Facing Air Pollution with Smart Homes

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Challenge

- Analyse data from [luftdaten.info]
- Use external Data Sources for improved results
- Create an analysis that answers questions that are relevant for the society
Motivation

- Stuttgart’s inhabitants are exposed to high particulate matter concentration within surroundings.
- Bad quality air can cause health issues or may lead to death [WHO].
- Minimize the particulate matter exposure to the inhabitants.
- Automatically open smart windows when the particulate matter concentration is low.
Data Sources

- Air pollution data from [luftdaten.info]
  - DHT22 and SDS011 sensor data

- Weather data from [DWD]
  - Wind direction, precipitation, air pressure

- VfB Stuttgart matches from Google (ad hoc)
  - Game days

- Topology data from Topographische Karten (ad hoc)
  - Elevation
Data Processing

- We take temperature, humidity from DHT22 sensor data and PM2.5 and PM10 values from SDS11 sensor data.

- We drop the columns which contains multiple NaN values set

- Removed the records, for conditions under which SDS011 and DHT22 do not work, as per the manual.

  (e.g. Temperatures lower or equal than -10 Celsius)
Data Fusion

- Two alternatives
  - Join by `datetime` with tolerance
  - Standardize the values in both (DHT22 & SDS11) sensors

- We chose standardization

- After standardizing the data by taking `average` of all attributes w.r.t timestamp on an hourly basis, we combined them into a single dataset
Data Integration

- Materialized integration
- Through join on timestamp and location
  - Timestamp standardization

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<th>P2</th>
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</table>

Example of standardization in the SDS11 dataset, which indicates P1 and P2 values. (P1=PM10,P2=PM2.5)
Technologies Used

IBM Bluemix :

Python

Flask Server

Plotly Graphs with Dash :
Architecture and Integration
Interaction Model
Interaction Model (2)

User changes selected data, triggers Javascript callback

Plotly library interpretes and re-renders the plot

New plot sent to the browser

Ajax request sent to Plotly-Flask server

Flask

1. User changes selected data, triggers Javascript callback
2. Plotly library interpretes and re-renders the plot
3. New plot sent to the browser
4. Ajax request sent to Plotly-Flask server
5. Flask
Insight 1: Commuter’s traffic

- Air pollution strongly correlates to commute traffic during the day
- The season also plays a strong factor on average Air Pollution
Insight 2: Season

- Average values of PM10 is 4 times higher in winter than in summer
- Average values of PM2.5 is 2 times higher in winter than in summer
- In Winter PM10 values are particularly low during day time
Insight 3: Wind Direction

- The higher the surroundings of the Stuttgart valley are, from which the wind is blowing, the higher is the air pollution (especially the PM10 values)
Insight 4: Soccer Games

- Stuttgart’s soccer stadium is close to the city center

- On game days, the air quality in Stuttgart is not as good as on non-game days
Smart Windows improve indoor Air Quality

- Open windows when outdoor particulate matter concentration is low.

- Opening times are optimized based on our insights:
  - Insight 1: Do not open windows during rush hours.
  - Insight 2: In winter the values are particularly low during day time.
  - Insight 3: Values are lower, when the wind direction is beneficial.
  - Insight 4: Avoid opening windows during soccer games (if you stay nearby).
Smart Windows: Idea

- Prevent Stuttgart’s inhabitants from breathing polluted air.

- Based on insights identify the optimal time of the day to open the window.

- Allow for window openings while inhabitants are not at home.
Smart Windows: Approach

- Using an algorithm, we can automate windows to open and close when air quality is good.

- Using the correlations displayed before (rush-hours, weekdays)

- Visualize common useful information (precipitation values, temperature, P1, P2)
Smart Windows: Algorithm

*PM10 and PM2.5 information taken from [AirVeda]
Demo
Conclusion

- We have analysed approximately 178k+ rows of data regarding air quality.

- We obtained 4 main insights:
  - commuter’s traffic, soccer games, season, and wind direction.

- Smart Windows open daily when the outdoor air quality is best.

- Better life quality due to less respiratory diseases caused by polluted air breath (such as asthma).
Future Work

What is do be done to implement the smart window?

- Integrate with Raspberry Pi for automating it with the window to open/close.

How can the formula be improved?

- Data of gases like NO2, SO2, CO, O3 should be integrated and considered in the formula.
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References

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  ?seo_data=%5Bobject%20Object%5D (last access in 26/02/19)