Cartography M.Sc.

Visualizing Connectivity within Innovation Ecosystems in Europe

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Outline

- Problem Statement
- Objectives
- Case Study
- Data Model
- Visualization Methods
- Prototype
- Outlook
- Conclusions

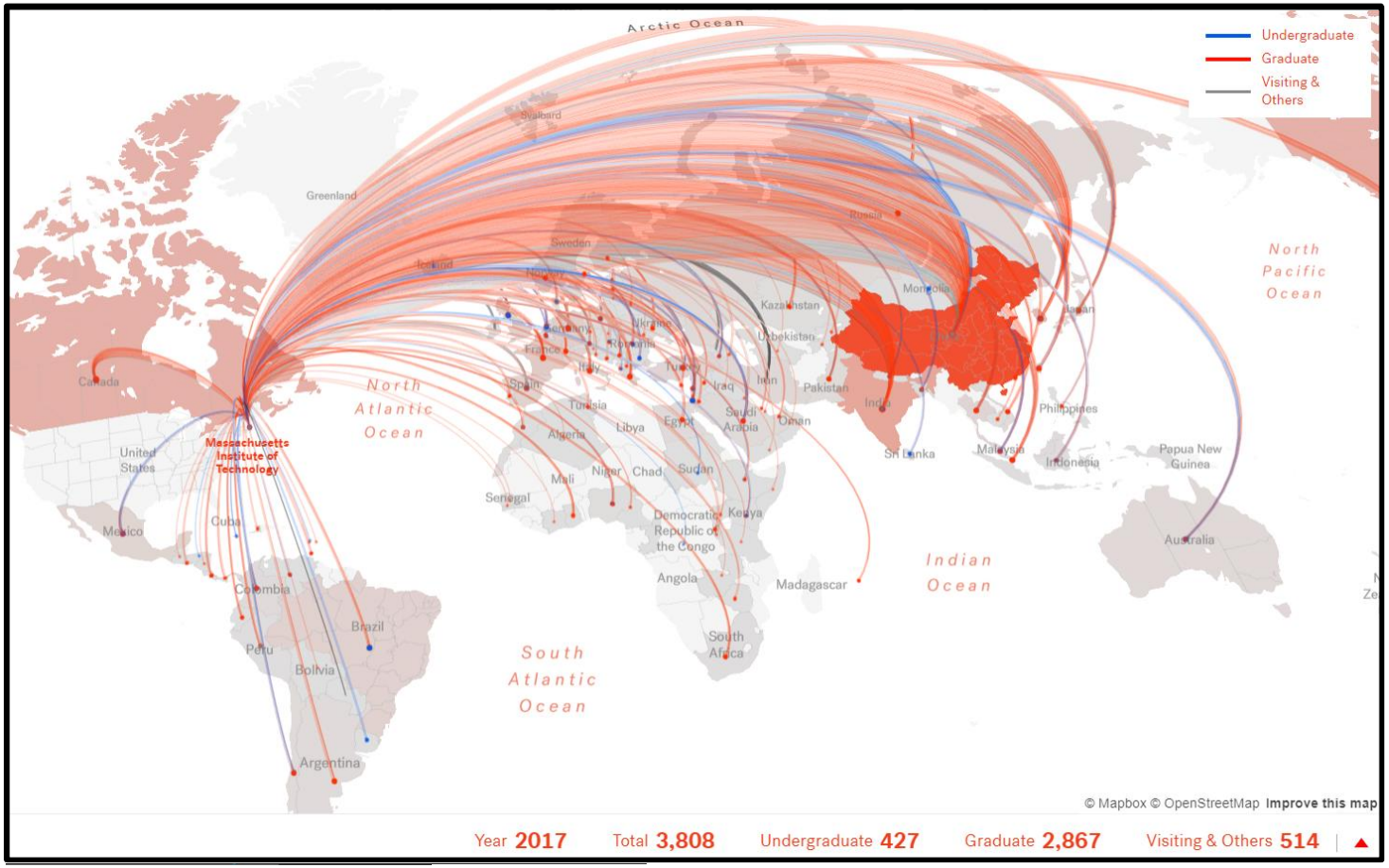
Problem Statement

Innovation Ecosystems

- The term refers to the economic dynamics of the complex relationships that are formed between the material resources and human capital, with a functional goal to enable technology development and innovation. (Jackson, 2011)
- Rising research field in economics.
- Promoting European innovation ecosystems was set as one of the priorities of the Program for Research and Innovation for 2020.
- Lack of visualization approaches addressing entire ecosystems.

Problem Statement

Related Projects



MIT World :: MIT Senseable City Lab - http://senseable.mit.edu/mit-world

Problem Statement

Related Projects

	Startup Heatmap Europe	Startup Hubs Europe	Startup Cartography Project	MIT World
Provides information on nodes	✓	✓	✓	✓
Provides information on links	✗	✗	✗	✓
Uses animation effects for transitions	✗	✗	✗	✓
The map provides not only locations, but also additional relevant information	✗	✗	✓	✓
Charts are linked to the map: changes on the map update the statistic charts	✓	✗	No charts	✗
User can look at the map and the charts simultaneously	✗	✗	No charts	✓

Objectives

Main Objective

To visualize clusters and networks among European Innovation Ecosystems and to map European competences as well as facilities that support technological advances.

Target Users

1. Researchers and decision-makers in charge of interpreting the driving forces and impacts of innovation development,
2. Young entrepreneurs that would like to start new businesses,
3. Parties seeking new partnership agreements.

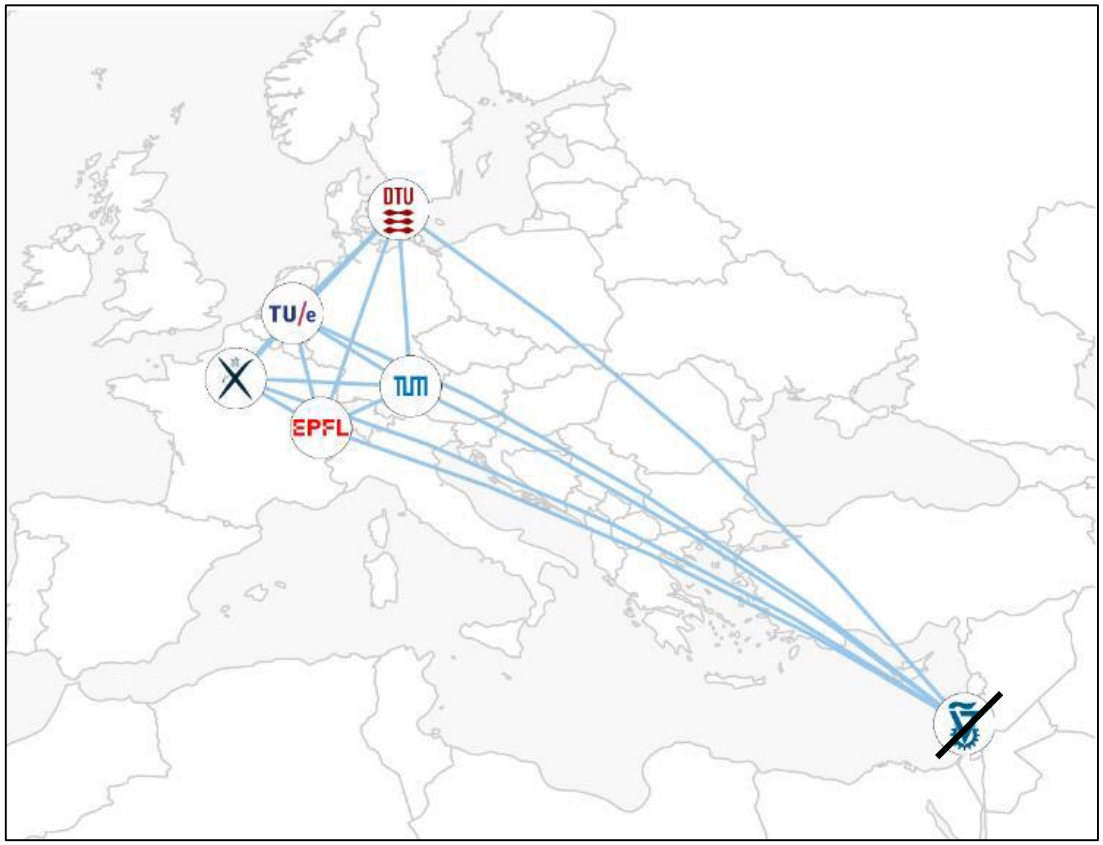
Objectives

Sub-Objectives:

1. To identify the elements that can best describe the complexity of spatial and non-spatial relations among clusters based on a selected case study.
2. To compare network visualization techniques and determine a suitable method that can emphasize the connectivity of science and technology across European boundaries.
3. To build a prototype of an interactive thematic web map enabled to visually represent scientific and technological networks and clusters based on a selected case study.

Case Study

The EuroTech Universities Alliance



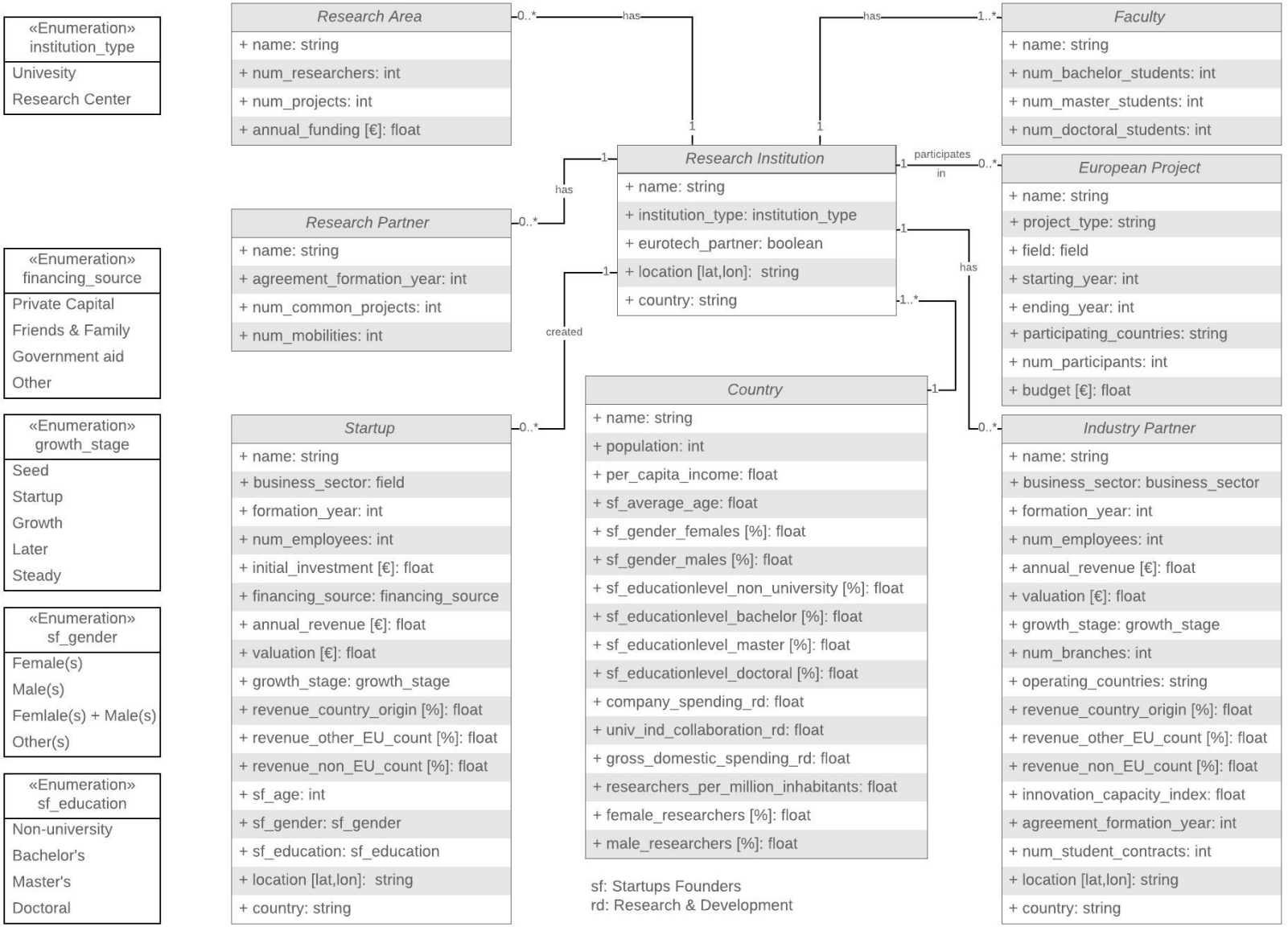
Fully engaged on the evolution of five disciplines:

- Entrepreneurship & Innovation
- Health & Bio Engineering
- Smart & Urban Mobility
- Data Science & Engineering
- High-Performance Computing

First Sub-Objective:

To identify the elements that can best describe the complexity of spatial and non-spatial relations among clusters based on a selected case study.

Data Model


«Enumeration» institution_type
Univesity
Research Center
«Enumeration» financing_source
Private Capital
Friends & Family
Government aid
Other
«Enumeration» growth_stage
Seed
Startup
Growth
Later
Steady
«Enumeration» sf_gender
Female(s)
Male(s)
Femlale(s) + Male(s)
Other(s)
«Enumeration» sf_education
Non-university
Bachelor's
Master's
Doctoral
Research Area
+ name: string
+ num_researchers: int
+ num_projects: int
+ annual_funding [€]: float
Research Institution
+ name: string
+ institution_type: institution_type
+ eurotech_partner: boolean
+ location [lat,lon]: string
+ country: string
Faculty
+ name: string
+ num_bachelor_students: int
+ num_master_students: int
+ num_doctoral_students: int
European Project
+ name: string
+ project_type: string
+ field: field
+ starting_year: int
+ ending_year: int
+ participating_countries: string
+ num_participants: int
+ budget [€]: float
Research Partner
+ name: string
+ agreement_formation_year: int
+ num_common_projects: int
+ num_mobilities: int
Startup
+ name: string
+ business_sector: field
+ formation_year: int
+ num_employees: int
+ initial_investment [€]: float
+ financing_source: financing_source
+ annual_revenue [€]: float
+ valuation [€]: float
+ growth_stage: growth_stage
+ revenue_country_origin [%]: float
+ revenue_other_EU_count [%]: float
+ revenue_non_EU_count [%]: float
+ sf_age: int
+ sf_gender: sf_gender
+ sf_education: sf_education
+ location [lat,lon]: string
+ country: string
Country
+ name: string
+ population: int
+ per_capita_income: float
+ sf_average_age: float
+ sf_gender_females [%]: float
+ sf_gender_males [%]: float
+ sf_educationlevel_non_university [%]: float
+ sf_educationlevel_bachelor [%]: float
+ sf_educationlevel_master [%]: float
+ sf_educationlevel_doctoral [%]: float
+ company_spending_rd: float
+ univ_ind_collaboration_rd: float
+ gross_domestic_spending_rd: float
+ researchers_per_million_inhabitants: float
+ female_researchers [%]: float
+ male_researchers [%]: float
Industry Partner
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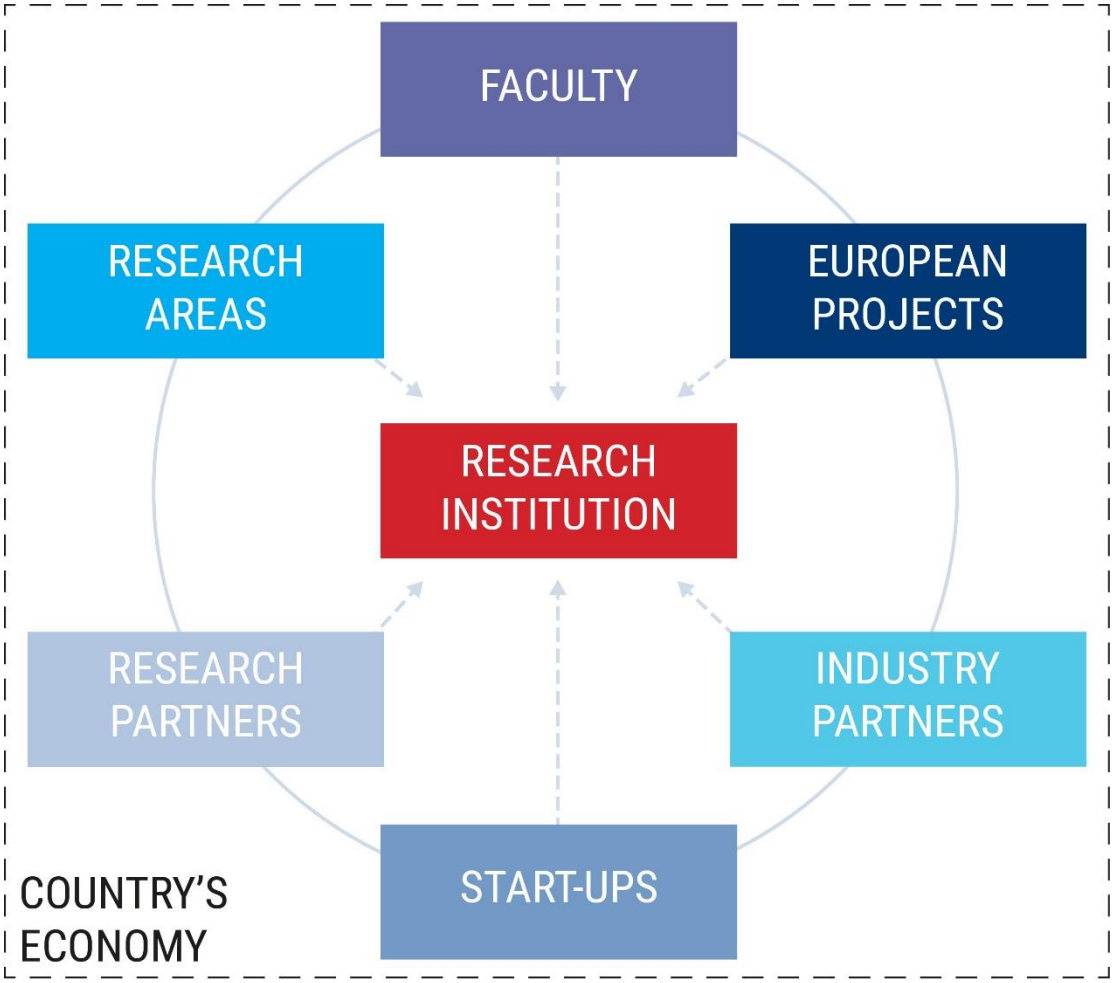
+ business_sector: business_sector
+ formation_year: int
+ num_employees: int
+ annual_revenue [€]: float
+ valuation [€]: float
+ growth_stage: growth_stage
+ num_branches: int
+ operating_countries: string
+ revenue_country_origin [%]: float
+ revenue_other_EU_count [%]: float
+ revenue_non_EU_count [%]: float
+ innovation_capacity_index: float
+ agreement_formation_year: int
+ num_student_contracts: int
+ location [lat,lon]: string
+ country: string
has
participates in
created
0..*
1..*
1
sf: Startups Founders
rd: Research & Development

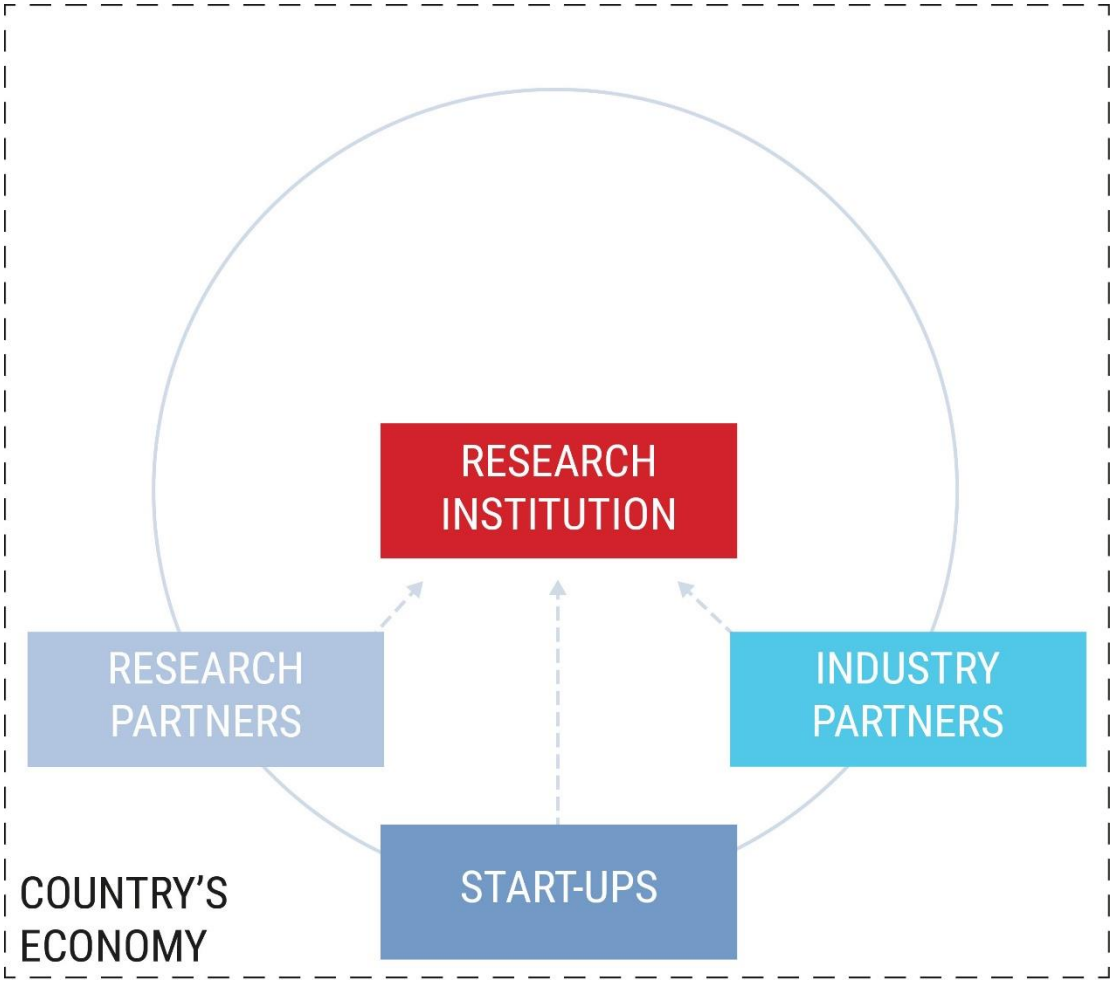
Data Model

Components of Universities' Innovation Ecosystems



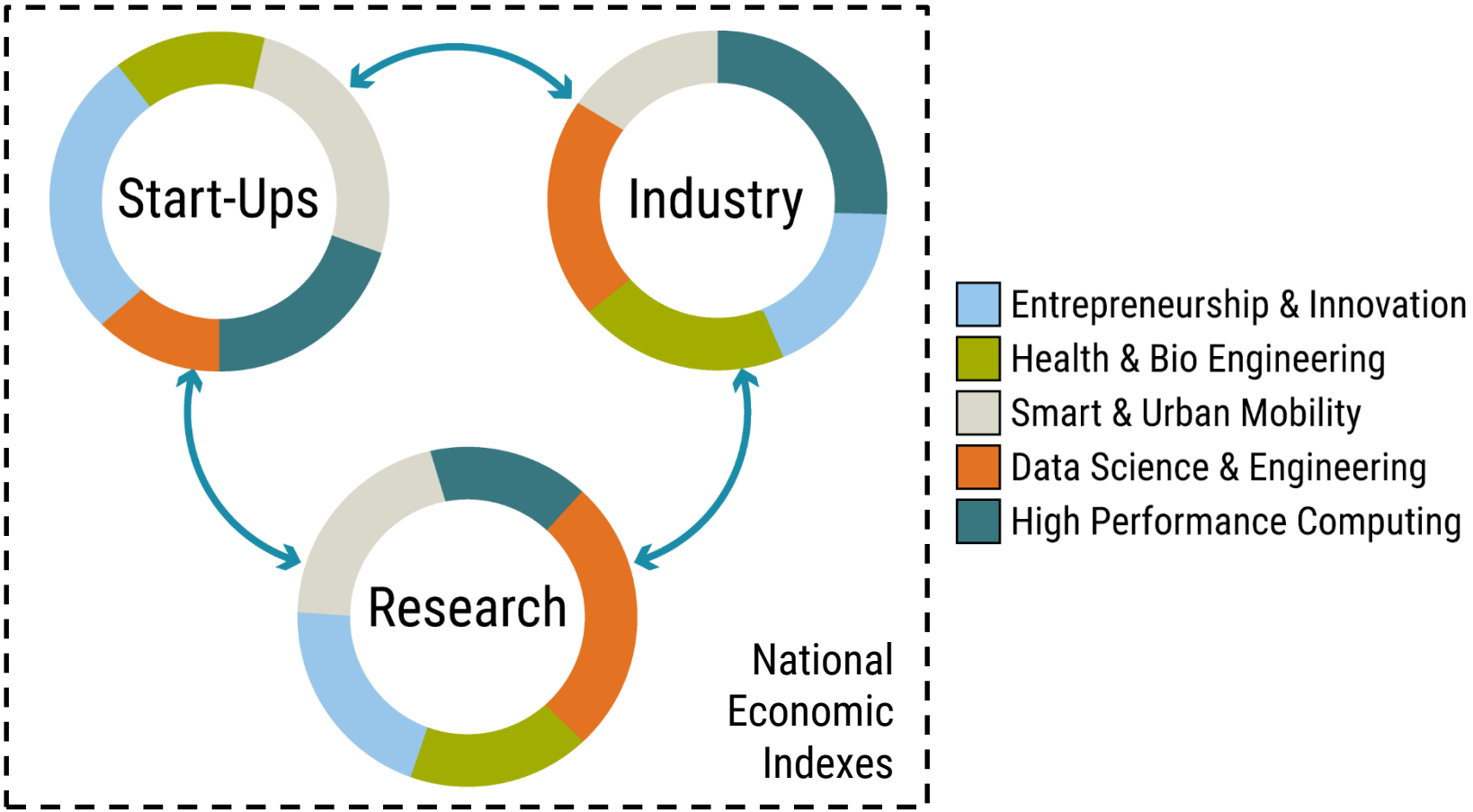
Data Model

Components of Universities' Innovation Ecosystems



Data Model

Components of Universities' Innovation Ecosystems



Data Model

Data Collection

- Data describing innovation ecosystems is:

  - Composed of spatial and non-spatial attributes.

  - Highly dynamic and heterogeneous.

- Available real data regarding each university's partnerships was collected.

- Missing data was randomly generated.

Data Model

Description of Tables in the Database

Name	Content	Usage
universities	Basic information	Place universities on the map
startups	Start-ups formed by former students	Provide statistical data for thematic map layers and charts
research	Research partners	Provide statistical data for thematic map layers and charts
companies	Associated companies	Provide statistical data for thematic map layers and charts
country_indexes	Economic indexes of countries	Draw the choropleth map

To retrieve the necessary input for the charts in the prototype, the open-source JS library TaffyDB was used.

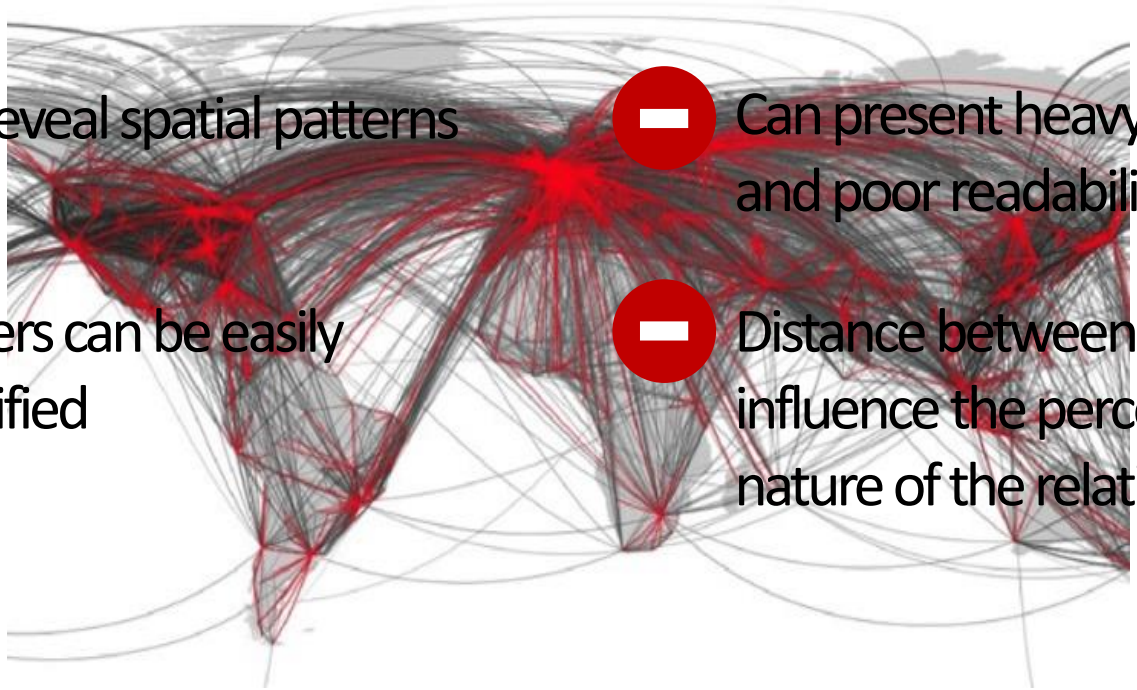
Second Sub-Objective:

To compare network visualization techniques and determine a suitable method that can emphasize the connectivity of science and technology across European boundaries.

Visualization Methods

Geographic Network Visualization

Nodes are placed on their geographic location



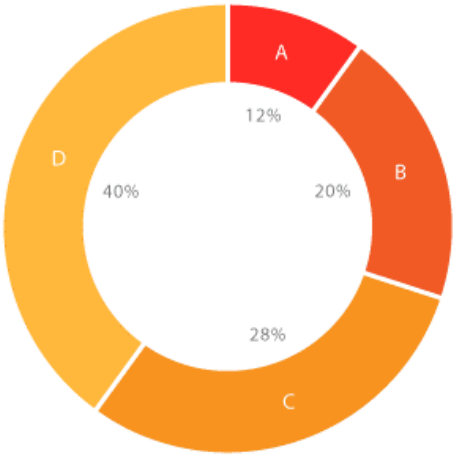
- ➕ Can reveal spatial patterns
- ➕ Clusters can be easily identified
- ➖ Can present heavy cluttering and poor readability
- ➖ Distance between nodes influence the perception of the nature of the relationships

Visualization Methods

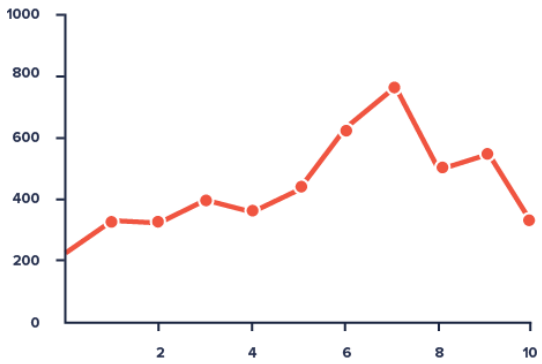
Data Visualization Charts

Data describing the innovation ecosystems is <u>quantitative</u>

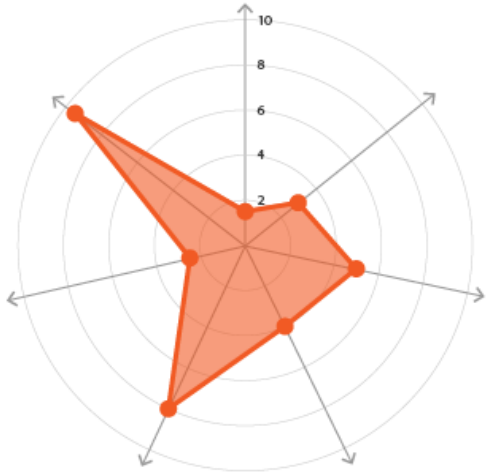
Donut Chart



Line Chart



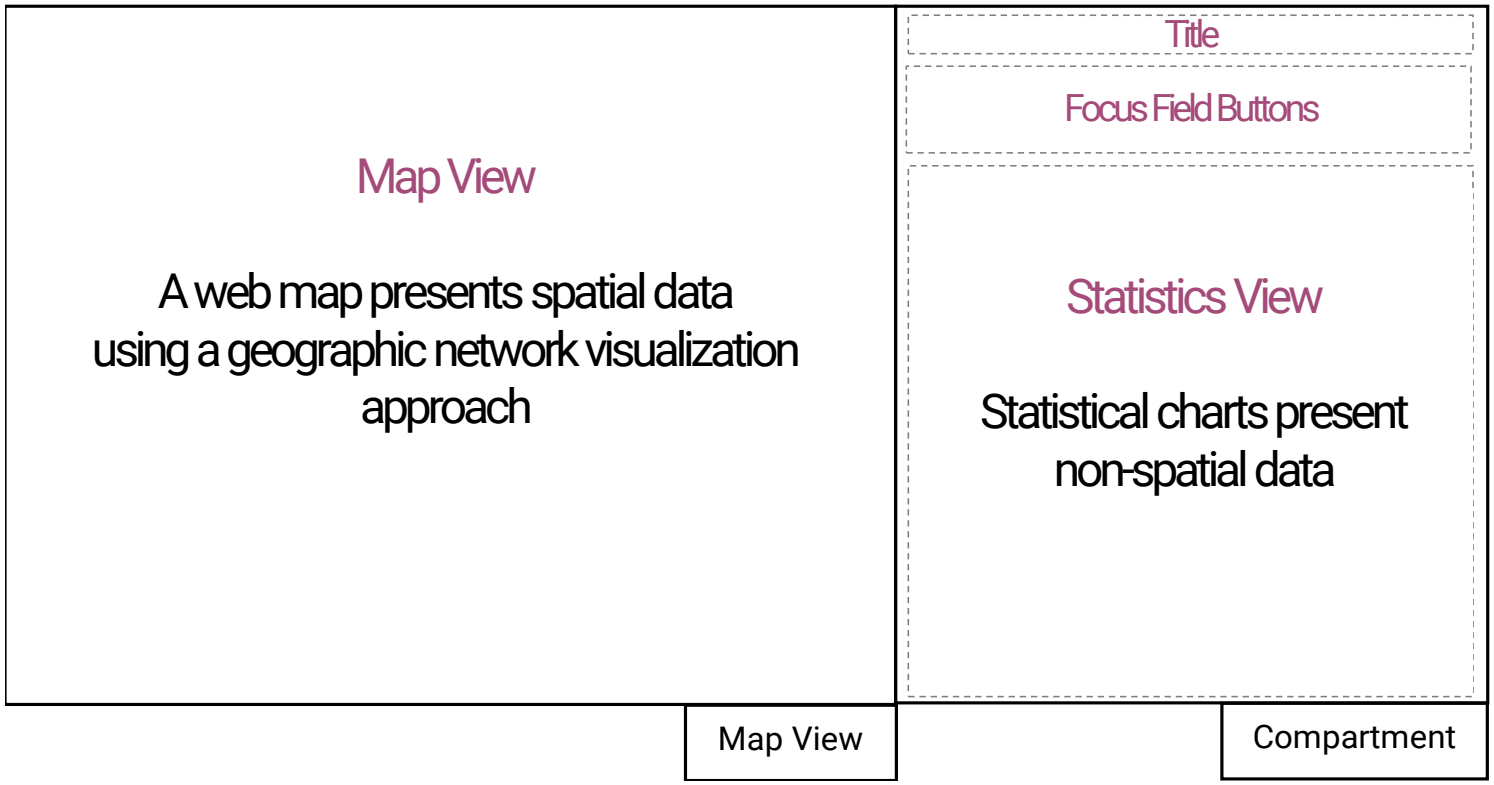
Radar Chart



Visualization Methods

Interactive Web Map

- HTML, JS, CSS , and D3 were combined to develop an interactive web map with the following layout:

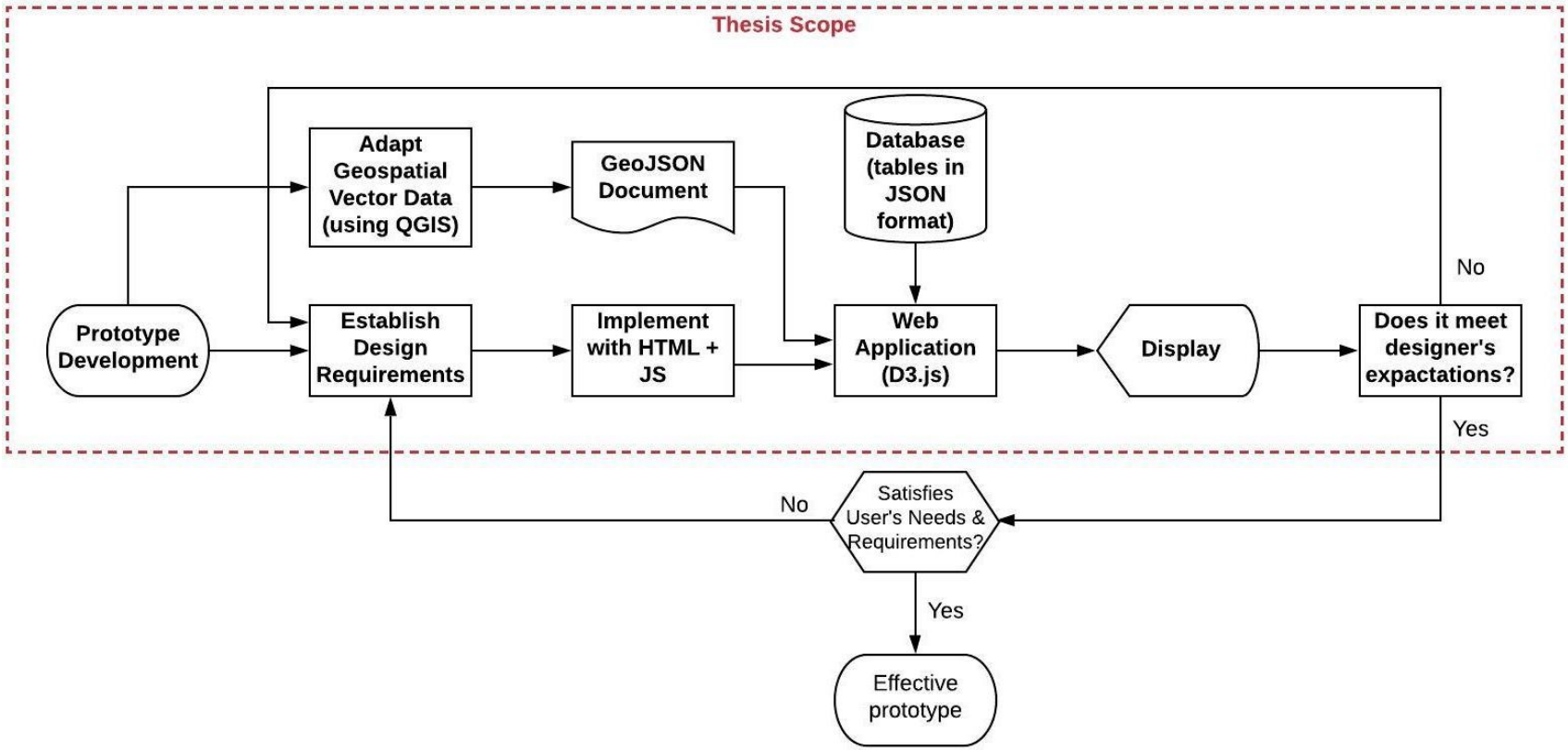


Third Sub-Objective:

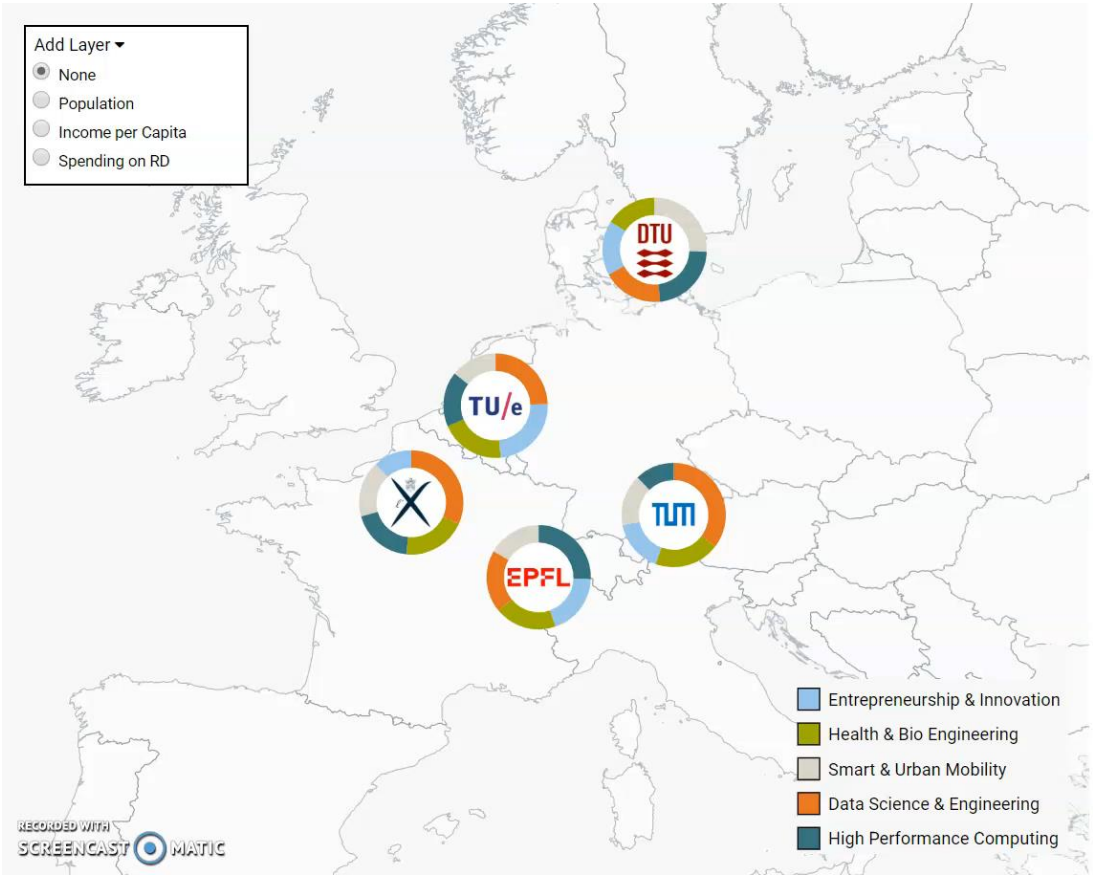
To build a prototype of an interactive thematic web map enabled to visually represent scientific and technological networks and clusters based on a selected case study.

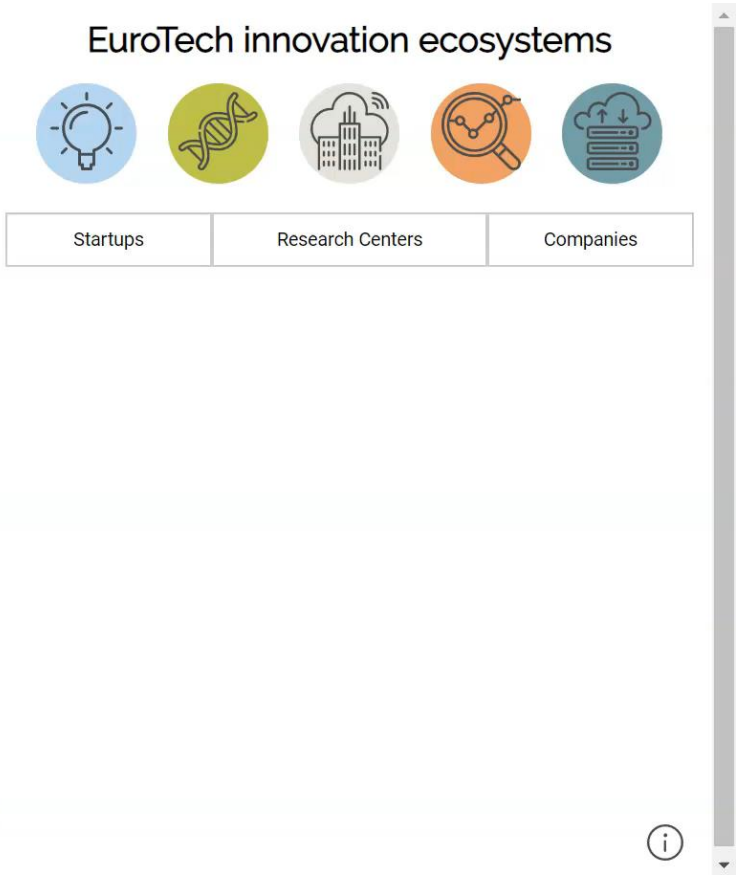
Prototype

Workflow



Prototype


Add Layer
None
Population
Income per Capita
Spending on RD
DTU
TU/e
EPFL
Entrepreneurship & Innovation
Health & Bio Engineering
Smart & Urban Mobility
Data Science & Engineering
High Performance Computing
RECORDED WITH SCREENCAST MATIC


EuroTech innovation ecosystems
Startups
Research Centers
Companies

Prototype

Comparison of Functionalities for Data Visualization

	Prototype	Startup Heatmap Europe	Startup Hubs Europe	Startup Cartography Project	MIT World
Provides information on nodes	✓	✓	✓	✓	✓
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Outlook

- Consult with specialists in innovation and entrepreneurship to validate the data model.
- Test other visualization methods.
- Improve the prototype by adding additional features.
- Conduct one or several user studies to validate the presented methodology.

Conclusions

- This thesis presents:
  - A data model that successfully integrates spatial and non-spatial data,
  - Visualization techniques that can handle and efficiently convey such data, and
  - An interactive web map prototype that integrates that data model and those visualization techniques.
- The methodology introduces a new approach for the visualization of innovation ecosystems.

Conclusions

- The project is in line with European policies:
  - By encouraging the development of European innovation ecosystems through the integration of education, research, and entrepreneurship.
  - By being fully developed in an open-source environment following the trends of Open Data.


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UNIVERSITÄT
WIEN
Vienna University of Technology