idil UNIVERSITÉ DE MONTPELLIER — INTER·DISCIPLINARY & IN·LAB GRADUATE PROGRAM

PhD offer in AI / Hydrodynamic modelling

Neural network study of urban flood risk and the impact of extreme spatio-temporal rainfall events

Laboratory: HydroSciences Montpellier and Inria LEMON, Montpellier

Supervision team: Carole Delenne (HSM, Université de Montpellier and Inria LEMON), Renaud Hostache (EspaceDev, IRD), Gwladys Toulemonde (IMAG, Université de Montpellier and Inria LEMON), Nicolas Meyer (IMAG, Université de Montpellier and Inria LEMON),

Skills required : AI; numerical modelling; applied mathematics; python and/or C++.

Keywords : Hydrodynamic modelling, Artificial Intelligence, Deep Learning, Flooding, Urban

Period: October 2024-September 2027

How to apply? To express your interest, please contact Carole Delenne (carole.delenne@umontpellier.fr).

When to apply? Before April 15, 2024

Application procedure: See below

Scientific context

Flood risk assessment and decision-making are mainly based on in situ water level observations and meteorological forecasts. Hydrodynamic models are rarely used in practice, as they are complex to implement and time-consuming to calculate. Although one-dimensional models are relatively fast, they are limited to modelling channelled flows and do not allow for the correct representation of overflows. Taking into account the geometry of the study area, particularly in urban areas, therefore requires a two-dimensional model, with mesh sizes of the order of a square metre, which means that simulations can only be carried out at neighbourhood level. Despite the considerable power of computers, real-time simulations on the scale of a conurbation remain inaccessible.

Larger-mesh models make it possible to speed up calculations while maintaining relative accuracy by using sub-mesh information. These models are based on a 'porosity' parameter that restricts flow capacity. Among them, the depth-dependent porosity model, SW2D-DDP, developed in 2018 at HSM-Lemon [Guinot et al 2018], has the advantage of being based solely on topographic data [Ayoub et al 2022]. However, despite the reduction in computation times compared with a fine mesh, porosity models are still too long for real-time crisis management while being slightly less accurate.

Objectives

Deep learning models such as LSTM (long short-term memory) have proved their effectiveness in a hydrological context, for example in rainfall-runoff modelling, but very few studies have tackled flood prediction in terms of water extent and depth. One of the main reasons for this is the need for a large learning database, in a field where validation data is almost non-existent. The aim of the thesis will be to develop an artificial intelligence model based mainly on the results of multi-scale hydraulic models. As the latter are based on a discretisation of space into cells (finite volumes), we plan to use AI models using a graph representation of the domain (Graph Neural Network), in which the nodes would contain the results in terms of water level and speed in the cells and the edges would represent the possible transfers of water and energy between cells. Particular attention will be paid to respecting the laws of physics that govern flows in shallow water, i.e. the laws of conservation of mass and momentum, thus placing us in the field of hybrid AI.

The application to the city of Montpellier will enable impact studies to be carried out for different scenarios.

Context of the thesis

This thesis is part of the Eau-PI-UM project funded by the IDIL program. The general objective of the project is to propose mathematical and physical models that will provide a better understanding of flooding in urban environments. This thesis offer, which covers the hydraulic part of the project, is coupled with another thesis, which addresses the statistical issues of rainfall fields for the simulation of extreme events. During impact studies carried out by design offices, highly simplifying assumptions are made about rainfall fields: uniform in space and at best 'double triangles' in time. In study areas such as Montpellier, the use of spatio-temporal fields seems necessary for a correct representation of the so-called “episodes Cévenols”.

The successful candidate will therefore be required to collaborate with researchers from other disciplines.

Application procedure

Application deadline: April 15, 2024, 23H CET

To apply for IDIL mirror doctoral contracts, student candidates must complete their applications and send them by the deadline to the following email address: idil-team@umontpellier.fr, and fill in the Microsoft Forms application form at the same time.

Important: in order to be taken into consideration, the format of the subject of the application email must strictly comply with the following methodology:

[IDIL PhD Application: Subject n° 3 – Doctoral school B – Surname – Name]

Please copy and paste this and simply put your Surname and Name

Details of the application form can be found at the following link (in French):

https://idil.edu.umontpellier.fr/inscrivez-vous-dans-un-doctorat-interdisciplinaire/

Items that must be included in the application for evaluation (don't forget to fill in the application form as well):

- Covering letter, signed and dated
- CV
- Transcripts of grades from L3, M1 and M2 (or all years of equivalent study, e.g. engineering degree) with ranking

The link to the application form to be sent in parallel for all student applicants:

https://forms.office.com/e/w97RmAL6RU