# Chair of Cartography:  Topics for Theses
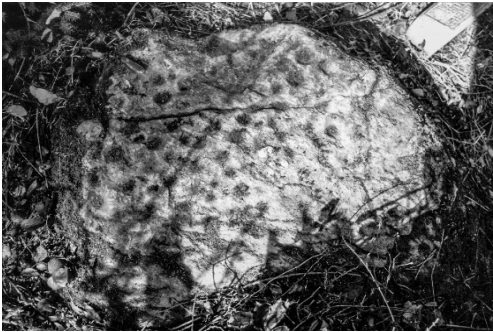
(Bachelorarbeiten, Geomatics Projects MSc (1 or 2), Master Theses)

**Last update:  2025-04-23**
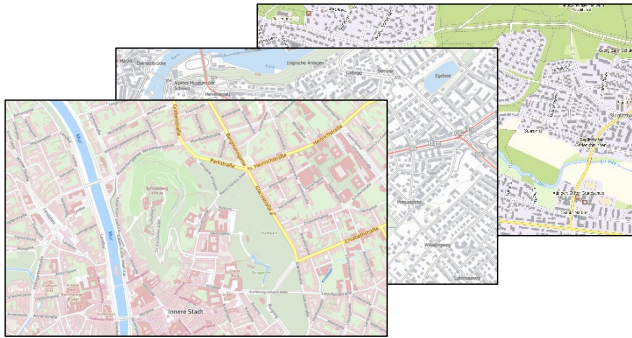
## Inhalt / Content

## Bachelorarbeit

| | |
|---|---|
| **Fachbereich** | **Kartografie** |
| **Leiter/in (inkl. E-Mail-Adresse)** | Prof. Dr. Lorenz Hurni (lhurni@ethz.ch) |
| **Betreuer/in (inkl. E-Mail-Adresse)** | Prof. Dr. Lorenz Hurni (lhurni@ethz.ch)<br>Luca Gaia (gaial@ethz.ch)<br>Dr. U. Schwegler (SSDI) |
| **Titel** | **GIS-Anwendung für Steindenkmäler-Inventare** |
| **Beschrieb** | Steindenkmäler sind geologische Kultur- und Naturgüter von regionaler, nationaler oder auch internationaler Bedeutung. Sie können den Geotopen zugerechnet werden und umfassen vielfältige Steinobjekte, die in den allermeisten Fällen menschliche Bearbeitungen aufweisen. Typische Vertreter sind Schalensteine, also Blöcke oder Felsplatten, die schalenartige Vertiefungen aufweisen, die aus prähistorischer Zeit stammen können. Es gibt aber auch Steindenkmäler mit anderen Bearbeitungen wie Inschriften, Zeichnungen oder Veränderungen für technische Zwecke.<br>In der vorgeschlagenen Bachelorarbeit soll eine GIS-Anwendung konzipiert werden, welche die Verwaltung grösserer Steindenkmäler-Inventare, aber auch die gezielte Recherche nach bestimmten Eigenschaften solcher Objekte zulässt.<br>Dazu steht einerseits ein Datensatz mit 331 Findlingen (mit und ohne Bearbeitungen) im Längholz bei Biel zur Verfügung, er verfügt über Punktinformationen mit einigen wenigen Attributen pro Objekt. 54 dieser Findlinge wurden aufgrund dieses Inventars unter Schutz gestellt (Findlingsreservat Längholz).<br>Es steht ein zweiter Datensatz zur Verfügung: Das Schweizerische Stein-Denkmäler-Inventar verfügt über mehr als 5000 Objekte und sehr viele Einzelattribute. Die Daten sind öffentlich über eine einfache Google-My-Maps-Anwendung und in HTML-Form verfügbar. In einer Arbeit an der Uni Bern wurde exemplarisch versucht, Informationen aus der HTML-Seite zu extrahieren und via Wikidata zu visualisieren. Nun steht aber auch ein besser strukturierter Excel-Datenbank-Auszug zur Verfügung. Dieser soll hinsichtlich Inhalts, Struktur und Inkonsistenzen überprüft werden und es soll damit das Potential für relevante inhaltliche Abfragen und interessante Analysen und Visualisierungen erkundet werden. Dies soll einerseits dem Inventar selbst aber ev. auch dem Atlas der Schweiz zugutekommen. Die prototypische Umsetzung kann in einem GIS nach Wahl (z. B. ArcGIS oder QGIS, ev. in einem WebGIS) erfolgen.<br><br><br>*Schalenstein mit 30 Schalen im Längholz.* |
| **Besonderes** | Voraussetzungen: Gute GIS- und Geodatenbank-Kenntnisse |
| **Gruppenarbeit:** | Ja |
| **Anzahl Personen pro Gruppe:** | 1–2 |
| **Total Anzahl Personen für Thema:** | 1–2 |
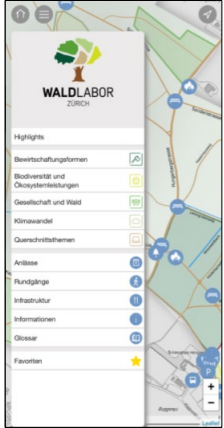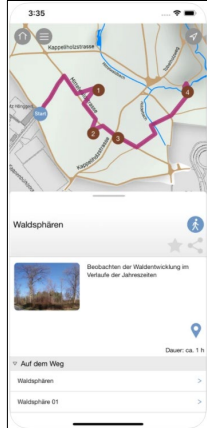
# Bachelorarbeit  or  Geomatics Projects MSc  or  Master Thesis

| | |
|---|---|
| **Chairs / Institutions (incl. e-mail)** | **Institute of Cartography and Geoinformation** <br> **Chair of Cartography** |
| **Leading professorship** | Prof. Dr. Lorenz Hurni (lhurni@ethz.ch) |
| **Further advisors (incl. e-mail)** | Dr. Andreas Neumann (aneumann@ethz.ch) <br> Christian Wohlert (cwohlert@ethz.ch) |
| **Project title** | **Considerations of a Good Map Design for Base Maps in Digital Atlases, such as the Atlas of Switzerland** |
| **Abstract and work packages:** | Base maps form the visual figurehead of multifunctional online-based map applications. They are used for contextual spatial orientation and the localisation of map content. A distinctive map design is created through the selection and composition of special signatures, fonts and colour schemes. <br><br> In connection with the reorganisation of the Atlas of Switzerland into a web atlas, the base map is also being revised. This includes both the cartographic design and the technical realisation. Challenges in the case of the Atlas of Switzerland lie in the large number of map themes and the active influence of the end user on the final visual appearance of the map composition. A base map, or possibly a selection of base maps, must be able to provide a meaningful and coherent cartographic foundation for a wide variety of thematic content levels. <br><br> As part of a bachelor's or master's thesis/master's project, consideration should be given to a suitable signature language for the new Atlas of Switzerland. Ideally, an analysis of existing base map products, such as Swisstopo, basemap.at, basemap.de, etc., regarding the cartographic presentation and the communicative orientation/ communicative potential of these base maps will serve as the basis for this. This is followed by your own considerations on the language of colour and form, which are based on the current scientific and cartographic discourse and can therefore serve as a basis for the revision of the base maps for the Atlas of Switzerland. Further focal points in this context could be the handling of different levels of generalisation, the possible use of 3D signatures and the resulting implications for the underlying data structure (raster/vector-based). <br><br>  <br> Sources: basemap.at, Light Base Map (admin.ch), basemap.de <br><br> For further reading: <br> - Atzl, C., Mittlböck, M., Knoth, L. (2022). Design decisions for multidimensional digital and interactive basemaps of urban environments. *Cartography and Geographic Information Science*, *49*(3), 220–236. https://doi.org/10.1080/15230406.2021.2015719 <br> - Raposo, P., Touya, G., Bereuter, P. (2020). A Change of Theme: The Role of Generali-zation in Thematic Mapping. *ISPRS International Journal of Geo-Information*, *9*(6), 371. doi: https://doi.org/10.3390/ijgi9060371 |
| **Number of students per group** | Project Work: 1 <br> Thesis: 1 |
| **Maximum number of groups** | 1 |
| **Language** | English (Bachelorarbeit auch auf Deutsch möglich) |
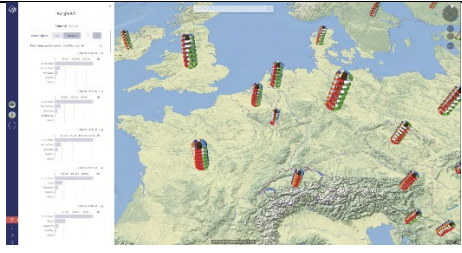
# Geomatics Projects MSc  or  Master Thesis

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|---|---|
| **Chairs / Institutions** | **Chair of Cartography** |
| **Leading professorship** | Prof. Dr. Lorenz Hurni (lhurni@ethz.ch) |
| **Further advisors (incl. e-mail)** | Katharina Henggeler (khenggel@ethz.ch)<br>n.n. |
| **Project title** | **Unsupervised Classification of Illustrative Cartographic Styles** |
| **Abstract** | Illustrative maps or map elements (e.g., hand-drawn, iconographic, or perspective; see also Figure 1) show a high potential for applications where inspiring creativity and encouraging discussion are key objectives – e.g., for spatial design. It is unclear, however, which illustrative styles are best suited for this purpose. In general, there is no clear definition and categorisation of cartographic styles.<br><br><br>*Figure 1: Exemplary hand-drawn, iconographic, and perspective map excerpts (from left to right).*<br><br>Unsupervised classification through feature clustering can help to identify the patterns within the data which might not be immediately apparent through visual inspection alone. It can potentially help to conceptualise the definition and categorisation of cartographic styles. Pre-trained image feature extractor as well as metadata information can be used as feature descriptors for clustering.<br><br>Thus, the goal of this project is to investigate unsupervised classification of illustrative maps so as to categorise and conceptualise different cartographic styles. |
| **Work Packages (tentative)** | WP1: Collecting and preparing the maps to be classified by digitalising maps from 1–2 books. |
| | WP2: Literature review of existing style categorisation schemes and methods as well as unsupervised classification / clustering techniques. |
| | WP3: Determining feature descriptors and applying classification methods. |
| | WP4: Interpreting the classification results and compare it with existing style categorisation schemes. |
| **Number of students per group (1–3)** | Project Work: 1–2<br>Master Thesis: 1 |
| **Maximum number of groups** | 1 |
| **Language** | English |

## Geomatics Projects MSc or Master Thesis

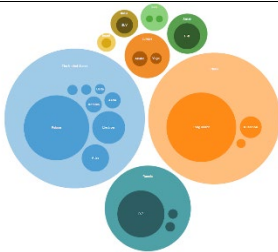| | |
|---|---|
| **Chairs / Institutions (incl. e-mail)** | **Institute for Cartography and Geoinformation (Chair of Cartography and Chair of Geoinformation Engineering); Waldlabor Zürich** |
| **Leading professorship** | Prof. Dr. Lorenz Hurni (lhurni@ethz.ch) |
| **Further advisors (incl. e-mail)** | Katharina Henggeler (khenggel@ethz.ch) Aline Bornand (WSL) (aline.bornand@wsl.ch) Andreas Garzotto (andreas@garzotto.com) Tianyi Xiao (xiaoti@ethz.ch) |
| **Project title** | **3D Augmented Reality Visualisation of Biomass for the Waldlabor Zurich App** |
| **Abstract and work packages** | The Waldlabor Zürich (www.waldlabor.ch) – the first forest laboratory of Switzerland (located right next to the ETH Hönggerberg Campus) – aims to study the various forms of how society interacts with forests. In turn, the collected knowledge as well as the Waldlabor itself and its projects are to be made available to the public. To avoid a jungle of sign posts but still give location-based information when exploring the forest, the Waldlabor App (link to the android app, link to the iOS app, link to the web app) was developed. Currently, it features a regular 2D map with primarily metadata about the individual Waldlabor projects. However, 3D visualisations in combination with augmented reality would be more intuitive and also possibly more accurate.  *Screenshots of the Waldlabor App (left: Android, right: iOS).* Thus, the goal of this geomatics project is to implement (and evaluate) a prototype of an augmented reality visualisation of selected 3D tree data from a specific project; namely the Swiss Biomass project (https://www.wsl.ch/de/projekte/swiss-biomass-berechnung-von-biomasse-und-kohlenstoffanteil-im-schweizer-wald/). Specifically, it is intended that students tackle the following tasks: <br> - Implement and compare different setups of markers to find the most effective but unobtrusive setup for a marker-based localisation; <br> - visualise the biomass data (TLS point cloud data, cartographic representtation of biomass parameters) in a way that can be understood by the interested layperson; <br> - implement a user-interface that facilitates an interactive visualisation; <br> - optional: evaluate the developed prototype in a user study. <br><br> The prototype is to be developed independently from the app but with the clear aim to be integrated into the app afterwards. Successful results may be presented at the annual Waldlabor-Day. |
| **Number of students per group (1–3)** | Project work: 2–3 Master Thesis: 1 |
| **Maximum number of groups** | 1 |
| **Language** | English (preferred) or German |

# Geomatics Projects MSc or Master Thesis

| Chairs / Institutions (incl. e-mail) | **Institute for Cartography and Geoinformation** <br> **Chair of Cartography** |
|---|---|
| **Leading professorship** | Prof. Dr. Lorenz Hurni (lhurni@ethz.ch) |
| **Further advisors (incl. e-mail)** | Dr. Andreas Neumann (aneumann@ethz.ch) <br> Alexander Müdespacher (amuedespacher@ethz.ch) |
| **Project title** | **Improving User Interaction in the Atlas of Switzerland Using Natural Language Processing (NLP) and Transformer-based Language Models** |
| **Abstract and work packages** | The exploration and analysis of complex geographic information in the Atlas of Switzerland poses significant challenges for the average users, so-called "interested laypersons". These difficulties manifest themselves in thematic exploration and navigation, as well as in finding and analysing specific data and map features. A collection of user feedback and documented problems serves as a starting point for this work. <br><br> The goal of this master's thesis is to develop innovative approaches based on the known challenges that use natural language processing (NLP) and transformer-based language models to improve the user experience. In particular, these technologies should help to make complex geographic content easier to understand and to optimize user interaction with the Atlas of Switzerland. <br><br>  <br> *Figure 1: Simplified Illustration of a LLM (Source)*    *Figure 2: Atlas of Switzerland GUI with Comparison Tool.* <br><br> The task begins with a comprehensive literature review of current approaches and methods for using Large Language Models (LLMs) and NLP to improve the user experience. Best practices and successful implementations in similar contexts are also systematically examined. <br><br> Based on the insights gained, concepts and solutions will be developed that address the use of LLMs to improve user interaction in the Atlas of Switzerland, with a focus on the challenges identified earlier. Selected concepts will be implemented in a prototypical way, ideally using low-code tools, and evaluated through user testing to measure their expected impact on user experience. <br><br> Finally, the results of the analysis, concept development and evaluation are combined to develop concrete recommendations for action regarding feasibility, technical viability and potential challenges. A critical reflection on the limitations and potential of using LLMs in the specific context of the Atlas of Switzerland concludes this work. |
| **Number of students per group (1–3)** | Project work: 1–2 <br><br> Master Thesis: 1 |
| **Maximum number of groups** | 1 |
| **Language** | English |

# Geomatics Projects MSc or Master Thesis

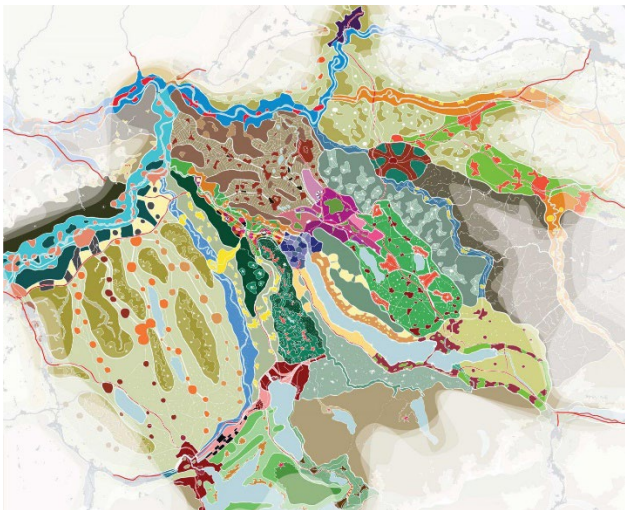| Chairs / Institutions | Institute for Cartography and Geoinformation<br>Chair of Cartography |
|---|---|
| Leading professorship | Prof. Lorenz Hurni (lhurni@ethz.ch) |
| Further advisors (incl. e-mail) | Dr. Andreas Neumann (aneumann@ethz.ch)<br>Alexander Müdespacher (amuedespacher@ethz.ch)<br>Remo Eichenberger (remoe@ethz.ch) |
| Project Title | **Analysis of User Tracking Data to Optimize the Use of the Atlas of Switzerland** |
| Abstract | The analysis of user tracking data from the Atlas of Switzerland aims to develop a thorough understanding of user behaviour and to derive optimizations. The present data set includes detailed information about how users interact with key functionalities such as the search function, thematic navigation, or maps. This data set was collected over a longer period of time but has not yet been subject to a systematic analysis.<br><br>The aim of this work is to exploit the potential of these data sets in order to derive data-driven recommendations for the future development of the Atlas of Switzerland.<br><br>The work begins with a thorough examination of the topic of user analytics. In doing so, fundamental concepts, methods and best practices of user data analysis are studied in order to develop a comprehensive understanding of the requirements and possibilities in this area.<br><br><br><br>*Figure 1: Leveraging analytics for enhanced UX/UI. (Source)*<br><br>This is followed by the definition of metrics that can effectively measure the use of a digital atlas. Subsequently, the existing data set is systematically analyzed along these metrics. This analysis includes a quantitative evaluation of usage patterns, such as the frequency of interaction with certain functionalities, the time spent on different maps, and the identification of particularly popular or problematic features. In addition, the popularity of different maps, and the time spent exploring the maps can be analyzed - also in combination with the respective base maps. The results of this analysis are synthesized to generate insights that provide a better understanding of current usage.<br><br>Finally, based on the insights gained, concrete recommendations for action are developed. These are aimed at both the functional further development of the atlas and the future design of the user analytics. Suggestions for new or improved functionalities are made, and a set of metrics and measurement points are defined that can be used in the next generation of the atlas. |
| Maximum number of groups | 1 |
| Number of students | Project work: 1–2<br>Master thesis: 1 |
| Language | English |

# Geomatics Projects MSc or Master Thesis

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|---|---|
| **Chairs / Institutions (incl. e-mail)** | **Institute of Cartography and Geoinformation Chair of Cartography** |
| **Leading professorship** | Prof. Dr. Lorenz Hurni (lhurni@ethz.ch) |
| **Further advisors (incl. e-mail)** | Dr. Andreas Neumann (aneumann@ethz.ch) Alexander Müdespacher (amuedespacher@ethz.ch) |
| **Project title** | **Improving the Thematic Navigation in the Atlas of Switzerland by Using Interactive Data Visualization or Self Organized Maps** |
| **Abstract and work packages:** | The Atlas of Switzerland features several hundred map topics. Each map has a number of metadata attached. Users can find maps by either using the search functionality, by navigating the hierarchy of categories (filtering through drop-down widgets), by exploring a long list of map titles or by using a timeline view. Neither of these methods provides a good overview of the available maps at a glance. A full list of the available metadata of all maps, their layers and linked multimedia information will be provided. It should be examined if alternative interactive visualizations from the domain of data visualization could be used to visualize and explore the large number of map topics provided by the Atlas of Switzerland. First ideas of such visualizations include bubble charts, sunburst charts, knowledge maps or SOMs (self organized maps), but additional data visualization types should be explored.    *Figure 1: Sunburst chart example. (Source)* *Figure 2: Hierarchical Bubble Chart Example. (Source)* *Figure 3: Example of a SOM (self-organized map).* This project or master's thesis should develop a concept for a new thematic navigation of the map topics in the Atlas of Switzerland - the navigation should combine visualization and interactivity and explore drill-down navigation or spatial navigation in SOMs. Ideally, two to three different ideas could be developed as a prototype and evaluated about their strengths and weaknesses. |
| **Maximum number of groups** | 1 |
| **Number of students** | Project work: 1–2 Master thesis: 1 |
| **Language** | English |

# Geomatics Projects MSc or Master Thesis

| Chairs / Institutions (incl. e-mail) | **Chair of Cartography** |
|---|---|
| **Leading professorship** | Prof. Dr. Lorenz Hurni (lhurni@ethz.ch) |
| **Further advisors (incl. e-mail)** | Dr. Sidi Wu, ETH Zurich (sidiwu@ethz.ch)<br>Dr. Yizi Chen, ETH Zurich (yizi.chen@ethz.ch) |
| **Project title** | **Interactive Stylization of Topographic Maps Using Prompt-Driven Diffusion Models** |
| **Abstract and work packages:** | Recently, Stable Diffusion models have achieved great success in image generation. We can create visually stunning images by using a text prompt to guide the image generation. Prior work in this group has developed a system generating topographic maps by conditioning Stable Diffusion with ControlNet, using the vector data to control the spatial layout, as shown in Figure 1 (left).<br>This project builds on that work, aiming to explore how textual prompts can guide the stylistic transformation of maps – allowing users to reimagine topographic maps in creative visual styles while preserving their geographic structure, as illustrated in Figure 1 (right).<br><br><br><br>*Figure 1. Left: The architecture of ControlNet[1] (already implemented). The spatial control is input together with the simple text prompt to generate images. Right: The expected system with interactive textual prompts to stylize the maps.*<br><br>The goal of this project is to design, implement, and evaluate an interactive system that enables users to stylize topographic maps using textual prompts, based on the already developed map generation system. Specially, you will:<br>- Explore textual prompts to describe map styles<br>- Fine-tune textual inversion embeddings to represent styles, in combination with pre-trained ControlNet models<br>- Integrate this interactive feature into the existing web applications<br>- Investigate evaluation protocols for the generated maps<br><br>[1] https://github.com/lllyasviel/ControlNet |
| **Number of students per group (1-3)** | 1 |
| **Particularities** | Experience with Python and deep learning is recommended. |
| **Language (incl. report, oral presentation and poster)** | English |

# Master Thesis

| Chairs / Institutions | **Chair of Cartography** |
|---|---|
| **Leading professorship** | Prof. Dr. Lorenz Hurni (lhurni@ethz.ch) |
| **Further advisors (incl. e-mail)** | Katharina Henggeler (khenggel@ethz.ch)<br>n.n. |
| **Project title** | **Generating *Raumbilder* with Machine Learning for Spatial Design** |
| **Abstract** | Investigating and understanding the region of interest is a key task in spatial design (de: raumplanerisches Entwerfen). An increasingly popular method for this is the creation of a *Raumbild* (literally: spatial image), an example of which is shown in Figure 1. These are maps that visualise the prominent landscape structures of the region of interest. Traditionally, spatial planners create them from various geodata (e.g., land cover, DEM, soil suitability map) using GIS software and through visual analysis combined with manual sketching on printed geodata.<br><br><br>*Figure 1: Metrobild Zurich – an example of a Raumbild for the metropolitan area of Zurich.*<br><br>The aim of this project is to explore to what degree such Raumbilder can be generated using machine learning. An existing set of Raumbilder as well as spatially corresponding input data (DEM, land cover, soil suitability map) will be used for training and afterwards testing an existing architecture (e.g., U-Net). Finally, the generated Raumbilder are to be evaluated in terms of logical consistency and usefulness from a spatial planning perspective (e.g., classes and spatial shapes that make sense). |
| **Work Packages (tentative)** | WP1: Preparing the maps as annotations |
| | WP2: Literature review of existing supervised learning techniques |
| | WP3: Training deep learning model(s) and applying them for generating the *Raumbilder* |
| | WP4: Evaluate the classification results (the generated *Raumbilder*) |
| **Number of students per group (1-3)** | 1 |
| **Maximum number of groups** | 1 |
| **Language** | English |

# Master Thesis

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|---|---|
| **Chairs / Institutions (incl. e-mail)** | **Chair of Cartography** |
| **Leading professorship** | Prof. Dr. Lorenz Hurni (lhurni@ethz.ch) |
| **Further advisors (incl. e-mail)** | Dr. Sidi Wu, ETH Zurich (sidiwu@ethz.ch)<br>Dr. Yizi Chen, ETH Zurich (yizi.chen@ethz.ch) |
| **Project title** | **Temporal Alignment of Vector Map Features Using Geometric and Semantic Matching** |
| **Abstract and work packages:** | Historical maps contain rich spatial information about urban structures, infrastructure, and place names. While vectorization methods can extract features from different time periods, aligning these features across maps remains challenging due to surveying and production errors, map generalization, and distortions. This project proposes to develop a method that aligns vector features across historical maps spanning over 150 years, using both geometric properties and semantic information extracted from map texts (e.g., street names or place names). By leveraging recognized text as semantic anchors, the project aims to improve the reliability and accuracy of temporal feature linking.<br><br>The final result will support a spatio-temporal knowledge graph that can track the evolution of geographic features and enable rich spatial and temporal queries—laying the groundwork for future research in historical GIS, urban transformation studies, and digital humanities.<br><br><br>*Figure 1: Illustration of the overall pipeline.*<br><br>The project will focus on aligning and linking vector features (e.g., buildings, streets, hydrology) from various maps across time, both geometrically and semantically, to support further spatio-temporal queries. A baseline deep learning model for aligning features within the same map source will be provided. The project should extend it by aligning features across different sources and enriching the semantics in matching. Specifically, you will:<br>- Investigate geometric alignment for features across different map sources<br>- Extract the semantic information from maps through text recognition<br>- Enhance feature matching by integrating geometric and semantic cues<br>- Build a structured, queryable representation of temporally linked features |
| **Particularities** | Experience with Python and deep learning is recommended. Basic GIS knowledge is required |
| **Number of students per group** | Master Thesis: 1 |
| **Maximum number of groups** | 1 |
| **Language** | English |