INTERNATIONAL DOCTORATE IN CIVIL AND ENVIRONMENTAL ENGINEERING

BOOK OF ABSTRACT

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Pisa - School of Engineering
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International Doctorate in Civil and Environmental Engineering

Book of Abstract

An integrated system combining floating breakwater, oscillating water column device and floating photovoltaic

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Doctorate Cycle: XXXVI

Joint title with TU Braunschweig [De]

Supervisors: Lorenzo Cappietti, Nils Goesberg

Doctorate Thesis: An integrated system combining floating breakwater, oscillating water column device and floating photovoltaic

Keywords: Floating breakwater, numerical simulation, floating photovoltaic, very large floating structure, transmission coefficient

Abstract:

The environmental problems and energy crisis have drawn wide concern. The seawater level rising caused by greenhouse effects makes the seaward countries and islands facing the crisis of land deflation. The development of maritime structures is a potential solution to expand human activity space to response to the high cost of land resource. Meanwhile, the worldwide energy demand is surging, and the fossil energy, which is gradually exhausted, is still the main power source in most countries, which leads to the aggravation of greenhouse effect. Therefore, the development of marine structures and sustainable energy are placing increasingly important roles. In this paper, different integrated system combing very large floating structure (VLFS) and other marine technologies, such as integrated VLFS-OWC systems, for different purposes are summarized. And the research methods of standalone VLFS and oscillating water column (OWC) systems are discussed. The applications and studies of floating solar photovoltaic (FPV) systems in different regions (freshwater and seawater) are discussed separately. The integrated systems coupling multiple offshore renewables for fully utilizing offshore energy (wind, wave and solar) and ocean space are summarized. Finally, the possibility of combining VLFS, offshore wave energy and solar energy is briefly discussed for further conducting the research focusing on the coupling of those three in the future.

Digital Earth Fabrication

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Doctorate Thesis: Additive Manufacturing of Smart Building components and Smart Structures

Keywords: Additive Manufacturing, Earthen Materials, Digital Fabrication, Computational Design, Structural Desing,

Abstract:
The research project aims to investigate of the combination of Additive Manufacturing for Construction Industry and earth as a building material. The project will be developed through the identification and classification of Digital Earth Fabrication techniques in order to develop and characterize a earthen mix-design for Digital Earth Fabrication. The project will follow the scientific method with a sequence of experimental tests and numerical simulations in order to validate and compare the results obtained through the develop of case studies. The research projects works on Material Science, Robotic and Digital Fabrication, Numerical and Computational Design, Structural Design.

Machine Learning techniques applied to UAV imagery for macro-plastic detection in the fluvial environmental

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Doctorate Thesis: Machine Learning techniques applied to UAV imagery for macro-plastic detection in the fluvial environmental

Keywords: Plastic Detection, Fluvial Environment, UAV, Multispectral image, Thermal image, RGB image

Abstract:

Plastic pollution has a severe impact on the ecosystem, altering its natural equilibrium and causing serious health issues to both flora and fauna. Several actions have already been undertaken in order to reduce the plastic litter dispersion in the environment, both in terms of changing human behavior and of implementing methods for detecting and collecting the already dispersed ones. My thesis focuses on the latter, and, in particular, on plastic litter detection on the fluvial environment. To this aim, an Unmanned Aerial Vehicle, provided with a multi-spectral and a thermal camera, has been used, in order to: allow affordable periodic monitoring of relatively long river reaches, detect even quite small macroplastics, based on their spectral signature. More specifically, since the cameras used in our data collection campaigns are not synchronized, my work over the past few months has aimed to develop a strategy for the co-registration of acquired images. This task has proven to be quite challenging due to the limited number of recognizable visual features in images captured while flying at a low altitude over a river. The proposed methodology, which relies on maximizing the correlation between multispectral and thermal images, has yielded reasonable results in the considered case study. Furthermore, to complete my entire project, the co-registered datasets will be subjected to a previously developed ML approach, in order to accurately detect plastic objects. In the implemented method, the outcome is determined by the combination of several random forest classifiers and a selection criterion based on the area.

An innovative IGA-BEM Fully nonlinear model for FOWT: Experimental tests and model updates

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Doctorate Thesis: An innovative IGA-BEM Fully nonlinear model for FOWT

Keywords: Wave Flume, Offshore, IGA, Wind Energy

Abstract:

In recent years the Offshore Wind Energy field has become important due to the energy targets that Europe is aiming to reach in the next future. Often numerical tools used in this field are efficient but not really accurate, while if you need to observe higher order phenomena, the accuracy is paid with an unaffordable computational cost. This part of the thesis aims to produce an experimental dataset, simple and reliable, to validate numerical methods. The tests are performed in the Twins Wave Flume of the TU Braunschweig with a rectangular box as a platform, in order to have a simple model that could give a response as close as possible to a 2-dimensional motion. Tests cases are various regular waves of different order, performed thanks to a piston type wave maker. The model is anchored to the bottom through tensioned cabled and both the dynamic response and the cable forces has been measured. The results show expected 2-dimensional responses and nonlinear effects can be seen in the higher order test cases. These results will be used as a validation for the IGA-BEM model that is currently in development. In particular the model, is being updated with a fourth order Runge Kutta scheme.

Construction site planning by using advanced simulation methods -Progress and research results

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Doctorate Thesis: Construction site planning by using advanced simulation methods

Keywords: Probabilistic hazardous event estimation, Construction site planning, Agent-based Modeling and Simulation, Building Information Modelling (BIM), Health & Safety management

Abstract:

Construction sites are complex and dynamic environments where the continuous mutual interactions among a sheer number of entities (e.g. workers, machines, equipment) and activities determine the frequent occurrence of unpredictable hazardous events that makes risk estimation one of the most challenging tasks of Health & Safety (HS) management. In recent years, the growing adoption of BIM and IoT supported HS Managers in the improvement of construction site planning and monitoring and hence increased workers' safety. Nonetheless, probabilistic estimation of hazardous events and related risk estimation still heavily relies on HS Managers' field experience. This contribution proposes a novel framework for the adoption of an Agent-Based Modeling and Simulation approach integrated with BIM in a game engine environment for the probabilistic estimation of collision events in construction sites, between workers and heavy vehicles. Starting from the data of a complete 4D BIM model and identified the phases related to the built activities, by extracting project data and planning data of site activities to create my ABS scenario, run a significant number of simulations for each scenario and extract data relating to the registered hazardous events in terms of collisions between different kind of agent for each site activity/phase, combining them to visualize the distribution of hazardous events for each site activity scenario, in form of heat-maps. The results may suggest prescriptions and measures for the optimization of the safety at the level of site layout and activities planning.

Development, implementation and testing of a semantic digital twin prototype for workplace performance assessment

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Doctorate Thesis: Data-driven workplace management enhancing workers' well-being and productivity with artificial intelligence

Keywords: Digital Twin, Workplace performance assessment, Well-being and productivity, Linked Data, Information Container for linked Document Delivery (ICDD), Semantic Web, Internet-of-Things (IoT)

Abstract:

Nowadays, despite the growing attention to indoor environmental quality and comfort, existing workplaces still often fail to meet employees' expectations and needs, affecting their well-being and productivity. In order to improve management decisions, crucial insights can be provided by the timely correlation of objective workplace conditions and subjective workers' feedback, collected through Ecological Momentary Assessment (EMA) method. This presentation shows and discusses a prototypical Digital Twin for the assessment of workplace performance, based on the integration of IoT, BIM and Semantic Web technologies. Relevant use cases and requirements are defined, and a layered system architecture is presented along with its implementation. For capturing the workplace's environmental properties, a sensor network based on the Zigbee communication standard is proposed for its data transmission efficiency. The measured data, converted in the lightweight MQTT protocol, are streamed to an InfluxDB time series database where they are stored along with the incoming workers' feedback collected as survey responses with a dedicated web application. These time series data are queried and transported into a developed web platform for integrating BIM and RDF data within the standardized structure of Information Containers for linked Document Delivery (ICDDs). Inside this platform, the IFC model of the workplace, the measured data, and the worker generated RDF data according to the WOMO ontology for occupant-centric workplace management are linked. The capabilities of the workplace Digital Twin prototype are finally demonstrated querying the

linked heterogeneous data to fulfil management tasks in a case study provided at the end of the presentation.

An intelligent building from an existing building: integrated redevelopment, innovative storage system for energy from renewable sources

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Doctorate Thesis: An intelligent building from an existing building: integrated redevelopment, innovative storage system for energy from renewable sources

Keywords: Industrial buildings, Integrated redevelopment, Energy saving, Smart control strategies, Energy management

Abstract:

In Italy the industrial sector accounts for the 22% of the total final energy demand. Most of manufacturing buildings are characterised by critical energy issues as well as structural ones. The former mainly related to thermal insulation and airtightness and the latter to inadequate structural response of load bearing structure and connections in case of seismic events. This occurs because most of buildings are built before 90s. In the presentation an update about the general retrofitting protocol for existing industrial buildings stock is presented. In order to improve the overall performance in an integrated way, different improvement interventions are proposed concerning the external layout, the structural , the external envelope, and the systems. The solutions are detailed for the different typological variants outlined in a previous phase of the research. To validate the protocol, its application is presented to highlight the expected impacts of the solutions with reference to different multidisciplinary aspects. In particular new developments about LCA based considerations, lighting analysis and control strategies, HVAC systems, and energy management are introduced.

An integral methodology for the special inspection of concrete bridges with bonded post-tensioned cables

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Doctorate Thesis: An integral methodology for the special inspection of concrete bridges with bonded post-tensioned cables

Keywords: PT bridges, NDTs, Special Inspections, Probability of Detection

Abstract:

The present work aims to provide an in-situ inspection methodology for prestressed concrete bridges with post-tensioned cables (PT bridges). The adoption of non-destructive techniques (NDT), already widely employed in other engineering fields, is proposed, providing reliable information with a relatively low impact on the existing infrastructure. For each of the specific inspection topics (i.e. cables' layout detection, defect localization and quantification, estimation of residual prestressing force), the proposed investigation procedure was calibrated through a deep experimental test campaign, including both laboratory tests, and applications to existing viaducts located on the Italian highways. Then, a multiphase methodology is proposed. The aim is to provide an answer about how to perform the safety assessment and how deep the preliminary knowledge campaign to consider the PT bridge completely investigated shall be. Regarding the particular NDTs studied in the research, a specific reliability assessment is proposed. One of the focuses is on the Ultrasonic Tomography methodology in inspecting defects of grouting inside the ducts since this situation is considered the most dangerous one for the trigger of corrosion phenomena. Many studies exist about UT's application in PT structure inspection, but the reliability assessment of the technique still needs to be completed. The proposal is to model the inspection outcomes through the Probability of Detection (POD) curve, which gives information about the maximum defect size that the system can miss, stating a certain confidence level. Since the number of tests is limited due to practical issues, a Bayesian approach is employed to estimate the model parameters better.

Zero-Energy Analysis in Triple Triangle Systems

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Doctorate Thesis: Cells and Tissue Mechanics

Keywords: Energy level, Tissue, Triple Triangles

Abstract:

In the context of tissue energy, considering a system of triangles sharing a common base, we aim to determine configurations where triangles exhibit the same area (A = A0) and perimeter (P = P0). Using properties of ellipses, it's discerned that the shared base represents the line connecting the foci of these ellipses. The compatibility condition, can be shown through the relationship between the preferred area (A0) and perimeter (P0). Selecting values based on this relationship ensures the system's energy reaches zero. In the context of triple triangles surrounded by two ellipses, the conditions for equal areas and perimeters result in bigger triangle being equilateral, while the smaller triangles are isosceles. The chosen configuration of equal perimeters and areas is unique in achieving uniformity in all parameters. The report concludes that by adhering to the established compatibility conditions, a zero-energy state in the triangle system can be achieved, ensuring the desired configuration's uniqueness.

Microplastic retention by lagoons surrounded by vegetation in wetland areas

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Doctorate Thesis: A Microplastic Budget Methodology to model plastic pathways, degradation and storage in rivers, coastal areas and open seas

Keywords: Emerging contaminants, Unidirectional flow, Nature-Based Solutions, Shallow aquatic vegetation, Treated water

Abstract:

In the last 70 years the production of plastic has raised exponentially (Ostle et al., 2019) causing the accumulation of plastics and microplastics (<5mm) in environmental ecosystems and becoming a source of pollution in the atmosphere (Habibi et al., 2022), water (Zhang, 2017) and sediments (Abidli et al., 2018). The assessment of possible hotspots where they can accumulate might give information on the potential areas that can require further attention and management to prevent these hotspots act as new microplastic sources. Microplastic particles pollute seawater and freshwaters. Wetlands are transitional areas between land and sea that can act as buffer for microplastics. In the current study, the impact of a lagoon surrounded by emergent aquatic vegetation is under study in a laboratory set-up. A lagoon has been constructed in a flume dominated by a unidirectional flow. The lagoon is surrounded by emergent aquatic vegetation (Juncus maritimus) with different patch lengths, Lpatch. Four different Lpatch were considered and compared with the non-vegetation case and the no-lagoon case. 22 sediment traps where set on the bed of the flume at different positions along the x-axis. Four different microplastics were considered, accounting for a total of 22 experiments. Results demonstrate that the presence of deep zones (lagoons) and aquatic vegetation in wetlands act as buffers for microplastics that are advected to the ecosystem by sediment particle laden currents. They play differential roles in the distribution of microplastics producing a segregation that depends on the microplastic characteristics being transported and the length Lpatch.

Aerobic Granular Sludge for Partial Nitritation

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Doctorate Thesis: Aerobic Granular Sludge technology for the transition to biorefineries: process optimization and resource recovery

Keywords: Aerobic Granular Sludge, Partial Nitritation, Nutrient removal

Abstract:

The experimental work carried out at UAB involves inoculating a custom-designed reactor with aerobic granular biomass and managing the process by removing organic carbon and nutrients such as nitrogen and phosphorus. Once a sufficient biomass concentration was achieved, the feed medium was changed by removing organic carbon. The objective of the experimental activity is to enrich mature aerobic granules with autotrophic nitrifying biomass in order to establish a stable partial nitritation process under mainstream conditions, whose effluent can be further treated with an ANAMMOX reactor downstream. The main challenges of this activity concern the stability of aerobic granules once organic carbon is no longer available and the management of competition between autotrophic Ammonium Oxidizing Bacteria (AOB) and Nitrite Oxidizing Bacteria (NOB). In fact, to achieve a partial nitritation process, it is necessary to avoid the complete oxidation of nitrogen compounds, and thus, NOB must be rendered non-competitive through the application of metabolic selections.

IGA-based computational methods for the analysis of complex structural systems, with application to artery stents

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Doctorate Thesis: IGA-based computational methods for the analysis of complex structural systems, with application to artery stents

Keywords: IGA,IGA-C,Curved Beams,Nonlinear Materials,Stents

Abstract:

The objective of my research regards the application of computational methods based on Isogeometric Analysis (IGA) to solve beam structures with complex geometries. IGA (and the collocation method IGA-C) presents some advantages than respect classical standard Finite Element Methods (FEM). In particular, the research focuses on the modelling and the numerical simulation of biomedical devices, like artery stents. These stents are structures with complex shape and topology, that are modelled with beam elements, instead of using 3D solid elements, in order to reduce the computational costs, ensuring a high efficiency in the formulation. Since these complex structures are generally made with complicated materials, which are usually described only for 3D continuum, it is often advantageous to use a 3D material law. For this reason, an important part of the research activity is to define an isogeometric beam formulation in which general 3D constitutive laws are employed. Instead of adopting classical one-dimensional constitutive models for beams, the objective is to adopt a general 3D constitutive model for a continuum body in beam elements, by maintaining the beam kinematic assumptions. The formulation in which I am working is obtained starting from the 3D constitutive law for a solid, by adopting a tested algorithm capable of statically condense the strains not compatible with the stress conditions of a beam element. With this formulation it is possible to model better the real simulation of real materials. The final goal is to analyze artery stents accurately and efficiently, including geometric and material nonlinearities.

Testing different methodologies for shoreline detection from optical and SAR satellite images

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Doctorate Thesis: Coastal Environment Monitoring through satellite, terrestrial and airborne remote sensing

Keywords: shoreline extraction, classifier, threshold, multispectral, radar

Abstract:

Preliminary results of a systematic study of different image processing methodologies and various algorithms to distinguish the water/soil separation line will be presented and discussed. The methodologies are being tested with GNSS measured shorelines and manual digitized from orthopotos reference shoreline in Castelldefels beach (Catalunya) and in Feniglia beach (Italy).

Expected Impact of ITS and Automated Vehicle Technology on Safety and Capacity of Roundabout Corridors - 44th Plenary Meeting

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Doctorate Thesis: Expected Impact of ITS and Automated Vehicle Technology on Safety and Capacity of Roundabout Corridors

Keywords: Roundabout Corridors, Braess Paradox, Safety, Efficiency, ITS, Automated Vehicles, Simulations

Abstract:

My research project starts with the concept that road intersections are no longer considered and evaluated as isolated means, but as part of a system. In the first phase I will implement the studies concerning roundabout corridors both as regards the phenomena related to equilibrium (in particular the Braess paradox), and as regards the analysis of safety and efficiency, through dynamic simulations and geographical and safety investigations carried out with various software including: Aimsun, SSAM, GIS, etc... In detail, the Braess paradox is a problem that makes it difficult to estimate flows on evolving road corridors and it will be approached in a theoretical and practical way, using statistical methods and robust mathematics applied to the geography of transport. Instead, the second phase regards the study and application of new mobility and transport technologies, through modelling and subsequent experimentation, always to roundabout corridors, focusing on ITS and mobility with automated vehicles and on their interaction with the functionality and the geometry of the system of intersections in terms of emissions, efficiency and traffic safety. My research will be conducted through experimental applications in Pisa (Italy) and in Avignon (France). In this presentation, after a brief summary of the state of the art, I will focus on the results obtained from the simulations of the Italian roundabout corridor and on the first elaborations of the French one.

A study in favor of more sustainable textile districts

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Doctorate Thesis: Identification of strategies to increase the environmental sustainability of the Prato textile district

Keywords: textile industry, metals' removal, organic pollutants, reclaimed wastewater reuse, membrane treatment, BMP tests

Abstract:

The textile district of Prato has a centralized wastewater treatment system. Since it mostly treats textile wastewater, Baciacavallo WWTP is subjected to the Integrated Environmental Authorization, which requires the adoption of the BAT related to the textile industry. With the publication of the updated version of the textile BAT, the plant's removal capacity for some specific contaminants needed verification. Therefore, three monitoring campaigns were conducted to perform mass balances. Prato has also the largest water recycling plant in Europe. However, the effluent of the refining section is too hard for textile processes. An Ultrafiltration-Nanofiltration pilot plant was installed to remove water hardness and substitute the ion-exchange resin technology which increases chlorides in the wastewater. In the coming months, a full-scale plant will be designed, and a steady-state model of the wastewater treatment system will be developed to monitor chloride concentration. A laboratory-scale plant will be used to remove water hardness for the dyeing process and evaluate membrane performance for effluent treatment and reuse. The textile district of Terrassa (Spain) uses a decentralized wastewater treatment system. The sludge produced by the WWTP downstream of the textile companies cannot be valorized and must be landfilled. Biochemical Methane Potential (BMP) tests were conducted to determine whether the digestion of Baciacavallo sludge (a mixture of urban and textile sludge) yields higher-quality biogas than that of textile sludge alone. The experiment aimed to demonstrate that anaerobic digestion of textile sludge is efficient enough to be applied to full-scale implementation.

A methodology for deriving analytical fragility curves for masonry churches using non-linear stochastic analysis

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Abstract:

The present phase of the thesis study focuses on the formulation of an analytical strategy for the derivation of fragility curves for masonry churches. In the previous stages of the thesis, the entire portfolio of surveyed churches was statistically analysed in order to define prototype buildings. The one-nave typology was chosen for the calibration of a novel methodology for the definition of a simplified vulnerability index. The methodology starts by performing non-linear static (pushover) analyses where mechanical properties are evaluated as random variables, assumed to vary within specified ranges. A sampling technique is used to generate input variables from the probability density functions of mechanical parameters. The probability distributions of each damage state are subsequently determined from the obtained capacity curves. Conversely, the N2 method is used to determine the probability density function of the displacement demand corresponding to different levels of PGA. Finally, fragility curves can be derived by convolution of the complementary cumulative demand distribution and the probability density function of each damage state. The output of this phase, i.e. the probability of failure associated with a predefined limit state for different selected PGA values, will be used as a starting point to calibrate a new seismic vulnerability index for churches.

MSW Characterization: Case Studies in Tuscany and Catalonia

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Doctorate Thesis: Urban Mining and Life-Cycle Thinking: new approaches in solid waste management towards a circular economy

Abstract:

The management of municipal solid waste (MSW) significantly contributes to global warming through the emission of greenhouse gases (GHGs). As the global urgency towards sustainable waste management amplifies, MSW management's role is evolving from a basic urban hygiene service to a key player in waste recovery and recyclAn increasing number of corporations and service managers are undertaking holistic projects to quantify the carbon footprint of MSW chains. This is crucial for informed decision-making directed at climate change mitigation. Waste generation and composition are essential in calculating the carbon footprint, as they chiefly influence GHG emissions from treatment plants. Adhering to the latest IPCC guidelines necessitates a revised waste classification, incorporating all biodegradable fractions and those emitting fossil carbon during combustion. This calls for the inclusion of fractions like pruning and diapers, to improve emission modelling during biological degradation or combustion processes. Addressing this gap, this study delves into overall waste and undifferentiated waste composition in Tuscany, Italy, and Catalonia, Spain. Our research notably identified two waste categories: "textiles and leather" and "adult and baby diapers". The significant presence of these categories in mixed waste suggests considerable impacts from their management at TMB plants, emphasising a potential necessity for dedicated collection and recycling channels. A planned statistical analysis will further explore the relationship between socio-economic factors and waste composition, offering insights into the waste distribution drivers.

Impact of nutrient limitation and duration of famine on the structure and performance of a PHA accumulating community

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Abstract:

The selection of a mixed microbial community rich in PHA-accumulating bacteria was performed using a Sequencing Batch Reactor (SBR) with a maximum working volume 1.4 L. The reactor was inoculated with activated sludge from a tannery wastewater treatment plant. The SBR was subjected to a traditional feast and famine regime, modified with an uncoupled feeding and with an intermediate settling and a subsequent discharge of the supernatant. A specific amount of biomass was purged at the end of the cycle to maintain a constant sludge retention time. The SBR was fed with two synthetic solutions: one consisting of 80% acetate and 20% proprionate, the other of nutrients in limiting concentrations. Both solutions contain 3 gCl-/L to maintain a slight salinity. The sludge was aerated and stirred continuously, except during settling and supernatant removal. The temperature was controlled at 26 °C, not the pH, kept free to change, as was the dissolved oxygen. The reactor operated for nine months under nitrogen-limited conditions, thereafter the selected biomass was used to inoculate two identical SBRs (SBR1 and SBR2) maintained under phosphorous-limited conditions for one month. Later, the length of famine phase was doubled in the SBR2. Three microbial communities rich in PHA accumulating bacteria have been selected. The type of limiting nutrient seems to affect the accumulation rates and the bacterial community, not the storage capacities. Increasing the duration of the famine, on the other hand, greatly affects the performance accumulation that seems to more then double at the end of the feast.

Overtime reliability assessment of prestressed concrete bridges with post-tensioned tendons

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Doctorate Thesis: Development of probabilistic models and monitoring plans for the real-time reliability assessment of existent prestressed concrete bridges with post-tensioned tendons

Keywords: Reliability, Time-dependency, Post-tensioned concrete, Bridges, Sensitivity

Abstract:

In the presentation, the aim and methodology of the PhD thesis are briefly introduced and explained, and the already-done work is outlined. Then the problem of assessing the service life of existing bridges is specifically addressed. Starting with the general issue of existing structure assessment, attention is focused on prestressed concrete bridges with post-tensioned cables. Notably, the presentation focuses on the progressive deterioration observed in such structural types, with particular attention given to the corrosive processes affecting cables, highlighting that the initiation of corrosion depends on the fulfilment of specific thermodynamic conditions. The framework employed for degradation and mechanical modelling is defined. It adopts a probabilistic approach, thereby enabling the calculation of the in-time probability of structural collapse and, hence, the overall service life expectancy. In the end, the significance attributed to each input variable is evaluated through a sensitivity analysis. Conclusively, findings, conclusive remarks, and ongoing research are presented.

Influence of CSOs on spatio-temporal distribution of plastic in rivers

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Doctorate Thesis: Influence of CSOs on spatio-temporal distribution of plastic in rivers

Keywords: Microplastics, CSOs, rivers, riparian vegetation, Pyrolisis-GCMS

Abstract:

My research topic is about the presence of microplastics (MPs) in rivers coming from sewage system focusing the attention on the contribution of Combined Sewer Overflow (CSOs). One side the research is focused on the definition of a methodology for the detection of microplastics in water samples. The protocol is based on the use of Pyrolysis-GCMS unit for the detection and the quantification of MPs in environmental water samples, and on an extraction phase of the samples to isolate the microplastics from the matrix and the organic compounds. In the presentation some of the results obtained from the experiments performed will be shown. On the other side, my research investigates the fate of MPs once they reach the river. Several physical experiments have been performed using a rectangular cross-sectional hydraulic flume. The aim of these experiments is the investigation of the interaction between MPs and riparian vegetation. Several experiments have been run with different particles density and leaf area configuration, changing the number of leaves attached to each plant settle up in the channel.

Biological processes for the treatment and recovery of resources from industrial wastewater based on the selection of halophilic and halotolerant microbial consortia

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Doctorate Thesis: Biological processes for the treatment and recovery of resources from industrial wastewater based on the selection of halophilic and halotolerant microbial consortia

Keywords: Halophiles, wastewater, produced water, organic carbon

Abstract:

Worldwide, more than 5% of effluents are saline or hypersaline (Navada & Vadstein, 2007). This percentage will increase in the future also due to the growing industrialization. Saline effluents are produced by several industries, such as oil and gas production, leather, agro-food and aquaculture (Intrasungkha et al., 1999; Lefebvre and Moletta, 2006). Appropriate microorganisms called halophiles because they grow and thrive at specific salt concentrations (higher than seawater salinity) could be used successfully in the treatment of saline effluents; however, there is rather a lack in the literature about the use of halophilic and halotolerant microbial consortia in wastewater treatment (Mainka et al., 2021). In particular, the research activity focuses on the biological treatment of wastewater generated during oil and gas extraction. The experimental activity has consisted of operating an SBR reactor with a heterotrophic halophilic biomass that exhibits the capability to degrade efficiently the organic carbon from easily biodegradable compounds (acetate and yeast extract) under high salt concentrations (110 gNaCl/L). The ongoing experimental work involves the implementation of techniques for the upcoming operation of bioreactors, with a specific focus on methodology used to detect the carbon concentration within the system.

Bioplastics biodegradation in recycling of organic fraction of municipal solid waste

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Supervisors: Claudio Lubello, Teresa Gea

Doctorate Thesis: Organic waste recycling and food packaging composting: the influence of bioplastics

Keywords: Organic waste, Bioplastics, Biodegradation, Municipal Solid Waste

Abstract:

Compostable food packaging, particularly bioplastics, is often identified as a cause of problems in industrial facilities, despite being certified as compostable according to the EN13432 standard. Nevertheless, the attainment of high-quality compost production is intrinsically linked to the biodegradation of all food packaging materials, including compostable bioplastics. The identification of advanced technologies and management strategies for composting facilities plays a fundamental role in achieving environmental objectives while concurrently mitigating operational costs. The degradation of bioplastics is notably contingent upon the provision of optimal environmental conditions during the composting process, including factors such as temperature, long-time scales, and humidity. These conditions unfortunately do not strictly represent the highly variable conditions of industrial composting plants. Furthermore, the biodegradation process is subject to: bioplastic type and thickness, combination of waste treatments, proportion of bioplastics within the initial waste matrix, and composition of the surrounding substrate. I will present the results of a series of laboratory-scale experiments aimed at assessing the disintegration behaviour of various types of bioplastics. The bioplastics under examination include PBAT, PLA, Mater-bi, and PBSe, in both film and rigid forms. These experiments are conducted under varying environmental conditions and they are compared to the performance of alternative materials, such as paper bags, pulp plates, and fruit peels. The results obtained from the laboratory-scale tests will undergo a comparative analysis with data acquired from an industrial-scale assessment, where the materials exhibit superior rates of degradation.

Analysis of the thermal performance of three types of energy micropiles in summer conditions

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Doctorate Thesis: The use of low enthalpy geothermal energy through the installation of micropiles

Keywords: Energy micropiles, Thermal performance, existing buildings

Abstract:

Since the first application of piles as energy geostructure in Austria in the 1980s, the use of geostructures has steadily increased worldwide. Energy geostructures are complex systems that combine structural, geotechnical, and thermal performance. They utilize the soil thermal energy at shallow depths to provide heating and cooling to buildings, allowing to reduce both the consumption of non-renewable energy and the harmful carbon emissions. Micropiles are small piles having a diameter between 90-300 mm and a length up to 30 m. Mostly for structural retrofitting and rehabilitation of buildings, the use of micropiles can be extended to provide heating and cooling to existing buildings by exchanging heat between the ground and the buildAlthough energy micropile (EMP) systems are very similar to energy pile (EP) systems, their behavior cannot be assumed to be similar both from the mechanical point of view and the thermal point of view. Nevertheless, the thermal performance of micropiles in terms of specific heat flux (about 30W/m in fine grained soils after 6months of heating) has been found encouragHowever, many aspects of energy micropiles should still be looked at. As a first step of my Ph.D. research project, the thermal performance of three types of energy micropiles in summer condition has been analyzed through numerical simulations with the software COMSOL Multiphysics, with the aim of identifying the most important parameters for an appropriate thermal design of energy micropiles. This represents a first step for an efficient coupled thermo-mechanical design of energy micropiles.

Sensitivity of water stress indices to climate change in Tuscany (Italy)

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Doctorate Thesis: Water Stress Indices through a fully distributed hydrological model

Keywords: Water resources management, climate change, hydrological balance, water stress index

Abstract:

Water resources are fundamental to ecosystems, human survival, and socioeconomic development. In the face of climate change, understanding its impacts on water availability, quality, and management is imperative. This study focuses on Tuscany, Italy, employing advanced methodologies to assess the multifaceted relationship between climate change and water resources. The study integrates climate projections, hydrological modeling, and water management data to comprehensively evaluate the impacts of climate change on Tuscany's water resources. The foundation of this study rests upon the integration of cutting-edge methodologies and a deep appreciation for the complex interplay between climate, hydrology, and human activities. At its core, our research hinge balances on the application of the MOBIDIC (MOdello di Bilancio Idrologico DIstribuito e Continuo) hydrological model—a powerful tool capable of dissecting the intricate energy and water balances within the region's watersheds (Yang et al., 2014). In the face of a changing climate, this research extends its purview to consider the RCP8.5 scenario—a high-emission pathway that forecasts the altering climatic conditions of the future in Italy (Spano et al. 2020). By employing this scenario, we seek to elucidate how climate change might reshape Tuscany's hydroclimatic landscape, affecting water availability and ecosystem dynamics.

Numerical Modeling in vulnerability analysis of urban trees

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Doctorate Thesis: Multi-risk analysis for natural hazards and climate change in urban environments

Keywords: numerical modeling, vulnerability, multi-risk, wind, rain

Abstract:

Tree anchorage is a primary function for plant survival which may reach its limit under extreme conditions such as windstorms. To gain deeper insights into tree anchorage and influential factors underlying the process, the mechanical effects of root morphology and the material properties of roots and soil on the tree-overturning process was assessed by a newly developed finite element model. The root system was represented in a 3D root pattern, utilizing specific beam elements in PLAXIS software. The model is flexible to generate any root shape system and evaluate the effect of wind and rain as two natural hazards that affect the stability of urban trees. These results provide insight into simplified tree anchorage expressions for the prediction of wind-induced uprootThe model will be further used in a multi-risk framework to study the vulnerability of urban trees to the relevant hazards.

Determination of channeled emissions fingerprints aimed at identifying and localizing olfactory nuisances

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Supervisors: Riccardo Gori

Doctorate Thesis: A sensing network for high spatio-temporal resolution monitoring of fugitive emissions from wastewater treatment plants

Keywords: Solid Phase MicroExtraction, channelled emissions, nuisance odours

Abstract:

Observation and characterization of environmental pollution in industrial areas are particularly important to provide indications on responsibility for nuisance odours and advise on policy interventions. The aim of this study is to use the Solid-Phase MicroExtraction (SPME) technology to measure airborne VOCs, in no-equilibrium conditions directly coupled with atmospheric measurements taken on a mini-drone, to identifying a fingerprint of the channelled emissions. The SPME has been developed and validated in recent years to measure different categories of VOCs using various sorbent phases. Lab gas chromatographic/mass spectrum analysis of collected SPME fibres allowed the detection of a wide range of VOCs. The combination of this information collected during the monitoring campaign allowed the implementation of a Gaussian Plume model that estimates the VOCs' concentration on the ground. SPME fiber was exposed to the channelled emission for 30 seconds during the mini-drone flight. The exposure time is a compromise between two contrasting requirements: to lower detection limits for all compounds (since the longer is the exposure time the larger will be the mass of compounds present on fibers) and to increase the possibility to achieve a successful sampling (the emission could be stopped once the presence of the sampling device is noticed). From the results obtained, it emerges that coupling SPME technique and mini-drone fully satisfies the requirements for assessing the fingerprint of a channelled emission and is suitable for the implementation of a high spatio-temporal resolution monitoring system of odour nuisance the final goal of the research.

Physics-Informed Machine Learning methodology for long term Structural Health Monitoring of historical constructions

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Doctorate Thesis: Physics-Informed Machine Learning methodology for long term Structural Health Monitoring of historical constructions

Keywords: Structural Health Monitoring, Machine-Learning, Ageing Damage

Abstract:

The main objective is to investigate how to distinguish between sudden/fast-varying and ageing/slow-varying damage analysing long-term Structural Health Monitoring (SHM) data acquired on historical constructions (HC), with a Physics-Informed Machine Learning (PIML) approach. Damage can occur suddenly, in the short-term, and have an immediate effect on the structural behaviour (i.e., a seismic event), but it can also develop progressively, over time, in the long-term and have a cumulative effect on the structural behaviour (i.e., ageing phenomena). Analysing the latter can provide insight specifically for HC. The research is divided into three major steps: gathering and pre-processing long-term SHM data, extract relevant features and apply a ML algorithm for the distinction of fast and slow-varying damage. In particular, the main issues to tackle in the research are the following: the selection and preparation of case-studies, the comparison between physical and latent features with the used of Neural Networks and Autoencoders, the combination of data with different sampling frequencies to capture both types of damage, the use of environmental and operational features to possibly predict structural response and trend development, and ideal definition of thresholds to obtain an estimation of the remaining useful life of the structure. The presentation with provide an explanation of the research question, an updated on the work carried out on the selected case-studies and finally it will describe the state of progress in the methodology development.

Vehicle driving Safety analysis under strong wind impacts while driving on long-span bridge

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Abstract:

The wind field characteristics of a bridge site are the key issues for driving the safety assessment condition of mountain canyon terrain. Field measurements on a bridge deck were conducted to investigate the microclimate wind environment at the vehicle level. Moreover, W-V-B coupled system were analyzed to investigate how wind direction and intensity impacted on the vehicle dynamic responses, the driving safety and comfort were discussed as well.

Experimental Characterization and Numerical Modelling of Damage in Advanced Composite Materials

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Doctorate Thesis: Experimental Characterisation and Numerical Modelling of Damage in Advanced Composite Materials

Keywords: Composite, Delamination, Fracture modes, Finite elements

Abstract:

This study focuses on investigating damage in advanced composites, with a particular emphasis on interlaminar fracture toughness. Interlaminar fracture toughness strongly depends on the relative amount of the three basic fracture modes. Standard testing procedures have been established for fracture modes I and II by using the Double Cantilever Beam (DCB) and End-Notched Flexure (ENF) tests, respectively. In addition, for fracture mode III, no standard procedure exists yet, however, the Edge Crack Torsion (ECT) test is very commonly used. As an alternative, the Split Cantilever Beam (SCB) has been proposed in the research project. Some preliminary results will be presented from finite element simulation of the tests.

An approach for geo-referenced heat network planning on urban residential district levels under integration of renewable energies and storage options

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Joint title with TU Braunschweig [De]

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Doctorate Thesis: Investigation of decarbonization potentials of hydrogen usage in the Italian and German residential building sector and related technical, economic and regulatory aspects

Keywords: heat network planning, renewable energies, storage, geo-referenced, residential districts, City Energy Analyst, ArcGIS

Abstract:

The presentation introduces an approach for geo-referenced heat network planning on urban residential district levels under integration of renewable energies and storage options. As heating networks are identified to be a critical factor in terms of the German energy transition towards climate neutrality, the decarbonization of heat networks especially in residential quarters by integrating huge amounts of renewable energies in combination with storage opportunities like hydrogen is essential to reach this goal. Data availability and quality are important parameters for the planning of energy and heat providing systems. Therefore, an approach was developed and tested that improves the planning of heat networks through the integration of multiple available data sources for buildings and related energy performance indicators, available renewable energy sources as well as the resulting district heating network. While available building and energy information were used within open-source simulation software City Energy Analyst developed by ETH Zurich to calculate and simulate all relevant building energy parameters and renewable energy inputs, geo mapping software ArcGIS was used to map the results. The approach was further tested for an existing residential quarter in Braunschweig, Germany.

Solution of Laplace equation using NURBS surfaces in IGA-BEM framework

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Doctorate Thesis: Offshore wind energy: advanced computational models for the simulation of large floating turbines for the Mediterranean Sea

Keywords: Laplace equation, Boundary Value Problem, Singular Integral, Desingulariz method, IGA-BEM

Abstract:

The boundary element method (BEM) is an efficient technique to solve problems involving differential equations since it requires only boundary discretization. Mixed Eulerian-Lagrangian (MEL) technique will be employed to solve Fluid Structure Interaction (FSI) problems. It has two main steps which at the first the Laplace equation need to solve in the Eulerian frame. In this study, geometry and variables are described using Non-Uniform Rational B-splines (NURBS) as a novel approach. Employing NURBS provide an accurate representation of complex geometries and improve the numerical efficiency by reducing number of variables. The main challenge in BEM is solving weakly and strong singular integrals which causes because of fundamental solution and its derivative respectively. Desingularized method is employed to avoid singular integrals by moving source point along the normal vector. Singularity of integrand is vanished due to non-coinciding source point and computational points. This method is robust but needs to consider effective parameters carefully. Thus effect of various parameters, including desingularization distance, number of gauss point, degree elevation, knot insertion and shifting coefficient have been investigated. Our findings suggest an optimal desingularization distance between 0.5 to 2, as deviations beyond this interval potentiate ill-conditioned integrals or computational inaccuracies. Furthermore, an increase of the number of Gauss points always improves accuracy, though with increase in computational cost . To obtain enhanced results in degree elevation, it is necessary to employ 2.(p+1) gauss points.

Advanced traffic analysis and conflicts control at grade-separated intersections on highways

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Doctorate Thesis: Advanced traffic analysis and conflicts control at grade-separated intersections on highways

Abstract:

Understanding road user behaviour is essential to improve traffic conditions and safe driving environments, especially in the context of Connected and Automated Vehicles (CAV). Road safety modeling, using crashes and conflicts as research indicators, is a traditional key tool for understanding road user behaviour. However, the detection of multi-road users' conflicts, the interpretability of the results and the real-time evaluation are still missThe main objective of this study is to focus on the reconstruction and analysis of road user behaviour, including the development of interpretable artificial intelligence methods to implement real-time traffic safety analysis, and propose strategies both to improve road safety and to optimise traffic flow. Firstly, an advanced YOLO algorithm will be implemented for detecting, tracking and capturing multiple road user characteristics in videos. This adapted algorithm will allow real-time traffic conflict detection considering multiple road users simultaneously; previous algorithms, available in literature, only focus on a single road user. In addition, an advanced machine learning algorithm will be proposed to predict potential conflict events, which innovatively combines unsupervised learning algorithms to quantify safety thresholds and classify conflict severity to extract conflict hotspot areas. The relationship between conflicts and crashes will also be studied using Deep Neural Networks (DNN). As final step, a driving simulator scenario approach will be carried out in a 3D environment to simulate vehicle interactions and to analyze specific risk scenarios. The final specific objective is to co-design and test real-time traffic control strategies for motorway entry and exit ramps.

Data-driven techniques to discover constitutive models and to design shape changing structures with applications to patient-tailored stents

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Doctorate Thesis: Data-driven techniques to discover constitutive models and to design shapechanging structures with applications to patient-tailored stents.

Keywords: Data-Driven techniques, Machine Learning, Constitutive Law, Shape memory material, Cardiovascular Stents

Abstract:

The research project aims to investigate data-driven techniques for discovering constitutive models and designing shape-changing structures, with a specific focus on the application of patient-specific cardiovascular stents made from shape-memory materials. The primary goal of the research is to identify and analyze patterns and relationships within the data to derive constitutive models for shape memory materials, bypassing conventional techniques, and then design shape-changing structures, particularly customized stents for individual patients. Multiple sets of data representing the topological configuration of the stent will be used in the isogeometric analysis to determine the deformed shape of the stent under certain loading conditions. These topological configurations and the deformed shape of the stent will serve as training data for the data-driven model. The aim is to explore how data-driven techniques can assist the design process in an inverse way by incorporating patient-specific data to optimize the stent's performance and match the doctor-specified shape in terms of the centerline coordinates of the stent.

Multi-risk analysis of the WEFE Nexus for the development of successful Green Communities, valuing Ecosystem Services

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Co-tutelle University:

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Doctorate Thesis: Multi-risk analysis of the WEFE Nexus for the development of successful Green Communities, valuing Ecosystem Services

Keywords: flood risk, ecosystem services, Green Communities

Abstract:

Detailed study of the Green Communities already set in Italy, including some aspects of the flood risk assessment procedure. Exploration of the new technologies available and under development for flood risk management and modellDevelopment of some case studies. Study of Python programming language, focusing on the data science applications. Improvement in HEC-RAS software modelling skills, especially regarding 2D unsteady simulations.

Infected dwellers estimate through wastewater data

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Co-tutelle University:

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Doctorate Thesis: Wastewater-based Epidemiology: leveraging sewage water to mitigate clinical data biases

Keywords: Wastewater, sewage, epidemiology

Abstract:

As wastewater surveillance and One Health approaches are gaining traction, we are working on SARS-CoV-2 genomic concentration measured in 7 different sewage treatment plants. The data was collected between 2020 and 2021 for the pilot, 2021-2023 for the remainder. We devised a framework to polish wastewater data and show promising correlation with COVID-19 clinical tests. We also show how in recent times, due to the lower number of clinical tests analyzed, wastewater can show pandemic trends that the traditional sources do not detect. We also try to construct a first estimate of the number of infected people served by each plant using wastewater data.

Geometrically exact theory of curved beams undergoing finite strains

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Supervisors: Roberto Paroni

Doctorate Thesis: Mechanical modeling and optimization of ultra-lightweight structures

Keywords: Geometrically exact theory, curved beams, finite strains

Abstract:

Lightweight structures, such as membranes, shells and composite, pleated, folded, inflatable, and lattice structures, are widely used in many advanced applications of different engineering fields such as structural, mechanical and aerospace domains, due to their outstanding structural efficiency and versatility. Among these, lightweight morphing and reconfigurable structures, such as textured materials, bistable auxetic metamaterials, origami- and kirigami-inspired structures, self-foldable and deployable systems, just to mention a few examples, have attracted increasing attention in the past few years. The most attractive features of this class of structures are certainly their capabilities to exhibit unconventional mechanical properties and responses, and to withstand severe loading conditions while limiting the overall weight. It is not by chance that these structures are frequently found in nature as a result of the evolutionary self-optimization process. To fully take advantage of the extraordinary mechanical performances of these structures and related materials, especially when their weight is taken to extremes (ultra-lightweight materials and structures), reliable and advanced theoretical models are needed, but they are not currently always available. These models are indeed necessary in order to setup design optimization strategies and algorithms to analyze such structures. Both modeling and optimization challenges will be addressed within a common theoretical framework, namely adopting variational approaches. Variational methods are based on energy minimization concepts, rely typically on intelligible energetic quantities, allow for rigorous analyzes and offer a rational way for the development of numerical solution algorithms.

Recovery of carbon and raw materials from sewage sludge through integrated thermo-chemical processes

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Doctorate Thesis: Recovery of carbon and raw materials from sewage sludge through integrated thermo-chemical processes

Keywords: sewage sludge, raw materials recovery, carbon, phosphorous, circular economy, waste valorization, thermochemical processes, chemical processes, slow pyrolysis, hydrothermal carbonization, chemical leaching, chemical precipitation

Abstract:

This research intends to study the integration of thermo-chemical processes to recover valuable raw materials (particularly carbon and phosphorous) from the sewage sludge originated by wastewater treatment plants (WWTPs), aiming to increase WWTPs sustainability. Year 1 bibliographic research focused on the state of the art of sewage sludge treatment, and of slow pyrolysis, hydrothermal carbonization, chemical leaching, and precipitation, object of the next lab-scale experimental activity. This included the characterization of a sludge from conventional activated sludge system, and an aerobic granular sludge (AGS). After both sludges slow pyrolysis and the acid leaching of the produced solids (chars), the inorganic compounds were recovered from the liquid leachate by chemical precipitation. This integrated process was also tested on conventional sewage sludge (CAS) by RE-CORD's slow pyrolysis and chemical leaching pilot plants. By leaching, >95% phosphorous was extracted from both CAS and AGS chars and recovered as precipitate. However, the high concentration of silica reduced CAS leached char carbon content (<30%). CAS precipitate, in addition to phosphorous (4%), contained aluminium and iron, dosed as chemicals in the WWTP, which lowered the precipitate quality for the use as fertiliser. Conversely, the absence of aluminium-based chemicals in the AGS system determined a higher AGS leached char carbon content (>50%) and a lower AGS precipitate aluminium concentration. Future investigations will include silica removal from char, Si-based composite materials production, and inorganic compounds selective recovery. Furthermore, a preliminary lab-scale experimental program was outlined to study the integration of hydrothermal carbonization to slow pyrolysis and chemical leach.

Vulnerability assessments to heat and air-pollution in urban environments: case study for Prato

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Abstract:

Urban environments present numerous challenges linked to environmental hazards and climate change. Critical events of urban heat and air pollution are two issues that can have negative effects on the residents' health of a city. The spatial distribution of the intensity of Urban Heat Island (UHI) and Urban Pollution Island (UPI) during hazardous periods should be linked to other indicators proxying the vulnerability of the population, in order to assess risk at fine scale level. This could help municipalities intervene on targeted areas of a city with public policies, such as Nature Based Solution (NBS) or afforestation projects. This presentation shows the state of art of the research on the relations between population vulnerabilities and the mentioned hazard by means of Prato municipality as case study. Data, materials and methods used will be presented and some preliminary results will be illustrated. Specifically, relations between income and social deprivation levels of the Prato's population with intra-urban heat and particulate matter (PM) spatial patterns will be shown. So far, results have showed that income and social deprivation are negatively correlated to heat intensity, indicating that richer people - who may adapt better to heat than poorer ones – live in less hazardous districts of Prato. Concerning PM, wealth and social wellbeing are not anti-correlated.

Two-echelon freight urban distribution system: A test case in Livorno

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Doctorate Thesis: Design, simulation and optimization of innovative strategies for managing urban freight logistics based on a Urban Distribution Centre

Keywords: Two-echelon urban distribution system, UDC localization problem, last mile city logistics.

Abstract:

The research in this second PhD period has regarded the two-echelon freight urban distribution system, that is a solution to the UDC localization problem. At first, a state of the art of this system has been carried out, regarding cities in northern Europe, U.S. and east Asia. Afterwards, a test case has been studied for the city of Livorno. In particular, in our study, the UDC is located in the Interporto Toscano Amerigo Vespucci, the medium distance distribution is carried out by means of trains, the transhipment takes place in the former rail station of Livorno San Marco, close to the city centre, and finally the last mile distribution is performed by electric small vans. To do this, the following activities have been carried out: extraction of the graph for the city of Livorno; definition of a trial demand; adjustment for the current case of the software already used for the van platooning system applied to the city of Lucca. In addition, some collateral works were done: 1.Participation in the Summer School in Naples about the last innovation in urban logistics; 2.Contribution to the research activities of the European project Circumvectio Plus, that concerned port telematization and documental flow management; 3.Development of a Mixed Logit Model for the modal split on Alpine passes.

Indoor spatial modelling for heritage building management

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Co-tutelle University:

Supervisors: Valentina Bonora

Doctorate Thesis: Experimental workflow through free and open-source software for the creation of a non-conventional platform for overcoming GIS and BIM limits in the management of built heritage

Keywords: Indoor spatial modelling, IndoorGML, Heritage buildings, building information modelling

Abstract:

The study deals with a novel way to build an informative model for the management of heritage buildings. The BIM paradigm, which is the current standard, is suitable for new buildings, but has critical issues when applied to existing and historic buildings, as the Scan-to-BIM process is still challenging and ineffective when geometric or semantic information is missing. This could be overcome with an information system where semantic information (even if incomplete) can be collected during the survey. It can also include survey data, which can speed up the implementation of the information system, allow validation of results and enable future updates. A pre-spatial framework for recording relevant data on spaces, structures and surveys is proposed, not as an alternative system to existing standards such as IFC, but as an interim management tool for data storage, spatial querying and preparation for implementation in other standards. It can also be used immediately for building management. The main difference of the proposed system is that the information collected during the survey is essentially about spaces, rather than construction features. Therefore, my study tests the creation of an information system based on the IndoorGML scheme, an OGC standard used so far for indoor positioning and navigation. In IndoorGML, a Node-Relation Graph represents topological relationships, such as adjacency and connectivity, between cells, which can be both spaces (rooms) and construction features, such as walls or doors. The proposed system does not compete with BIM, but increases the interoperability of data, including survey documentation.

THE WEFE nexus seen from an ecosystem services perspective

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Doctorate Thesis: Assessment of the water-energy-food-ecosystem nexus using ecosystem services on watershed level

Keywords: resources management,nexus,Water management,ecology

Abstract:

In the contemporary realm of sustainable resource management, understanding the intricate relationships between water, food, and soil ecosystem services is of paramount importance. This study embarks on a novel approach by applying Boosted Regression Trees (BRT) to a hydrological model, integrating it with environmental predictors to elucidate these relationships. BRT, known for its ability to handle non-linear relationships and interactions, offers a robust technique to dissect complex ecological associations. Our methodology initiated with the calibration of the hydrological model using historical data, followed by the integration of a suite of environmental predictors, ranging from soil properties, climate variables, to land use patterns. The BRT algorithm was then employed to discern patterns and predict potential outcomes based on various scenarios. Results demonstrated that BRT, with its gradient boosting mechanism, provided a nuanced understanding of how changes in one ecosystem service can propagate effects on others. For instance, alterations in water availability showcased a ripple effect on soil health, which in turn influenced food production capacity. Furthermore, the study identified key environmental predictors that act as pivotal nodes in these interdependencies. Conclusively, the study paves the way for a deeper understanding of the intertwined nature of ecosystem services. The application of BRT on a hydrological model, complemented by environmental predictors, provides stakeholders and policymakers with actionable insights. These insights emphasize the need for holistic and integrated strategies to ensure the sustainability of water, food, and soil ecosystem services.

From BIM to Digital Twin. Definition of a BIM-based DB for public administration

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Doctorate Thesis: From BIM to Digital Twin. Data integration in life cycle information management of existing assets

Keywords: BIM, DT, IFC, FM, IoT

Abstract:

The operational phase of a real estate asset accounts for approximately 80% of the overall investment and management costs throughout the entire life cycle of the building, and the activities of space management and monitoring of building components and systems play a crucial role in ensuring the well-being and health of users. The AECO industry is transitioning towards a new framework governed by data-driven processes. In this context, BIM can support the utilization of big data generated throughout different stages of the building's life cycle, thereby establishing itself as a central dynamic repository of information used by a facility managers to achieve specific objectives. The proposed study aims to define a processing framework for the collection and management of data aimed at the implementation of DT of existing real estate assets, created based on the integration between BIM platforms and IoT. Until now the research has seen a first part of literary review and a collaboration with the University of Florence's Building Area to understand the needs in the management area of a public organization. A BIM guide has been developed, based on their best practices, and a mapping process between the assets type, with their respective properties, in University's DBs and their respective BIM objects is in progress. The contribution is part of a broader research activity carried out as part of the PNR Project, "BIM2DT. BIM-to-Digital Twin: information management to support decision-making in the building life cycle".

Assessment of Community Resilience using System Dynamic Modelling

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Doctorate Thesis: Community Resilience to Flood Risks: The case of cultural cities

Keywords: Flood, Cultural city, Community Resilience, System Dynamics Modelling, Florence

Abstract:

Italy's cities are increasingly at risk from flooding and the resulting harm to people and the economy. In response to these difficulties, there has been a surge in interest to enhance the resilience of cities to flood hazards. As a result, a number of hypotheses have been put out, and resilience frameworks built upon these theories have been created. This study intends to contribute to these endeavors by providing a quantitative evaluation and dynamic evolution of resilience in the city of Florence in the Tuscany region of Italy. The study applied the concept of System Dynamics Modelling (SDM) in the setting of a significantly historical city at the risk of floodFor this research, twenty indicators of resilience were identified and categorized under four groups of resilience namely economical, social, organizational and infrastructural dimensions. Data for each of these indicators was collected from various sources mainly from the commune of Florence open data platform. Even if the scope of the study is the city of Florence, some indicators like health care required data of regional communes, while others have spatial resolution of the region. Data points were collected for a temporal resolution of one year, and quantitative analysis was made for the first twenty years since the year 2000. Preliminary analysis of the data indicates that although there are improvements in socio-economic conditions and consequential growth in resilience, there is still opportunity for development, which will be investigated in follow-up studies.

Criteria and Methodologies for Sustainable Management of River Sediment

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Doctorate Cycle: XXXVIII

Joint title with TU Braunschweig [De]

Supervisors: Luca Solari, Simona Francalanci, Jochen Aberle

Doctorate Thesis: Criteria and Methodologies for Sustainable Management of River Sediment

Keywords: Morphodynamics,Bedforms,River Bars,Sediment supply

Abstract:
Criteria and Methodologies for Sustainable Management of River Sediment Abstract: Rivers are complex and dynamic natural systems influenced by a multitude of factors, including sediment transport and bedform dynamics. As dynamic and intricate natural systems, rivers continuously shape their morphology in response to various hydrological and sedimentary factors. Among the most captivating geomorphic features that emerge from the interplay of these forces are alternate bars, which are represented by an alternating sequence of deposit and scour separated by diagonal fronts. These bars play a crucial role in river hydraulics, sediment transport, and ecological processes. Most of the fundamental analytical theories of alternate bars assume that the sediment supply is equal to the channel's sediment transport capacity and are unable to account for supply unsteadiness. There is still a lack of information in the literature about the effects of combining external forcings such as variations in the sediment supply, and flow variability. A literature review is an ongoing work but, the study will address three core questions. This study addresses three core questions: 1. Do alternate bars reach equilibrium with unsteady sediment input? 2. How do alternate bars, in terms of growth rate, amplitude, wavelength, and celerity, respond to sediment input variability? 3. Does incorporating the Morphodynamic time scale offer advantages over the classical approach? Such knowledge is essential for river management and restoration efforts, as it can help predict and mitigate the effects of altered sediment regimes on river ecosystems and infrastructure.

On the identification of artery stent target shape from 3D anatomy reconstruction

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Doctorate Cycle: XXXVIII

Co-tutelle University:

Supervisors: Enzo Marino

Doctorate Thesis: A new efficient and accurate isogeometric analysis approach to the simulation of shape-changing artery stents—towards patient-tailored 4D printed stents (ISOStent4D)

Keywords: Isogeometric Analysis (IGA), B-spline, Interpolation, Frenet-Serret frame, Bishop frame

Abstract:

In the field of biomedical engineering, shape programmable artery stents are groundbreaking structures, capable of reopening occlusions adjusting to the vessel tortuosity. From the mechanical point of view, they consist in a system of spatial curved beams made of materials characterized by a complex behavior. Among the challenges in modeling these structures, the accurate reconstruction of vessel geometry, aimed at identifying the target shape of artery stents, is a crucial task. This presentation delves into an innovative approach that leverages Isogeometric Analysis (IGA) and curve framing for the reconstruction of vessels from patient 3D imaging data. The process commences with data extraction from patient image data. The data points are interpolated using B-splines, enabling a seamless transition from discrete data to a smooth and continuous vessel representations. Secondly, the rotation matrix of the vessel's centerline, which is crucial to effectively reconstruct the vessel lateral surface and to identify the occlusion, is computed. To do so, The Frenet-Serret frame has been a traditional choice, however, it fails where the curvature is ill-defined (i.e., zero curvature points). As a robust alternative, we employ the Bishop frame, a rotation-minimizing frame that ensures a robust reconstruction of the vessel geometry. Moreover, The B-spline interpolation technique is employed to reconstruct the stent geometry and then translated and rigidly rotated along the vessel's centerline using the rotation matrix of the vessel's centerline. By advancing our understanding of these techniques, we unlock the potential for more accurate, comprehensive vessel reconstructions, ultimately enhancing patient care and medical diagnostics.

Adaptation Of Coastal Protection Structures Against Sea Level Rise by Stilling Wave Basin Crest Modification

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Doctorate Cycle: XXXVIII

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Doctorate Thesis: Adaptation measures for sloping rouble mound breakwater crests to withstand sea level rise

Keywords: Climate Change, Sea Level Rise, Overtopping, Crest Modification, Stilling Wave Basin

Abstract:

Rapid economic growth and urbanization process of İzmir city in Turkiye takes place around Izmir Bay, which contributes greatly to the development of the city. However, the negative effects of climate change grow with unplanned urbanization and inadequate infrastructure problems, making Izmir vulnerable to natural disasters. Coastal floods are the most important of these natural disasters, and it has become essential to take adaptation measures for coastal protection structures in Izmir Bay. This study focuses on improving the Stilling Wave Basin(SWB) crest modification through experimental methods as an adaptation measure. The experiments were carried out at the Marine Engineering Laboratory of the University of Florence(Italy). The geometric properties and hydrodynamic conditions of the experimental setup were designed at 1/16 Froude scale, based on the Izmir Bay. In total, 63 SWB geometric configurations were tested under 4(four) hydrodynamic conditions, the overtopping discharge of each experiment was measured. Also, reference tests without SWB modification with the same crest elevation were tested under the same hydrodynamic conditions. When comparing results with and without SWB crest modification, it shows that the applied modification significantly reduces the overtopping discharge.