Geomatics Master Project 2 - Autumn Semester 2024

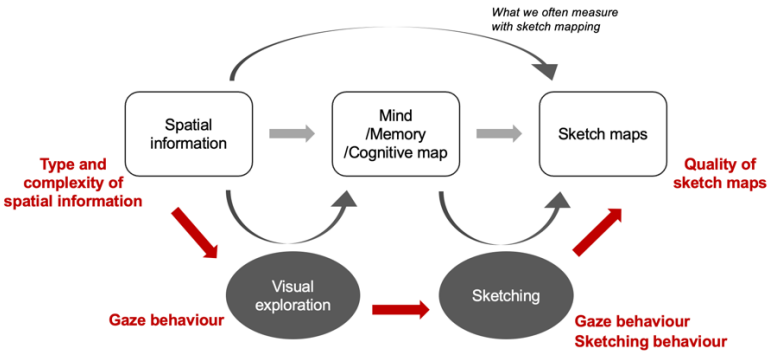
The following list covers a collection of possible thesis topics for Master students in Geomatics.

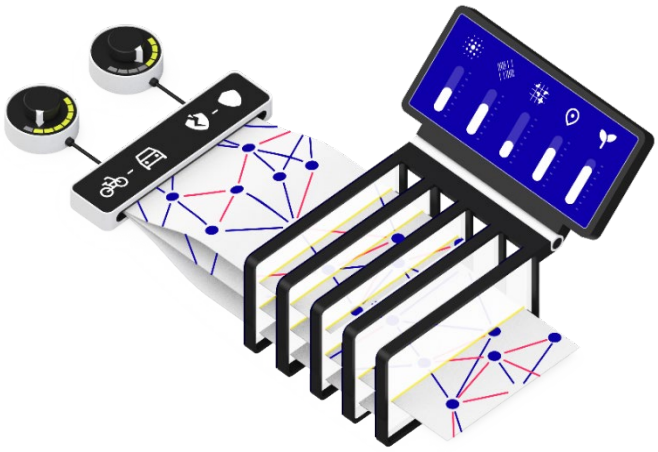
Your individual assignment will be adjusted with respect to scope and research/practical focus. You are also welcome to suggest topic adjustments to account for your individual interests.

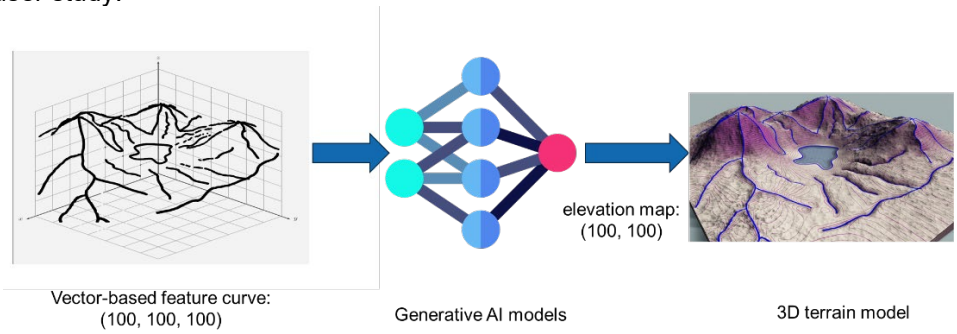
Please contact the advisor / supervisor of each respective topic for more information.

Content:

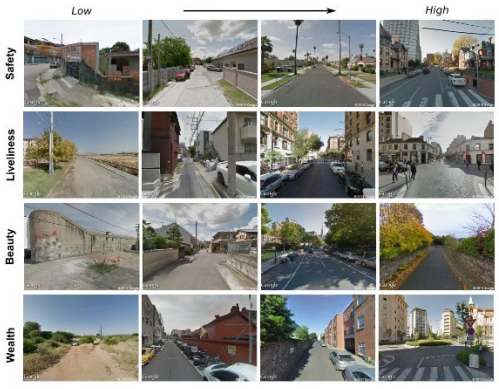
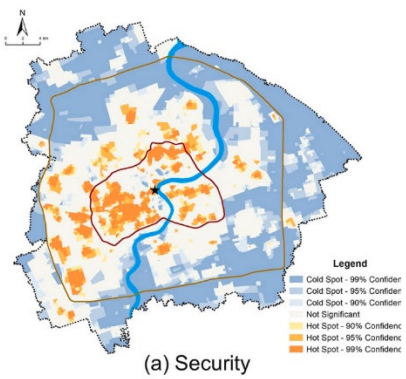
Exploring cognitive processes during sketch mapping from gaze 2
Building an evaluation tool for the E-Bike City 3
AI-supported 3D sketch mapping in XR for avalanche search and rescue 4
Predicting Urban Perception Using Geotagged Street View Images 6

Chairs / Institutions (incl. e-mail)	**Chair of Geoinformation Engineering / Institute of Cartography and Geoinformation**
Leading professorship	Prof. Dr. Martin Raubal (mraubal@ethz.ch)
Further advisors (incl. e-mail)	Dr. Sailin Zhong (sazhong@ethz.ch) Dr. Peter Kiefer (pekiefer@ethz.ch)
Project title	**Exploring cognitive processes during sketch mapping from gaze**
Abstract and work packages:	Sketch mapping is an established method to externalize mental models of spatial information and assess spatial knowledge. Can eye gaze tell us more about the cognitive processes behind it? The geoGAZElab has collected 2D sketch maps of five maps from 42 participants, including gaze data during the memorization of a simple map, the sketch sequence during the sketching phase, and interview responses on their strategies. This project aims to explore the connection between these three data sources and to unveil the cognitive process during sketch mapping.  Work packages: - WP1 – sketch mapping gaze analysis: Analyzing the collected sketch mapping dataset described above. For instance, analyzing (i) Santa Barbara Sense of Direction Scale (SBSOD) scores vs. sketch map quality, (ii) region-based ET features vs. sketching sequence, (iii) strategies in visual exploration vs. sketching of spatial information vs. gaze sequence using the Dynamic Time Warping algorithm. Explore visual search research methods and apply to this dataset. The student should have some basic programming ability. Familiarity with Python and/or R language is a plus. Experience with or interested in quantitative/qualitative analysis methods related to eye-tracking data is highly recommended.
Number of students per group	1
Maximum number of groups	1
Language (incl. report, oral presentation and poster)	English

Chairs / Institutions (incl. e-mail)	**Geoinformation-Engineering**
Leading professorship	Prof. Dr. Martin Raubal (mraubal@ethz.ch)
Further advisors (incl. e-mail)	Nina Wiedemann (nwiedemann@ethz.ch) Ayda Grisiute (agrisiute@ethz.ch), Lukas Ballo (lukas.ballo@ivt.baug.ethz.ch)
Project title	**Building an evaluation tool for the E-Bike City**
Abstract and work packages:	In urban areas, cycling is unmatched by other transport modes in terms of sustainability, health, and space efficiency. However, the lack of cycling infrastructure in Zurich is a major obstacle, preventing many people from cycling regularly. In the E-bike City D-BAUG lighthouse project [1], seven research groups are collaborating on a visionary idea: Dedicating ~50% of the road space to (e-)bikes. A key part of the project is the design and evaluation of the street network. For this purpose, we have developed optimization approaches and evaluation frameworks. However, planning bike networks is a comprehensive task and requires more sophisticated functionalities. The task for this project is to extend an existing web app that serves as a prototype for showcasing the algorithms and evaluation frameworks for the E-bike City. First, students will add more comprehensive functionalities that allow them to smoothly visualize evaluation results. In the background, the app will need to call a Python backend that executes different evaluation tasks that utilize contextual open-source data (air pollution, blue-green infrastructure, Street View Imagery (SVI)) based on multi-criteria user input. Ultimately, the tool should aid users in designing their evaluation objectives. Second, students will integrate additional SNMan Python toolkit [2] network pre-processing functionalities. The project will be a team effort, including frontend development and backend development.  [1] https://ebikecity.baug.ethz.ch/en/the-project.html [2] https://github.com/lukasballo/snman/
Number of students per group	2-4
Maximum number of groups	1
Language (incl. report, oral presentation and poster)	English

Chairs / Institutions (incl. e-mail)	**Chair of Geoinformation Engineering / Institute of Cartography and Geoinformation**
Leading professorship	Prof. Dr. Martin Raubal (mraubal@ethz.ch)
Further advisors (incl. e-mail)	Tianyi Xiao (xiaoti@ethz.ch) Dr. Sailin Zhong (sazhong@ethz.ch) Dr. Yizi Chen (yizchen@ethz.ch) Dr. Peter Kiefer (pekiefer@ethz.ch)
Project title	**AI-supported 3D sketch mapping in XR for avalanche search and rescue**
Abstract and work packages:	Avalanches frequently happen in the alpine with lives still being taken every year (e.g., in Zermatt 2024). Search and rescue (SAR) personnel need to communicate about space in order to collaborate effectively in such emergencies. A particularly intuitive way to communicate about space is through sketching. In this project, we explore novel collaborative 3D sketch mapping techniques to support the communication between a commander and a frontline rescuer during avalanches. We aim to design a simulated avalanche scene for two users, develop a generative AI-based terrain creation method, and evaluate this method through a user study.  *Figure 1 The idea to convert 3D strokes into 3D terrain models through generative AI. Screenshot adapted from https://perso.liris.cnrs.fr/eric.galin/Articles/2010-terrain.pdf* Work packages: - WP1 – Avalanche scene development: Implement a collaborative avalanche SAR scenario in XR by adapting an urban SAR scenario. This will require an understanding of the avalanche SAR procedure. Collaborate with WP2 to integrate the generative AI model into this scenario's 3D sketch mapping tool. - WP2 – Generative AI data collection and model creation: Use our existing AR 3D sketching tool to collect terrain datasets. Test and train different generative AI models for 3D strokes to 3D shapes and compare with an existing terrain generation model developed by the geoGAZElab team. - WP3 – User study design and execution: Design and execute a user study to evaluate if the XR-based 3D sketch mapping approach can improve communication for SAR operation in simulated avalanche scenes. Collaborate with WP1 on the adaptation of avalanche scenes for experiment design and design design data logging schema (e.g., eye-tracking data through VR/AR devices). Amend an existing ethics application for this experiment and analyze the experiment results. The student for WP1 should have experience or interest in 3D modeling software (e.g., Rhino, blender) and developing XR technologies via Unity, MRTK toolkit, and XR plugins. Students should have some basic programming ability. Familiarity with

	the C# language is a bonus. Knowledge of Photon Engine is a plus. This project will mainly work with HoloLens 2 and Meta Quest 3/Pro. The student for WP2 should have experience with Pytorch and basic deep learning knowledge and be familiar with Python language. Students who work with generative AI require knowledge of generative models (GAN, diffusion model), and knowledge of 3D computer graphics (meshes, point clouds, and voxels) is highly recommended. The student for WP3 should have experience with research methods, quantitative/qualitative analysis methods, and interest in empirical studies.
Number of students per group	2 or 3
Maximum number of groups	1
Language (incl. report, oral presentation and poster)	English

Chairs / Institutions (incl. e-mail)	**Geoinformation-Engineering**
Leading professorship	Prof. Dr. Martin Raubal (mraubal@ethz.ch)
Further advisors (incl. e-mail)	Lin Che (linche@ethz.ch) Dr. Peter Kiefer (pekiefer@ethz.ch)
Project title	**Predicting Urban Perception Using Geotagged Street View Images**
Abstract and work packages:	Policymakers, urban planners, and social scientists widely agree that the physical appearance of a city and the public's perception of it significantly influence the behavior and health of its residents. Based on this premise, Dubey et al. collected a large amount of street view images from 56 cities and acquired perception scores on six dimensions of the urban environment—safety, liveliness, boredom, wealth, depression, and beauty—through crowdsourced human annotations [1]. Leveraging this public dataset, numerous studies have employed computer vision techniques to predict people's perceptions of cities [2]. Although this dataset spans a vast geographical area, the potential of its geographical information has not been fully utilized or explored. In this project, we aim to thoroughly investigate the influence and impact of geographic context on the prediction of urban perceptions. Additionally, we will analyze the spatial distribution patterns of people's perception scores. Objectives: 1) Conduct a concise review of the most recent prior methods on this task. 2) Develop methods and models and benchmark them against existing baselines.   (a) Security [1] Dubey, A., Naik, N., Parikh, D., Raskar, R., & Hidalgo, C. A. (2016). Deep learning the city: Quantifying urban perception at a global scale. In Computer Vision–ECCV 2016: 14th European Conference, Amsterdam, The Netherlands, October 11–14, 2016, Proceedings, Part I 14 (pp. 196-212). Springer International Publishing. [2] Guan, W., Chen, Z., Feng, F., Liu, W., & Nie, L. (2021). Urban perception: Sensing cities via a deep interactive multi-task learning framework. ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM), 17(1s), 1-20.
Number of students per group	1
Maximum number of groups	1
Language (incl. report, oral presentation and poster)	English