Deep Generative Modelling of Extreme Natural Catastrophes

Aleksandar Arandjelović

Institute for Statistics and Mathematics
WU Vienna University of Economics and Business
aleksandar.arandjelovic@wu.ac.at

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Climate change is increasing the frequency and severity of weather-related claims, posing substantial risks to both human life and the global economy. According to NOAA's National Centers for Environmental Information (NCEI), the year 2024 alone saw 27 individual weather and climate disasters in the United States causing more than $1 billion in damage, resulting in at least 568 fatalities and $182.7 billion in total losses. Accurately modelling the distribution of event frequencies and severities is therefore crucial for effective climate risk management – not only to mitigate loss of life, but also to anticipate economic damage. Using the International Disaster Database (EM-DAT), we present a probabilistic machine learning framework to model the frequency and severity of extreme weather events. While traditional Bayesian hierarchical modelling often relies on computationally intensive Markov chain Monte Carlo (MCMC) techniques to approximate posterior distributions, generative adversarial networks (GANs) have become a popular method for learning to generate data that matches the statistical properties of observed data. In this talk, we demonstrate how conditional Wasserstein GANs (cWGANs) can be used to efficiently approximate posterior distributions. We compute posteriors for the frequency and severity of extreme weather and climate events such as severe storms, floods, droughts and wildfires. If time permits, we also discuss how cWGANs can be used to support parameter calibration via the expectation-maximization (EM) algorithm.

This talk is based on joint work with Pavel V. Shevchenko (Macquarie University) and George Tzougas (Heriot–Watt University).