ETH zürich

«MEET & SHARE YOUR RESEARCH» Day

BOOK OF ABSTRACTS

9th OCTOBER, 2019 at Bellavista

ETH Zürich, Campus Hönggerberg

D BAUG
Departement Bau, Umwelt und Geomatik
Department of Civil, Environmental and Geomatic Engineering

ASB
Association of Scientific Staff at D-BAUG

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SIMPLIFIED ANALYSIS METHODS FOR ROCKING FOUNDATIONS

Max Sieber
max.sieber@igt.baug.ethz.ch
IGT - *Institute for Geotechnical Engineering, ETH Zürich*

During strong seismic events, a structure may be exposed to seismic loading which way exceed its design level. In such cases, the conventional capacity design aims to guide failure to structural members. Such design philosophy can lead to a disastrous failure as the collapse of the Hanshin Expressway Fukae bridge during the 1995 Kobe earthquake demonstrated. A novel design concept known as "rocking isolation", which either allows the foundation to uplift or to mobilize its bearing capacity, acts as a safety valve protecting the superstructure. Particularly for large intensity earthquakes that clearly exceed the design limits the novel design concept shows superior performance than conventional capacity design. Since the performance assessment of rocking–isolated structures requires dynamic simulation (time history analysis), there is a need for simplified analysis methods that are computationally efficient and simple in application. The present study investigates the robustness of three simplified analysis methods that differ in complexity and idealization. The methods are assessed by comparison with nonlinear FE time history analysis of a single bridge pier supported on a shallow square foundation, lying on a stiff undrained clay stratum. The FE model encompasses the entire soil-foundation-structure interaction and is subjected to 29 real ground motion records as well as 300 artificially synthesized ground motions.

MASS TRANSPORT, CHEMICAL REACTIONS AND MICROBIAL PROCESSES IN SUBSURFACE ENVIRONMENTS

Joaquin Jimenez-Martinez
joaquin.jimenez@eawag.ch / jjimenez@ethz.ch
IfU - *Institute of Environmental Engineering, ETH Zürich*

The subsurface is a topologically complex environment. The heterogeneity in the flow field – a mosaic of regions of high and low velocity–, the rheological properties of the fluids involved, and the presence of partially miscible or immiscible phases (e.g., air and contaminants) are some of the parameters that control solutes mixing (the process that brings reactants into contact with each other) and chemical reactions in subsurface environments. Microbiology plays a major role in these environments, both in controlling the local fluid dynamics (by clogging and re-routing of flow due to biofilm formation) and the biogeochemical cycles (nutrients, trace elements, remediation of contaminants). Firstly, we will present the consequences of mixing processes on the kinetics of fluid-fluid and fluid-solid reactions in porous media. In particular, the impact of the presence of an immiscible phase. Secondly, we will focus on the control of porous media geometry and boundary conditions on the bioclogging, and on the observed dynamic behavior: intermittent bioclogging.

DEEP LEARNING-BASED DISPLACEMENT VECTOR FIELD ESTIMATION USING POINT CLOUD DATA FOR DEFORMATION MONITORING OF NATURAL SCENES

Zan Gojcic
zan.gojcic@geod.baug.ethz.ch
IGP - *Institute of Geodesy and Photogrammetry, ETH Zürich*

Areal-based deformation monitoring based on point clouds can be a very valuable alternative to the established point-based monitoring. However, due to naively establishing the pointwise correspondences, established deformation analysis approaches for point clouds do not expose the true 3D changes in parts, which actually did change. Herein we extend the recently proposed algorithms that establish pointwise correspondences in the feature space, with a neural network based outlier detection algorithm capable of classifying the putative pointwise correspondences into inliers and outliers based on information only extracted from the point clouds. We demonstrate the proposed approach on two data sets, including a real case data set of a landslide located in the Swiss Alps. We show that while the traditional approaches greatly underestimate the magnitude of the displacements, our approach can correctly estimate the true 3D displacement vectors.

DYNAMIC RIVER WIDENING: A SUITABLE RIVER RESTORATION METHOD?

Cristina Rachelly
rachelly@vaw.baug.ethz.ch
VAW - *Laboratory of Hydraulics, Hydrology and Glaciology, ETH Zürich*

Co-authors: Volker Weitbrecht, David F. Vetsch, Robert M. Boes

Natural riverscapes are characterized by an intricate interlocking of aquatic and terrestrial habitats, high biodiversity, and strong temporal and spatial dynamics. However, many river systems are heavily impacted by anthropogenic activities. Channelization and straightening have disconnected rivers from their floodplains and reduced their morphological variability. The operation of hydropower plants, gravel extraction sites, and sediment retention basins has further changed the hydrological and sedimentological regime and reduced the heterogeneity of the riverscape. In Switzerland, the revised Swiss Water Protection Act (WPA) of 2011 initiated two extensive restoration programs. One is aiming at the restoration of hydropower related impacts until 2030, the other at the restoration of 4000 km of the most impacted river reaches until 2090.

Dynamic river widening is a restoration method aimed at reviving the natural morphodynamic processes of a river reach. The length of the widening may vary from a few hundreds of meters to several kilometers, although the latter is typically not feasible in the densely populated surroundings of heavily impacted rivers. The bank protection is removed on one or both sides of the channel to initiate the widening. Depending on the situation, further erosion inducement measures may be necessary. Ideally, the subsequent flood events will widen the channel bed and continuously reshape the topography, thus providing a larger variety of aquatic and terrestrial habitats compared to the channelized river (Figure 1). River widening also provides potential refugia, i.e., habitats that persist during extreme events such as droughts or floods.

The temporal and spatial development of a dynamic river widening is of fundamental interest for planning and flood protection, and it is dependent on various parameters, i.e., the hydrological conditions, sediment transport, the erosion resistance of the banks, etc. In this project, we focus on the influence of sediment supply on the development of the river width and the topographical variability, given that the sediment continuity in many Swiss rivers is heavily impaired. Large-scale laboratory experiments and numerical modeling are combined to identify the influence of a sediment deficit on the temporal and spatial development of a one-sided dynamic river widening. We quantify erosion rates, the topographic variability, and the patchiness of the bed surface, and we observe the distribution of suitable habitats for different hydrological scenarios. It is hypothesized that a sediment deficit will distinctly slow down and limit the morphodynamic processes, thus providing less suitable habitats.

This project is part of the research program 'Riverscapes - sediment dynamics and lateral connectivity', co-financed by the Swiss Federal Office for the Environment. The research program emphasizes the interdisciplinary and transdisciplinary nature of river restoration.

Figure 1: The dynamic river widening Heustrich on the Kander River self-formed during an HQ_{50} flood in 2005. Local bank protection structures were built on the left bank between 2006 and 2009. (2004-2013 © swisstopo, 2018 VAW).

WOOD-BASED BUILDING MATERIALS

Dr. Huizhang Guo[*1, 2]
* *huguo@ethz.ch*
[1] IfB - *Institute for Building Materials, ETH Zürich*
[2] *Empa-Swiss Federal Laboratories for Materials Science and Technology*

High-performance wood materials have attracted significant attention in recent years because of excellent property profiles achieved by relatively easy topdown processing of a renewable resource. A crucial flaw of the renewable wood scaffolds is the low flame retardancy and easy outdoor degradation, which we tackled by bioinspired mineralization in an eco-friendly processing step and transparent UV protection coating, respectively. The formation of the biomineral struvite, commonly found in urinary tract stones, was used for the infiltration of hierarchical wood structures with the necessary ions followed by an in situ synthesis of struvite by ammonium steam fumigation. Struvite decomposes prior to wood, which absorbs heat and releases non-flammable gas and amorphous MgHPO4 resulting from the degradation, which promotes insulating char formation. As a result, the mineralized wood can hardly be ignited, and the treatment actively suppresses the heat release rate and smoke production. The hydrolysis of titanium isopropoxide is initiated by the OH-groups of wood, as well as the moisture in the wood cell wall, and subsequently results in a cerium-doped TiO2 layer, which not only seals the wood surface from direct exposure to hydrolytic enzymes but also prevents the wood surface from UV irradiation. This novel wood protection method provides a greener and safer alternative to traditional biocidal wood preservatives or organic coating and has the potential to extend the service life of wood materials particularly in outdoor applications as well as for archaeological wood conservation.

A LIFE-CYCLE BASED ENVIRONMENTAL ASSESSMENT OF THE SULFIDIC TAILINGS REPROCESSING AND REMEDIATION

Lugas Raka Adrianto
Adriant@ifu.baug.ethz.ch
IfU - *Institute of Environmental Engineering, ETH Zürich*

Tailings as the residues of mining operation have been continuously being produced at huge amount in the EU mining industries. These residues, when poorly managed, would become a detrimental environmental hazard in addition to its acid mine drainage effects. Nevertheless, given the contents of these tailings such as valuable metals and its minerals for construction applications, it is critical to transform this waste problem into a resource-recovery opportunity through sustainable processes in the future.

Directly utilizing these tailings as inputs to produce different outputs, however, is not sufficient to justify that a process is environmentally friendly; the processes developed must be evidently better from a life cycle perspective than business as usual. This project aims to provide a life cycle based environmental assessment of the sulfidic tailings reprocessing and remediation in selected EU mine sites. Within the European Training Network 'SULTAN' H2020, this work should assist to find novel technologies for resource recovery and wastes valorization from mining industries. Performing life cycle assessment (LCA) at early process design would allow hotspots identification for environmental performance improvements before industrial scale is installed. Furthermore, an environmental assessment of the conventional tailings disposal method is also conducted to have the basis of comparison with the new processes.

By analyzing the environmental assessments of tailings through multiple processing routes, the results will further provide holistic views of mine wastes resource-recovery solutions. Thus, this dissertation will contribute to a more comprehensive mine tailings life cycle inventory model, both at different processes scales and conventional tailings facility for enhancing its overall ecological performance.

DYNAMIC CONGESTION PRICING FOR URBAN MULTI-REGION NETWORKS

Alexander Genser
gensera@ethz.ch
IVT - *Institute for Transport Planning and Systems, ETH Zürich*

Co-authors: Anastasios Kouvelas, Institute for Transport Planning and Systems, ETH Zürich

The growing number of people living in cities results in rising mobility demand, and as a consequence, the limited capacity of traffic networks gets more stressed. Hence, congested network links are causing travel delays and negative impacts on the environment, postulating for a methodology to overcome this challenge. Considering the broad range of traffic management systems, congestion pricing is very effective to tackle today's cities traffic problems. Dynamic congestion pricing is a useful tool not only to mitigate traffic congestion but also to influence people's route choice. Dynamic tolls at the entrance of a protected region can give network users an incentive to reconsider their travel route and allow traffic management operators to direct a transportation network towards the system optimum. Computation of the optimal route guidance can be utilized as a benchmark for the pricing strategy of a corridor and significantly improve the performance of a transportation network. The presented work focuses on a multi-region-network to find the optimal route guidance solution (i.e., the system optimum). In addition, different pricing strategies can be tested and compared to the optimal benchmark solution. The work shows a significant improvement of the traffic situation in the multi-region network by applying strategic dynamic congestion pricing.

CENTRIFUGE MODELLING OF 3D PRINTED MASONRY STRUCTURE

Lorenzo Del Giudice
delgiudice@ibk.baug.ethz.ch
IBK - *Institute of Structural Engineering, ETH Zürich*

Earthquakes are among the most fatal natural hazards causing thousands of casualties every year. Masonry structures constitute a large portion of the building stock worldwide in spite of their proven high vulnerability to seismic actions. Understanding the earthquake behaviour of masonry structures is therefore crucial.

The research in this field it is still an open subject not only because of the large varieties of materials and construction methods but also because the dynamic interaction of structural components is much more complicated than in Reinforced Concrete or Steel structures. Therefore, there is a need for system-level testing so that the interactions between the different loadbearing components can be properly accounted for. However, full-scale system-level testing in Civil Engineering structures involves constructing a real building and shaking it until collapse. Clearly, this is very expensive both in terms of equipment (shaking table large enough to accommodate a full-size masonry building may cost hundreds of millions of euros) and in terms of the specimen (i.e. a whole building).

To reduce the cost, testing on reduced-scale components has been the rule over the years. However, this method has two main limitations. First, the scaling factor is limited because the geometric scaling changes the mechanical properties of the materials due to size effect. Second, in order to keep similarity of stresses between the real structure (prototype) and the model, extra masses have to be added causing a variation of the mass distribution of the model structure.

Our goal is to overcome both these limitations by 3d printing small scale masonry-like structures and perform a shaking table test. 3d printing technology gives us the opportunity to create a material with target properties by changing the printer's parameters. This allows us to print a material with properties that preserve similitude with respect to the prototype material. The non-homogeneous nature of masonry will be taken into account by optimizing the micro-geometry of the mortar joints in the model structure. The second limit of reduced-scaled testing, i.e. preserve similitude of stresses without changing the mass distribution of the model, can be achieved by modulating gravity acceleration g placing the shaking table in a geotechnical centrifuge. This experimental method will drastically reduce the cost of system-level testing allowing for studies under multiple configurations and excitations. Moreover, it will be possible to perform multiple tests to either statistically validate the existing numerical models or to calibrate new ones.

In this presentation we will present some first results of static tests of the 3d printed material printed using our new 3d printer that uses Binder Jet technology.

INVESTIGATING THE MECHANICAL PROPERTIES OF BIOFILM STREAMERS

Giovanni Savorana
savorana@ifu.baug.ethz.ch
IfU - *Insitute of Environmental Engineering, ETH Zürich*

Co-authors: R. Rusconi[1] , R. Stocker[2] , E. Secchi[2]
[1] Department of Biomedical Sciences, Humanitas University, 20090 Pieve Emanuele (MI), Italy
[2] IfU-Insitute of Environmental Engineering, ETH Zürich

Across many different habitats, bacteria are often found within surface-attached communities known as biofilms [1]. In this mode of growth, bacteria are embedded in a self-secreted matrix of extracellular polymeric substances (EPS). This matrix greatly enhances bacterial resistance to harsh environmental conditions and antimicrobial treatments, and thus hinders our ability to remove detrimental biofilms in medical and industrial applications.

Despite the importance of the matrix to biofilm survival, little is known about its material properties; examples of open questions are how the material properties are related to the chemical composition of the biofilm matrix and how they are shaped by environmental features like fluid flow. Investigating these relations would allow for a better understanding of the mechanisms underlying biofilm resistance to mechanical stresses and would possibly lead to new removal strategies.

Here we present a microfluidic platform that allows the reproducible growth of filamentous biofilm structures suspended in flow, known as streamers [2], in controlled chemical and flow environment. We use the stretching of the freestanding streamers induced by a controlled variation of the flow rate as a probe of their mechanical resistance. We developed a theoretical framework to estimate the material properties of biofilm streamers from the flow-induced deformation measured in our experiment. Thanks to this platform, we are able to investigate the role of the different EPS components [3] and ambient flow in determining the biofilm rheological properties.

References [1] S. Lecuyer, R. Stocker and R. Rusconi, New J. Phys. 17, 030401 (2015) [2] R. Rusconi, S. Lecuyer, L. Guglielmini, H.A. Stone, J. R. Soc. Interface 7, 1239-1299 (2010) [3] E. Secchi et al., paper in preparation

AN OVERVIEW OF CONFIGURATORS FOR INDUSTRIALIZED CONSTRUCTION

Jianpeng Cao
cao@ibi.baug.ethz.ch
IBI - *Institute of Construction & Infrastructure Management, ETH Zürich*

To improve productivity, the construction industry is increasingly adopting methods of industrialized construction. A key strategy to support industrialized construction is to leverage an adaptable product development platform, i.e. a configurator. Although many benefits of configurators (e.g. mass customization) have been witnessed in the manufacturing industry, the application of configurators in construction is limited and immature. This paper reviews eleven configurators in academic research and four configurators in industry practice. First, using a comparative analysis, the authors generalize three strategic typologies of configurators developed and implemented for industrialized construction. Second, stakeholder requirements are identified for each typology. Finally, the technical approaches, including related methods and theories, are reviewed using a framework of three-tier architecture decomposition. The findings contribute to practice by allowing AEC stakeholders to understand strategic typologies and customer requirements for configurators. This can assist in guiding the future development of mass-customized configurators.

DIFFERENCES IN PERCEPTION OF PERI-URBAN AND URBAN RESIDENTIAL LANDSCAPES

Jens Fischer
jefische@ethz.ch
IRL - *Institute for Spatial and Landscape Development, ETH Zürich*

Urbanization is unprecedented both in time and space, creating new landscapes, which are neither rural nor urban. The resulting often uniform landscapes influences humans' sense of place and ultimately their motivation to change places. Understanding how humans perceive peri-urban landscapes constitute the goal of this research work. In particular, we explore differences in human perceptions of traditional old city and new peri-urban residential zones.

For this first exploratory study, we used state of the art 3D visualizations made from point cloud data obtained in situ and presented to the participants through virtual reality goggles for a complete immersion into the scene. Forty-eight participants recruited among ETH students were exposed to two scenes located in the Netherlands: one scene corresponds to an urban residential area located in old Utrecht, and the second scene corresponds to a Utrecht peri-urban residential zone named Houten. Electro Dermal Activity (EDA) is used to measure affective responses to the scenes, while a questionnaire is used to understand the cognitive dimension of the choices.

Results show clear differences (statistically significant) in both the affective and the cognitive responses to the scenes. EDA show a higher arousal when exposed to the peri-urban scene compared to the urban scene, while participants preferred the urban old city residential zone to the peri-urban uniform area (37 preferences for the urban old-city vs 11 preferences for the peri-urban scene). The urban old city residential scene was perceived as more mysterious, complex, and with a high level of activity. Individuals expressed more willingness to live and to participate in this environment. In contrast, the peri-urban scene was perceived as more natural and in the need of change. No differences were measured concerning legibility, coherence and security between the scenes.

ANOVA analysis showed that participants living in urban areas preferred not to live in the peri-urbans, contrasting with persons living in peri-urban zones that were willing to live both in the urban and in the peri-urban areas. Relationships between the preferred recreational and living locations were also found, demonstrating that if one recreates in rural areas, he or she would be less willing to live in the urban zones. Also participants that preferred rural recreation where more aroused in the peri-urban scene that the ones preferred to recreate in urban areas. In summary, our results show that there are marked differences in perception of urbanized environments: Accordingly to the Feelings-as-Information theory, an older urban environment generates a more cognitive-driven process, during which the available information provided by the stimulus has to be further processed (indicators of mystery) and is known to be linked to a higher motivation to initiate landscape change, while the peri-urban process triggers a fast affective response, which points to a bottom-up processing style limiting creativity. These are first cues to better understand how place-making can be fostered in increasingly uniformed urbanized environments.

PHYSICALLY-BASED MODELLING OF THE FUTURE EVOLUTION OF SCANDINAVIAN AND ICELANDIC GLACIERS

Loris Compagno
compagno@vaw.baug.ethz.ch
VAW - *Laboratory of Hydraulics, Hydrology and Glaciology, ETH Zürich*

Due to global climate change, the majority of glaciers worldwide are losing volume. This trend is expected to continue in the future, with serious consequences for sea level, water availability, and hydropower production. In this study, we used a further developed version of the GloGEMflow model to predict the evolution of Scandinavian and Icelandic glaciers until 2100. GloGEMflow explicitly accounts for both surface mass balance and ice flow. The model is initialized with three distinct observational climate dataset and reanalysis products (E-OBS, ERA-I, ERA-5), while future climate is prescribed by both global circulation models (GCMs) and with high-resolution regional climate models (RCMs). Different climatological models are used to create an ensemble and to analyze glacier model sensitivity. The mass-balance model is calibrated with glacier specific geodetic ice volume change data. Under various representative concentrations pathways, we find that Scandinavian glaciers will lose between 63 % and 96 % in 2100 of their volume with respect to 2018. In the same time period Icelandic glaciers are expected to lose only between 20 % and 79 %.

The results indicate a large spread in glacier response to future climate, especially with a low CO2-emission scenario.

CAPILLARY DEPOSITION OF MICROORGANISMS FOR THE STUDY OF CELLS IN SPATIALLY CONTROLLED ENVIRONMENTS

Roberto Pioli
piolo@ifu.baug.ethz.ch
IfU - *Institute of Environmental Engineering, ETH Zürich*

Co-authors: E. Secchi[1], M. A. Fernandez Rodriguez[2], L. Alvarez Frances[2], F. Grillo[2], L. Isa[2], R. Stocker[1]
[1] DBAUG, ETH Zürich, Switzerland
[2] DMATL, ETH Zürich, Switzerland

Controlled and precise deposition of microorganisms into defined spatial arrangements offers unique and innovative possibilities for the study of microbial physiology and interactions. Full control over the geometrical arrangement is highly desirable due to the crucial importance of distances in microbe-microbe interactions, arising from their dependence on the propagation of chemical signals. Coupling accurate spatial patterning and full control over environmental conditions would provide a powerful and versatile platform for single-cell studies in microbial ecology. To this end, we have developed a microfluidic platform to extend a capillary deposition technique originally designed for colloidal particles, called sCAPA [1] (sequential capillarity-assisted particle assembly), to bacterial systems. This technology exploits the capillary forces resulting from the controlled motion of an evaporating droplet inside a microfluidic channel to capture individual particles or microorganisms in an array of traps microfabricated onto the substrate. Sequential depositions allow the generation of the desired spatial layout of single or multiple microorganisms (Fig.1). We successfully calibrated this new technique on colloidal particles and tested it on bacteria. We expect that the coupling of single-cell deposition and microfluidic technology allows both geometric patterning and precise control of environmental conditions, and thus opens up a window into the physiology of single microbes and the ecology of microbe-microbe interactions as shown by preliminary experiments

Fig. 1. False color SEM image of E. coli RP437 cells deposited in 2μm dumbbells traps (4μm long, 2μm large, and 1μm deep).

[1] S. Ni, J. Leemann, I. Buttinoni, L. Isa, H. Wolf, Sci Adv **2**(4), e1501779–e1501779 (2016)

IMPROVING MATERIAL FLOWS FOR CONSTRUCTION PROJECTS THROUGH DIGITAL SUPPLY CHAIN COORDINATION

Qian Chen
chen@ibi.baug.ethz.ch
IBI - *Institute of Construction and Infrastructure Management, ETH Zürich*

Good planning and control of material flow processes are critical to ensure the successful execution of construction projects. Coordination of the material flows and information flow is a fundamental component to achieve proper planning and control, which requires intensive collaborative work between networked project participants. Research has indicated that the integrated use of Building Information Modeling (BIM) and Radio Frequency Identification (RFID) tracking technology can improve the coordination of material flows as well as facilitate the collaboration between participants. Nonetheless, the current use of these technologies does not exploit their potential in a redefined workflow to systematically integrate with comprehensive look-ahead planning (LAP) procedures to precisely manage the material flow process with high granularity. Project participants need to track the changing demand and status of materials over time in a way that they make best use of information to make decisions collaboratively and consistently through the whole process from material estimation to final assembly. This research introduces a new collaborative process by integrating look-ahead planning workflows into the existing integrated 4D models (i.e., integrating BIM and RFID technology). An integrated information management system (IIMS) based on BIM and RFID technologies is also developed to enable the integration of information from BIM software and RFID tags. The IIMS consists of ten modules, i.e. modules for task planning, material estimation, material ordering, material production, location tracking, delivery, quality inspection, re-shipping, material status and change request. By aligning the use of IIMS with the LAP procedures, it enables the project participants to observe on-site status and changing material needs from actual construction progress to directly inform project participants in a timely manner. Information on dynamic material demands, delivery status, and corresponding construction tasks is collected from 4D models and automatically linked with short term look-ahead plans in an integrated BIM-RFID database. The look-ahead plans are tracked and updated on a daily basis to evaluate the actual progress onsite and make timely alerts of 'decision points' of material production and delivery specifically to suppliers and contractors. This improvement is achieved primarily through increased accuracy of information available throughout the 4D model-based process, increased efficiency of information exchange, increased visibility of stakeholder decision-making, and improved timeliness of the deliveries.

SPATIALLY AND TEMPORALLY AWARE MACHINE LEARNING METHODS FOR HUMAN MOBILITY ANALYSIS

Henry Martin
martinhe@ethz.ch
IKG - *Institute of Cartography and Geoinformation, ETH Zürich*

Many of today's urgent challenges, such as green house gas emissions and climate change, air quality and health, or traffic and congestion, are closely linked to the movement of people and goods. A major cause for these problems is fossil fuel based individual transport, making individual mobility behavior change a requirement for solving them. Information and Communication Technologies (ICT) and Location-Based Services (LBS) play key roles in assisting and enabling behavior change towards a more sustainable mobility behavior. They can be utilized for a flexible and attractive public transport system and more flexible mobility options such as on-the-fly ride sharing and on-demand last mile buses.

These applications require an in-depth understanding of individual human mobility and therefore require efficient methods for the prediction of individual human mobility (e.g., next trip, next place or arrival time) and the semantic enrichment of passive and unlabeled tracking data (e.g., trip purpose or transport mode prediction/classification)

We propose a graph based representation of human mobility that is strictly motivated by properties that are inherent to human mobility and can be derived from domain research. This representation can be used to overcome domain specific problems that hindered the usage of deep learning methods for human mobility analysis. Examples are the existence of many but small tracking datasets recorded by different tracking devices and the integration of arbitrary structured context data.

The main part of this work focuses on the development of graph neural network (GNN) based methods to solve the prediction and labeling tasks. We identify three main challenges for this approach: (i): The creation and testing of a suitable graph representation for human mobility data; (ii): Training GNNs on dynamic and heterogeneous data; (iii): Generalization properties of the methods across different types of tracking data and to unknown users.

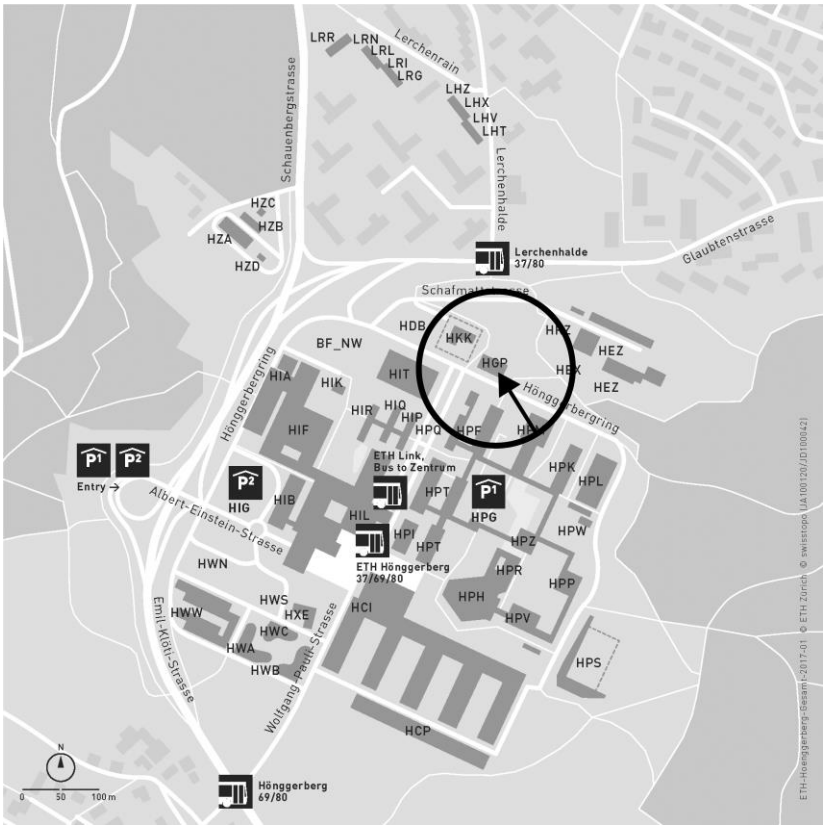

Fig.: Location of ‹‹Meet & Share Your Research›› Day, October 9th, 2019: Bellavista, HGP, ETH Zürich, Campus Hönggerberg

Organisation by ASB, the Association of Scientific Staff at D-BAUG (www.asb.ethz.ch)

Natalia Papathanasiou (IBI), Marion Frey (IfB), Dr. Maria Adobes Vidal (IfB), Firehiwot Nesro Kedir (IBI), Sebastian Davidis (VAW), Dr. Helge Fuchs (VAW), Kunkun Tu (IfB), Alina Galimshina (IBI), Antonia Nousiou (IGT), Dr. Andrea Gonzalez (IRL)

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