Cartography M.Sc.

User-Oriented Campus Routing

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Outline

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1. Introduction

- Background and motivation
- Research goal and objectives
- Research questions

Background and motivation

Introduction

- Significant time spent in indoor environments (home, work, and other indoor spaces)
- Structural complexity of indoor environments
- High fluctuation of user groups
- Only a few design guidelines for indoor navigation maps

Research goal and objectives

Introduction

- **Goal:**
  - Design and develop a campus routing application that facilitates orientation and navigation of various user groups (students, staff members, and visitors) on the TUM main campus.

- **Objectives:**
  - Adopt the appropriate visualization method for indoor spaces
  - Adopt the appropriate methods to evaluate map design and visualization as well as the usability and utility
  - Make use of evaluation results to identify research findings and propose future work recommendations

Research questions

Introduction

- *What map design principles and visualization techniques are appropriate for a campus routing system?*

- *What map elements, navigation network elements, and user interactions are needed for an effective and efficient campus routing system?*

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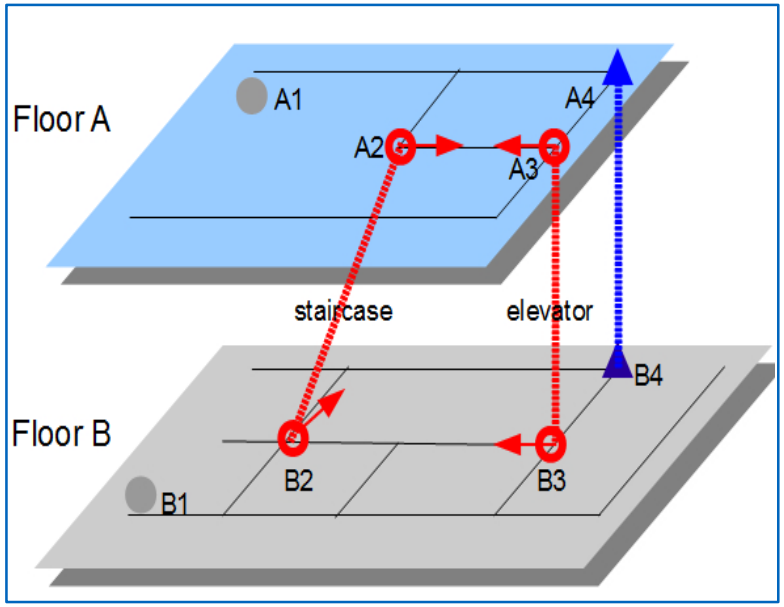
2. Related work

- Theoretical background
- Campus routing systems

Theoretical background

Related work

- Elements of indoor navigation systems:
  - Positioning/Orientation
  - Route planning
  - Route communication
- Structural indoor features as landmarks
- Map perspective and landmark representation make up to 30% of user satisfaction with map design for indoor spaces (Source [2])
- 3D maps have a considerable advantage compared to 2D maps when it comes to indoor navigations (Source [2])

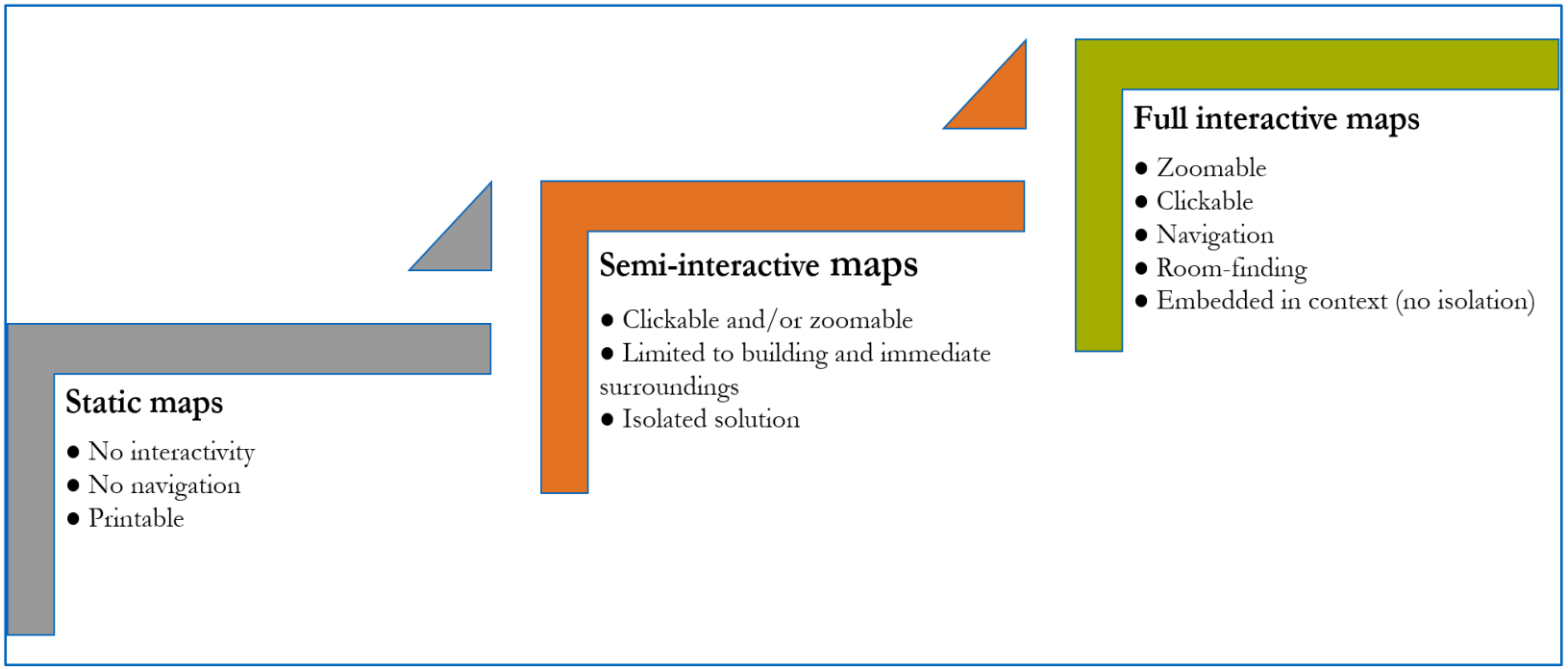


Multi-level indoor landmarks (Source [1])

Campus routing systems

Related work

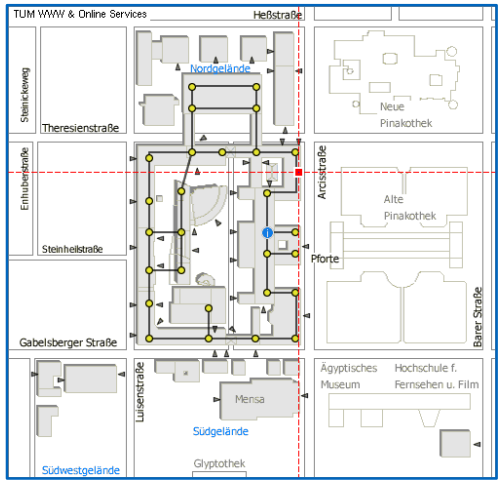
- Interactivity levels of campus maps based on their implementation:



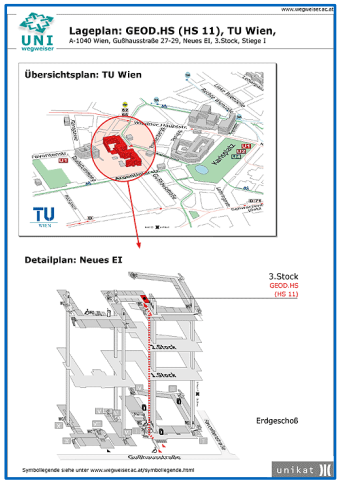
Categories of campus maps and their characteristics (Source [3])

Campus routing systems

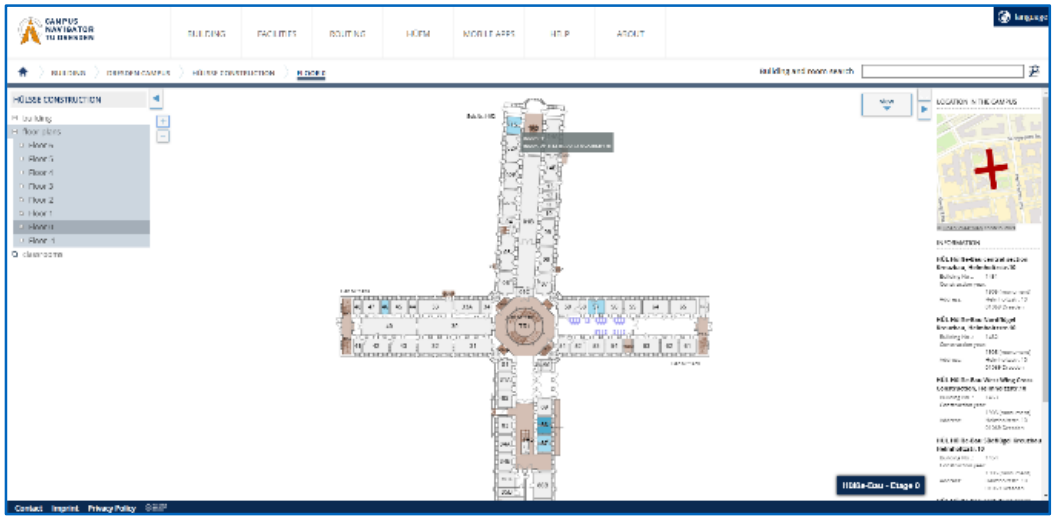
Related work



TUM "Roomfinder", room 1767 (Source [4])



TUW indoor spaces (Source [5])



TUD Campus Navigator (Source [6])

University of Applied Sciences Würzburg-Schweinfurt (FHWS) campus information system and route representation (Source [7])

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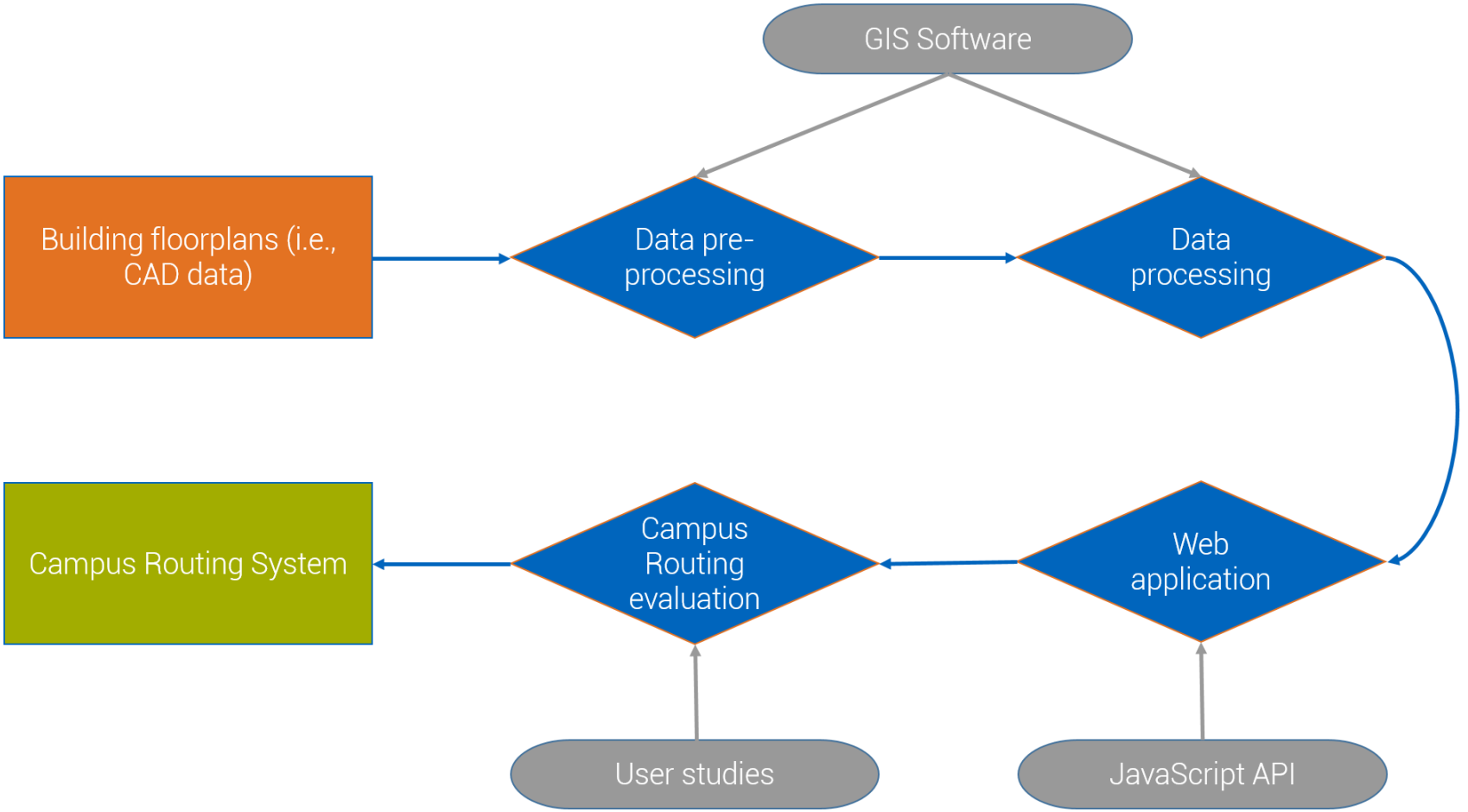
3. Methodology

- Workflow
- Data pre-processing
- Data processing
- Campus routing evaluation

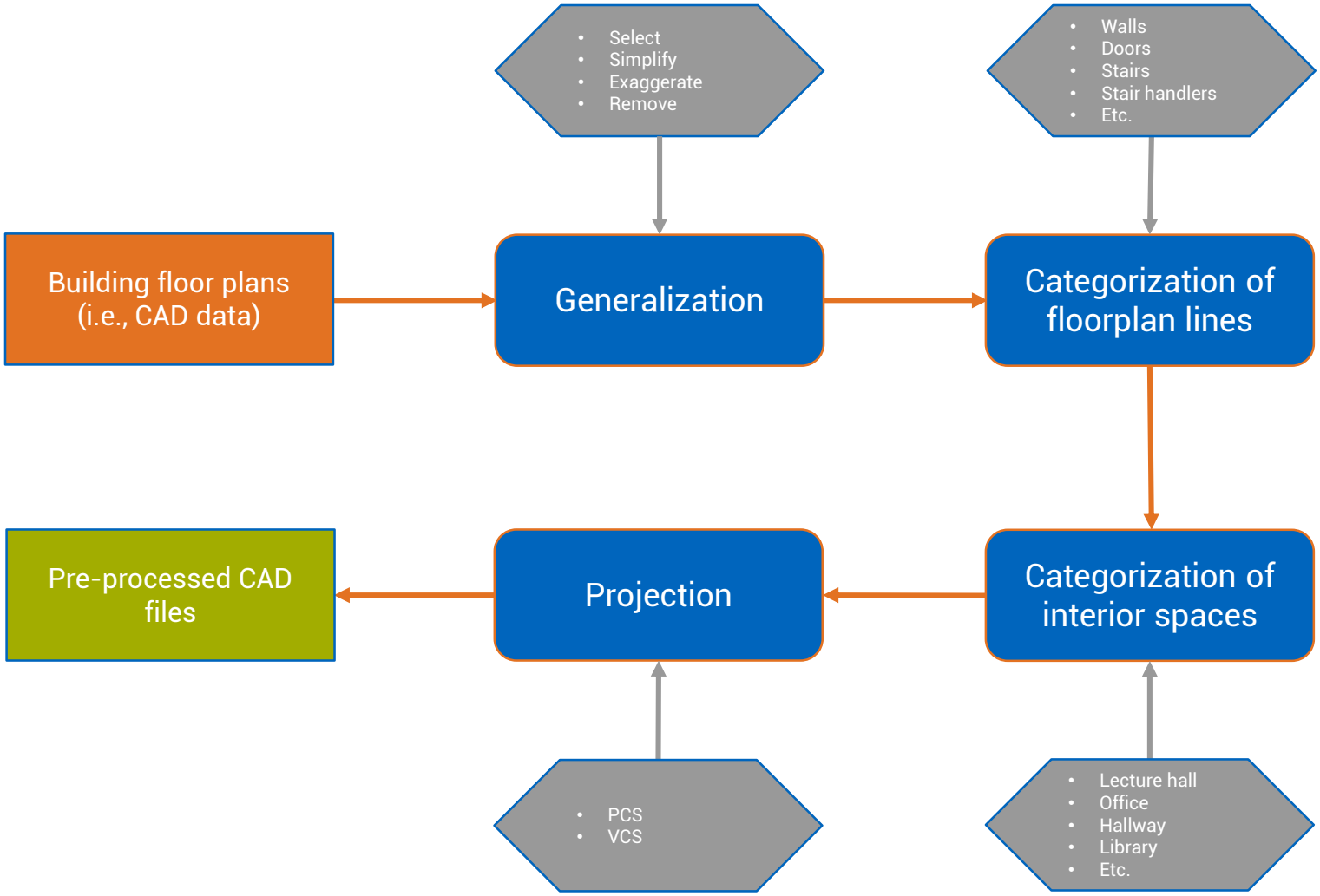
Workflow

Methodology



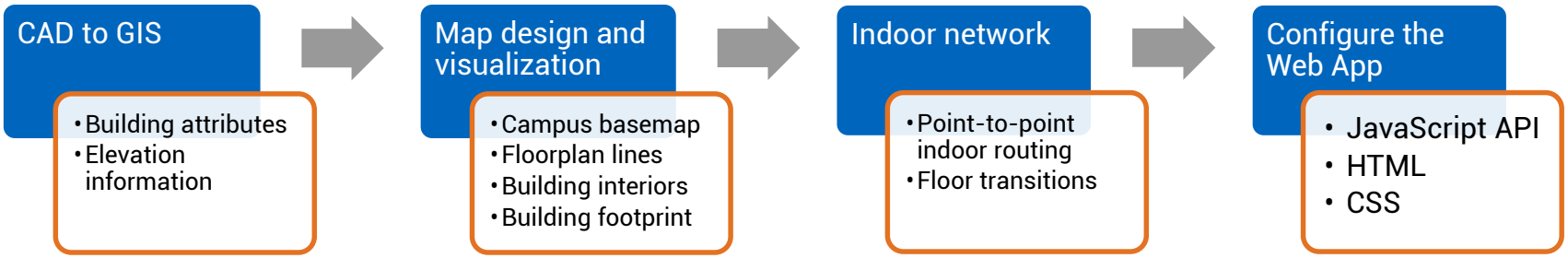
Data pre-processing

Methodology



Data processing

Methodology



Campus routing evaluation

Methodology

- Map design and visualization evaluation
  - Expert-based method
  - Background in Geosciences
  - Evaluate the applied design principles and visualization techniques

- Usability and utility evaluation
  - User-based method
  - Evaluate effectiveness, efficiency, and users' satisfaction

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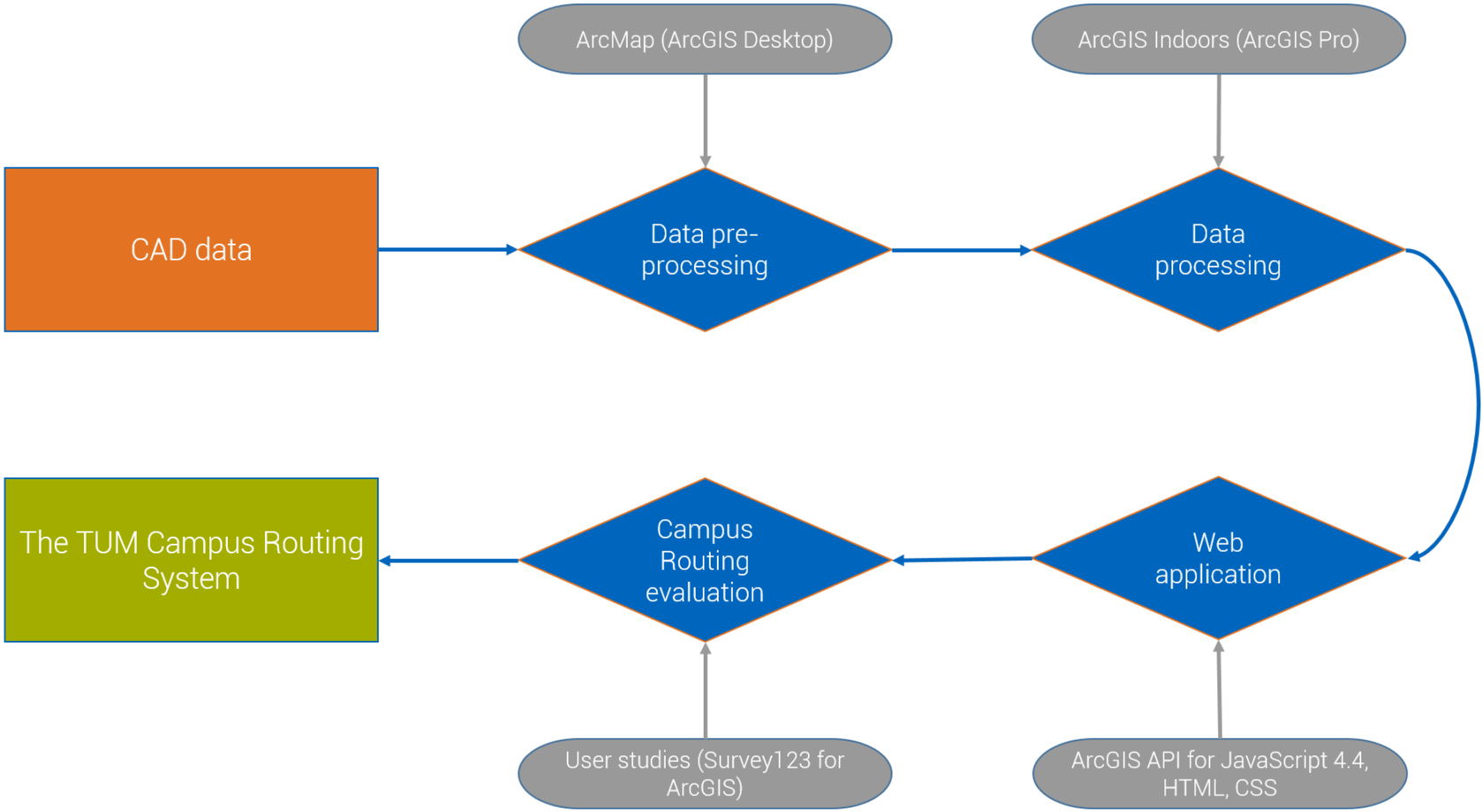
4. Case study

- Workflow
- The TUM Campus Routing System
- Map design and visualization evaluation
- Usability and utility evaluation

Workflow

Case study



The TUM Campus Routing System

Case study

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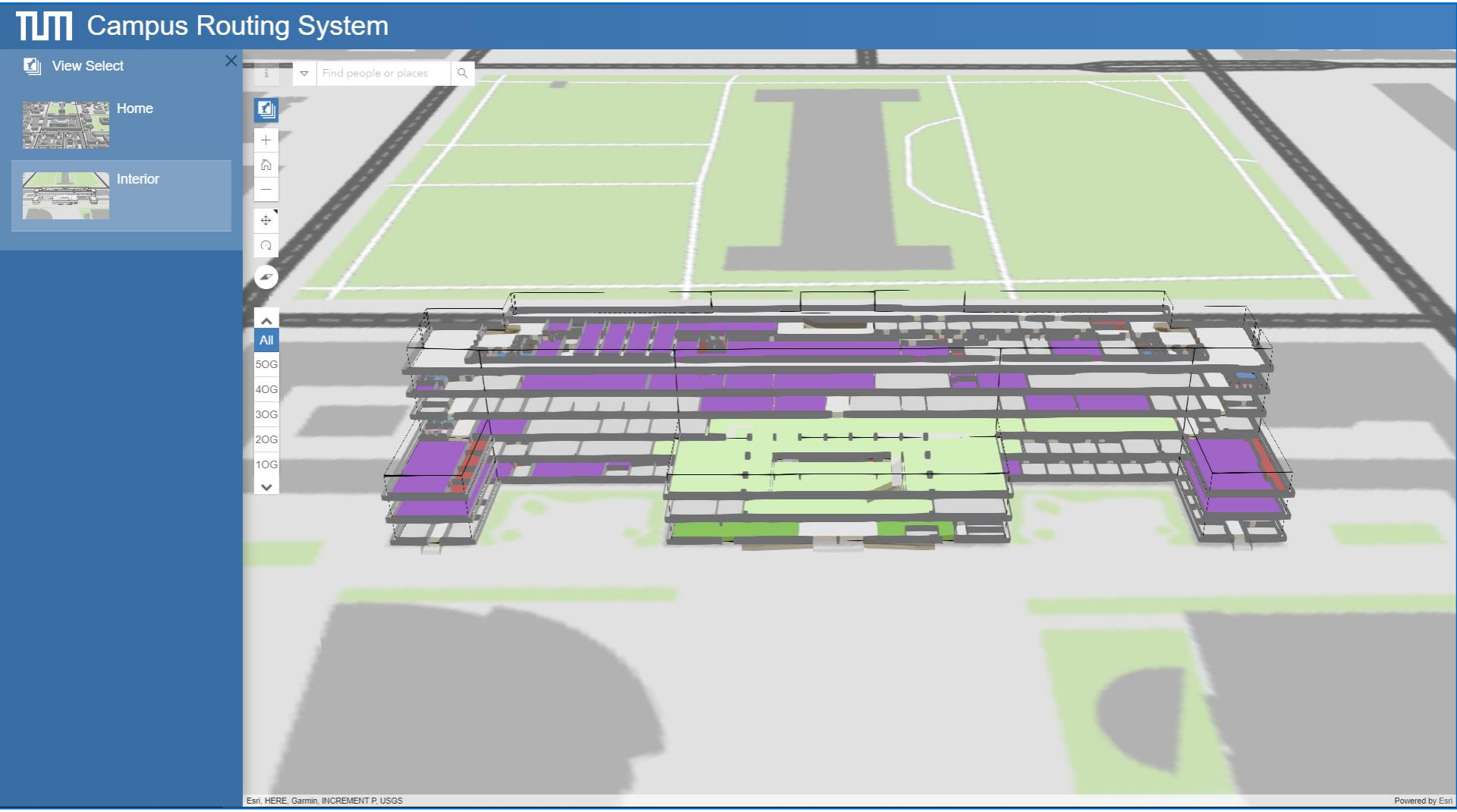
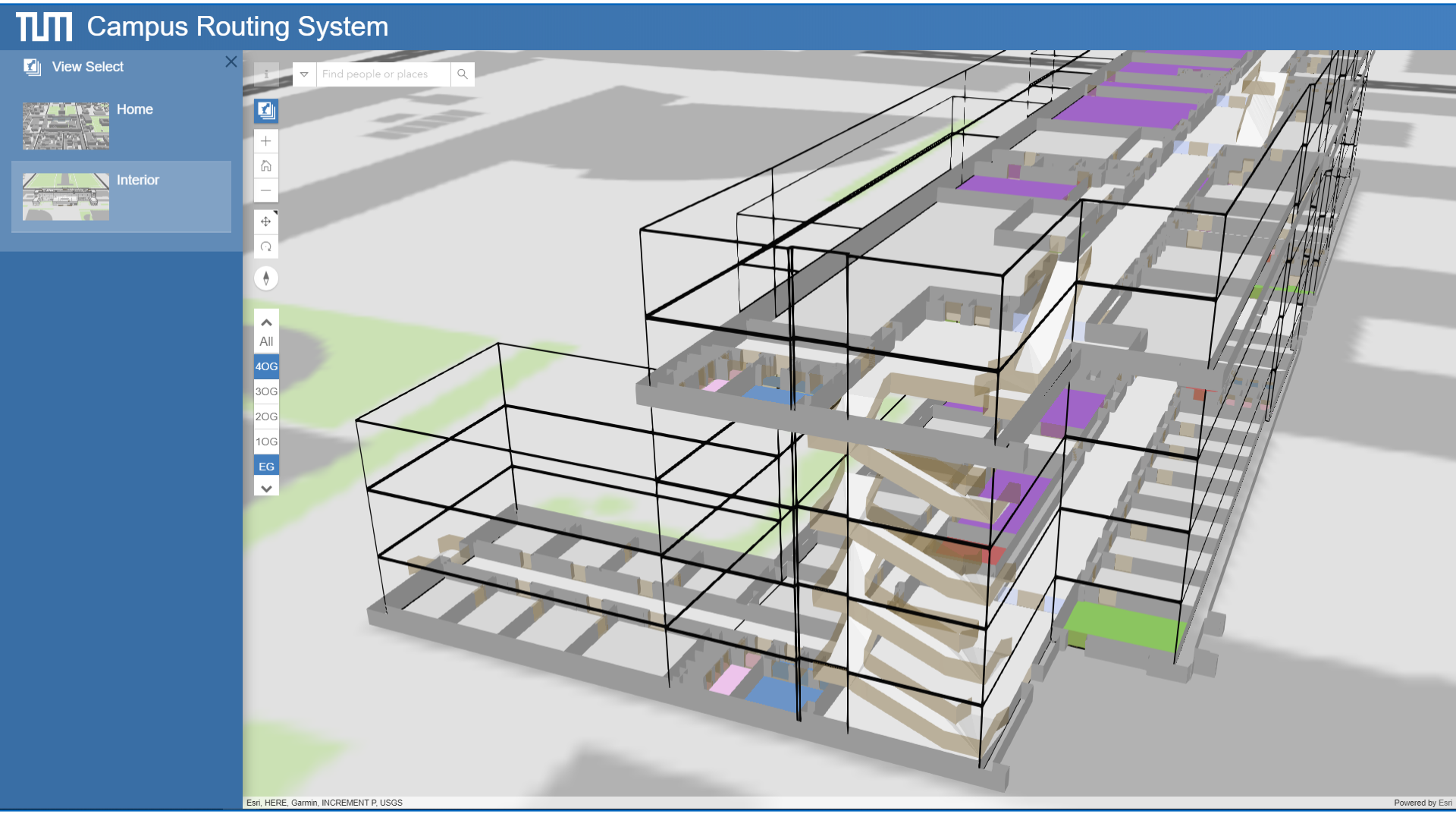
Case study



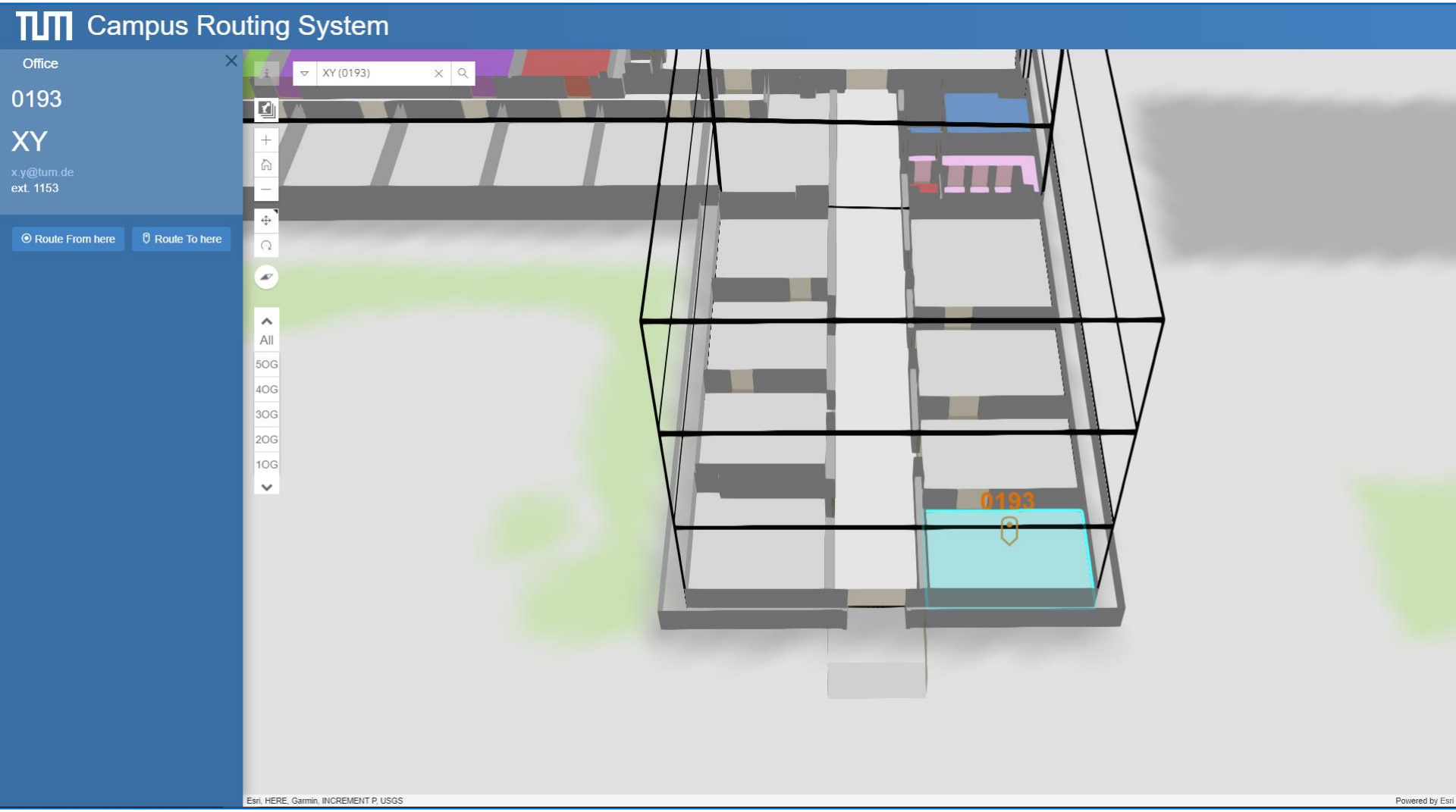
The TUM Campus Routing System

Case study



The TUM Campus Routing System

Case study



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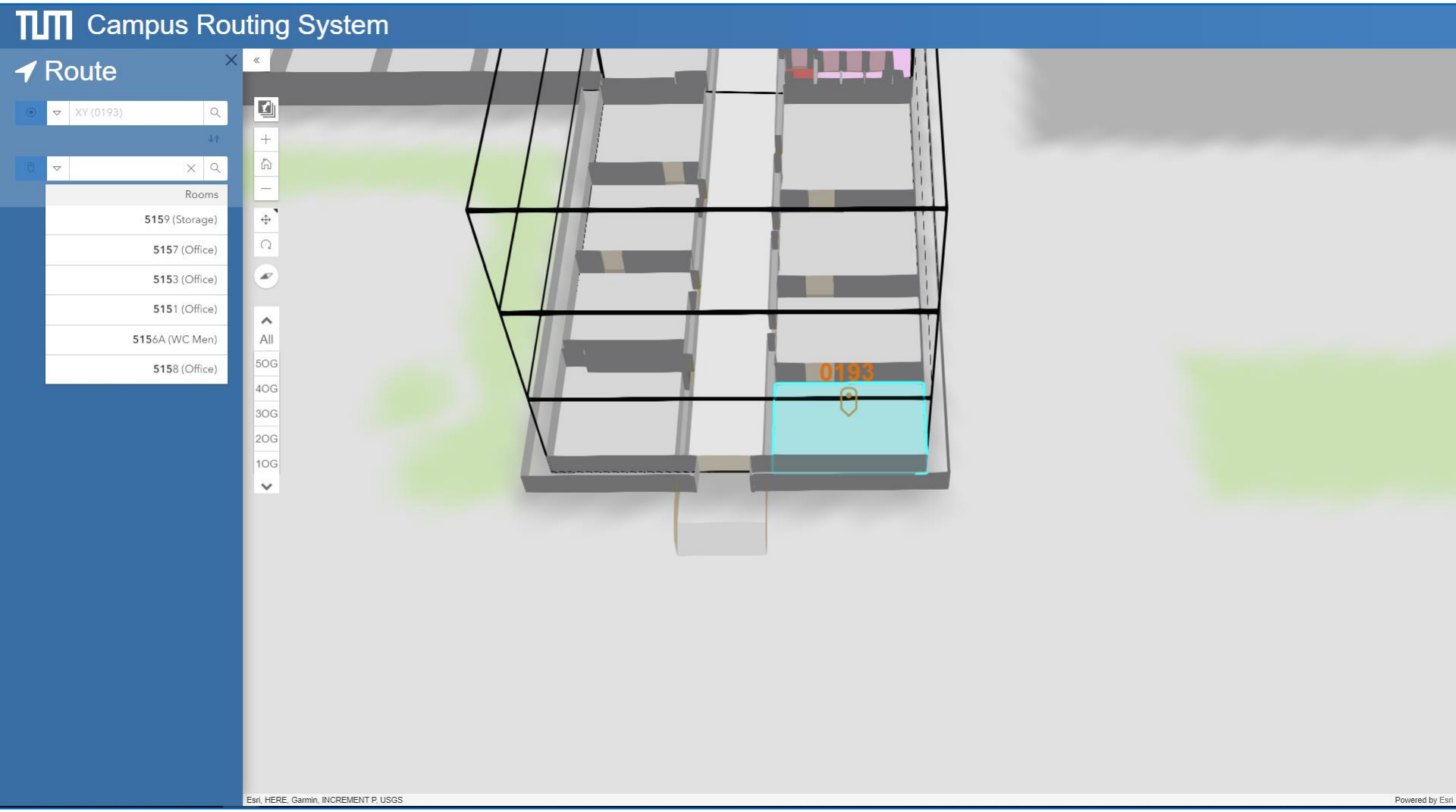

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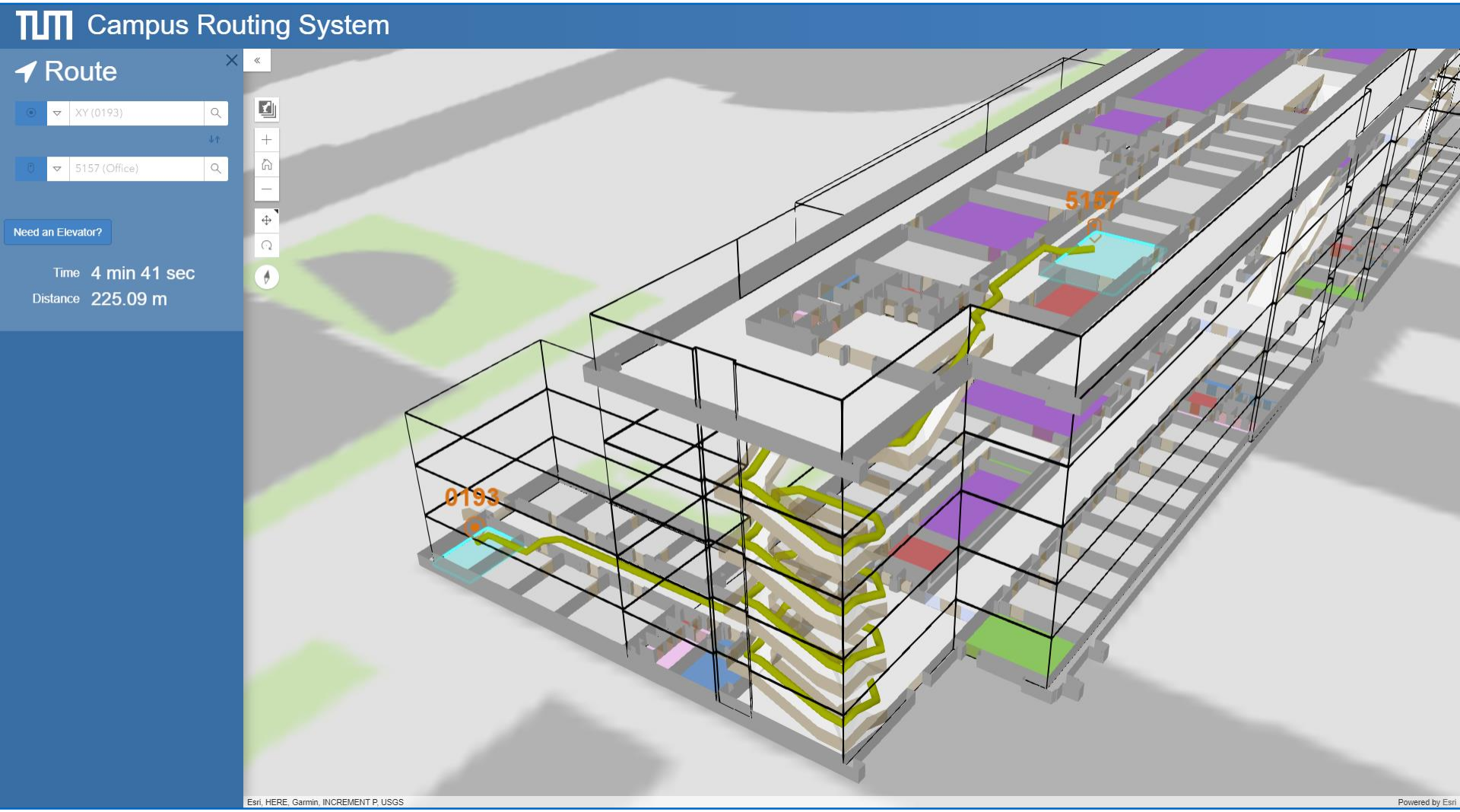
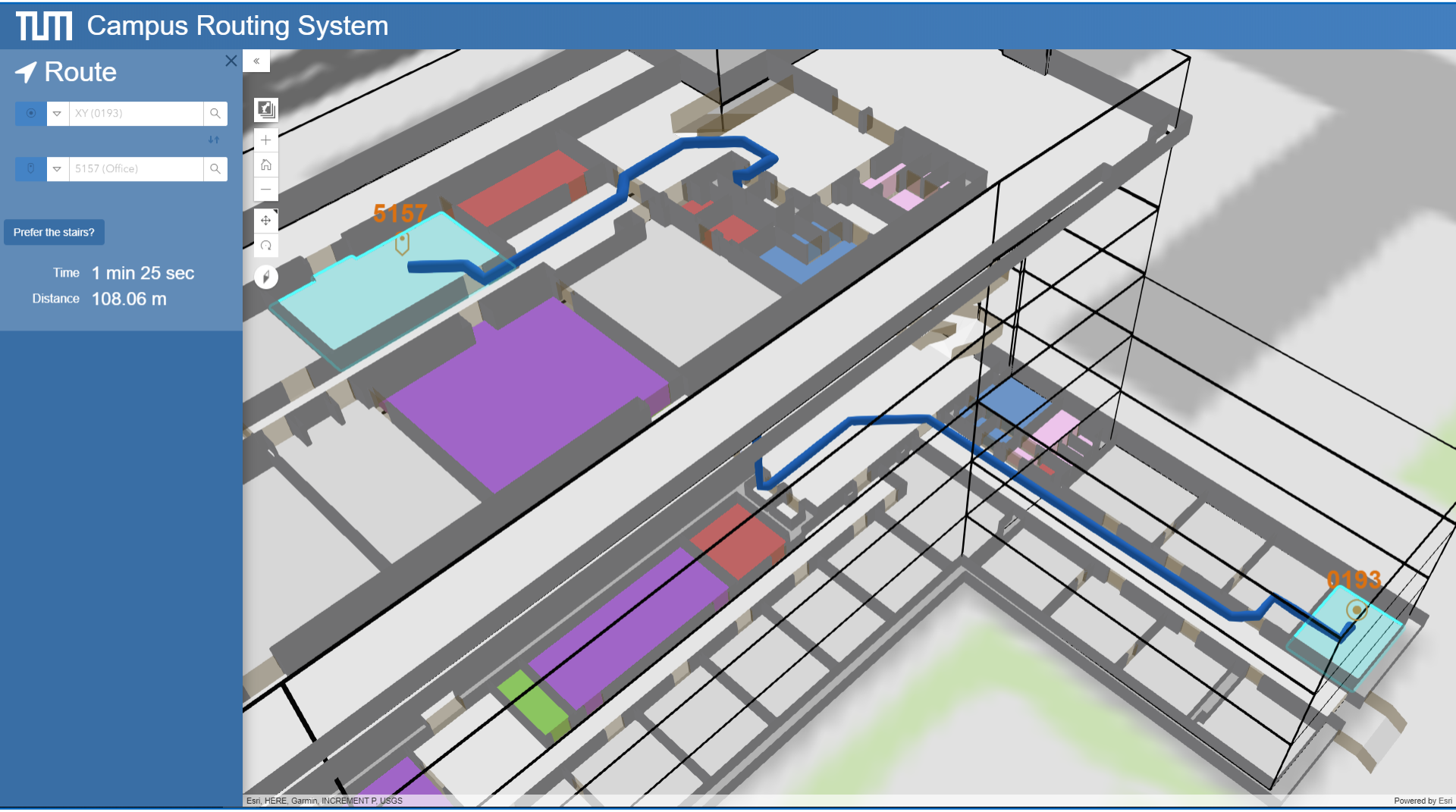


The TUM Campus Routing System

Case study



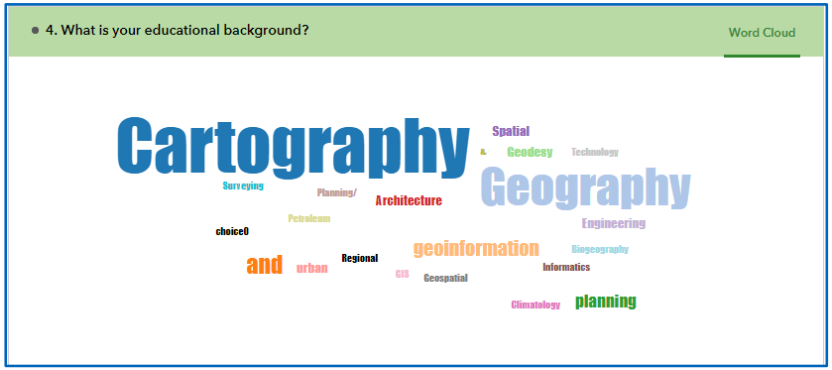
Map design and visualization evaluation

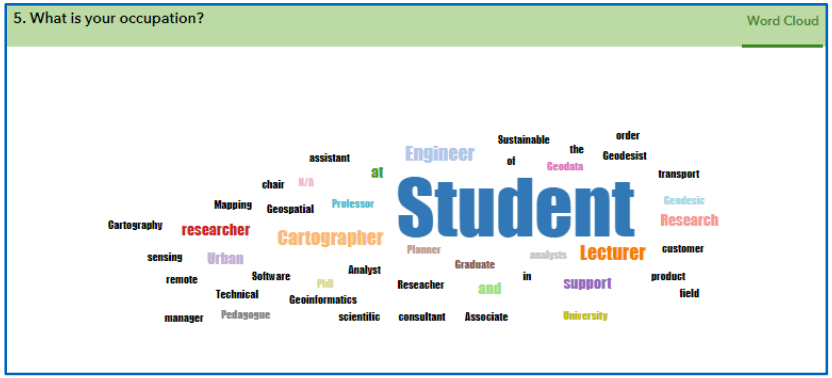
Case study

- Purpose: evaluate whether the design principles and visualization techniques applied for the TUM indoor spaces are appropriate and cartographically appealing.

- Quantitative method → survey:
  - General Information
  - Campus routing map design
  - Campus routing map use

- Expert-based method
  - Online distribution
  - 41 participants
  - Geosciences background





Usability and utility evaluation

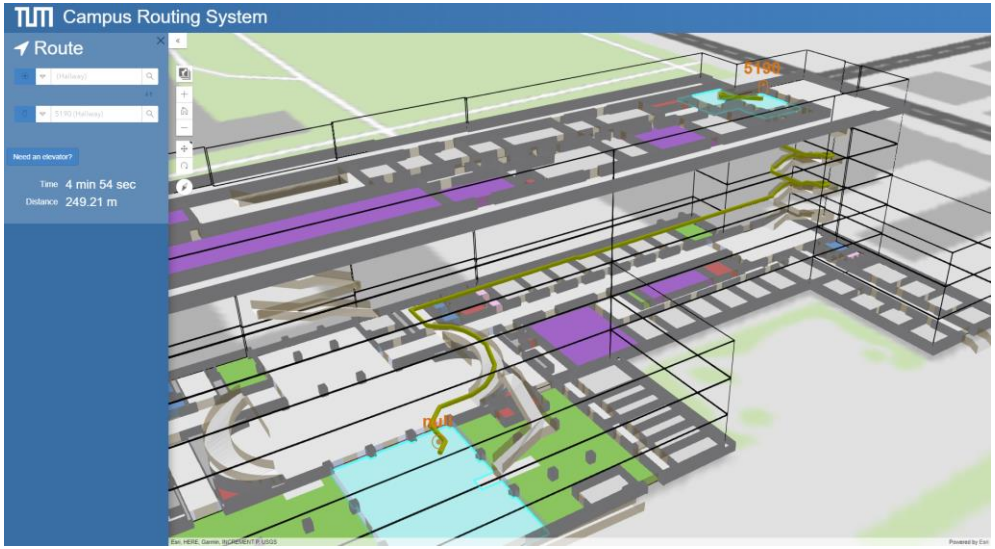
Case study

- Purpose: evaluate the usability and utility of the TUM CRS by measuring its effectiveness and efficiency of the TUM CRS based on users' interaction and experience with the model

- Mixed method of quantitative and qualitative data

1. Experiment:
   - The TUM main building
   - Define your position and search for the provided destination
   - Generate the route and navigate to destination
   - Think aloud
   - Participants observation
2. Survey:
   - General information
   - Interface design
   - Map and route design

- User-based method
  - First time visitors
  - 5 participants



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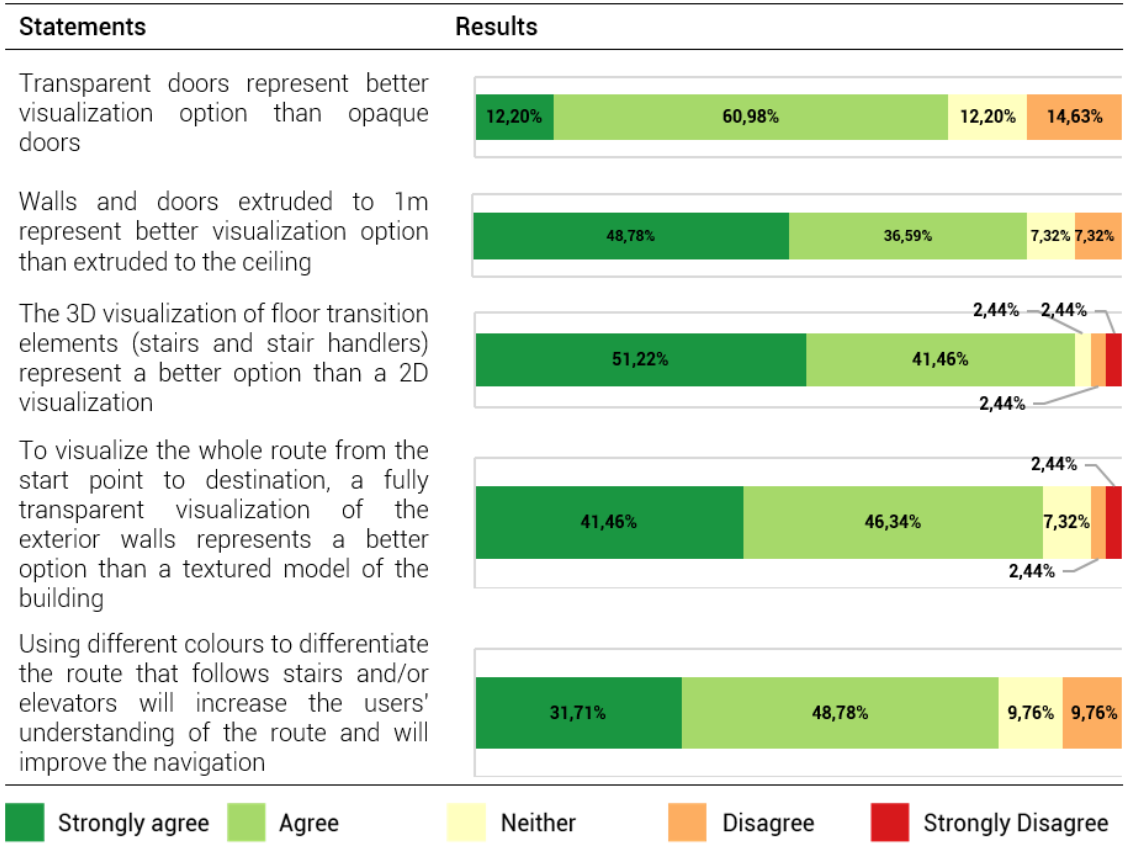
5. Evaluation results

- Map design and visualization
- Usability and utility

Map design and visualization

Evaluation results

- It is preferable to represent the doors with a level of transparency
- Walls and doors should be extruded to a certain height
- A transparent visualization of exterior walls should be used when users will generate a route between indoor spaces
- Different colours should be used when the route follows the stairs or elevators.



Map design and visualization

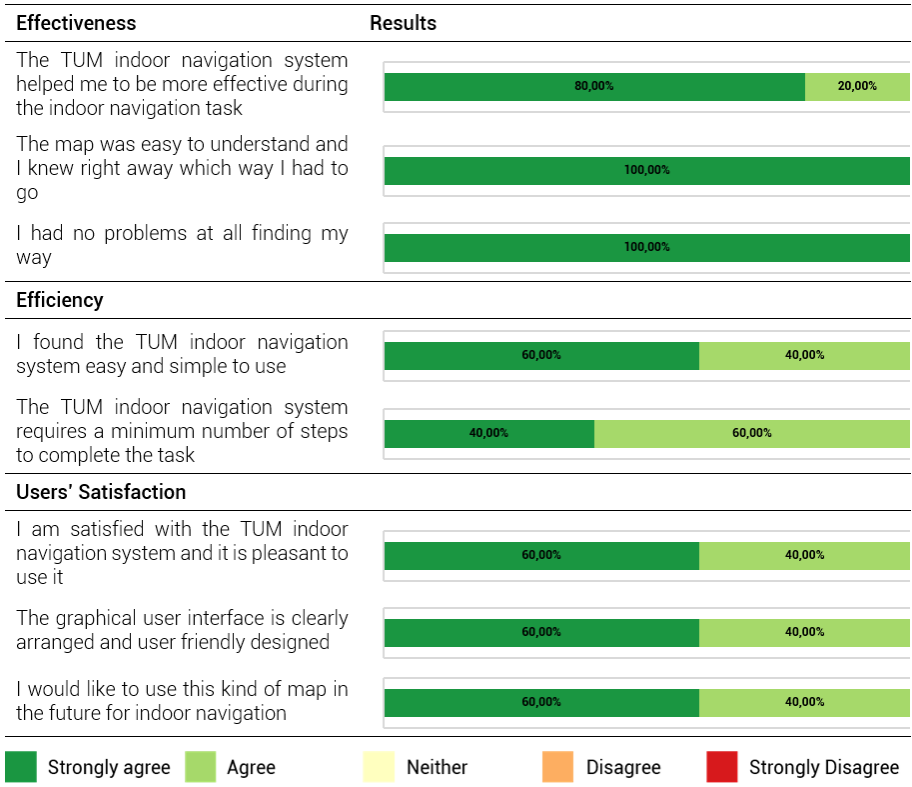
Evaluation results

"Based on what you have seen within this survey, how would you evaluate the developed campus routing model of TUM?"

Usability and utility

Evaluation results

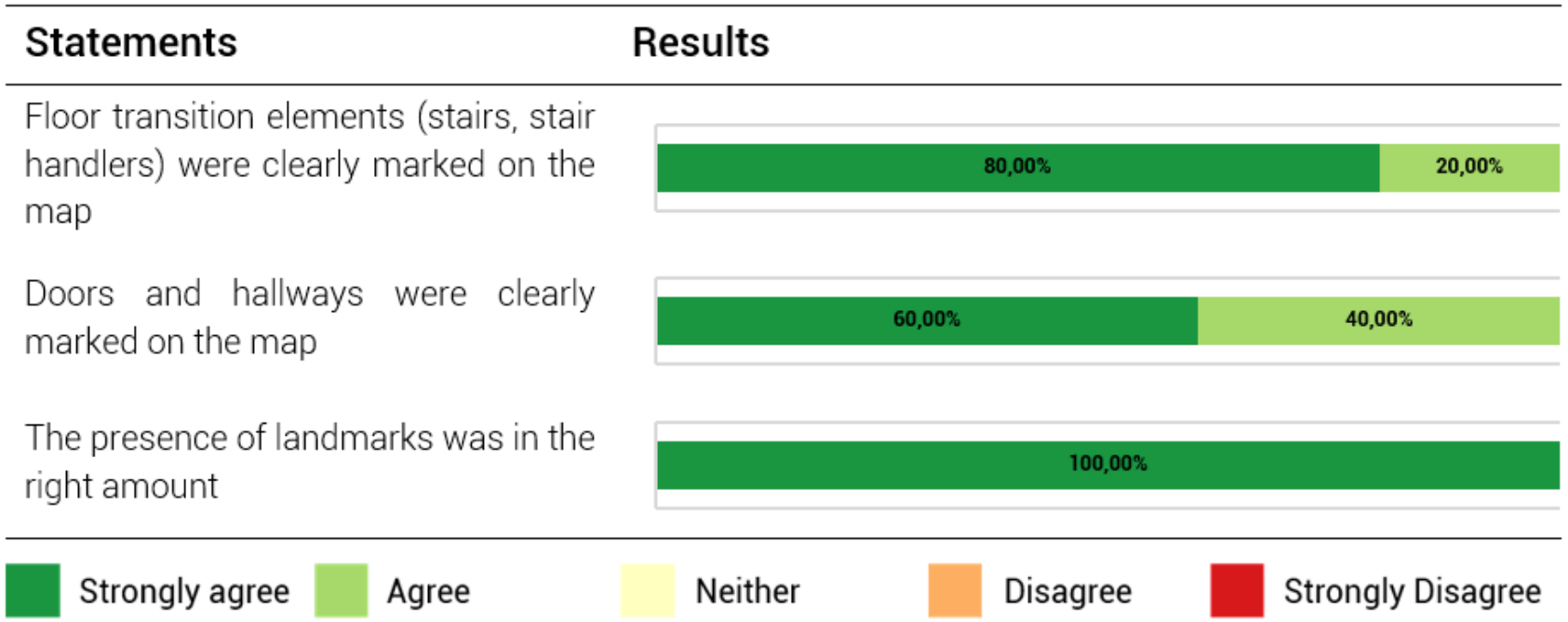
- Effectiveness: The TUM CRS helps users for a more effective indoor wayfinding process as they did not manifest any problems during the task and reached the destination easily.
- Efficiency: The TUM CRS represent an easy and simple to use indoor navigation system and requires a minimum number of steps to generate an indoor route.
- Users' satisfaction: The TUM CRS represent a pleasant indoor navigation app with a user-friendly interface.



Usability and utility

Evaluation results

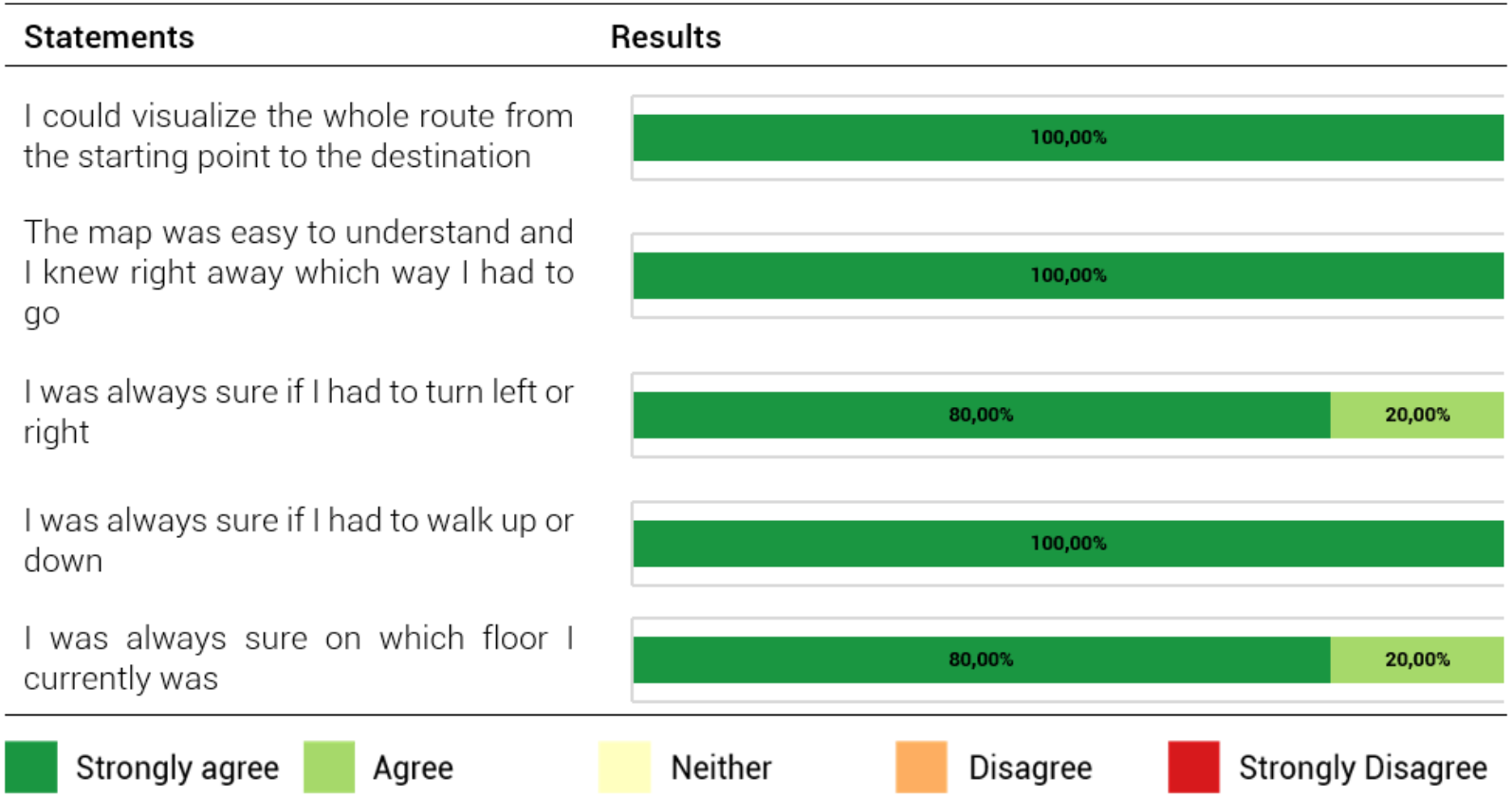
- *Hypotheses 1: Users can navigate in indoor campus environments with only a few or no landmarks, as long as the map design is intuitive and the route planning as well as the route representation avoid confusions among the users.*



Usability and utility

Evaluation results

Hypotheses 2: It is possible for the users to reach their destination in indoor campus navigation systems without the aid of indoor positioning and orientation techniques



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6. Discussion

Discussion

- The literature review on developing and designing a CRS is meagre due to missing literature and only little research.
- The number of exciting CRS taken into consideration to perform an interactivity evaluation could be expanded
- More literature review is needed to identify how and what visual variables should be applied to visualize indoor spaces
- Provide expert users with access to the interactive 3D model of the TUM CRS
- Apply other methods for the user studies to compare the results and reach more participants

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7. Research findings and future work

- Research findings
- Future work recommendations

Research findings

Research findings and future work

- Literature review identifies interactive 3D applications as the medium to visualize and convey indoor navigation systems
- The methodology adopted to develop the TUM CRS can be applied to other campuses and complex indoor spaces
- Expert-based method and user-based method are identified as the most appropriate methods to evaluate the TUM CRS
- The TUM CRS is an indoor navigation application, which makes use of structural features to plan and convey the route to various users in an effective and efficient way.
- High user satisfaction resulting from the user studies

Future work

Research findings and future work

- Future research on the correlation between visual variables and space use
- Apply various evaluation methods with a higher number of participants
- A better observation of users behaviour while using the model to navigate
- Connecting all buildings and campuses of the TUM in a single outdoor/indoor navigation system
- Deploy the TUM CRS as an interactive mobile application
- Enable indoor positioning and orientation by using APIs offered as additional services

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8. Sources

Sources

[1] Li, H. & N. A. Giudice (2012) Using mobile 3D visualization techniques to facilitate multi-level cognitive map development of complex indoor spaces. *Spatial Knowledge Acquisition with Limited Information Displays,* 21**,** 31-36.

[2] Lorenz, A., C. Thierbach, N. Baur & T. H. Kolbe (2013) Map design aspects, route complexity, or social background? Factors influencing user satisfaction with indoor navigation maps. *Cartography and Geographic Information Science,* 40**,** 201-209.

[3] Mittlboeck, M., L. Knoth & B. Vockner (2017) Universitäre Campus Maps – Beispiele aus Österreich und Nordamerika: Status quo & quo vadis? *AGIT – Journal für Angewandte Geoinformatik VDE Verlag, Herbert Wichmann Verlag, Berlin,* 3-2017**,** 374-382.

[4] TUM Roomfinder (https://portal.mytum.de/campus/roomfinder).

[5] TUW floorplans (https://wiki.fsinf.at/wiki/Raum:Hauptseite).

[6] TUD Campus Navigator (https://navigator.tu-dresden.de/).

[7] FHWS Campus-Informationssystem (https://gis.fhws.de/campus/campus_roeri_3D.html).


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