

Hypotheses of Electric Vehicle Charging Patterns

- Assessment of an exploratory spatio-temporal data analysis -

Research questions:

1. What hypotheses are intended and what ESDA methodology may support such intentions?
2. What geo-visualisation is needed to generate hypotheses by interactively studying the charge session data of individual charge stations and their physical surroundings?
3. How to generate hypotheses with the geo-visualization?
4. What can the analysis of hypotheses teach us about the use of an ESDA methodology for exploring charge session data?

Exploratory Spatio-temporal Data Analyses (ESDA) use human visual-cognitive and analytical capacities in combination with scientific visualization methods to explore spatio-temporal data. Current ESDA methods anonymize space, use a static representation of time, aggregate data or only show one or two attributes of the spatio-temporal object.

To test a new ESDA methodology we explored the charge session data of Amsterdam its electric vehicle charge infrastructure. The objective of this thesis research was to develop an ESDA method that uses a dynamic multi-variate geo-visualization of spatio-temporal electric vehicle charge data in an information rich online spatial environment to generate hypotheses on public charge behaviour in Amsterdam.

RQ1:

The ESDA method should allow the user to explore multiple variables of individual charge sessions (spatio-temporal objects) and relate these to information about the physical environment of the object in order to generate hypotheses on EV charge behaviour.

RQ2:

The ESDA tool needs to consist of two components: (1) a dynamic, multivariate geo-visualization of individual charge sessions (2) presented in an information rich graphical user interface (GUI) for interactive exploration. The GUI of Google Earth was chosen and with use of the plotKML R package the geo-visualization created.

RQ3:

An asynchronous online group discussion was chosen as a method to test the ESDA tool. It combined the advantages of working online with the possibilities of discussing as a group.

The method consists of two parts: a manual and a test. The manual was developed to explain the symbology, interaction options and the tool its intentions. The test was developed to generate user hypotheses on EV charge behaviour in Amsterdam.

RQ4:

The assessment of the ESDA methodology showed that the methodology has the potential to generate hypotheses on spatio-temporal processes in a detailed and information rich spatial context. The daylight visualization of GE had high added value for the exploration of spatio-temporal data and generated several hypotheses on the differences between EV charging during the day and night. The interface of GE added two extra spatial dimensions to the geo-visualization: Places (names and icons) and Street View. The results of the tool assessment showed that both these features were still barely used. Relationships between variables were mostly based on their general location such as a city district and not so much based on features specific for the spatial context of the charge session.

Lessons:

The assessment of the ESDA method highlighted areas for improvement for both the tool and the methodology. The representation of individual charge sessions provided a visual overload of information for some of the users.

It was concluded that the tool needs **semantic zoom options** (roll-up/drill-down) and **query possibilities** in order for the user to more specifically identify and compare spatio-temporal map objects. The users frequently wanted to compare space (just two charge stations), a particular time interval (every morning of every day) or a certain variable (sessions larger than 10 kWh).

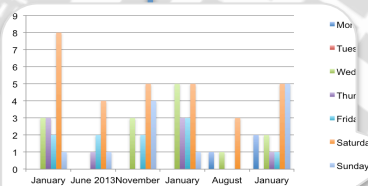
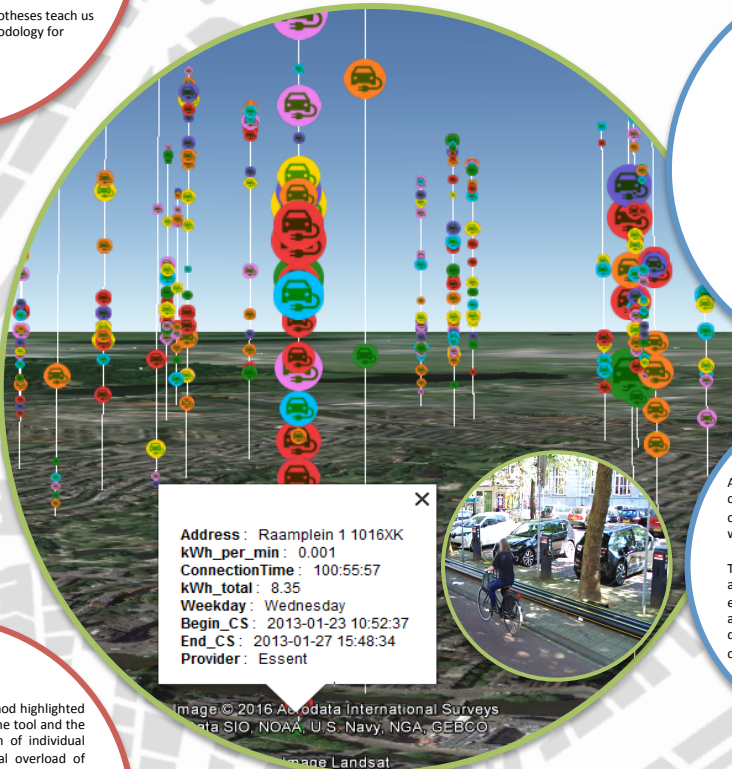


Figure 1: Number of charge sessions at Ouborg 7.

User hypothesis:

Address Ouborg 7 is mainly used on Saturdays.

Figure 1: The charge session data shows signs that this might be the case.

Explanation: Due to the allocation strategy of Amsterdam, whereby a new charge station is placed at request of an EV-driver, specific patterns of the requesting ev-driver can cause a pattern in the spatio-temporal visualization of the charge session data. This pattern may be unrelated to the geographic features in the area but more to the behavioural pattern of frequent users.

