**SENSORS DATA VISUALIZATION - EURAC**

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Capstone Project - 2021/2022

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## 1 Problem statement

This Capstone was proposed by EURAC Research, a private research center based in Bolzano, together with UNIBZ, for a better visualization of sensors data for air quality.

The area responsible for this project is the Center for Sensing Solutions, which provides a technological infrastructure for the other institutes and Centers of EURAC, such as a big data analytics platform and an environmental sensing laboratory.

This area develops projects of artificial intelligence in wireless sensor networks for air quality. The First Project, for example, aims to find solutions to improve the quality of the information given by low-cost sensors, which have limited accuracy and undergo serious ageing and drift over time.

To help in this project and in other EURAC projects involving sensors, the development of a notebook for a better visualization of the sensor data was requested.

## 2 Available data

For the development of this project, time-series data were made available. These data were obtained from low-cost sensors deployed at Adrian Platz and from the APPA monitoring station with EEA certified sensors.

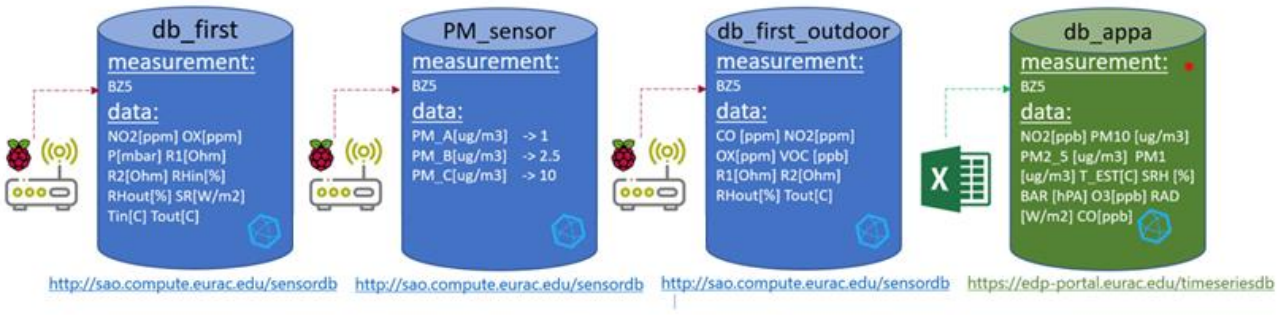
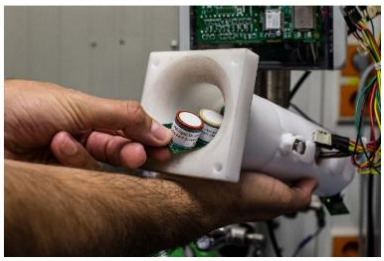



**Figure 1 – Schema of sensors data obtained for the project**

For visualization, the sensors have been classified into 4 types:

- Reference (ref): sensors certified by EEA from APPA monitoring station.
- Indoors (in): low-cost indoors sensors.
- Outdoors (out): low-cost outdoors sensors.
- Out_in (out_in): low-cost indoors sensors positioned apart from the others.



**(a)** **(b)** **(c)**

**Figure 2 – Example of low-cost sensors: indoors (a); indoors positioned apart from the others (b); outdoors (c).**

| Model variable | Sensor data |
|---|---|
| **NO2_ref** | NO2[ppb]_appa |
| **NO2_in** | NO2[ppm]_in |
| **NO2_out** | NO2[ppm]_out |
| **OX_ref** | O3[ppb]_appa |
| **OX_in** | OX[ppm]_in |
| **OX_out** | O3[ppm]_out |
| **P_ref** | BAR[hPA]_appa |
| **P_in** | P[mbar]_in |
| **P_out** | P[mbar]_out |
| **RH_ref** | SRH[%]_appa |
| **RH_in** | RHin[%]_in |
| **RH_out** | RH[%]_out |
| **RH_out_in** | RHout[%]_in |
| **SR_ref** | RAD[W/m2]_appa |
| **SR_in** | SR[W/m2]_in |
| **SR_out** | SR[W/m2]_out |
| **T_ref** | Tout[C]_appa |
| **T_in** | Tin[C]_in |
| **T_out** | T[C]_out |
| **T_out_in** | Tout[C]_in |

**Table 1 - Time series data considered**

## 3 Proposed solution

For a better visualisation of this data, some alternative libraries for graph construction were analysed, such as Ploty, Altair, Bokeh, Ggplot and Matplotlib; other alternatives of widgets like Ipywidgets, Tkinter, and Matplotlib widgets; and solutions of framework for creating interactive web applications, such as Dash and Datapane.

In the end, 2 solutions were chosen based on 4 criteria: the solution should allow iterative graphics, with an aesthetically pleasing graphic design, should be in python language, since the project is being developed in this language, and should be based on reliable and most used libraries.

Tests were realized with the 2 solutions proposed:

- Matolotlib, Ggplot with widgets.
- Plotly with Dash.

After performing the tests, the option Plotly with Dash was chosen, as with this solution it is possible to create professional visual graphics that can be presented in an application, with less programming effort compared to Matplotlib with widgets.

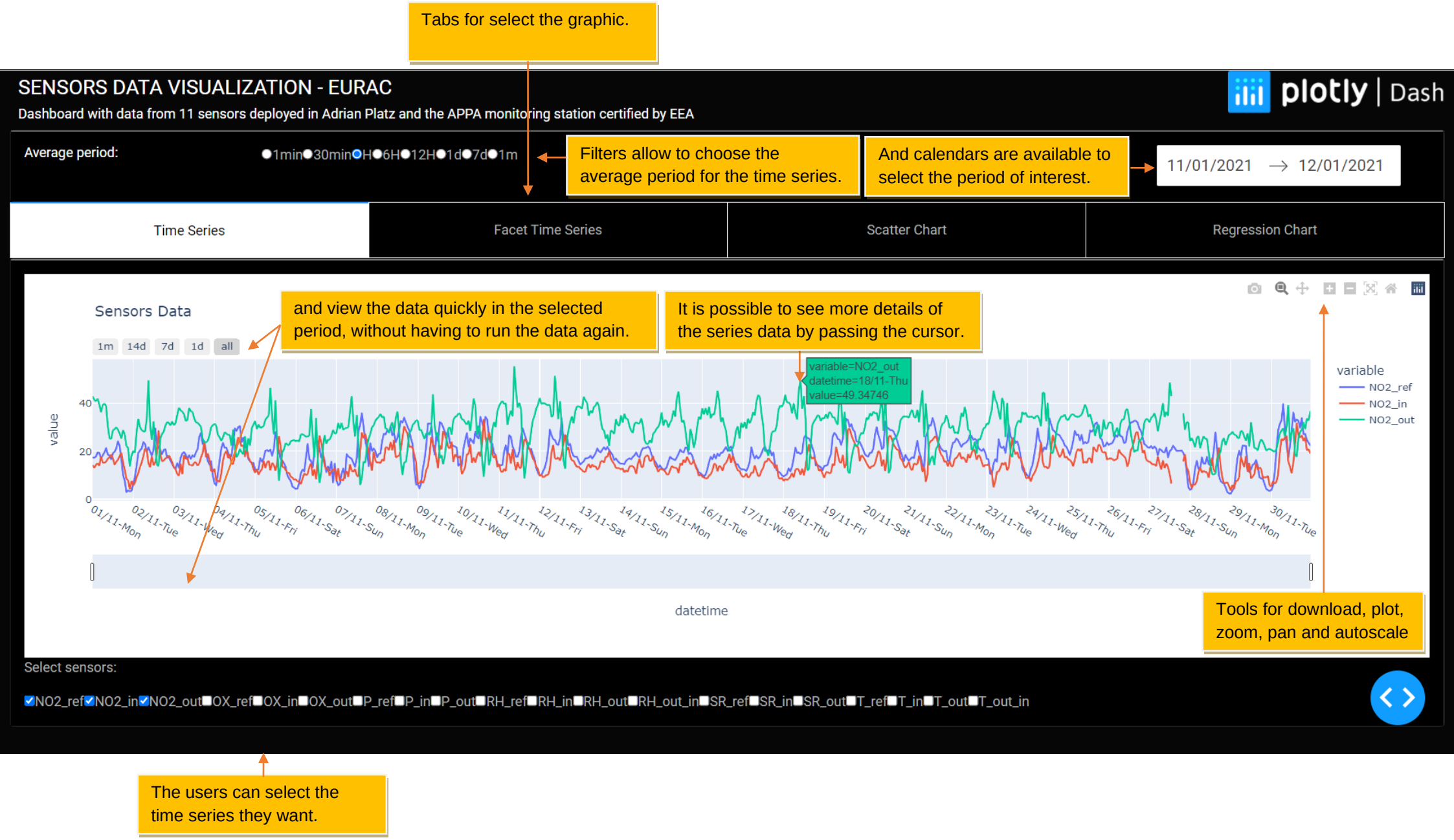
## 4 Results

The result was a creation of a dashboard for viewing sensors data, which can be used for other projects and allows the inclusion of other graphics in the future.

In addition, the developed system allows to overlap analytical plots and functions on time series. This is something that the current dashboards for data visualization (Telegraf, Grafana, etc.) are not yet capable of doing.

Below are presented the dashboard with some comments regarding the functionalities.

# Time Series Data



# Facet Time Series

The users can select the time series they want.

# Scatter Chart

The users can select the time series they want.

# Regression Chart

The users can select the time series they want.