Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information

Family name	Gourbesville
First name	Philippe
Email	gourbesv@unice.fr
Web reference	http://polytechlab.unice.fr/Personnel/Membres/gourbesville.html https://www.researchgate.net/profile/Philippe_Gourbesville
Lab name	Polytech Lab
Lab web site	http://polytechlab.unice.fr/index.html
Polytech name	Polytech Nice sophia
University name	University Nice Sophia Antipolis
Country	France

PhD information

Title	Virtual Reality (VR) and Augmentated Reality (AR)solutions for water realated natural disaster management and mitigation

Main topics regards to CSC list (3 topics at maximum)	Formation and forecast of serious natural disasters Techniques of simulation and application World change and evolution of the environment
Required skills in science and engineering	Advanced competences in coding, good knowledge of deterministic numerical models in physics and if possible in fluid mechanics, knowledge in Geographic Information subjects, interested for pluridisciplinary team & fluency in English

Subject description (two pages maximum)

Today, modern societies and especially urban environment are characterized by an increased vulnarability regarding natural disaters and in particular floods and inundations. Massive flooding can often have a devastating impact on the economy of a region and the livelihood of its people. Loss of human life, property damage, destruction of crops, loss of livestock, non-functioning infrastructure facilities, and the possibility of waterborne diseases are just some of the ways a flood can impact upon a community. The personal safety risks, reduction in purchasing power, mass migration, and loss of land value in a flood plain makes areas prone to flooding extremely vulnerable on several levels. The additional costs associated with rehabilitation, relocation of displaced people and removal of property from flood-damaged areas can also divert money that could be used in other sectors.
During the last 2O years, combined development of numeriacal methods and computational resources have allowed to develop hydroinformatics tools able to simulatecomplex flooding processes and are currently gradualy integrated within the Decision Support Systems (DSS) that are more and more popular and contribute to improve the crisis management processus and to provide additional safety to exposed populations. The availability of high resolution topographic data, associated with massive computational resources, allows today to engage new developments for uncertaity analysis and visualisation of results.
In hydraulics, deterministic numerical modelling tools based on approximating solutions of the 2D Shallow Water Equations (SWE) system are commonly used for flood hazard assessment. This category of tools describes water free surface behaviour (mainly elevation and discharge) according to an engineering conceptualization, aiming to provide to decision makers information that often consists in a flood map of maximal water depths. As underlined, good practice in hydraulic numerical modelling is for modellers to know in detail the chain of concepts in the modelling process and to supply to decision makers possible doubts and deviation between what has been simulated and the reality. Indeed, in

considered SWE based models, sources of uncertainties come from (i) hypothesis in the mathematical description of the natural phenomena, (ii) numerical aspects when solving the model, (iii) lack of knowledge in input parameters and (iv) natural phenomena inherent randomness. Errors arising from i, ii and iii may be considered as belonging to the category of epistemic uncertainties (that can be reduced e.g. by improvement of description, measurement). Errors of type iv are seen as stochastic errors (where randomness is considered as a part of the natural process, e.g. in climatic born data) At the same time, the combination of the increasing availability of High Resolution (HR) topographic data and of High Performance Computing (HPC) structures, leads to a growing production of HR flood models. For non-practitioner, the level of accuracy of HR topographic data might be erroneously interpreted as the level of accuracy of the HR flood models, disregarding uncertainty inherent to this type of data use, notwithstanding the fact that other types of above mentioned errors occur in hydraulic modelling.
Topographic data is a major input for fl ood models, especially for complex environment such as urban and industrial areas, where a detailed topography helps for a better description of the physical properties of the modelled system .In the case of an urban or industrial environment, a topographic dataset is considered to be of HR when it allows to include in the topographic information the elevation of infra-metric elements. These inframetric elements (such as sidewalks, road-curbs, walls, etc.) are features that in fluence flow path and overland flow free surface properties. At megacities scale, HR topographic datasets are getting commonly available at an infra-metric resolution using modern gathering technologies (such as LiDAR, photogrammetry) through the use of aerial vectors like unmanned aerial vehicle or specific flight campaign. Moreover, modern urban reconstruction methods based on features classification carried out by photo-interpretation process, allow to have high accuracy and highly detailed topographic information. Photo-interpreted HR datasets allow to generate HR DEMs including classes of impervious above ground features. Therefore generated HR DEMs can include above ground features elevation information depending on modeller selection among classes. Based on HR classified topographic datasets, produced HR Digital Elevation Model (DEM) can have a vertical and horizontal accuracy up to 0.1 m.

Even though being of high accuracy, produced HR DEMs are assorted with the same types of errors as coarser DEMs. Errors are due to limitations in measurement techniques and to operational restrictions. These errors can be categorized as: (i) systematic, due to bias in measurement and processing; (ii) nuggets (or blunder), which are local abnormal value resulting from equipment or user failure, or to occurrence of abnormal phenomena in the gathering process (e.g. birds passing between the ground and the measurement device) or (iii) random variations, due to measurement/operation inherent limits.Moreover, the amount of data that composes a HR classified topographic dataset is massive. Consequently, to handle the HR dataset and to avoid prohibitive computational time, hydraulic modellers make choices to integrate this type of data in the hydraulic model, possibly decreasing HR DEM quality and introducing uncertainty. As recalled in the literature in HR flood models, effects of uncertainties related to HR topographic data use on simulated flow are not yet quantitatively understood.

Today it is necessary to offer new ways to visualize the uncertainty of the results and at the same time, to offer to teh decision makers an easier access to the technical results of the numerical models. In order to visualize the floods impacts, virtual reality tools could be developed where the user is transported to the flooding location (and assess the flood damages and the benefits of mitigation in first-person perspective. The visualization of the flood simulations using virtual reality transports users into a simulated world and transforms watching the screen into a living experience. Compared with the original plane drawing, screen watching and sand table model, exhibition with virtual reality will no longer be limited by time or space. It also provides more comprehensive information with lower cost and better viewing experience. Several exeperiments have been already achieved with the Augmented Reality (AR) device of Microsoft HoloLens. This device allows to integrate HR topographical data and to display the results of the model simulations associated with error uncertainty. The research work will be focused on the new possibilities offered with VR and AR for the access to HR simulations results. The expected outcomes will contribute to elaborate operational tools that will be combined to the various hydraulic models used for the floods and inundation processes.

References

Abily, Morgan, Nathalie Bertrand, Olivier Delestre, Philippe Gourbesville, and Claire-Marie Duluc. "Spatial Global Sensitivity Analysis of High Resolution classified topographic data use in 2D urban flood modelling." *Environmental Modelling & Software* 77 (2016): 183-195.

Gourbesville, Philippe, Mingxuan Du, Elodie Zavattero, Qiang Ma, and Marc Gaetano. "Decision Support System Architecture for Real-Time Water Management." In *Advances in Hydroinformatics*, pp. 259-272. Springer, Singapore, 2018.