

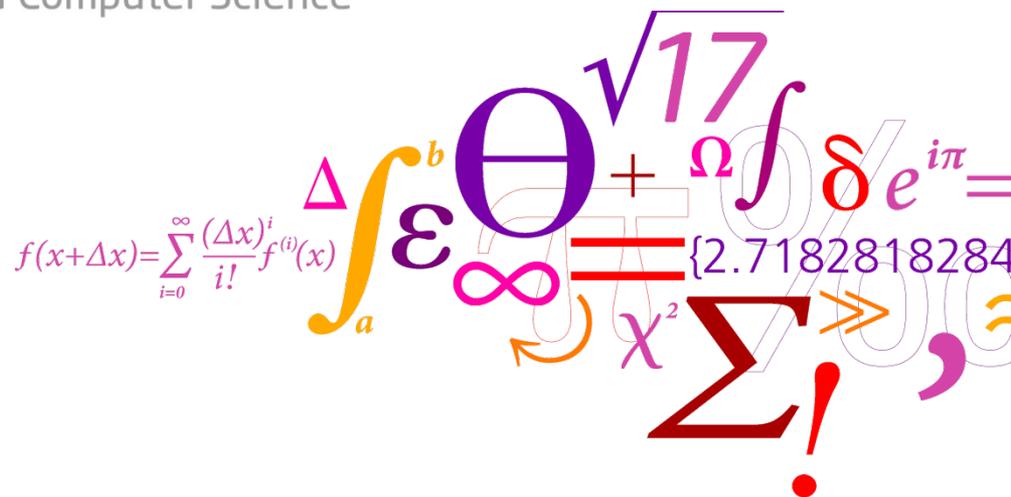
Software Engineering 2 (e20)

More details (on existing systems)

Ekkart Kindler

DTU Compute

Department of Applied Mathematics and Computer Science



- Idea
- Some screen shots
- Concepts (domain analysis)
- “Domain model”

Can we find a more efficient and faster way to **monitor**, maintain and manage the roads?

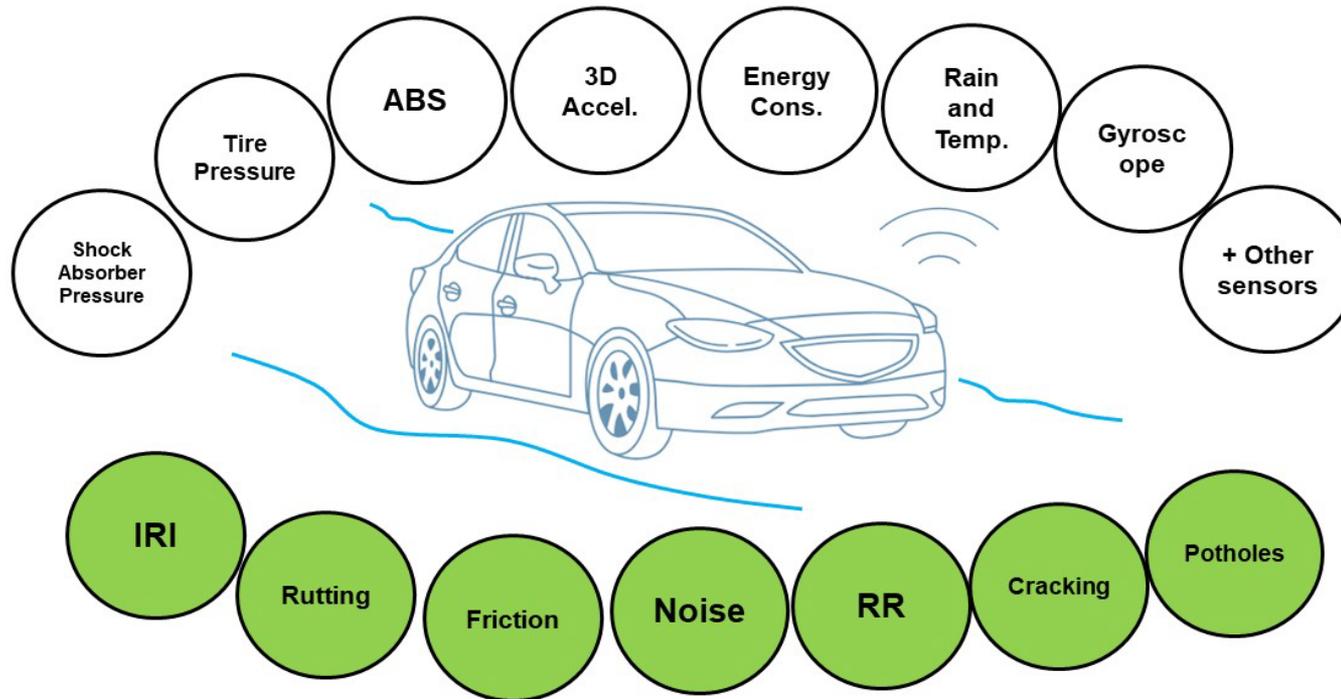


Modern cars are equipped with many sensors and can also provide further data including energy consumption.

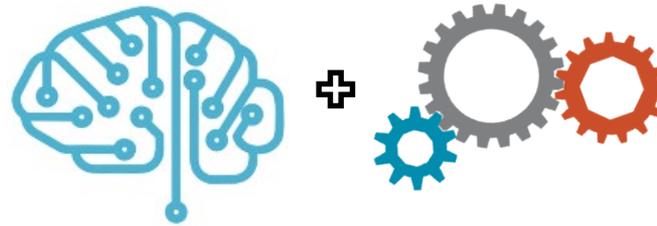
Can car sensors data be used to measure road conditions?



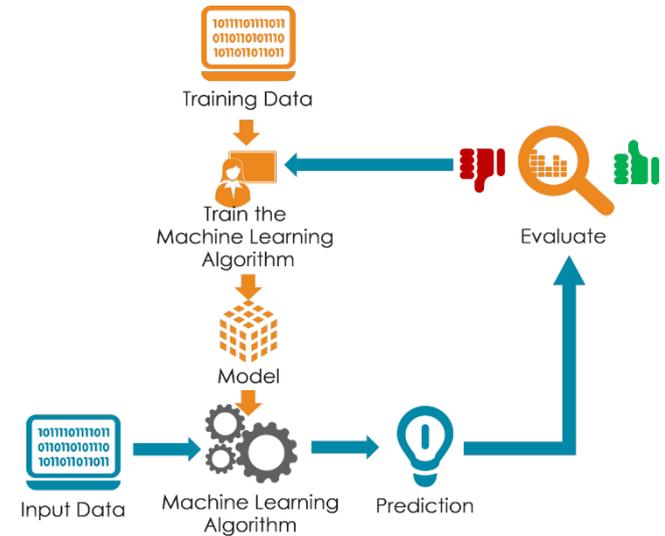
Car sensors (approx. 150 sensors)



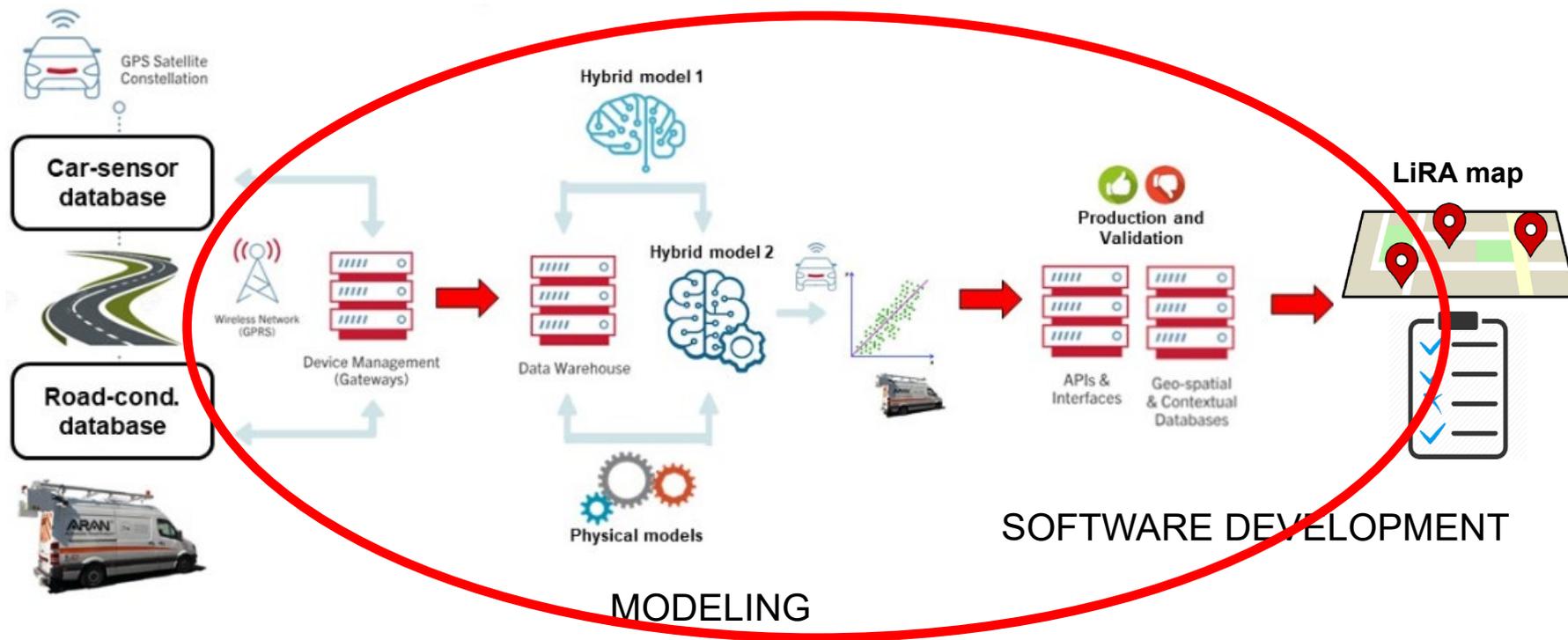
Road measures



- Training (supported by physical models)
- Validation & Testing (Municipality of Copenhagen)



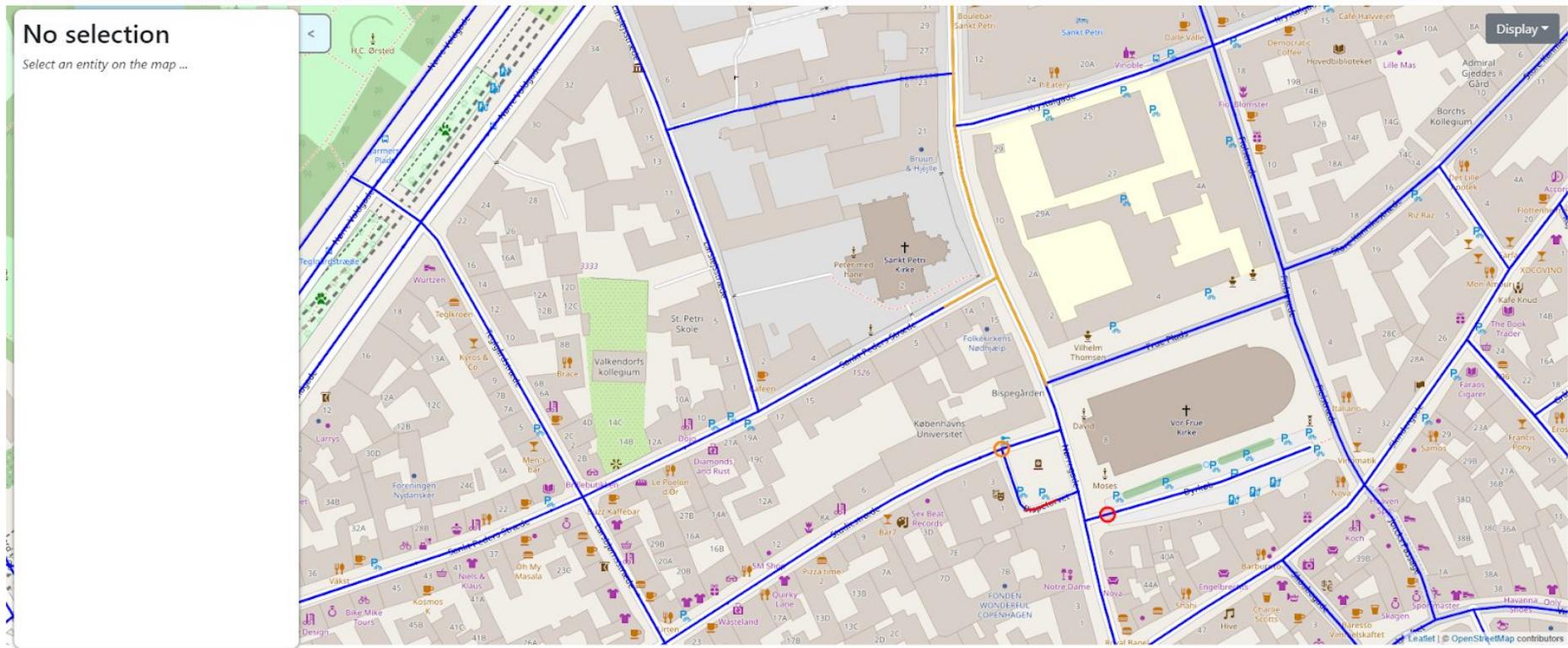
Overview



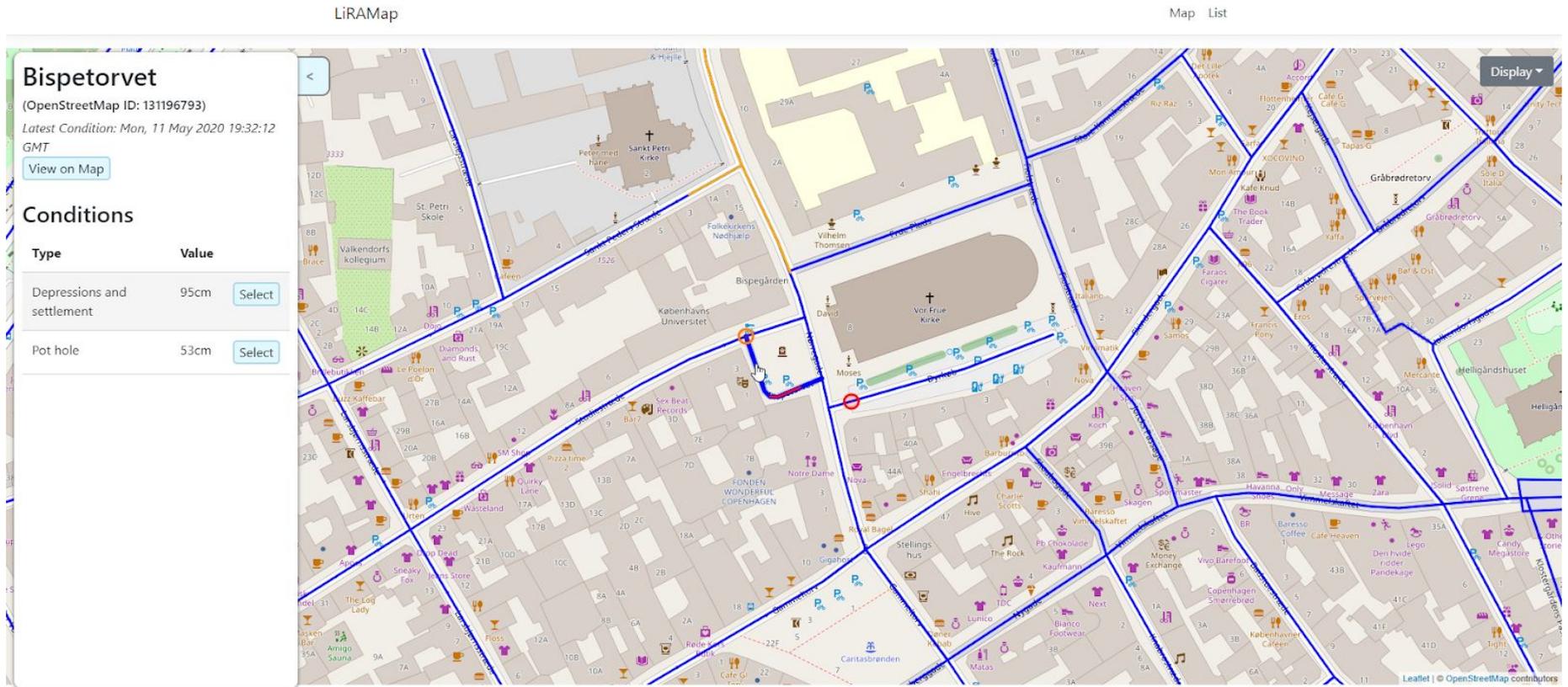
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LiRAMap

Map List



Source: Jonathan Drud Bendsen: LiRA Map: A Cloud-based Geo-information System for Road Maintenance. BSc project 2020.



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LiRAMap

Map List

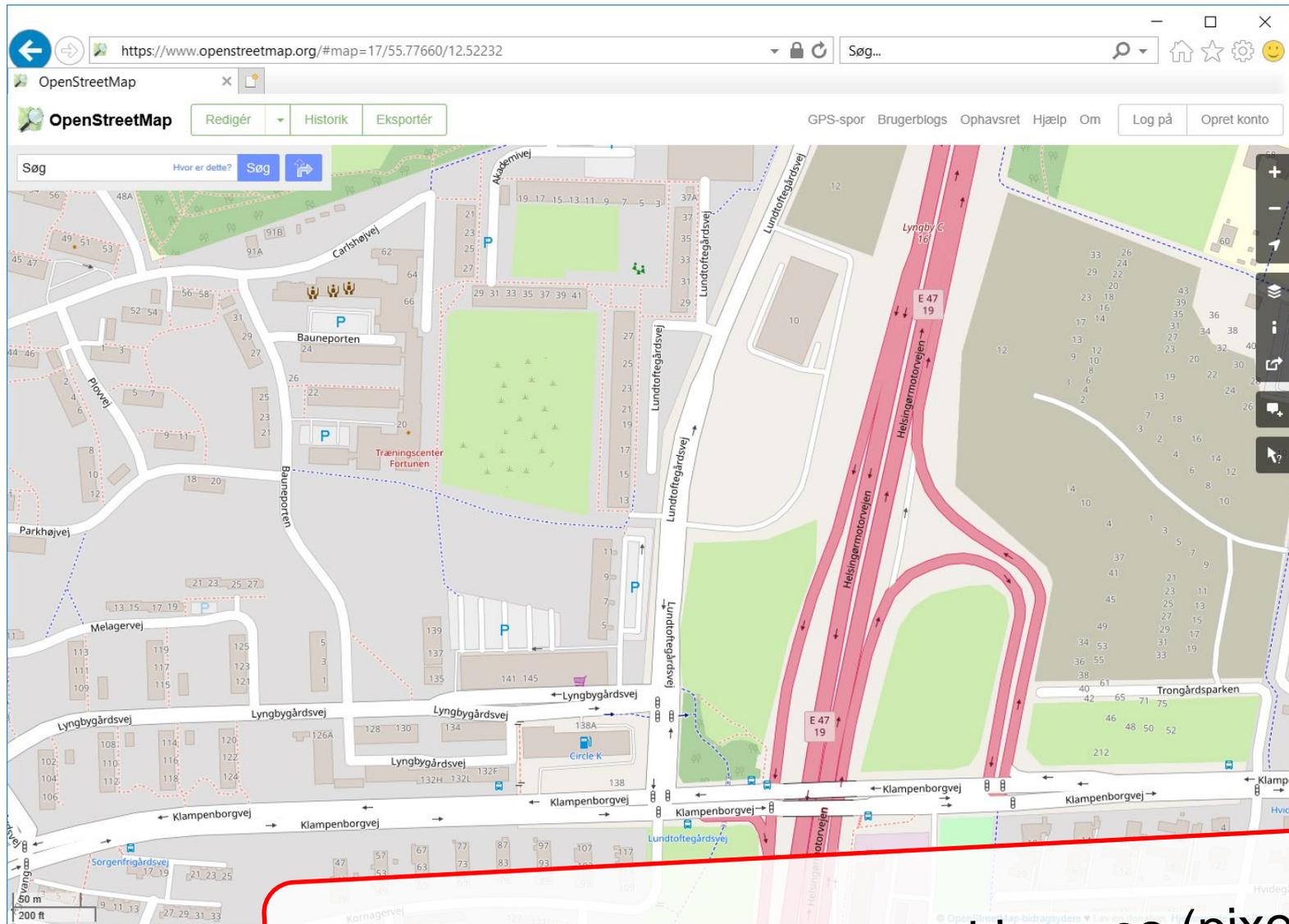


Source: Jonathan Drud Bendsen: LiRA Map: A Cloud-based Geo-information System for Road Maintenance. BSc project 2020.

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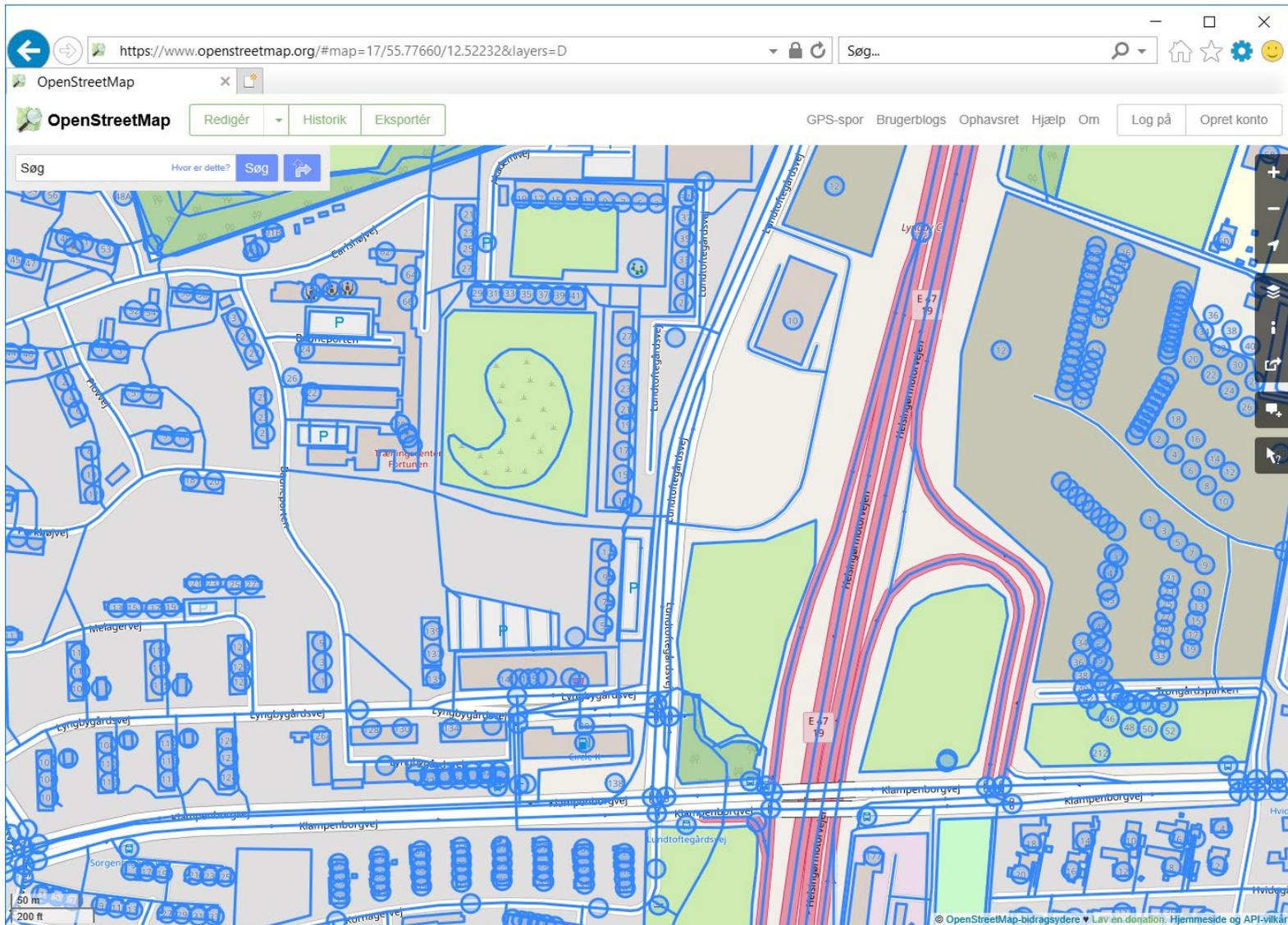
- Road conditions
 - Point condition (e.g. pothole)
 - Stretch condition (e.g. rolling resistance between to points); actually even a bit more tricky in practice (see Jonathan's thesis)
 - Condition refers to a point or a stretch, has a type and one or more values (type defines unit and what the condition means)
- Road concepts from OSM (but own terminology)
 - → see next slides

Open Street Map (OSM)



Basically, just geo-referenced images (pixels)!

OSM: Map Data



OSM: Way with Tags

The screenshot shows the OpenStreetMap interface. The browser address bar displays the URL: `https://www.openstreetmap.org/way/48931467#map=17/55.77660/12.52151&layers=D`. The page title is "OpenStreetMap" and the breadcrumb trail is "OpenStreetMap > openstreetmap.org > openstreetmap.org > openstreetmap.org > openstreetmap.org > Tag:natural=scrub - O... > Da.Key:lit - OpenStree...".

The left sidebar shows the "Søg" (Search) field and a "Veji: 16 (48931467)" entry. Below this, there is a description: "adding details in Lyngby-Taarbæk based on survey and http://www.tu.dk/.../mende-vejark...". It also mentions "Redigeret 11 måneder siden siden af Henrik PS" and "Version #9 · /Endringsæt #65592825".

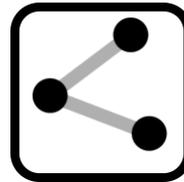
The "Egenskaber" (Properties) section contains the following table:

highway	motorway_link
lanes	1
oneway	yes
operator	The Danish Road Directorate
ref	16
surface	asphalt

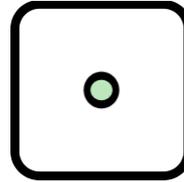
Below the table, the "Punkter" (Nodes) section lists several coordinates, including "202458304 (del af vejen — 48942316)" and "1584802303 (del af vejen — 14501197)".

The main map area shows a street network in Lyngby-Taarbæk, Denmark. A specific road, highlighted in blue, is circled in red. This road is identified as "Veji: 16 (48931467)" in the sidebar. The map also shows other roads like "E-47" and "Helsingørmotorvejen".

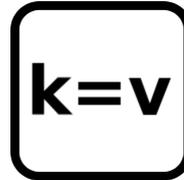
- Way / Section



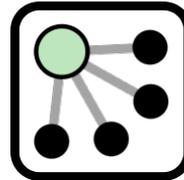
- Node / Point



- Tags / Attributes



- Relations



**Type of car data is flexible (not hard-coded):
dynamic measurement types**

**With and without GPS information
→ Interpolation of missing positions**

ref	16
surface	asphalt

Punkter
202400304 (del af vejen == 48942316)
1584802303 (del af vejen 145011971)
202456779
1359412928
29924912
29924914
202390667
3798428228
202390668
202390669
3798428227
202390670

The screenshot shows the OpenStreetMap interface. The main map area displays a road network with a specific road highlighted in blue and marked with yellow circular points. A red callout box is overlaid on the map, containing the text: "Align positions with map data: → Map matching".

On the left side, the "Veji: 16 (48931467)" information panel is visible, containing the following details:

- adding details in Lyngby-Taarbæk based on survey and <http://www.ltk.dk/kommende-vejarbejde>
- Redigeret 11 måneder siden siden af Henrik PS
- Version #9 · Endringsæt #65592825

Below this, the "Egenskaber" (Properties) table is shown:

highway	motorway_link
lanes	1
oneway	yes
operator	The Danish Road Directorate
ref	16
surface	asphalt

At the bottom left, a list of "Punkter" (Points) is displayed:

- 202400304 (del af vejen 48942316)
- 1584802303 (del af vejen 145011971)
- 202456779
- 1359412928
- 29824912
- 29924914
- 202390667
- 3798428228
- 202390668
- 202390669
- 3798428227
- 202390670

Attributes (“dynamic sections”):

- span parts of sections
- can span more than one section

highway	motorway_link
lanes	1
oneway	yes
operator	The Danish Road Directorate
ref	16
surface	asphalt

202456779
1584802303 (del af vejen 145011971)
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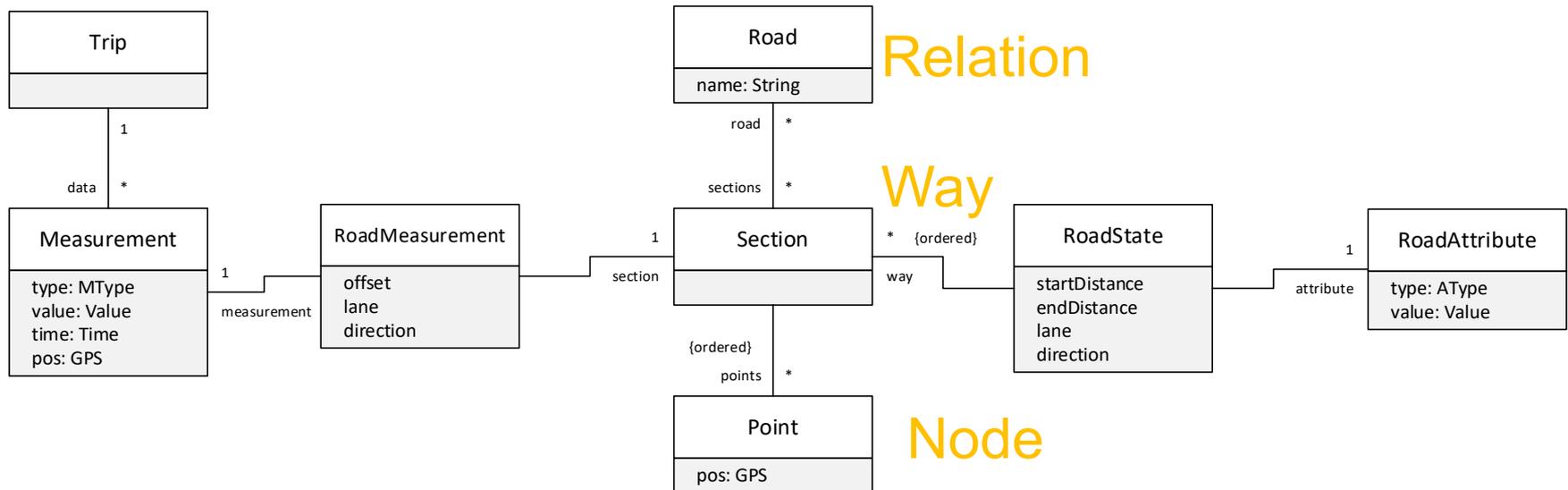
- Collect data raw data from cars (per trip)
- Clean data (done by AutoPi on care already)
- Calculate position for data without positions (Interpolation)
- Map positions to sections:
there are different services available for that, e.g.
<http://project-osrm.org/docs/v5.10.0/api/#general-options>

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Car Data (from GM)

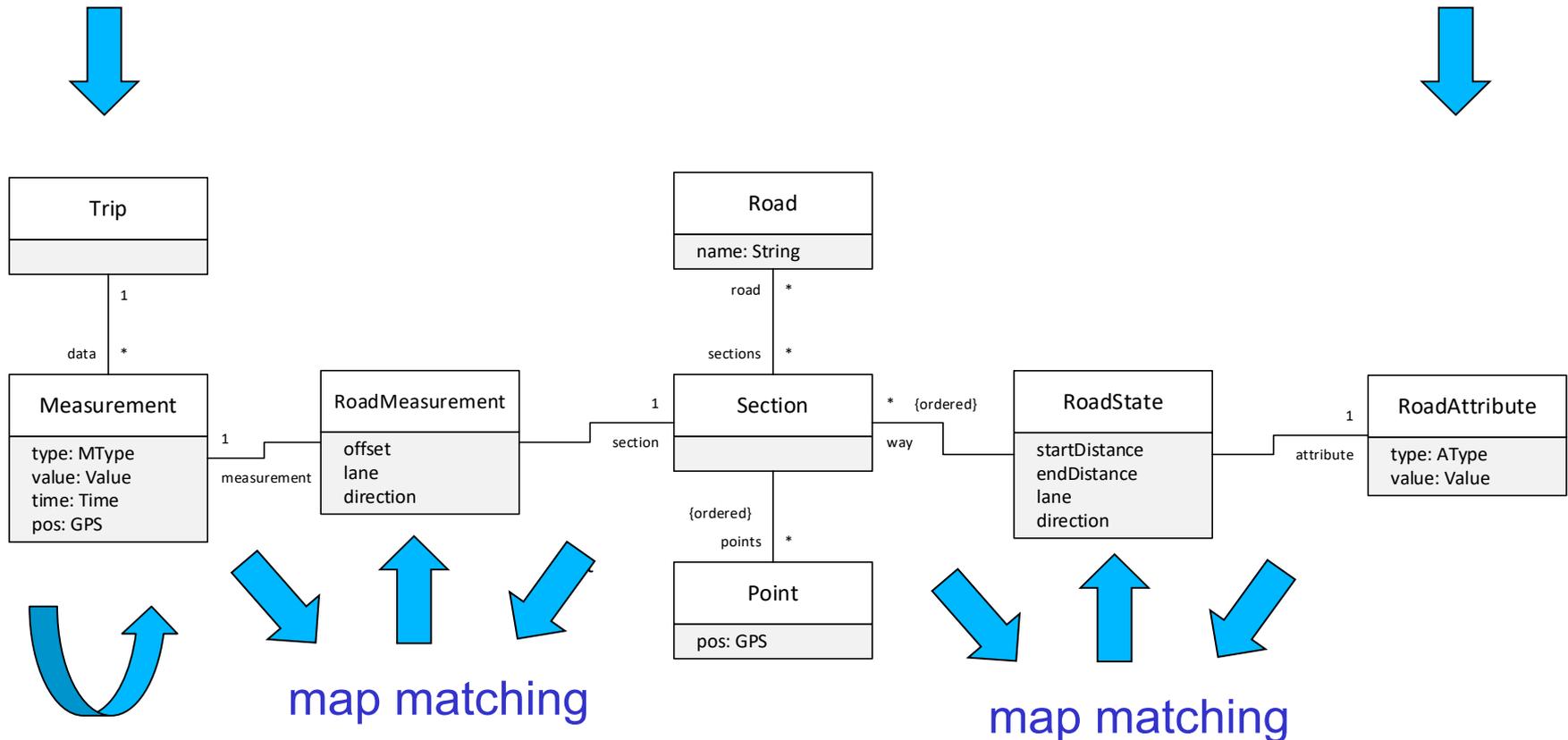
Static road data
(OSM, Sweco, ...)

Dynamic road data
...

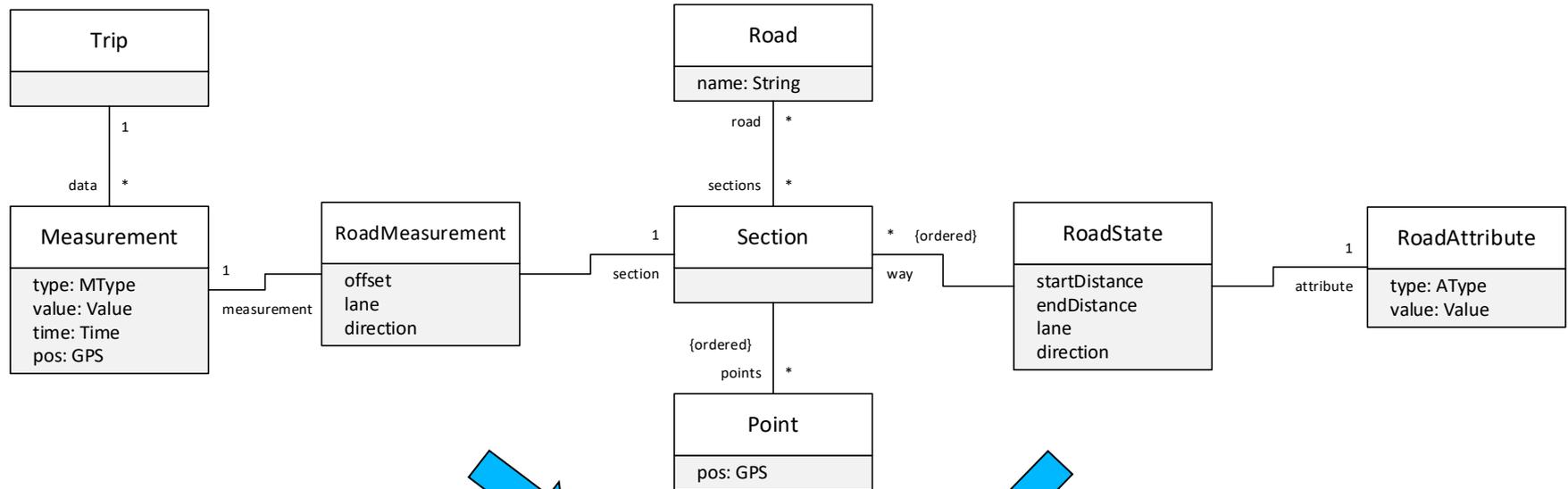


data collection (GM)

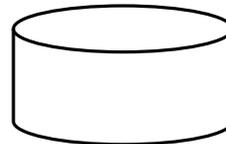
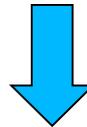
Initial data (VD)

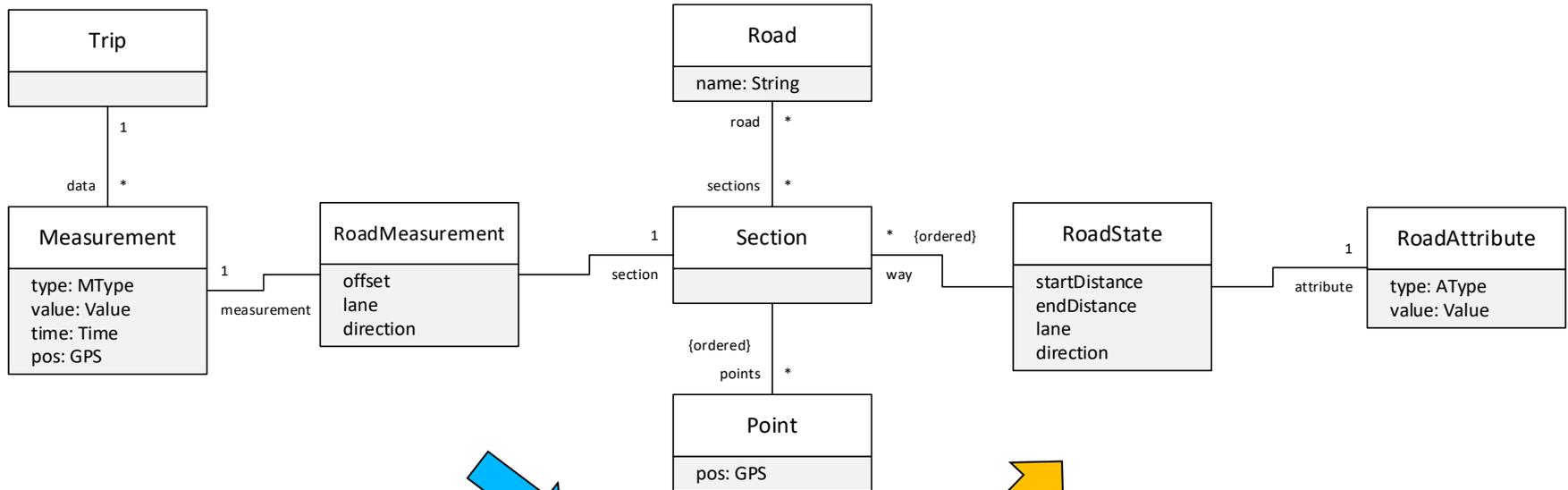


- data cleaning
- GPS interpolation

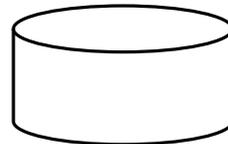


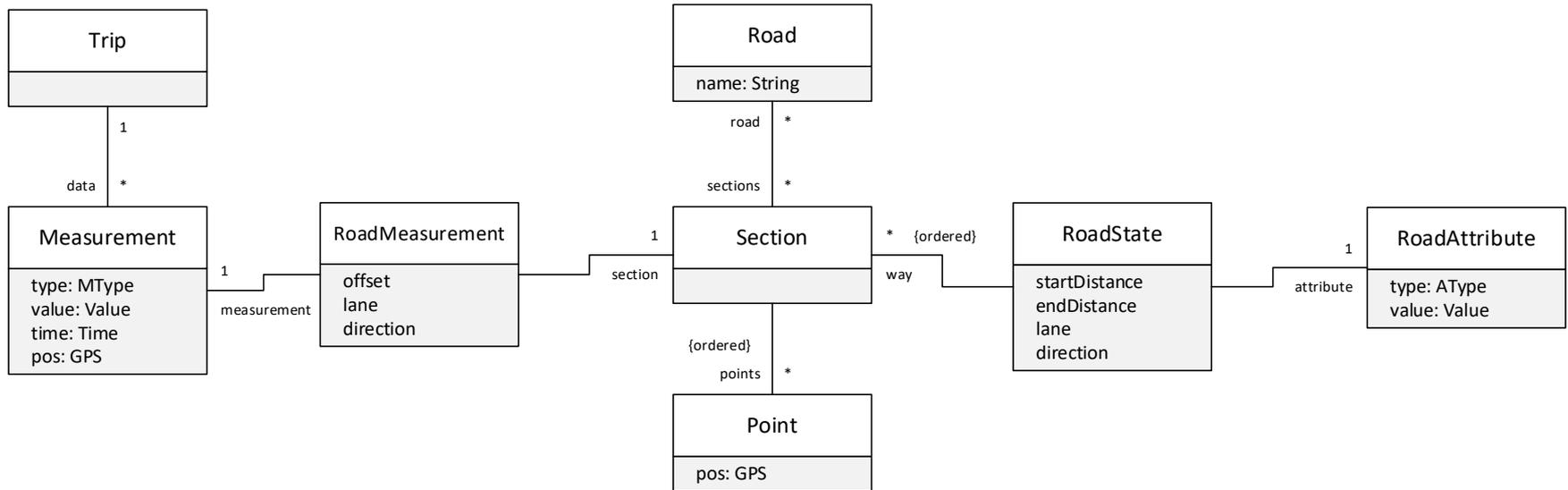
Machine learning





Machine learning





Data Collection

Machine Learning

LiRA Map

Note that this is just the rough idea!
Many aspects and details still missing!

