BRAIN-be 2.0

Belgian Research Action through Interdisciplinary Networks

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NETWORK PROJECT

SEISMOSTORM

Making Analog Seismograms FAIR to Enable Research

Contract - B2/202/P2/SEISMOSTORM

SUMMARY

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Context

Seismographs have recorded ground motion since the end of the 19th century until digital recordings became available in the 1970s (Okal, 2015). Pre-digital seismic records were typically created by using ink on white paper, scratching black-smoked paper, or by using light on photographic paper. With most of these legacy seismic data now stored in archives and exposed to physical decay, several projects in the last 20 years (i.e., Bent et al., 2020; Ferrari & Pino, 2003) started to dedicate resources to digitising them to preserve and exploit the unexplored scientific wealth they contain and, in turn, introduce them into the age of modern seismology. This effort has become increasingly important due to the increasing risk of permanently losing those ageing paper seismograms combined with their recently found exclusive potential in recovering the global oceanic climate for the last century (Lecocq et al., 2020).

Objectives

The Royal Observatory of Belgium (ROB) possesses a vast archive of legacy seismic data (Van Camp & Camelbeeck, 2004), some of which has recently been scanned. Our project used computer vision and recently developed machine learning approaches to digitise waveform data extracted from these scanned images. This process results in the creation of calibrated and time-coded seismic time series, which can subsequently be disseminated to the scientific community via international web services following seismic community-defined standards.

By providing access to continuous seismic data spanning the past century following the FAIR principles (findability, accessibility, interoperability, and reusability), the project aims to facilitate the investigation of historical oceanic climates using seismic data and to improve the accessibility to tools necessary for the digitization efforts across various institutes, observatories, and universities. Furthermore, the broad availability of quantitative observational data from around the world will significantly enhance existing oceanic wave models of the 20th century, contributing to climate research.

Conclusions

We meticulously compiled all the information on the seismic archive of the ROB, along with its metadata. Our decision to concentrate on Galitzin data was informed by the instruments' high response in the microseismic frequency band, rendering them ideal proxies for sea state analysis. We developed an algorithm to vectorize and extract digital seismic waveforms from scanned seismograms using traditional computer vision techniques, supplemented by a distinct module leveraging deep neural networks to address more complex scenarios, such as line inter-crossing induced by high-amplitude events like earthquakes. We also developed a tool to compare vectorized waveforms with theoretical microseismic ground motions derived from the WaveWatch III oceanic models, facilitating initial validation of the time series.

The work conducted within this project is continually evolving to ensure its enduring utility for the widest possible audience. Furthermore, the project has made significant contributions to the broader scientific community through the establishment of working groups, participation in international initiatives, provision of training courses, and ongoing contributions to a book chapter. Alongside targeted outreach efforts within the scientific community, initiatives aimed at engaging the general public were also undertaken.

Moreover, the project has catalysed new avenues of research and collaboration, including a master's thesis in machine learning, and has provided beneficial synergies with other projects at the Royal Observatory of Belgium, such as Belshake.

Keywords

Legacy seismograms, microseisms, seismic noise, oceanic storms, computer vision, deep neural networks, analog data.