Towards robust, reliable earthquake detection with deep neural networks

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Researchers are increasingly adopting machine learning techniques for seismic signal processing (Kong et al., 2018; Bergen et al., 2019). A number of recent studies (e.g. Perol et al., 2018; Ross et al., 2018; Zhu and Beroza, 2018) have achieved promising initial using results deep neural networks for automatic earthquake detection and phase-picking.

Decision support systems for scientific and engineering applications, including earthquake monitoring systems, often require high standards of robustness, stability, uncertainty quantification and/or interpretability. For deep neural networks –black-box models with hundreds of thousands of parameters –it can be challenging to answer key questions about the robustness of the system: *How is the system making decisions? How confident are we in the system's predictions?* And critically, *under what conditions do we expect the system to fail?*

In this talk, we explore the robustness of deep learning-based earthquake detection methods. Deep neural networks perform well in practice for a broad range of tasks but are known to be unstable under small perturbations of the data (Szegedy et al., 2014); we discuss the challenge this poses in seismic signal processing applications. We use adversarial classifier evasion techniques to reveal limitations and potential vulnerabilities of pretrained detectors proposed in the literature. We propose strategies moving forward for improving the reliability of deep learning-based systems for scientific applications.

Keywords: neural networks, seismology, earthquake detection, machine learning

