Technische Universität Berlin

AI-Driven Strategies for Optimal EV Charging Station Deployment

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Introduction

1. Situations
   - EVs as a solution for reducing greenhouse gas emission
   - Increasing the usage of EVs and the growth in the sales market
   - Challenges in deploying Charging infrastructure

2. AI-driven approach
   - Optimizing strategies for the deployment of EV charging stations
   - Pave the way to the integration with renewable energy sources

Challenges and Goals

1. Objectives
   - Explore AI methods for planning charging station deployment
   - Identifying key influencing factor

2. Challanges
   - Limited Parking availability
   - Variety of traffic flow patterns
   - Energy distribution (various energy or electricity capacity)

Data Collection

Exploring Standards, Metrics and Case Studies

Key Questions:

- What is utilization rate and why is it important?
- What is efficiency score ?
- Why the standards are important ?
- How and where did we collect the data ?

Data Collection

Charger Utilization Metrics

Utilization = Active time / Total available time

- **High utilization rates:** suggests adding **more** chargers
- **Low utilization rates:** Over-provisioning or **poor** placement

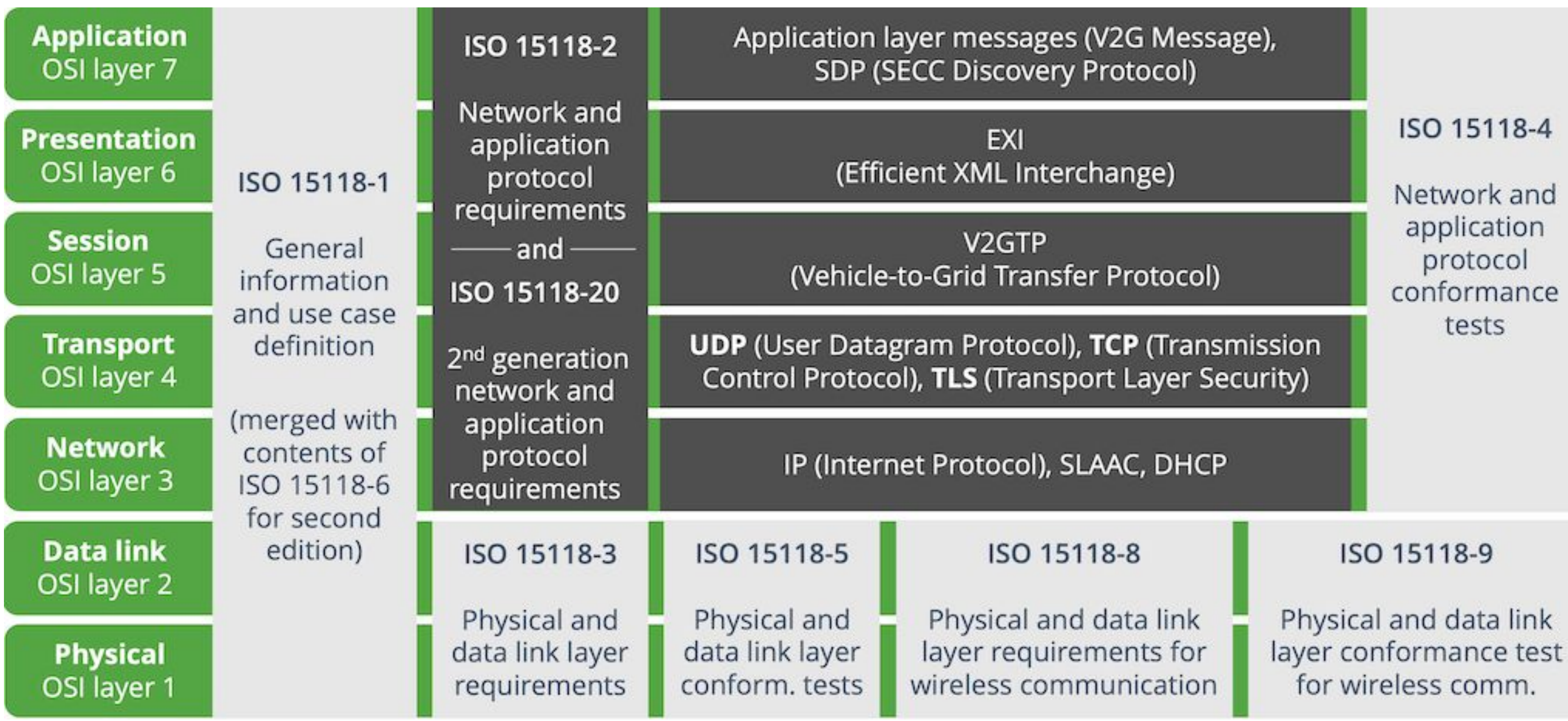
Efficiency score: Measures the ratio of energy delivered to vehicles versus the maximum capacity of the charger during a given period.

- **Low efficiency scores -** Suggest operational inefficiencies or underused stations
- **High efficiency scores -** Indicate effective energy delivery and charger utilization

Data Collection

ISO 15118: Communication Standards

- Communication protocols: EVCC ↔ SECC via cable or Wi-Fi.



ISO 15118

Data Collection

How and where did we collect the data ?

- Berlin Open Data

- To display geospatial data as map layers directly from a server

Elektro-Ladesäulen und Ladepunkte - [WMS]

Standort- und flächenbezogene Informationen zu Elektro-Ladesäulen im öffentlichen und öffentlich zugänglichen Raum auf privatem Grund, zu Ladepunkten im öffentlichen und... Details →

Geographie und Stadtplanung

Lizenz:	Stand:
dl-de-by-2.0	24.01.2025

Formate:

WMS (unbekannt) HTML

Methodology - AI Methods

There are 2 main types for our purposes:

Supervised Learning - Regression

- Labelled data
- Multivariable linear equation

Cons:

- Needs large amounts of labeled data
- Otherwise overfits

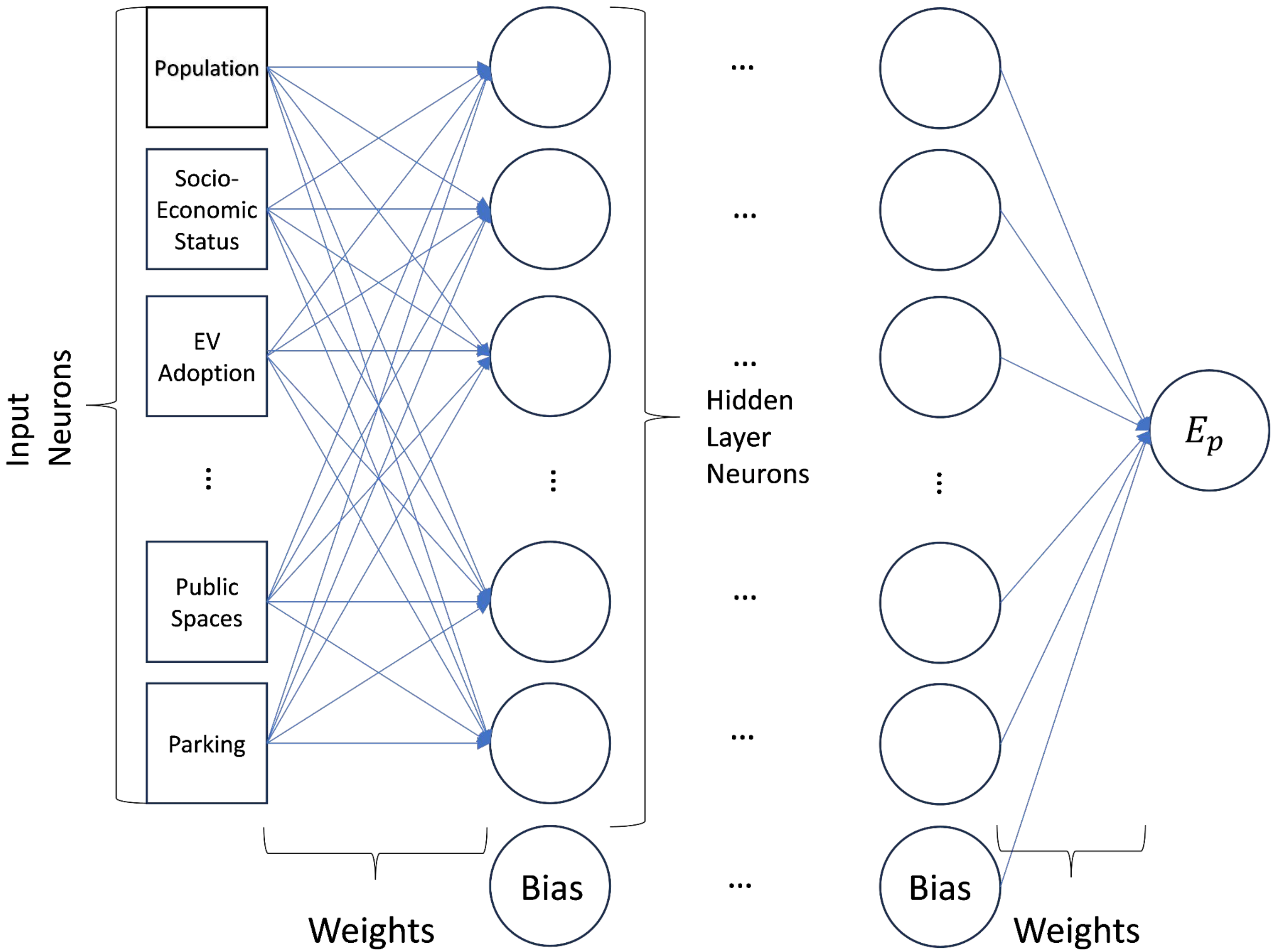
Unsupervised Learning - Clustering

- Unlabelled data
- Find patterns in the data
- Putting similar data into clusters

Cons:

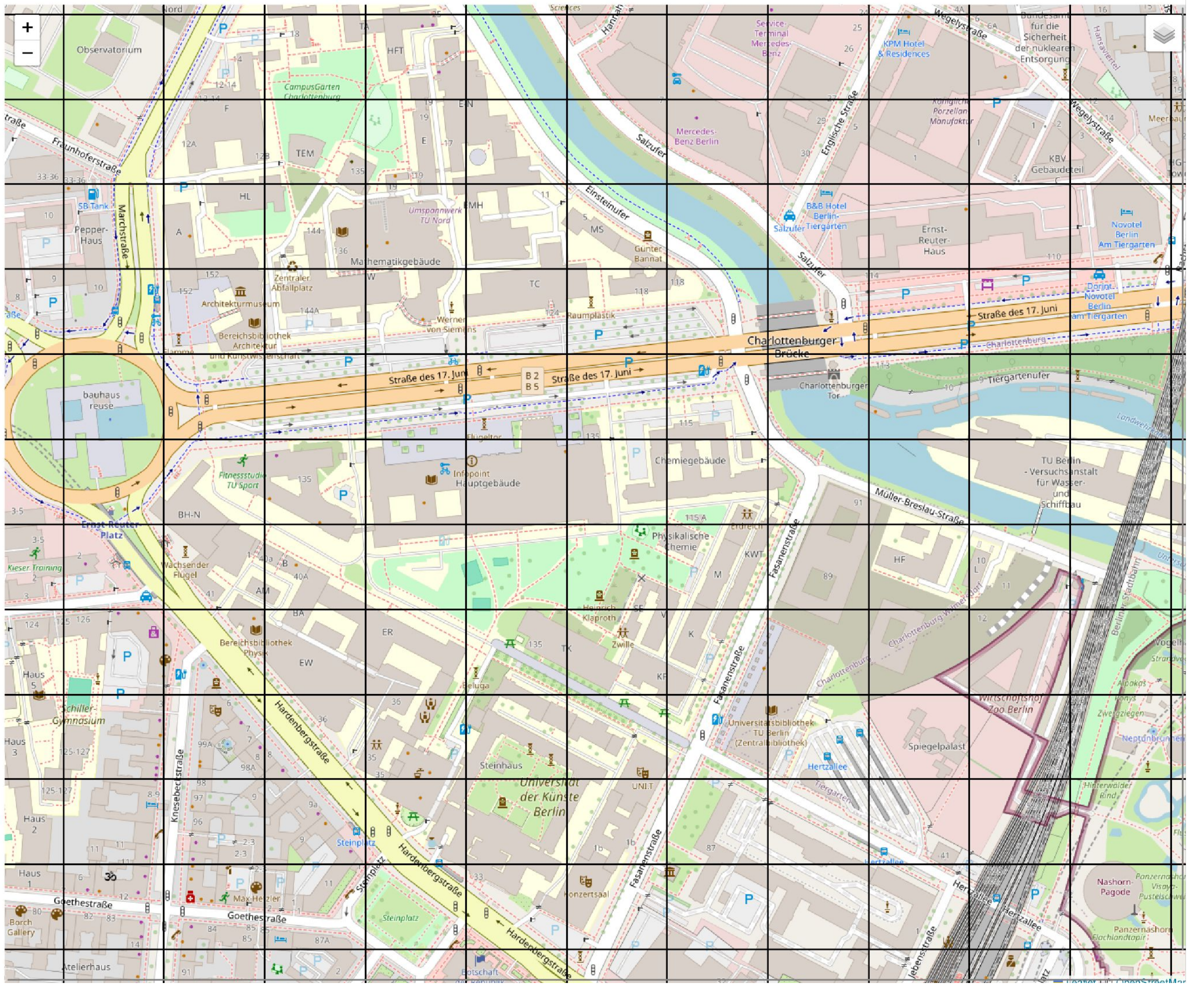
- Not decisive
- The patterns are not guaranteed to be meaningful

Methodology - Neural Networks



Grid Partition Method

The process of dividing a geographical area into smaller areas



Working With Open Data

EV charger utilization data is not publicly available

Two options:

Generating the utilization data

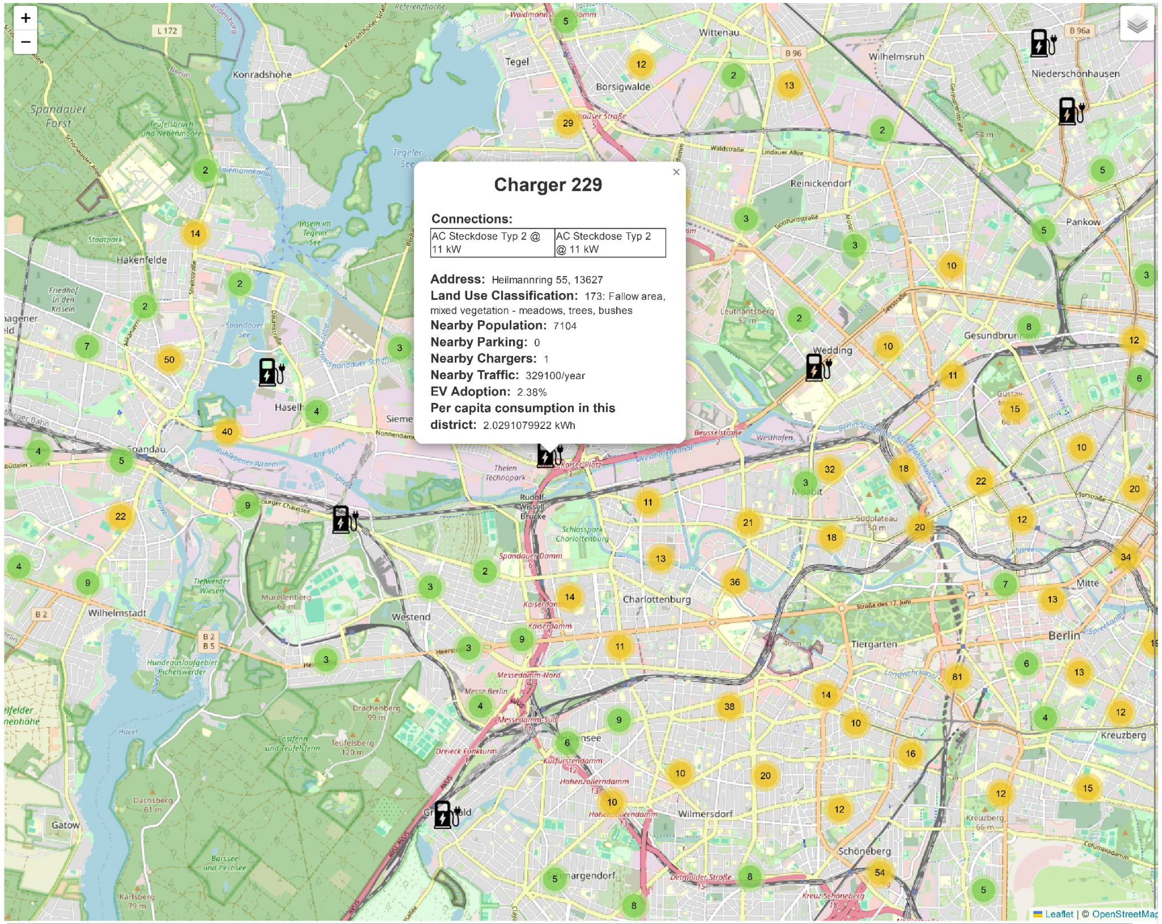
Variable	Units	Lower a	Best a	Upper a
Traffic, a_1	$Events/10^3 \cdot ADT$	17	35	53
Population, a_2	$Events/kPop$	-23	8	39
Competition, a_3	$Events/Comp$	-152	-77	-2
InterProv, a_4	$Events/InterProv$	980	1335	1690

Jayanath et al.'s regression coefficients

Niranjan Jayanath, Nathaniel S. Pearre, and Lukas G. Swan. “Geographic factors impacting the demand for public EV charging: an observational study”. In: World Electric Vehicle Journal 15.10 (Sept. 2024), p. 445. url: https://doi.org/10.3390/wevj15100445.

Using unsupervised learning(with clustering)

Visualization

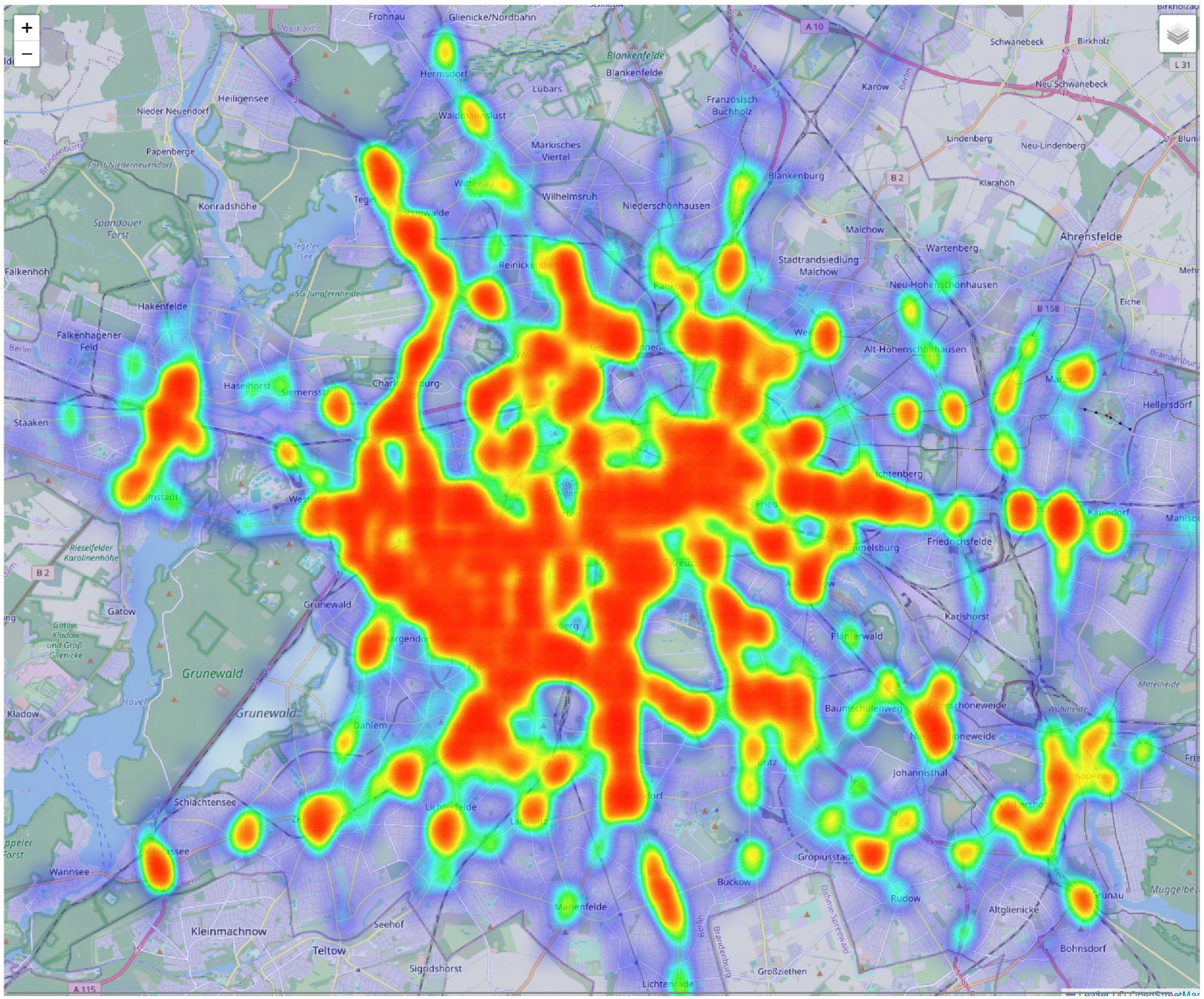


Visualization using a map

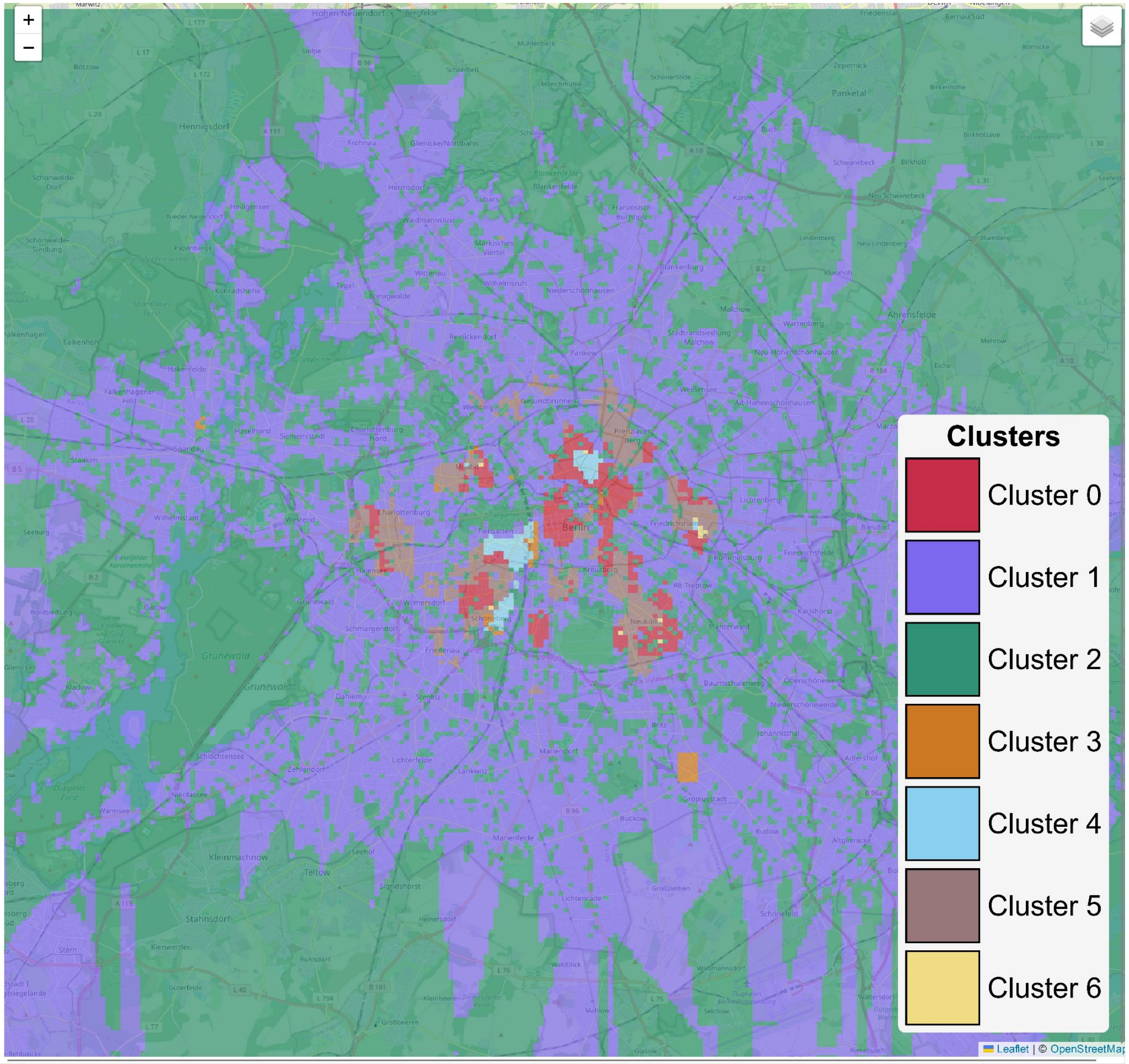
Created with JavaScript and Leaflet

aytacaydin.com/evtech

Using Jayanath et al.'s Regression Model



Unsupervised Learning



Conclusion

- AI-based strategies ensure optimal positioning of EV charging stations.
- Data-driven models identify the best points, taking into account critical variables such as traffic, environmental factors and energy distribution

Main Challenges:

- Data gaps - Limited availability of real-time charging usage data
- Environmental adaptability - The need to account for weather conditions and long-term demand changes.
- Scalability - Expanding infrastructure efficiently in both urban and rural areas.

Future Research:

- Integration of renewable energy to support sustainability.
- Demand forecasting models for better infrastructure planning.
- Enhanced data sharing to improve AI model accuracy.