

PROJECT TITLE: Developing Artificial Intelligence-based Methods to Detect and Characterise Explosions using Seismic Arrays**Research Group(s):** Geophysics**Lead Supervisors:** James Verdon; James Wookey (Earth Sciences, University of Bristol)**Co-Supervisors:** David Green; Stuart Nippres (AWE Blacknest)**Project enquiries:** james.verdon@bristol.ac.uk**Project keywords:** Forensic seismology; seismic arrays; machine learning; artificial intelligence**Funder:** NTR Network (<https://ntr-net.uk>)**Project Background**

Forensic seismology is the use of seismic observations to detect and characterise explosions associated with unauthorised development and testing of nuclear weapons. A global network of seismic arrays provides continuous monitoring in order to meet the Comprehensive Nuclear Test Ban Treaty (CTBT) requirements.

Seismic signals from explosions often have low signal to noise ratios, reflecting the relatively small size of explosions relative to large tectonic earthquakes, and the significant distance between the source and the seismic receiver. The use of array-based methods, where data from narrow-aperture seismic arrays (consisting of multiple stations spaced within a few km) are jointly processed (e.g., Selby et al., 2008), provides a powerful method to improve signal-to-noise ratios such that robust signal detection, discrimination (i.e., distinguishing between explosions and natural seismic sources such as earthquakes) and source characterisation can be performed.

Project Aims and Methods

In recent years, the development of AI-based methods for all aspects of the processing workflow has revolutionised the field of seismology. For example, AI has been used to denoise data-streams (Zhu et al., 2018), identify and pick seismic arrivals (Ross et al., 2018), and to characterise seismic sources (Kuang et al., 2021). However, the bulk of these methods have developed AI methods that function for single, isolated seismic stations, such as those which comprise most regional monitoring networks. In such networks, the data from each station is treated independently, given the large distance between each station.

This approach leaves a research gap for the development of analogous AI-based methods that are tailored specifically for narrow-aperture arrays used for CTBT monitoring. The close spacing between stations means that signals of interest will be coherent: this can be exploited by AI methods drawn from other fields which have shown significant potential in removing noise and identifying and sharpening signals (e.g., Lehtinen et al., 2018; Batson and Royer, 2019).

In this project, the student will develop deep learning models to process data streams from narrow-aperture arrays. They will benchmark model performance against existing, non-AI-based methods, and investigate the impact of AI-based methods on elements of analysis and interpretation that are downstream of denoising and signal detection.

Candidate

This project requires a student with an undergraduate degree in geophysics, geology, maths, physics, engineering, or a related discipline. We anticipate that the successful candidate will have some experience with common programming languages. The project would suit either a candidate with a strong background in geophysics/seismology willing to be trained in the use of machine learning methods, or a candidate with a strong background in AI willing to be trained in the fundamentals of seismology. We welcome and encourage student applications from under-represented groups and we value a diverse research environment.

Project partners

AWE Blacknest will play an active role as a partner in the supervision and support for the project. Blacknest's main function is to develop and maintain the expertise necessary to detect and characterise explosions associated with nuclear testing carried out by other countries. Blacknest operate the Eskdalemuir Seismic Observatory, which represents the UK's contribution to the international monitoring network of the Comprehensive Nuclear Test Ban Treaty, and have access to similar datasets from around the world. We anticipate that the student will undertake regular visits to

AWE Blacknest through the duration of the project, as well as a longer-duration placement or internship towards the latter stages of the project.

Training

Training will be tailored to the specific needs of the student. Anticipated training might be expected to include general training in seismology as well as the specific requirements of forensic seismology; the use of AI methods for signal processing; and the use of high-performance computing facilities.

Background reading and references

Batson, J., and L. Royer, 2019. Noise2Self: Blind denoising by self-supervision. DOI: 10.48550/arXiv.1901.11365.

Kuang, W., C. Yuan, J. Zhang, 2021. Real-time determination of earthquake focal mechanism via deep learning. DOI: 10.1038/s41467-021-21670-x

Lehtinen, J., J. Munkberg, J. Hasselgren, S. Laine, T. Karras, M. Aittala, T. Aila, 2018. Noise2Noise: Learning image restoration without clean data. DOI: 10.48550/arXiv.1803.04189.

Ross, Z.E., M-A. Meier, E. Hauksson, T.H. Heaton, 2018. Generalized seismic phase detection with deep learning. DOI: 10.1785/0120180080.

Zhu, W., S.M. Mousavi, G.C. Beroza, 2018. Seismic signal denoising and decomposition using deep neural networks. DOI: 10.1109/TGRS.2019.2926772.

Funding

The NTR-Net funding will cover tuition fees and a stipend for living costs for 3.5 years at the standard UKRI rate, as well as a budget for training, research costs, and travel.

Eligibility

UK nationals are preferred. Citizens of EU countries or other NATO member states may also be considered

Useful links

<https://www.bristol.ac.uk/earthsciences/postgraduate/>

Application deadline: 30th January 2026, 23.59 GMT

How to apply to the University of Bristol: <http://www.bristol.ac.uk/study/postgraduate/apply/>

Please select PhD in Geology as the programme in the online application system.