New Emergency Management in a Resilience Era Facing Health, Climate and Energy Challenges

6th to 10th December 2021

9th DECEMBER, 14:25 - 14:50
SESSION 13 IMPETUS PRESENTATIONS

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BIG DATA INGESTION AND ANALYTICS FOR PHYSICAL THREAT INTELLIGENCE

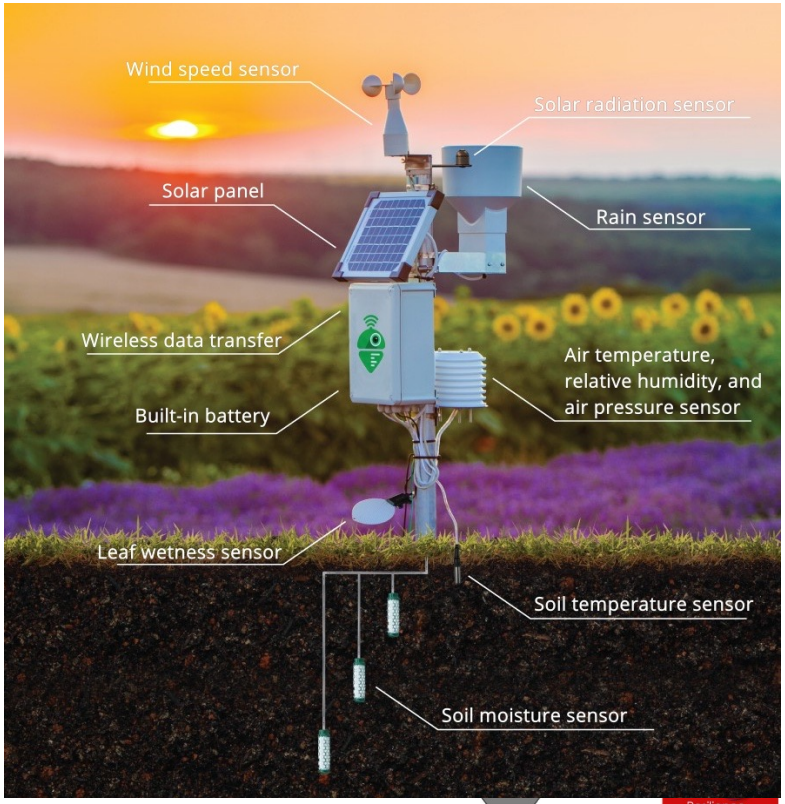
- The project IMPETUS aims to support law enforcement in establishing any threats / anomalies in advance, also with the aid of sophisticated automatic systems
- Expected impacts and results: the IMPETUS platform will make it possible to enhance the urban security of both cities involved (municipalities of Padua and Oslo)
- Elements of replicability: the platform can be replicated for each smart city depending on the sensor network made available by the municipality concerned
- Different types of sensors and possible applications

Urban traffic cameras

- A traffic camera observes vehicular traffic on the road.
- A monitoring center receives live video in real time and acts as a mediator with law enforcement if an accident or road safety problem occurs.

Meteorological sensors

- A weather sensor is a set of tools for measuring atmospheric conditions.
- Most of these sensors measure the
  - wind speed;
  - wind direction;
  - the temperature;
  - humidity;
  - barometric pressure;
  - rainfall;
  - UV or solar radiation.



Air pollution sensors

- Air pollution sensors are devices that monitor the presence of air pollution in the surrounding area.
- Most of these sensors focus on five components:
  - ozone;
  - atmospheric particulate matter (PM10, PM2.5…);
  - carbon monoxide;
  - sulfur dioxide;
  - nitrous oxide.

Sensors for detecting pollen levels

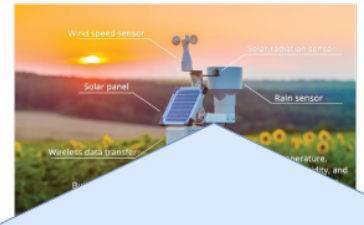
- Devices for detecting the concentration levels in the air of different pollen families.

Sensor metadata example

Timestamp yyyy-MM-dd*HH:mm:ss	X GPS coord	Y GPS coord	feat_1	feat_2	...	feat_n
2017-07-04*13:23:55	11.908710	45.404300	189	3	...	77

Sensor metadata example

- Several sensors that also provide temporal and spatial data



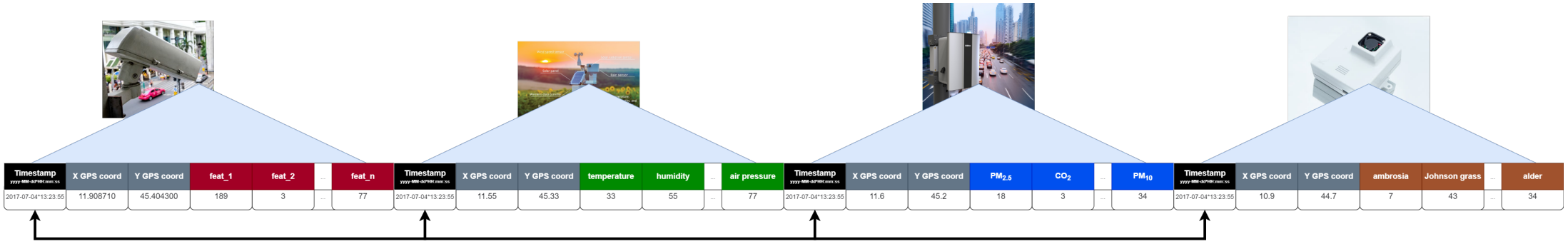
Timestamp yyyy-MM-dd*HH:mm:ss	X GPS coord	Y GPS coord	feat_1	feat_2	...	feat_n
2017-07-04*13:23:55	11.908710	45.404300	189	3	...	77

Timestamp yyyy-MM-dd*HH:mm:ss	X GPS coord	Y GPS coord	temperature	humidity	...	air pressure
2017-07-04*13:23:55	11.55	45.33	33	55	...	77

Several sensors that also provide temporal and spatial data

Sensor metadata example

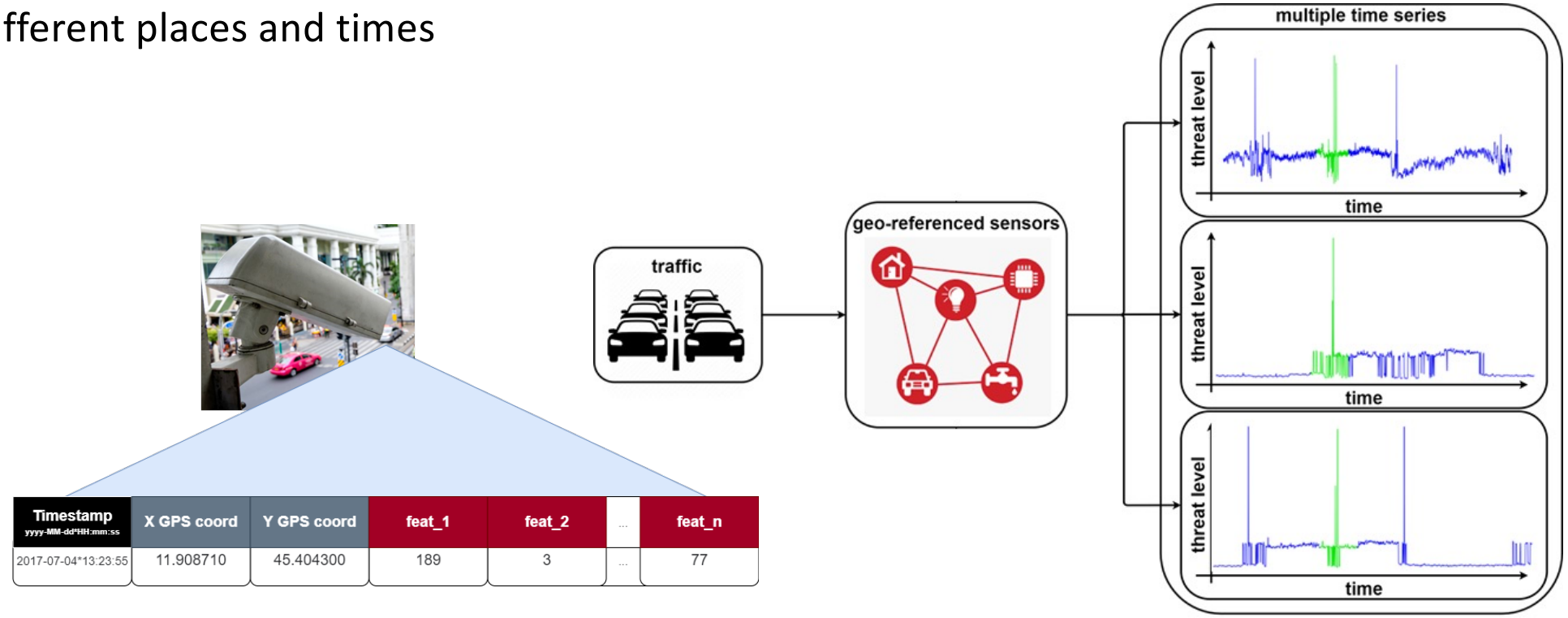
- Several sensors that also provide temporal and spatial data



Several sensors that also provide temporal and spatial data

Anomaly Detection

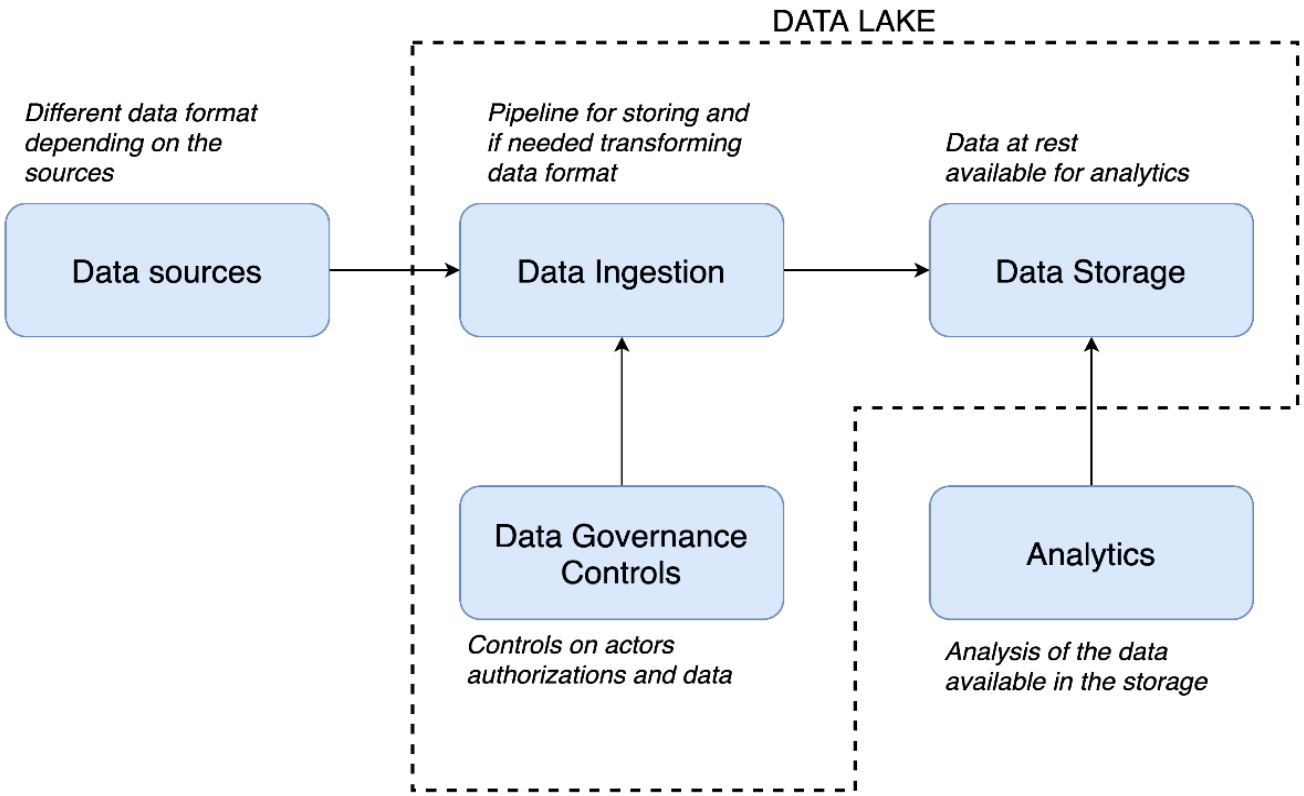
- An application example: identify anomalies in the distribution of camera metadata in different places and times



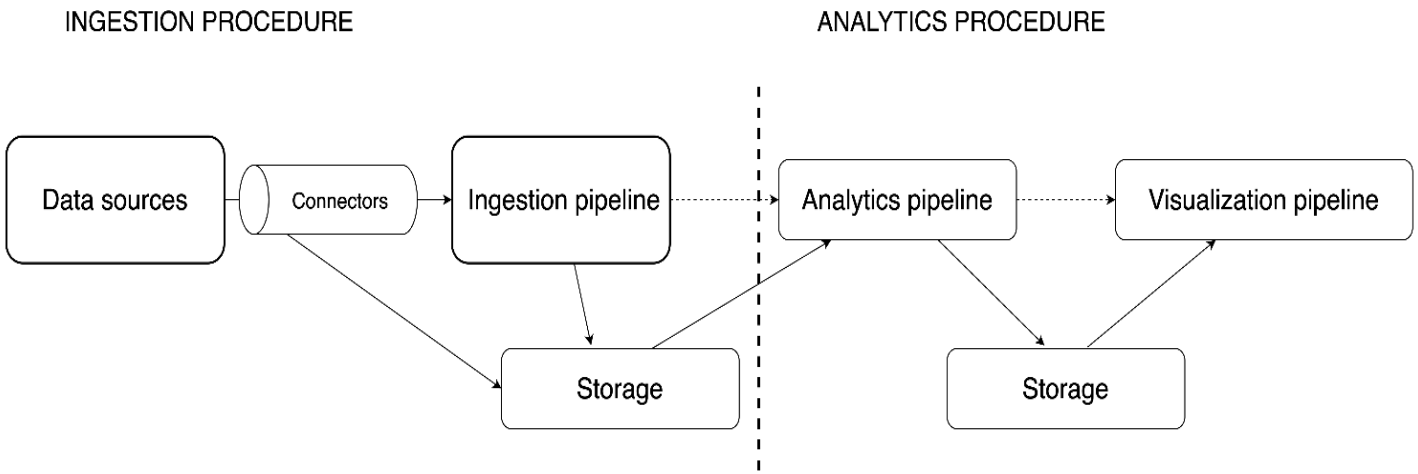
- When an anomaly is detected, the system will generate an alert

Conceptual View

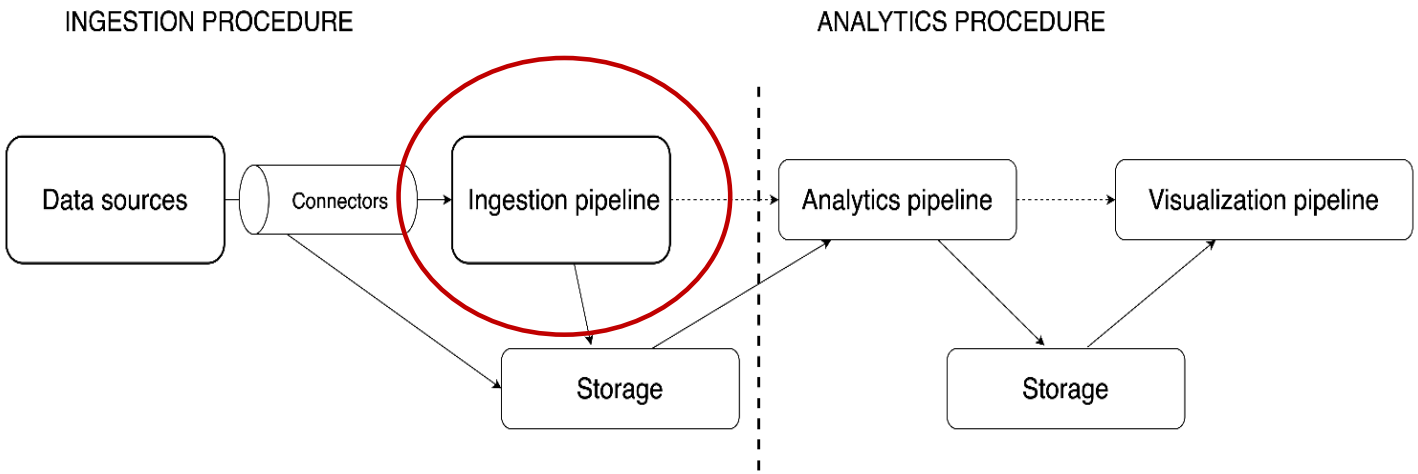
- Data management process
  - Collecting
  - Storing
- Maintain data
  - Secure
  - Efficient
  - Cost effective
- Offer data to analytics
  - Privacy-preserving preparation



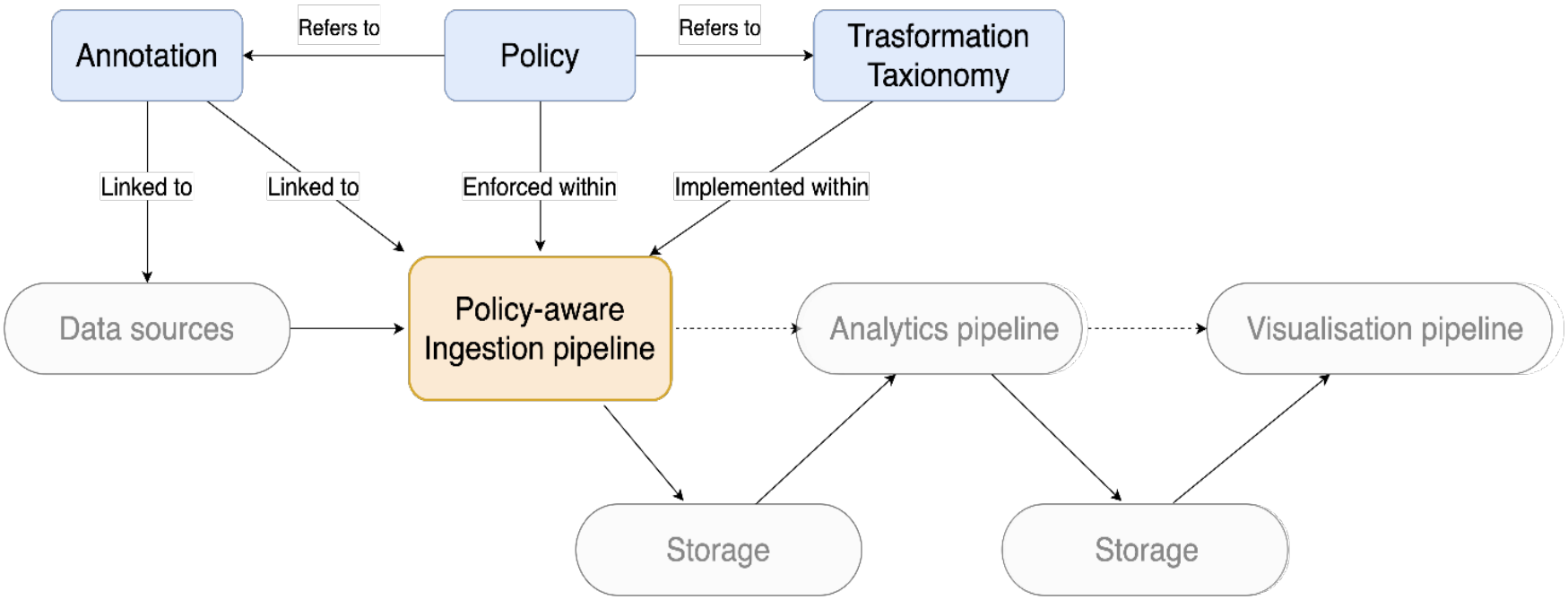
Architecture: Abstract view



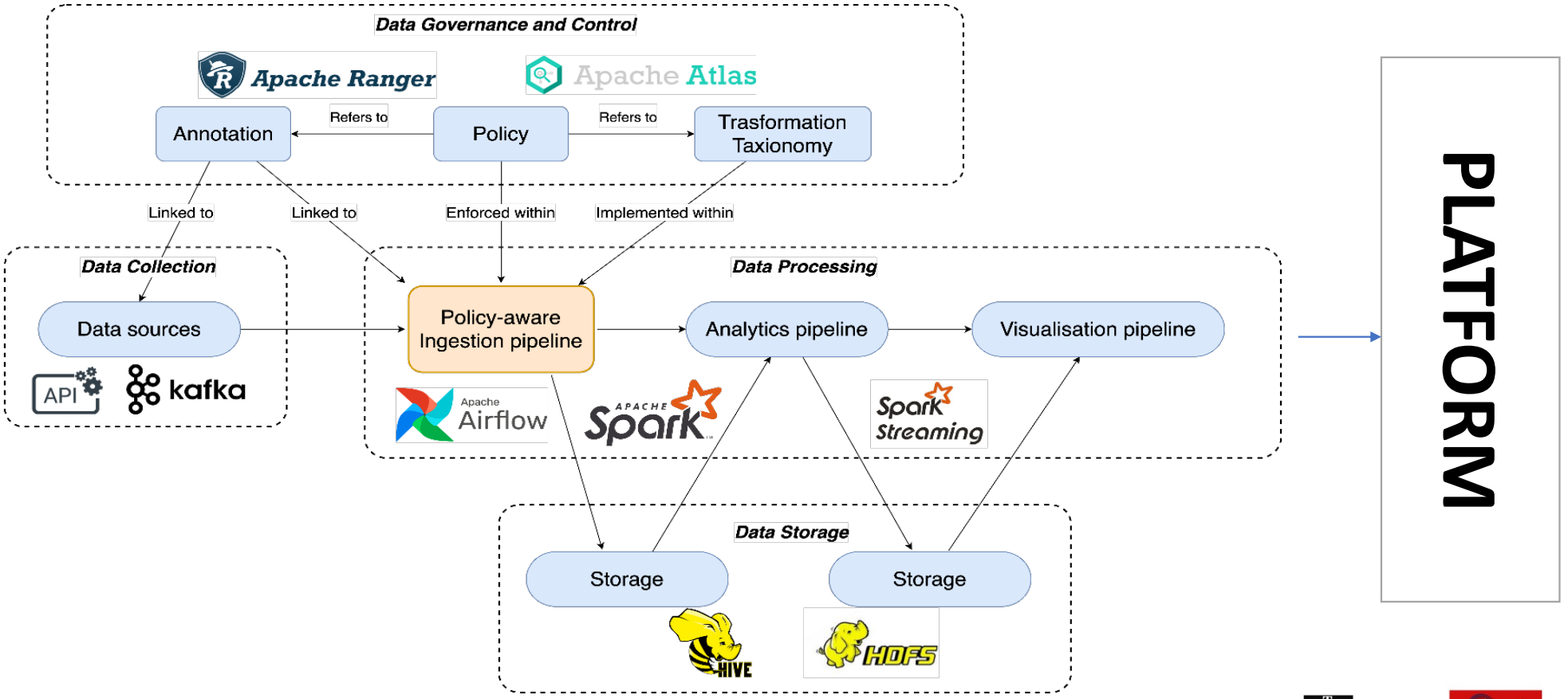
Architecture: Ingestion pipeline



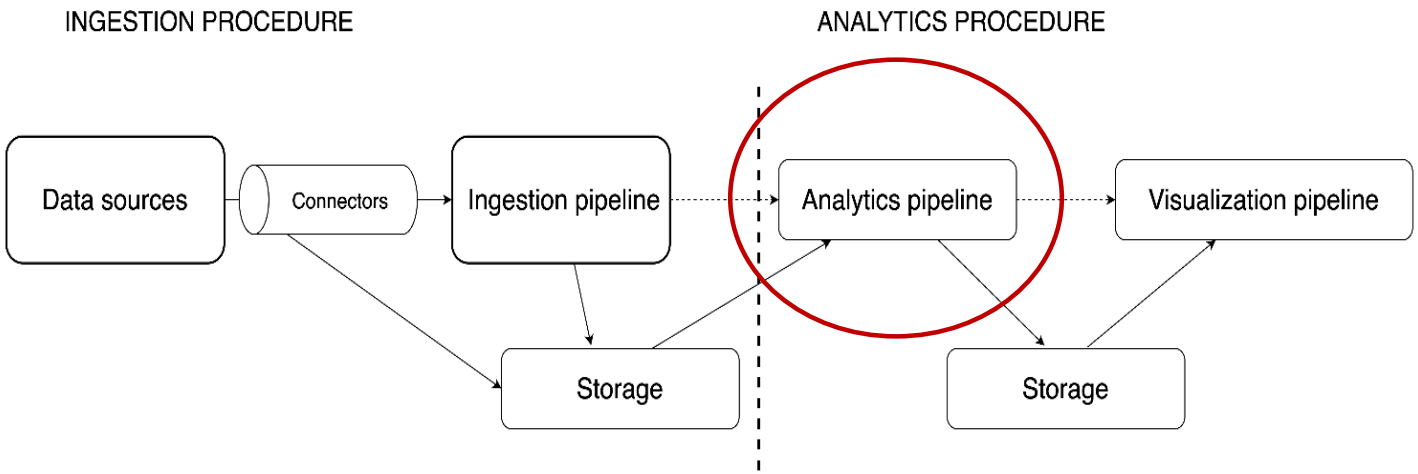
Architecture: ingestion time access control



Technologies and frameworks



Architecture: Analytics Pipeline



Detection of anomalies in the air (Padua)

- The dataset contains daily environmental information for the city of Padua, referring to the time period **2014** – **2019**, collected as batch.
- The dataset consists of a sample per day, excluding those days when measurements are not present.
- Data extracted from the ARPA Veneto website, Open Data section.
- The information extracted includes the following measurements:
  - date of measurement (dd/mm/yyyy)
  - air temperature at 2 metres (°C) (mean, min, max temperature)
  - precipitation (mm)
  - humidity at 2 metres (%) (min, max humidity)
  - concentrations of allergenic pollen in air (granules/m^3) per family (26 families)

Detection of anomalies in the air (Padua)

Anomaly detection task - Interpretability

Identify anomalies in environmental data distributions by considering different sensors in different places at different times

Timestamp	mean temperature	...	ambrosia	urticaceae
2021-04-15 10:00	15.1	...	20.0	50.0

Timestamp	mean temperature	...	ambrosia	urticaceae
2021-04-16 11:00	15.1	...	30.0	52.0

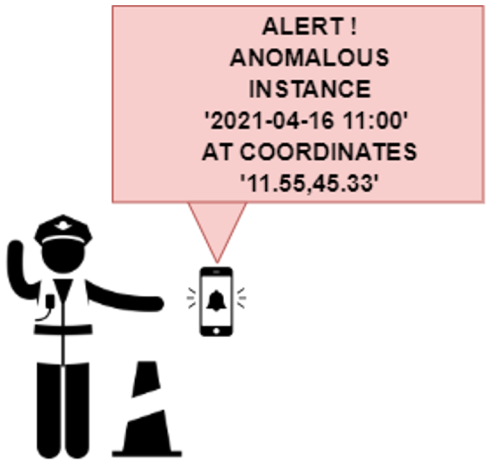
ALERT ! ANOMALOUS INSTANCE '2021-04-16 11:00'

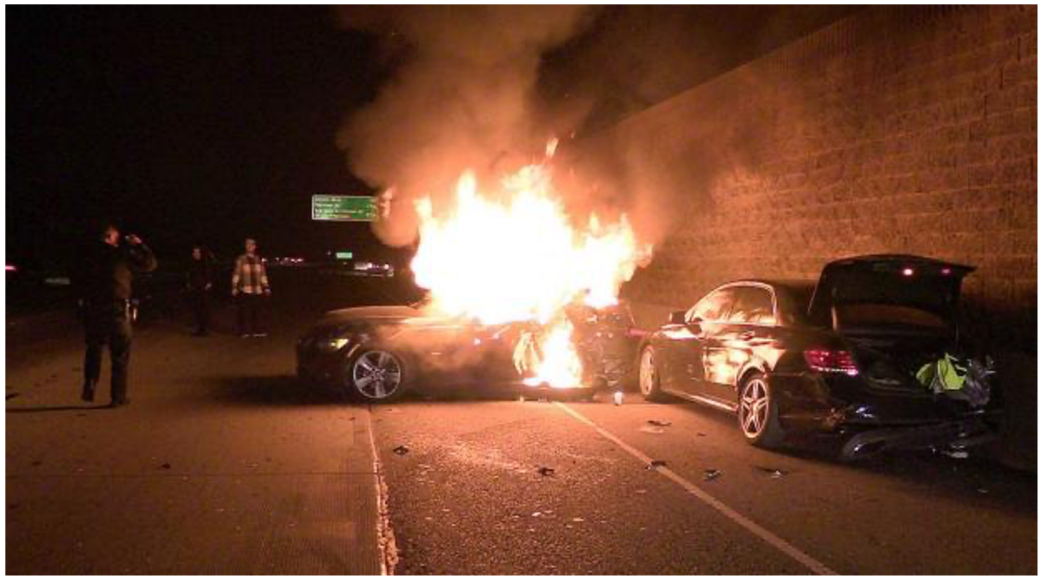
RANKING	IMPORTANCE
1. ambrosia	0.45
2. min humidity	0.24
⋮	
n. urticaceae	0.03

When an anomaly will be detected, the system will raise an alert and will provide a feature ranking according to the features importance in detecting the anomaly

Detection of anomalies in the air (Padua)

Interpretability – a real scenario





Timestamp	X coord	Y coord	...	traffic level (%)	CO2 (ppm)
2021-04-16 11:00	11.55	45.33	...	68	2205

RANKING		IMPORTANCE
1.	traffic	0.48
2.	concentration of pedestrians	0.21
3.	CO2	0.15
4.	temperature	0.07
⋮		
n.	ambrosia	0.001

Detection of anomalies in the air (Padua)

rainfall intensity	mm/6h	mm/12h	mm/24h
weak	0 - 5	0 - 10	0 - 15
moderate	5 - 15	10 - 30	15 - 45
strong	15 - 30	30 - 60	45 - 90
very strong	>30	>60	>90

Example of ground truth for rainfall intensity attribute

Each class in the ground truth is associated with an ‘anomaly weight’ in the range [0.0, 1.0]

e.g., for rainfall intensity, weak [0.0], moderate [0.33], strong [0.66] and very strong [1.0]

Detection of anomalies in the air (Padua)

Evaluation of the feature ranking

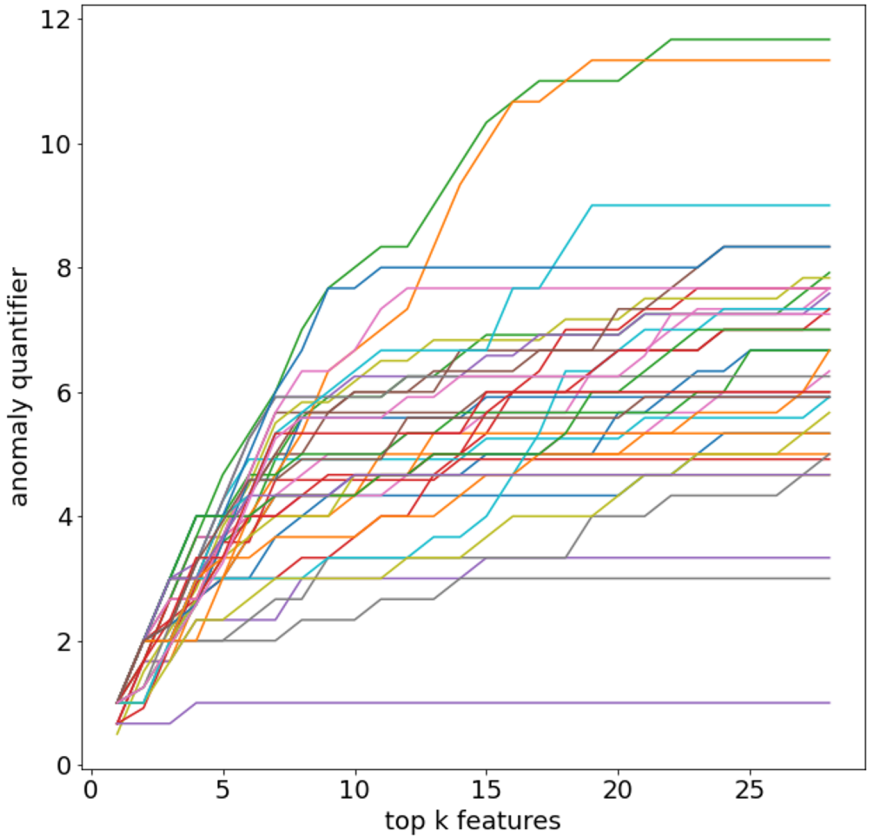
Given k the k-th position in the feature ranking

$$anomaly\ quantifier@k = \sum_{i=1}^{k} w_i$$

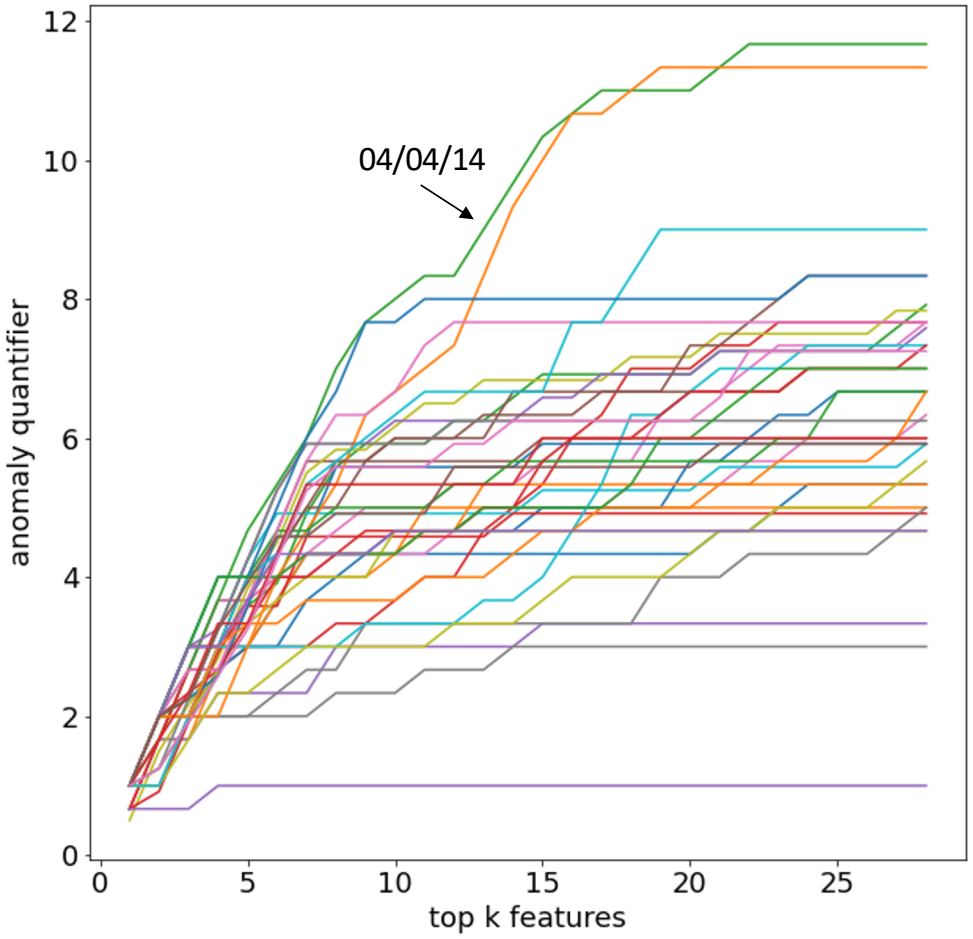
where w_i is the anomaly weight of the attribute in the i-th position, with $i \leq k$, if the ground truth of the attribute in the i-th position is defined.

Detection of anomalies in the air (Padua)

Using the environmental data of the city of Padua, the anomaly detector identified a total of 37 anomalies over the 395 test instances



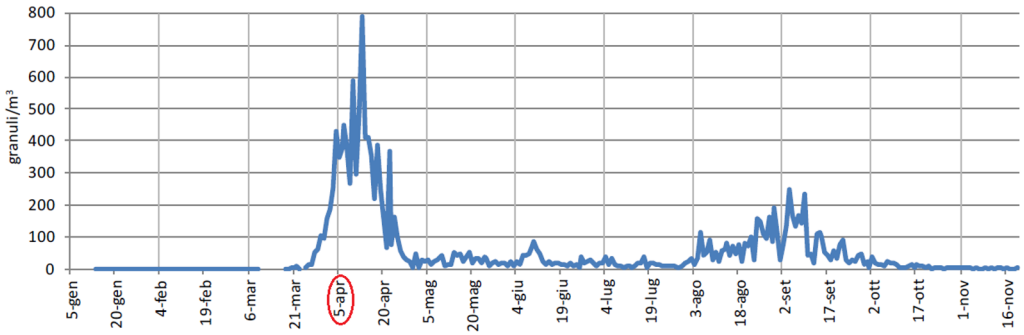
Detection of anomalies in the air (Padua)



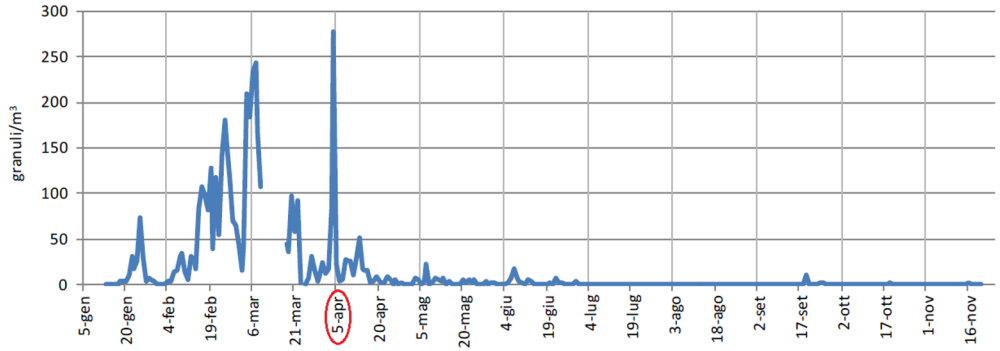
04/04/14 - top 10 feature ranking

1. urticaceae [1.00]
2. salix [0.67]
3. cupressaceae/taxaceae [1.00]
4. fagaceae [1.00]
5. quercus [1.00]
6. pinaceae [0.67]
7. corylaceae [0.67]
8. platanaceae [1.00]
9. betulaceae [0.67]
10. fagus sylvatica [0.33]

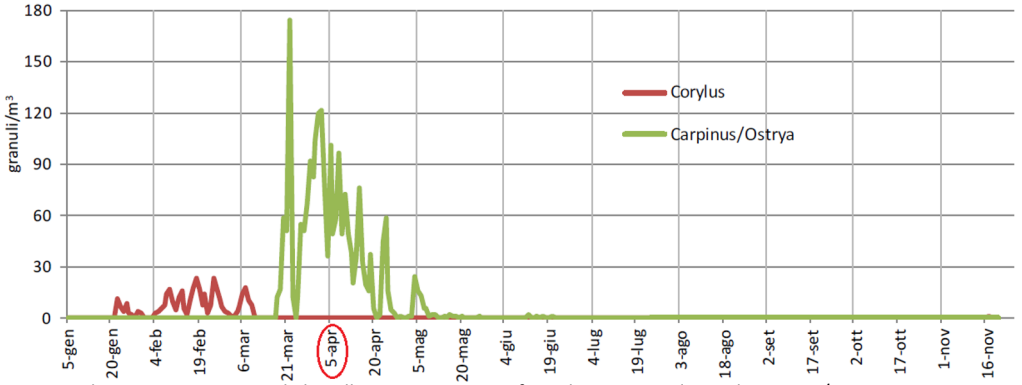
Detection of anomalies in the air (Padua)



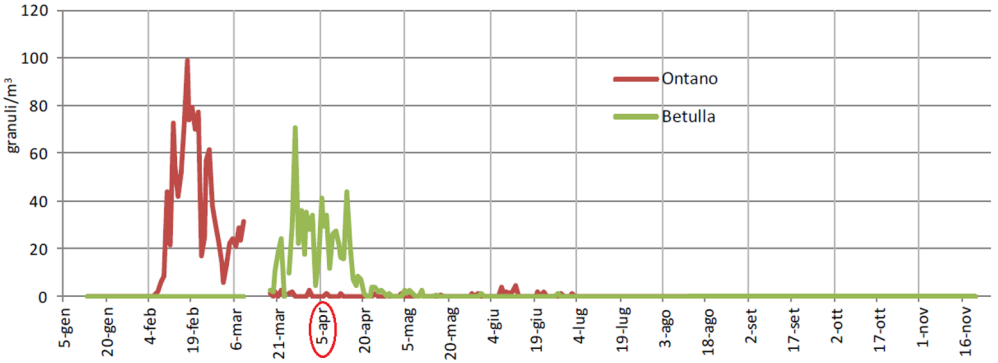
Padova station. Average daily pollen concentration of Urticaceae, year 2014.
Source: Pollini e Spore fungine allergenici nel Veneto, rapporto 2014, ARPAV.
Urticaceae, 1st position in the feature ranking



Padova station. Average daily pollen concentration of Cupressaceae/Taxaceae, year 2014.
Source: Pollini e Spore fungine allergenici nel Veneto, rapporto 2014, ARPAV.
Cupressaceae/Taxaceae, 3rd position in the feature ranking

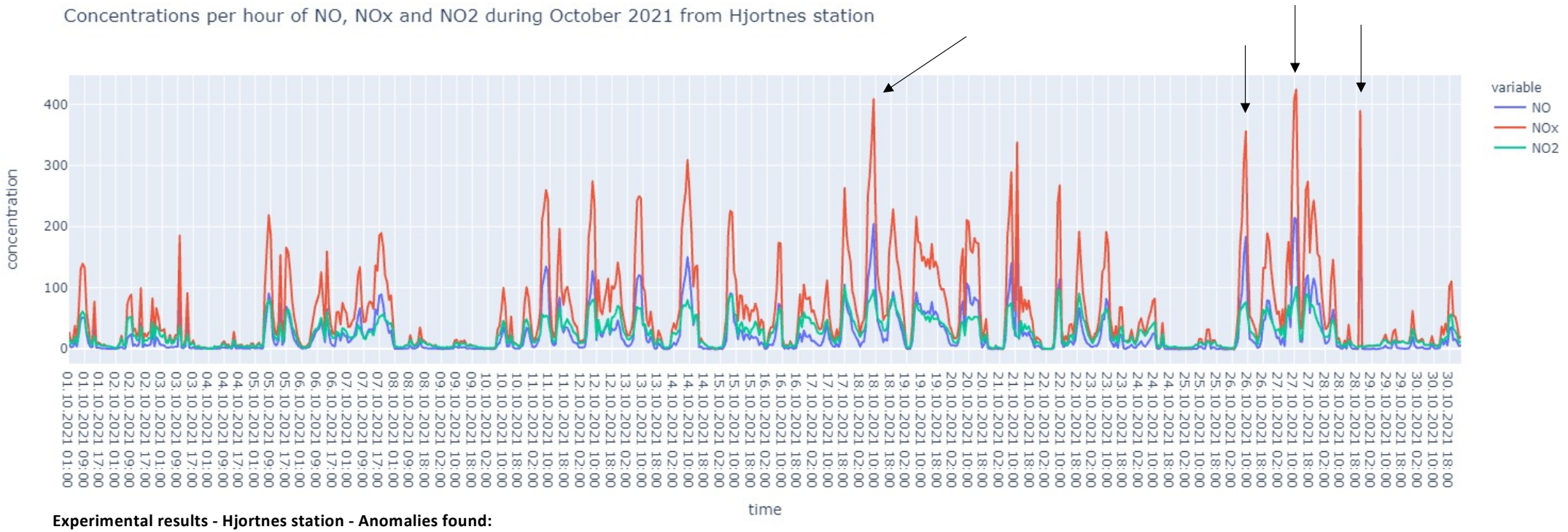


Padova station. Average daily pollen concentration of Corylaceae - Corylus and Carpinus/Ostrya, year 2014.
Source: Pollini e Spore fungine allergenici nel Veneto, rapporto 2014, ARPAV.
Corylaceae, 7th position in the feature ranking



Padova station. Average daily pollen concentration of Betulaceae – Alnus e Betula, year 2014.
Source: Pollini e Spore fungine allergenici nel Veneto, rapporto 2014, ARPAV.
Betulaceae, 9th position in the feature ranking

Detection of anomalies in the air (Oslo)



Experimental results - Hjortnes station - Anomalies found:

18/10/2021 08.00 – [**1. NOx**, **2. NO2**, **3. NO**]

18/10/2021 09.00 – [**1. NOx**, **2. NO2**, **3. NO**]

26/10/2021 09.00 – [**1. NOx**, **2. NO**, **3. NO2**]

27/10/2021 10.00 – [**1. NOx**, **2. NO**, **3. NO2**]

27/10/2021 11.00 – [**1. NOx**, **2. NO2**, **3. NO**]

28/10/2021 20.00 – [**1. NO**, **2. NOx**]

Conclusions

- Our method for the ***anomaly detection*** task, in addition to being able to analyze large amounts of data in a distributed way, allows us to correctly identify all anomalies although they are usually rare.
- The method avoids false normal cases by detecting the anomalies correctly for the air pollution quality of Padua and Oslo
- Furthermore, a qualitative analysis showed that the method is capable to catch anomalous levels of air quality variables for both the considered cities taking into account also the spazio-temporal autocorrelation

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https://cordis.europa.eu/project/id/883286