



Pôle mécanique seminar series

Smart geomechanics

Ioannis Stefanou

Date and Time: 29th of May (11:00 – 12:00 am)

Venue: Amphi 104 - Pôle Mécanique

Abstract

Geomechanics is a branch of engineering and geosciences that studies the mechanical behavior of the subsurface in response to natural forces and human activities. The subsurface is inherently complex and difficult to observe, making geomechanical problems challenging to analyze both theoretically and computationally. These challenges impact engineering applications, limiting the scope of what is achievable. However, recent advancements in control theory and artificial intelligence (AI) are providing new avenues for studying and managing subsurface behavior.

In this talk, I will present recent advances that integrate nonlinear control theory and AI in geomechanics. In particular, I will focus on the behavior of natural and anthropogenic seismic faults, which are responsible for both natural and human-induced seismicity. Novel mathematical results demonstrate how it is possible to stabilize a fault system and induce slow, aseismic slip with a predetermined velocity profile, even in the absence of detailed underground information. In other words, it is mathematically shown that earthquakes can, in theory, be prevented. These theoretical findings are supported by numerical simulations and laboratory-scale analogue experiments.

Going further, I will discuss how these insights can be applied to control human-induced seismicity in large reservoirs, potentially unlocking the Earth's remarkable potential for sustainable energy production and underground energy storage. Finally, I will highlight current progress and scientific challenges in mathematical and computational modeling, control theory, and related experimental research. These advancements bring us closer to a future where we can actively manage and optimize subsurface behavior in real time.

About the speaker

Ioannis Stefanou is Professor at ENSTA, member of the Institut Polytechnique de Paris, and researcher at the Institute of Mechanical Sciences and Industrial Applications (IMSI). He has studied civil engineering, mechanics and applied mathematics at the National Technical University of Athens, and did his PhD at the Laboratory of Geomaterials of the same institution. His main research interests are (geo-)mechanics, dynamics, earthquake control, induced seismicity, control theory, homogenization, machine learning and artificial intelligence. He is the PI of the ERC-StG 2017 project Controlling earthQuakes – CoQuake, of the Connect Talent 2019 project Controlling Extreme EVents – CEEV, awarded by the Pays de la Loire, of the ERC-CdG 2023 project Preventing human-induced seismicity to fight climate change – INJECT and of the IA-SUR chair of Hi! Paris.

