the models, especially between hybrid CNNs with machine learning and deep learning.

Keywords—Electromyography (EMG), Chronic Neck Pain, Hybrid CNN, Machine Learning