

Analisis Gelombang Seismik dengan Convolutional Neural Network (CNN) untuk Sistem Peringatan Dini Gempa Bumi Berbasis Data Seismometer = Seismic Wave Analysis Using Convolutional Neural Networks (CNN) for An Earthquake Early Warning System based on Seismometer Data

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Abstrak

Sistem peringatan dini gempa bumi bertujuan memberikan respons cepat segera setelah terdeteksi gelombang P, sebelum gelombang destruktif mencapai permukaan. Penelitian ini mengembangkan model klasifikasi gempa menggunakan arsitektur Convolutional Neural Network (CNN) 1D berbasis data seismometer dari Stanford Earthquake Dataset (STEAD). Deteksi awal kedatangan gelombang P dilakukan menggunakan metode Short-Term Average/Long-Term Average (STA/LTA), kemudian sinyal dipotong dalam beberapa variasi jendela waktu sebagai input model. Model dikembangkan dengan dua parameter ground motion sebagai label klasifikasi biner, yaitu Peak Ground Velocity (PGV) dan Peak Ground Acceleration (PGA), untuk membedakan gempa besar dan kecil. Hasil evaluasi menunjukkan bahwa jendela 3 detik setelah gelombang P memberikan performa terbaik, dengan akurasi sebesar 95,45% untuk PGV dan 94,95% untuk PGA. PGV menunjukkan stabilitas metrik yang lebih baik, terutama dalam mengenali gempa besar. Penelitian ini menunjukkan bahwa informasi pada fase awal sinyal cukup untuk mendukung klasifikasi cepat dan akurat. Penelitian ini diharapkan dapat memberikan kontribusi terhadap pengembangan sistem peringatan dini gempa bumi berbasis deep learning.

.....Earthquake early warning systems aim to provide a rapid response immediately after the detection of P-waves, before destructive shaking reaches the surface. This study develops an earthquake classification model using a one-dimensional Convolutional Neural Network (1D CNN) architecture, based on seismometer data from the Stanford Earthquake Dataset (STEAD). The initial detection of P-wave arrivals is performed using the Short-Term Average/Long-Term Average (STA/LTA) method, followed by segmentation of the signal into several time window variations for model input. The model is trained using two ground motion parameters as binary classification labels, namely Peak Ground Velocity (PGV) and Peak Ground Acceleration (PGA), to differentiate between large and small earthquakes. Evaluation results show that the 3-second window after the P-wave arrival yields the best performance, with an accuracy of 95.45% for PGV and 94.95% for PGA. PGV demonstrates better metric stability, particularly in recognizing large earthquakes. These findings suggest that information from the early phase of seismic signals is sufficient to support fast and accurate classification. This study contributes to the advancement of deep learning-based earthquake early warning systems that are both efficient and reliable.