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ArrNet: A Deep Neural Network for Confident Arrival Time Estimation

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Phase arrival time estimation for tele-seismic signals is a critical and fundamental step in the detection and localization of nuclear explosions and seismic study in general. Typically, this process involves heavy human interaction with more than half of all automatically detected arrivals being manually re-timed by a human analyst. Developments in Artificial Intelligence and specifically in the field of Deep Learning have produced architectures capable of tackling this task to minimize human involvement and improve the overall data processing pipeline. To this end, we introduce ArrNet, a deep Temporal convolutional Network (TCN) capable of reducing the mean residuals from automatic processing by more than 50%. ArrNet has been trained to be transportable by including data from all available IDC stations. It is capable of providing accurate arrival time estimates for any new station and across a wide range of signal to noise ratios. Additionally, ArrNet has been trained to produce measurements for the 94%, 80% and 50% confidence intervals by implementing quantile loss functions in addition to regressing the arrival time estimate. These margins are covariant with the observed errors and work as a confidence metric for the estimated arrival time in order to refine downstream location and association estimates.

Promotional text

This work explores the use of a temporal convolutional neural network architecture for improved three-component arrival time estimation, potentially enhancing the seismic signal processing pipeline used at the IDC for nuclear test monitoring and verification.

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