

Development of Seismological Studies enhanced by AI

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Earthquakes are fault rupture and slip abruptly releasing the accumulated strain energy, reflecting the physical properties of faults, such as stress, fault geometries, and frictional properties. Seismic waves from earthquakes are usable as indicators of the fault properties. While large earthquakes impact societies by seismic disaster, majority of earthquakes are small. Because of the overwhelming number, small earthquakes are more useful for that purpose.

Analysis of seismic data from numerous small earthquakes is a challenge. Thanks to the development of the permanent seismic network, such as Hi-net of NIED (NIED, 2019), we obtain huge amount of seismic data for many years. The process of seismic data and extraction of useful information on the fault properties and underground structures require help from fast and efficient computation. AI technology is the right thing to do and applied to various studies including the seismic phase picking (e.g., Ross et al., 2018a, 2018b; Zhu and Beroza, 2019; Mousavi et al., 2020) and P-wave first-motion polarity picking (e.g., Ross et al., 2018a; Hara et al., 2019; Uchide, 2020). The P-wave first-motion polarity made it possible to produce the stress map of Japan (Uchide et al., 2022; Uchide et al., this meeting).

We are studying the detection and identification of underground faults from hypocenter distribution and seismic later phase. We developed a fault identification method by a clustering analysis for hypocenter locations and point-cloud normal vectors (Sato et al., 2022, SSJ; Sawaki et al., under review). This method successfully detected the underground faults of the 2024 Noto peninsula earthquake (Sawaki et al., under review). As for the seismic later phases, we are developing a neural network model for detecting the S later phase (Amezawa et al., AGU, 2023, 2024). The later phases were used for determining seismic reflectors (Shiina et al., 2024). These studies are ongoing and trying to detail the underground structure including seismogenic faults.

We also apply AI to reveal tectonic tremors (Sagae et al., two presentations in this meeting, one paper under review). A neural network model screens seismic data from tremors', which improve the tremor detections. Applying their method to the S-net data (NIED, 2019), we improve the catalog of tremors around the Japan Trench.

AI technologies are surely improving our seismic data analyses and our understanding of the Earth and earthquake phenomena. Other emerging technologies such as the physics informed neural networks (PINNs) also have potential to contribute the further development of seismology and earth sciences. It is also true that existing techniques are still useful. We use both the traditional and novel ones depending on subproblems and solve interesting problems in the research domain.

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