



Digitisation of the Water Sector related to Software & Al





ONLINE

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NAIADES Speakers





a men

External Speakers

Some info



- This session will be entirely recorded and published on the NAIADES channels.
- Feel free to post your questions in the chat.

Please feel free to share your thoughts about the workshop on Twitter, via:

@naiadesproject, using
#NAIADESwebinars



Speakers

Moderation by:





Andreea Paunescu SIMAVI

Agenda



SESSION 1 – NAIADES presentations

- Al for Water Quality Management: Juan Fernández Montenegro, Aida Alvarez Díez, AIMEN
- Integrating external users with NAIADES internal services via Marketplace: Marius Jianu, SIMAVI
- Verifiable long-term data integrity in NAIADES: Tuuli Lõhmus, Guardtime

SESSION 2 – Invited speakers

• Sewer sediment deposition prediction using Machine Learning: Marc Ribalta, EURECAT

PANEL DISCUSSION & WRAP-UP





Al for Water Quality Management

Juan Fernández Montenegro, Aida Alvarez Díez, AIMEN



NAIADES Speakers





Juan Fernández Montenegro AIMEN



Aida Alvarez Díez AIMEN

Water quality

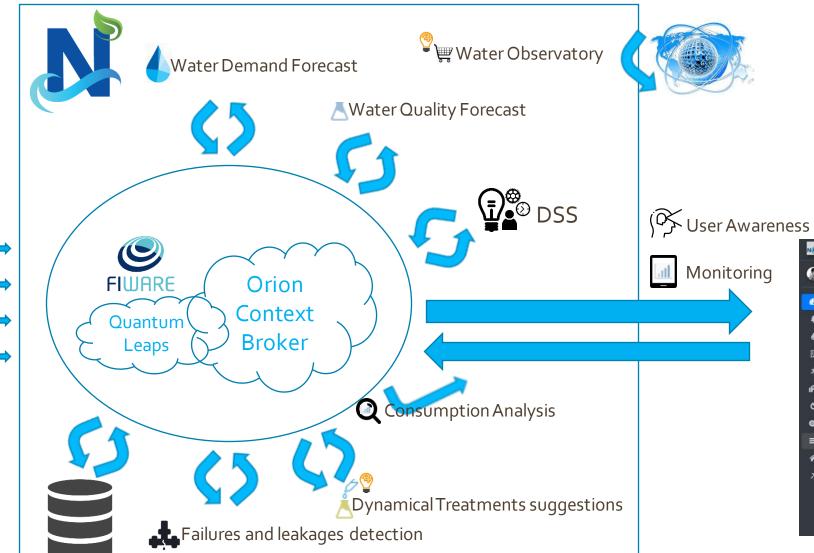


- Water covers 71% of the earth.
 - Ensuring access to good quality water is the main objective of the EU water policy.
 - Water quality is important for drinking and for the environment, directly affecting our health.
- quality is being affected by Water bodies land management, poor irrigation practices, waste practices, and increasing concentrations of chemicals.
- Water quality monitoring is necessary for:
 - Detecting water quality issues.
 - Planning water quality strategy.

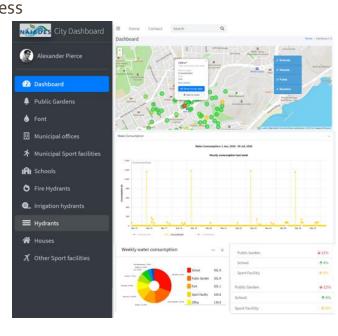


NAIADES Water quality services





Water Managers



Repository

∷≡

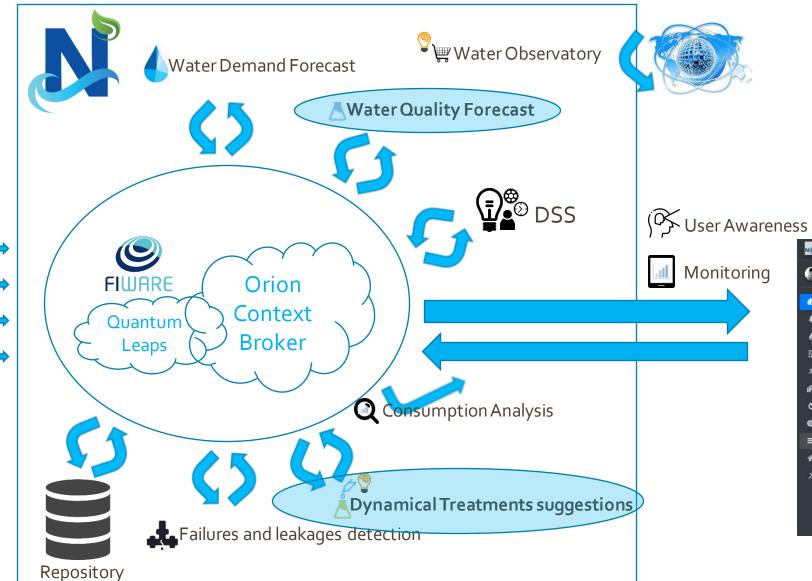
Cities,

Water

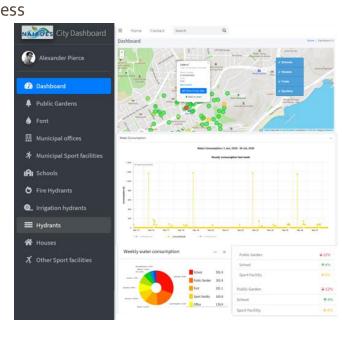
Utilities

NAIADES Water quality services





Water Managers



∷≡

Cities,

Water

Utilities

NAIADES Water quality Use Cases

3 pilot sites













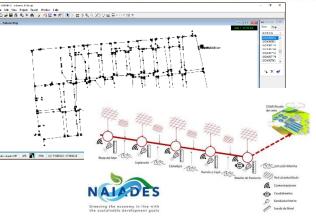


UCC1 - Watering



UCC2 - Fountains

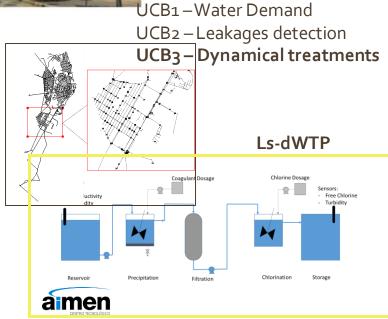
aimen



UCA1 – Water Demand

UCA₂ – Saline intrusion

UCA₃ – Dashboards for public buildings



NAIADES Water quality Use Cases

3 pilot sites











Brăila 📘

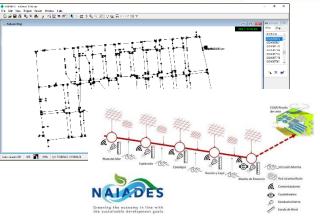


UCC1 - Watering



UCC2 - Fountains

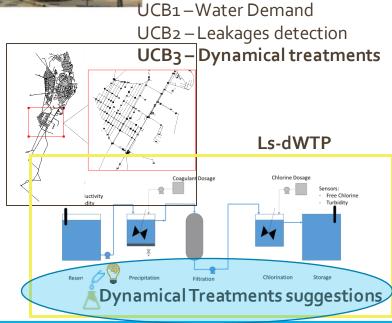
Water Quality Forecast



UCA1 – Water Demand

UCA₂ – Saline intrusion

UCA₃ – Dashboards for public buildings





- Context within NAIADES project:
 - Objective 4: Development of NAIADES Intelligence, Model and Algorithms for improved water management
- **Use case**: Carouge's public fountains (Switzerland)
 - City staff spend too much time monitoring water to ensure its quality
 - Maintenance practises are reactive



4/27/2022

- Reduce city staff workload
- Allow proactive maintenance to optimise maintenance, by reducing water use and avoid service cut-off; and ensure water quality.
- **Solution**: All water quality forecast for the next 48 hours in intervals of 6 hours apart:

Water quality parameters

Hq

Temperature Turbidity

Redox

Free Chlorine

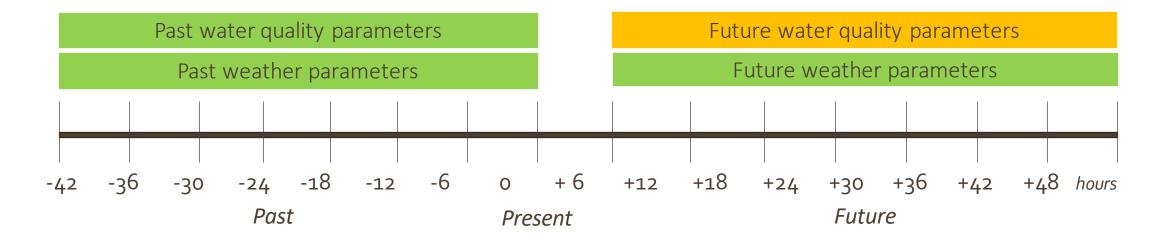
Total Chlorine

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DATA:

- Time series data from 25/06/2021 to 07/10/2021 every 4-5 minutes for:
 - Water quality parameters: pH, temperature, turbidity, redox, cl, freeChlorine and totalChlorine
 - Weather parameters: windSpeed, precipitation, relativeHumidity, air_temperature





MODELS:

- **LSTM**: this type of recurrent neural networks is a popular choice for time series forecasting, since they can learn complex patterns in data over long sequences, and thus, provide future predictions from the previous learned patterns. LSTMs have been already used for water quality predictions[1]
- 7 different LSTMs models were trained, one per quality parameter.
- **Preprocessing:** resampling to have samples separated by 6h, normalization, reframing of dataframe.

var1(t-42)	var2(t-42)	 var11(t-42)	var8(t+6)	 var11(t+6)
var1(t-36)	var2(t-36)	 var11(t-36)	var8(t+12)	 var11(t+12)
varı(t)	var2(t)	 var11(t)	var8(t+48)	 var11(t+48)

Flattened from top-left to bottom-right to form the feature vector

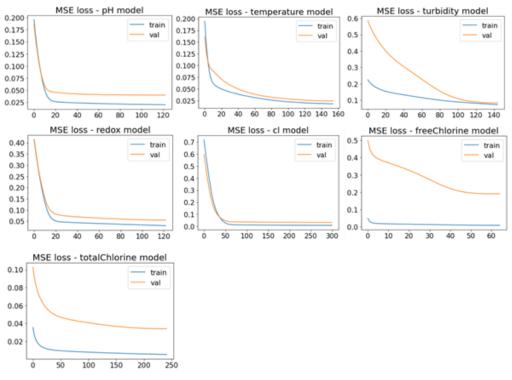
var1... var7 : water quality parameters var8... var11: weather parameters

LSTM model	# LSTM units	Batch size	
На	32	18	
temperature	32	16	
turbidity	24	24	
redox	24	16	
cl	16	16	
Free Chlorine	16	16	
Total Chlorine	16	16	



• RESULTS:

[RMSE, RMAE]



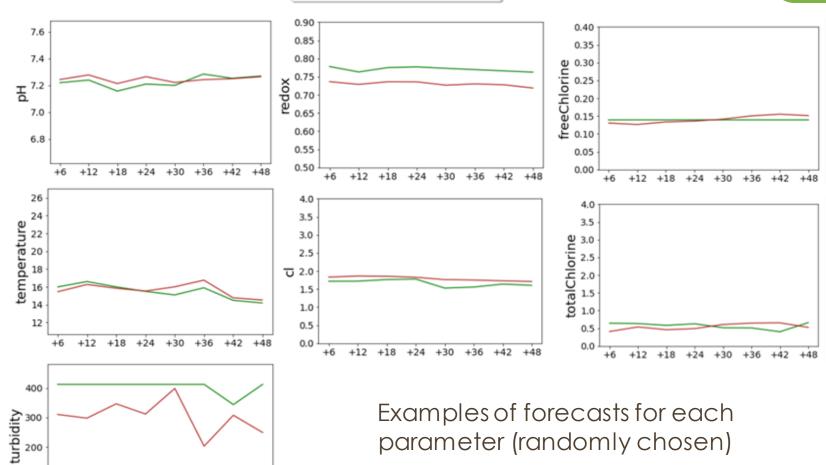
_		_			
Figure 5. A	ISE loss	for trail	nino and	validation set for each of the LSTM models trained on the different water quality parameters.	
0		/	0		

	рН	temperature	turbidity	redox	cl	Free Chlorine	Total Chlorine
+6	[0.086 ,	[1.536,	[86.750 ,	[0.031,	[0.212 ,	[0.039 ,	[0.332,
	0.259]	1.111]	7.767]	0.162]	0.389]	0.169]	0.533]
+12	[0.091 ,	[1.387,	[88.592 ,	[0.033,	[0.230,	[0.042 ,	[0.328 ,
	0.269]	1.065]	7.905]	0.162]	0.402]	0.177]	0.520]
+18	[0.103 , 0.278]	[1.695, 1.171]	[86.6 ₇₃ , 7.373]	[0.032 , 0.160]	[0.208 , 0.386]	[0.047, 0.185]	[0.355, 0.524]
+24	[0.101 ,	[1.551,	[108.528 ,	[0.035,	[0.247,	[0.055 ,	[0.343,
	0.281]	1.127]	8.547]	0.169]	0.427]	0.202]	0.526]
+30	[0.090 ,	[1.624,	[117.197 ,	[0.035,	[0.179 ,	[0.054,	[0.280 ,
	0.265]	1.149]	8.701]	0.168]	0.346]	0.199]	0.461]
+36	[0.086 ,	[1.698 ,	[154.343,	[0.034 ,	[0.176 ,	[0.061 ,	[0.291 ,
	0.257]	1.163]	10.785]	0.165]	0.343]	0.214]	0.445]
+42	[0.088 ,	[1.864,	[124.108 ,	[0.034 ,	[0.180,	[0.056 ,	[0.302 ,
	0.257]	1.229]	8.850]	0.161]	0.340]	0.207]	0.442]
+48	[0.084 ,	[1.494,	[154.187,	[0.040,	[0.190 ,	[0.051,	[0.299,
	0.259]	1.135]	10.440]	0.184]	0.337]	0.199]	0.475]

100



RESULTS:



real

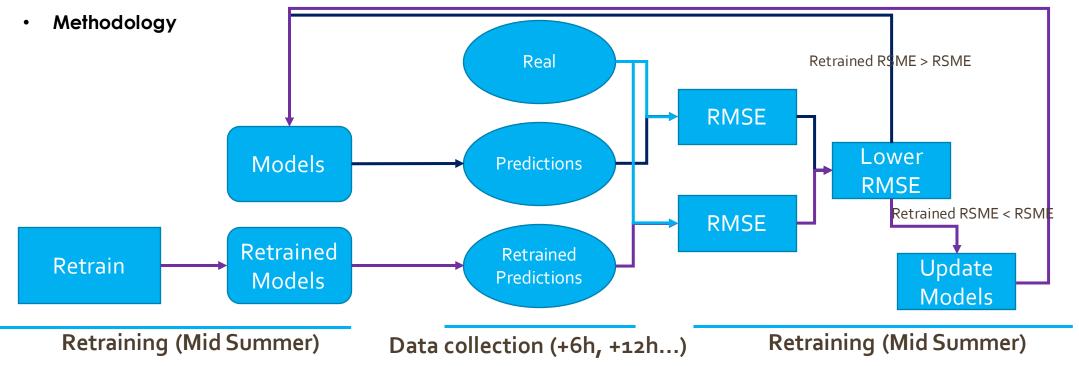
predicted

Examples of forecasts for each parameter (randomly chosen)

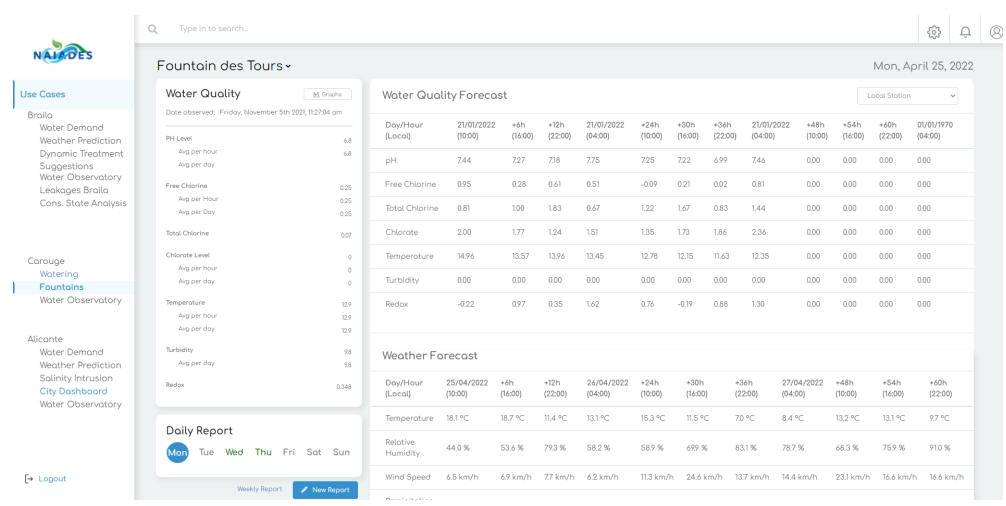
+12 +18 +24 +30 +36 +42 +48



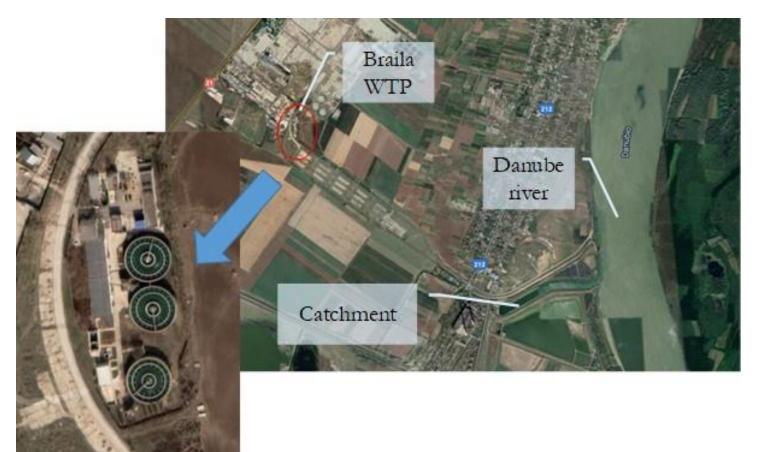
- Retraining/continual learning methodology:
 - For model optimization and to adapt to real data changes (data drift).
 - **Periodic Retraining**
 - Once a year on the middle of the fountains operational season (May to September).











Braila's Water Treatment Plant

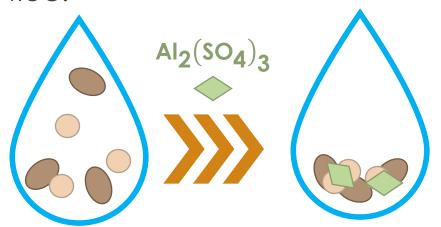
A WTP is a place in which the contaminants from wastewater are removed, making it possible to return it to the water cycle. Several processes take part in this (e.g., sedimentation & chemical processes)

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PROCESSES OF INTEREST

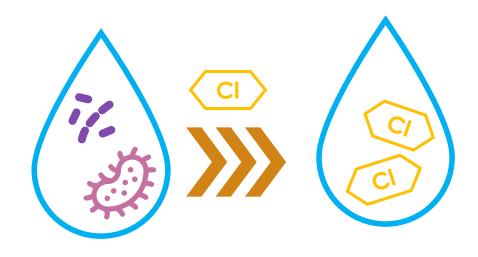
COAGULATION

Mixes chemicals into the water to bring the non-settling particles together into larger, heavier masses of solids called floc.



CHLORINATION

Adds chlorine to the water to kill parasites, bacteria, and viruses.





OBJECTIVES

- 1. Reduce the quantity of chemicals used in Braila's Water Treatment Plant while maintaining a high water quality
- 2. Suggest posible chemicals dosages for fringe cases



REINFORCEMENT LEARNING





Reinforcement learning problems involve learning what to do—how to map situations to actions—so as to maximize a numerical ward signal [...] Moreover, the learner is not told which actions to take, as in many forms of machine learning, but instead must discover which actions yield the most reward by trying them out.

Sutton, R. S., & Barto, A. G. (2018). Reinforcement learning: An introduction. MIT press.

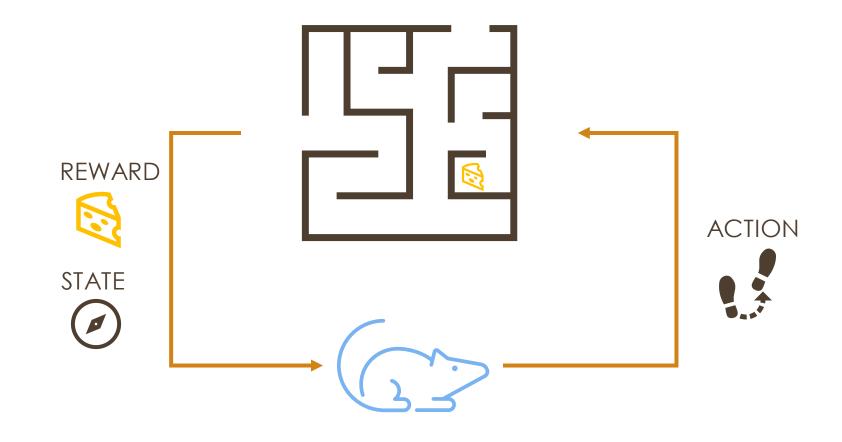


PARTS OF REINFORCEMENT LEARNING



Parts of a RL problem:

- Environment
- Agent
- Actions
- State
- Reward



Dynamical treatments Suggestions MULTI-ARMED BANDIT

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- Multiple possible actions
- Reward given by a probability distribution
- Agent does not have prior information related to the distributions
- Exploit vs Explore



















Dynamical treatments Suggestions DEFINITIONS/SET UP



ENVIRONMENTS (raw water)

ACTIONS (coagulant & chlorine)

STATE (treated water)

Turbidity [NTU]

рН

Conductivity [µS/cm]

 $Al_2(SO_4)_3$ dosage

[g/L]

Chlorine dosage [g/L]

Turbidity [NTU]

Residual chlorine [mg/L]

ENVIRONMENTS: 36

ACTIONS: 35

Our desired States are given by: Turbidity ≤ 5 NTUs $0.5 \text{ mg/L} \leq \text{Residual chlorine} \leq 1 \text{ mg/L}$



The reward is a lineal combination of the following factors:

- $\alpha \rightarrow$ The action taken produces the desired State
- $\beta \rightarrow$ The amount of product used
- $\gamma \to \text{The quality of the water after flocculation (takes into account the longevity of the filter)}$

α is prohibitive.

 γ is extrapolated from tables that holds all the posible combinations of environments & actions



a CALCULATION (TRANSITION MATRIX)

One Transition Matrix For each environment

Each element of the matrix has the probabilistic interpretation:

$$a_{ij} = P(S_i|A_j)$$

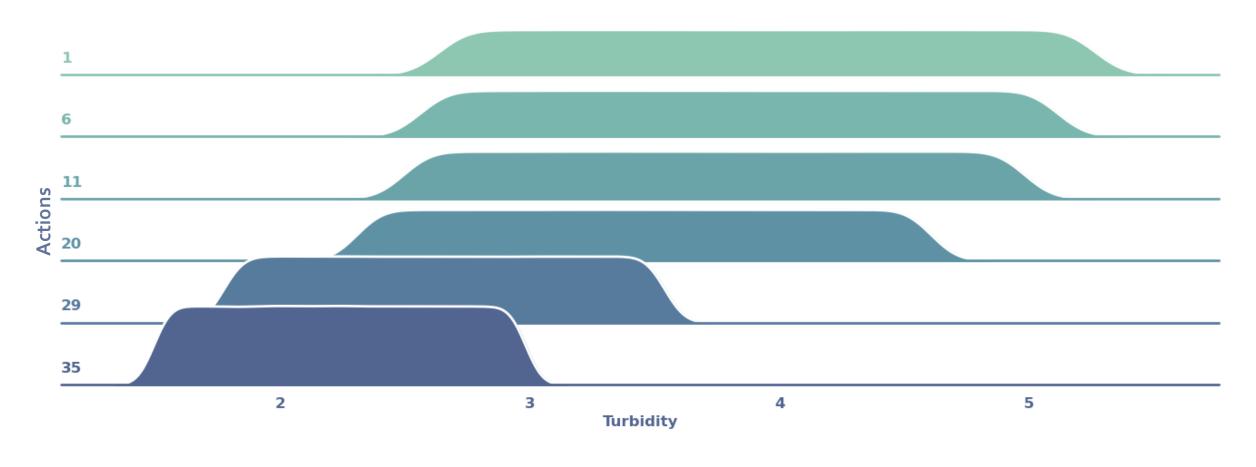
By necessity, for a given action, A_m :

$$\sum_{h=1}^{r} a_{hm} = 1$$

	A_1	A_2	 A_j	 A_k
S_1	a ₁₁	a_{12}		
S_2	a ₂₁	a_{22}		
S_i			a_{ij}	
S_r				a_{rk}

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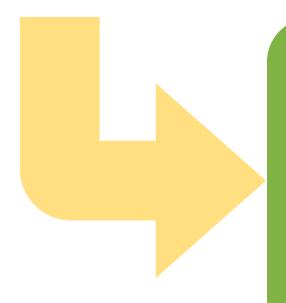
TRANSITION MATRIX'S INTERPRETATION



Dynamical treatments Suggestions NECESITY FOR SIMULATIONS



- Not enough data for all the possible scenarios and combinations
- Necessity of interaction Agent/Environment by Actions
- Data after flocculation (γ contribution)



STIMELA

- Can be integrated in a MatLab routine (Toolbox)
- Highly editable
- Open documentation
- Low cost

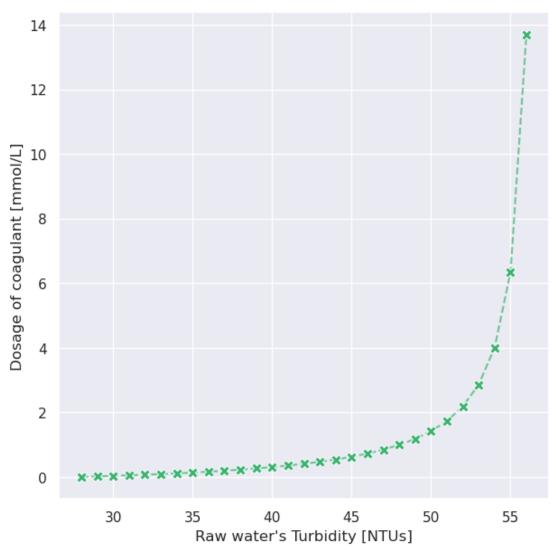
Dynamical treatments Suggestions STIMELA'S DESING OF BRAILA'S dWTP



Raw water Coagulation Flocculation Single media filter Chlorination

Dynamical treatments Suggestions STIMELA'S LIMITATIONS





Stimella does not correctly reproduce the coagulant process when the wasterwater has a high Turbidity associated

Dynamical treatments Suggestions NECESSITY FOR EXPERIMENTS



1. Model Validation

- 2. Data to supplement Stimela's:
 - 1. Fringe cases of high Turbidity
 - 2. Laboratory's scale data



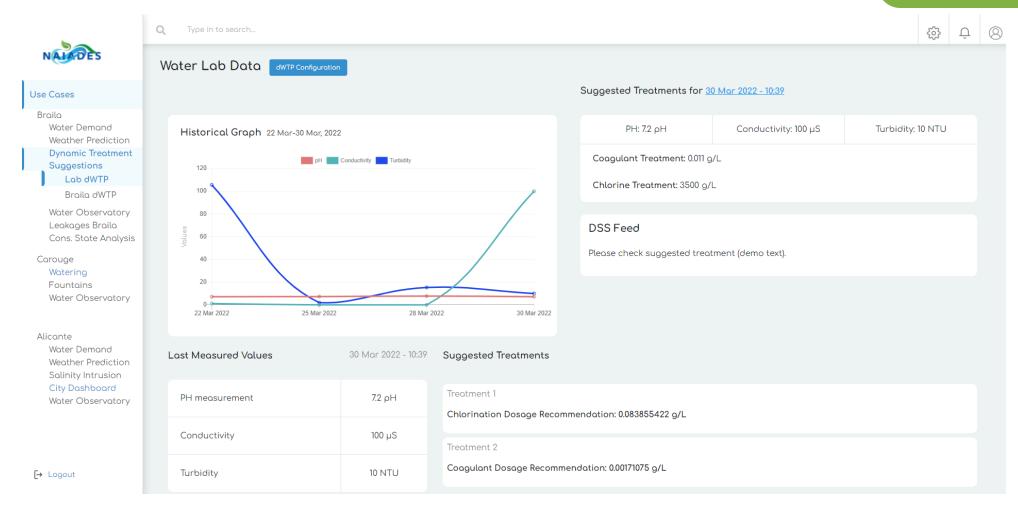




WHAT'S HAPPENING RIGHT NOW?

- Validation of the model with experiments in the laboratory setup
- Tweaking and improving the model with the new data





Ecosystem of Smart solutions requirements



NAIADES requirements:

- Interoperability:
 - FIWARE compatible data models (NAIADES data models: https://gitlab.distantaccess.com/naiades/dmv_public/-/blob/master/swagger.yaml)



- NGSI API
- Security:
 - Authentication (Tokens through Keyrock and Wilma)



- Data signature (blockchain technology KSI signature (https://m.guardtime.com/files/KSI_data_sheet_201509.pdf))
- **Modularity:**
 - Conteinarisation







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NAIADES Speaker





Marius Jianu SIMAVI





Integrating external users with NAIADES internal services via Marketplace

Marius Jianu, SIMAVI



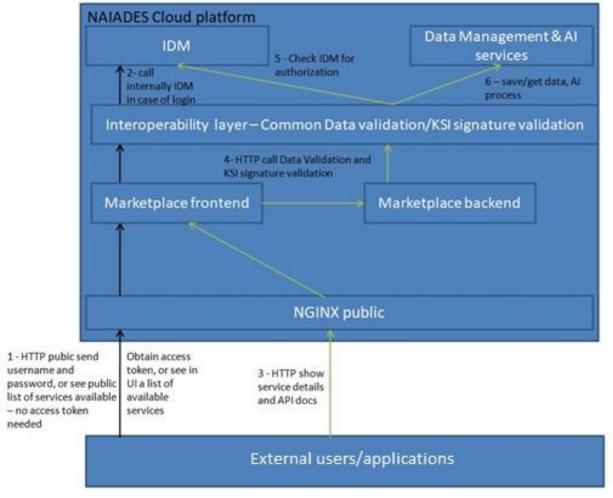
Marketplace – general aspects



- Marketplace component is an application in which the external users can see the list of available NAIADES services and the API integration support.
- Marketplace internationalization (EN, DE, ES, FR, RO)
- Marketplace content:
 - Public access:
 - The list of available NAIADES services
 - The description of the available services
 - Private access:
 - The API description for integration (in the UI) REST HTTP requests
 - Test possibility (in the UI) REST HTTP requests

Marketplace – architecture

- External users can access internal available NAIADES services just Through Marketplace component.
- Marketplace component access internal NAIADES services through interoperability layer





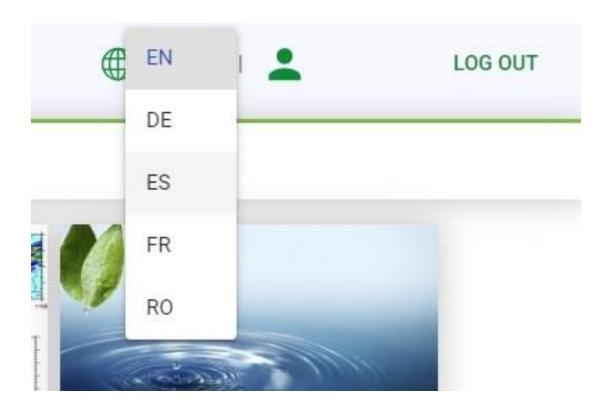
Marketplace – technical aspects

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- Marketplace component is composed of the following:
 - Marketplace UI
 - Angular with NodeJs
 - Marketplace backend
 - Java with Springboot
- Marketplace communication
 - Between Marketplace UI and Marketplace backend REST HTTP
 - Between Marketplace backend and NAIADES services REST HTTP
- Marketplace containerization
 - Docker with Docker compose configuration

Marketplace – internationalization UI

- NAIDES
 Webinar Series
- The Marketplace internationalization is available in five languages:
 - English, German, Spanish, French, Romanian



Marketplace – list of services

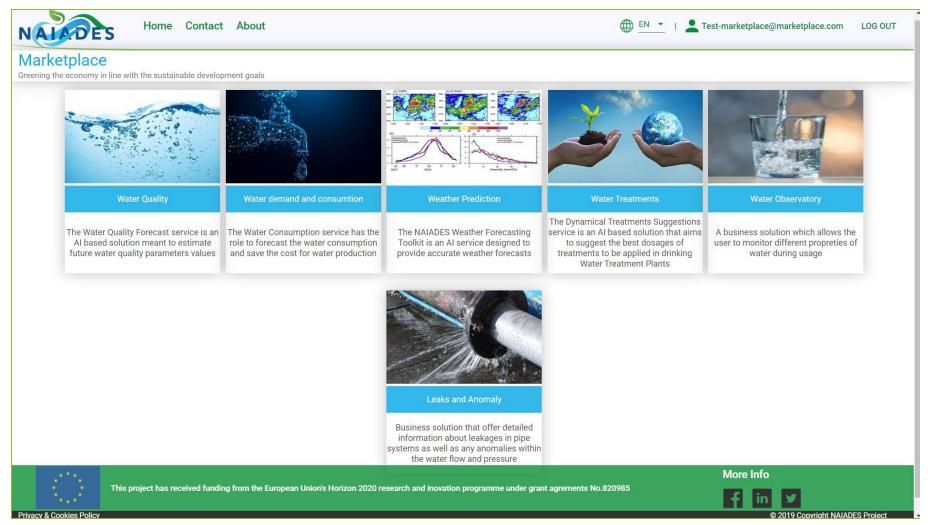


- The list of the available services could be seen with or without user authentication
- List of services
 - Water Quality
 - Water Demand and Consumption
 - Weather Prediction
 - Water Treatments
 - Water Observatory
 - Leaks and Anomaly

Marketplace – list of services UI

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• The list of services is public, and it could be accessed by the external users with or without authentication.

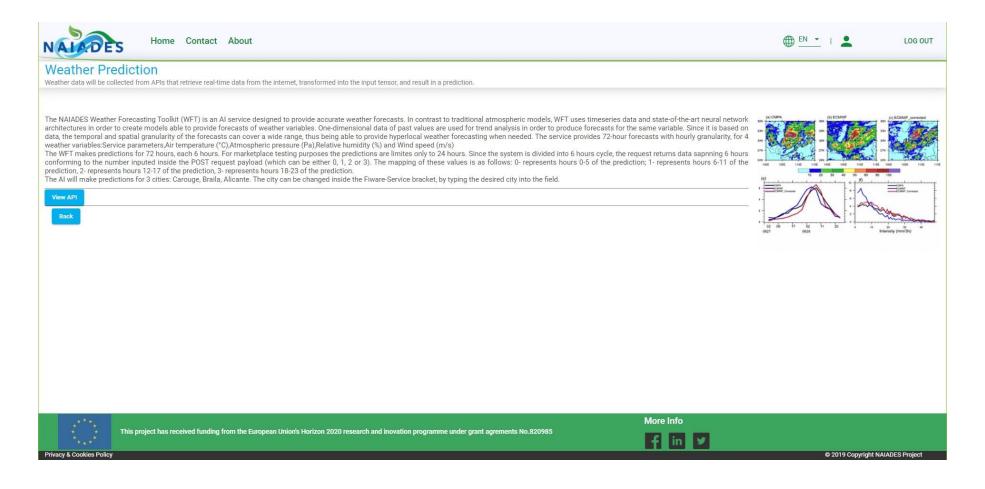


Marketplace – description of services UI

NAIDES

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• The description of services is public, could be accessed with or without authentication, by external users. Example Weather prediction services description

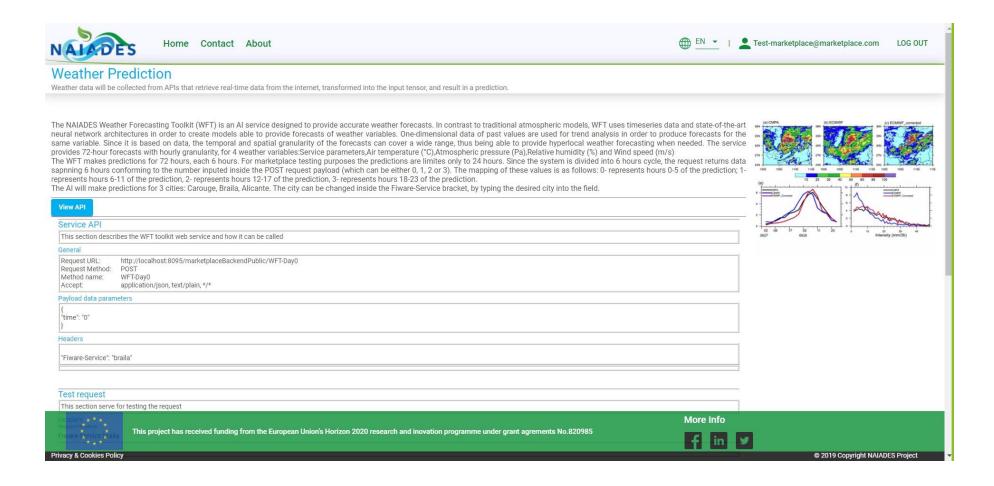


Marketplace – description of API services UI



• The API description of services is private, could be accessed just with

authentication, by external users. Example: Weather prediction service API description



Marketplace – test of API services UI



• The test procedure for the service APIs is private, could be accessed just with authentication, by external users. Example: Weather prediction service API test procedure

Test request	
This section serve for testing the request	
Request Headers	
Fiware-Service:braila	
General General	1
Request URL:	1
http://localhost:8095/marketplaceBackendPublic/WFT-Day0	
Request Method: POST	
Accept type - possible values: application/json, text/plain, */*	
/	
Payload data parameters	
Payload data parameters	
{time*, "0"	
}	
	4
Send request	
Response	
Response status 200 OK: true	
Response data ("id":urn:ngs:l-d:WeatherForecast:WeatherForecast:Day0-0";type":"WeatherForecast;"address";("type":"StructuredValue";();"metadata":();"date!ssued";("type":"DateTime";value":"2022-04-26T12:00:00.00Z";"metadata":());"dayMaximum";("type":"StructuredValue";value":("feelsLikeTemperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temperature":22.804754257;"temper	
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More Info	
This project has received funding from the European Union's Horizon 2020 research and inovation programme under grant agreemnts No.820985	y
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Marketplace – services APIs and authentication



• The APIs description and tests, used for integration between external apps and NAIADES Services require authentication.

- Marketplace Authentication and Authorization
 - Dedicated register form in Marketplace UI
 - Dedicated login form in Marketplace UI
- Authentication with NAIADES
 - Via NAIDES Keyrock IDM

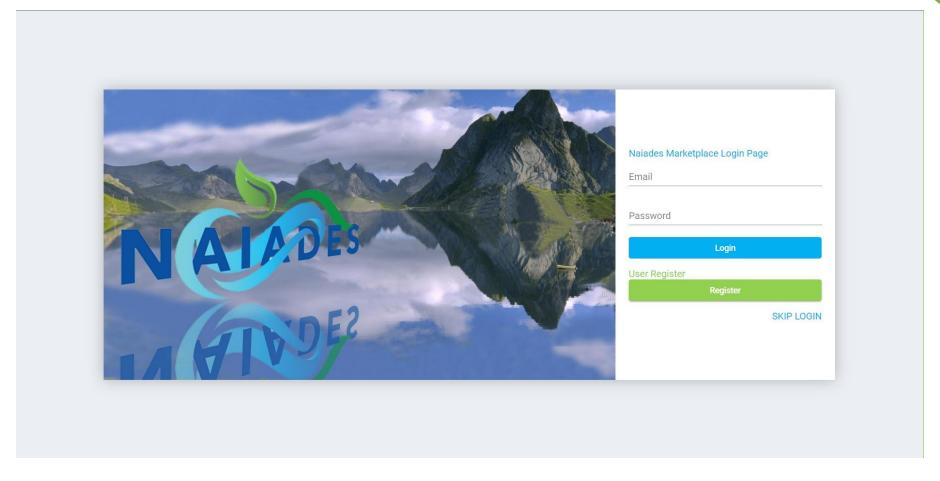
Marketplace – register form UI





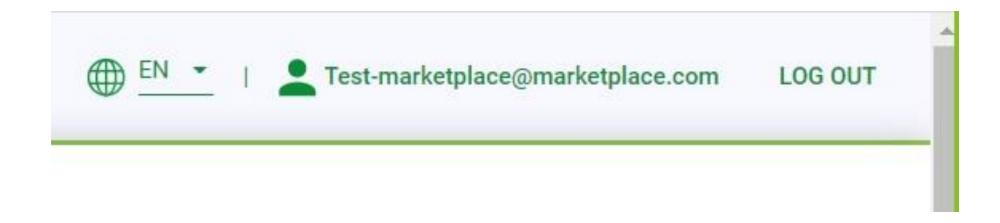
Marketplace – login form UI





Marketplace – successfully login UI









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NAIADES Speaker





Tuuli LõhmusGuardtime





Verifiable longterm data integrity in NAIADES

Tuuli Lõhmus, Guardtime



Plan for the talk



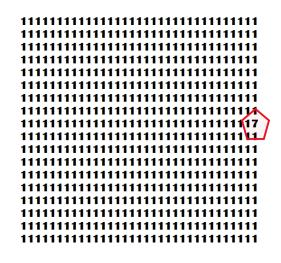
- What is integrity?
- Why check data integrity before using it?
- Integrity validation in NAIADES
- Future of data integrity

What is integrity?









- Integrity mechanisms ensure the product is **unchanged**.
- Data integrity ensures the **data consistency** throughout its life-cycle.
 - All data values are **unchanged**.
 - In some cases, the format must also be unchanged.
- Small changes are almost impossible to detect when looking at the data or analyzing it.

Why check data integrity before using it?



- In general, a lot of predictions, planning and decisions are based on data.
- If data has been modified maliciously or accidentally during the transport or storing process, the **analysis will be faulty**.
- Data integrity validation ensures that the **data is unmodified and can be trusted**.
- This includes being able to check in the **long term** without knowing any secret passwords.
- Integrity checking does not help if the data source (e.g. sensor) is producing faulty output.

Integrity validation in NAIADES





- NAIADES project uses a lot of data as an input for models and predictions (weather, water demand, water quality).
- Data integrity checking is one of the steps to ensure good quality input.
- Data integrity for all the data sent to NAIADES platform can be verified.

Integrity validation in NAIADES



INPUT DATA

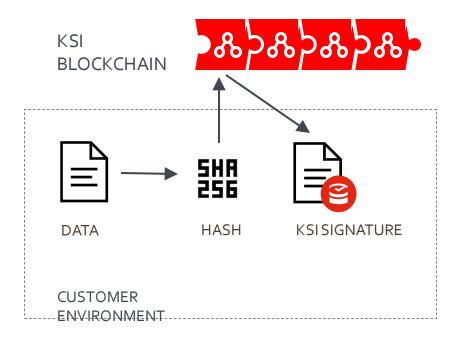
HASH FUNCTION

HASH VALUE



ONE-WAY ONLY.
REVERSING IMPOSSIBLE

- Cryptographic hash is a one-way function that where a significant change corresponds to a small change in data
- Data hashes are linked to KSI Blockchain
- Benefits of using KSI signatures
 - Signatures independently verifiable
 - Do not expire, long-term forensic proof
 - Overcomes technical limitation of other blockchain technologies



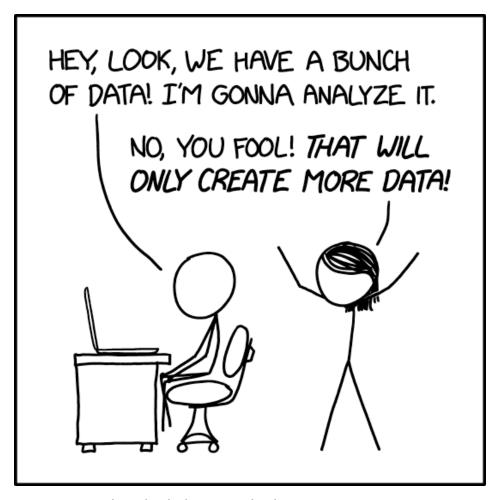
Integrity validation in NAIADES



- 1. Data is signed at the data source.
- 2. Signed JSON is sent to Data Model Validator (DMV) where the model is at first validated.
- 3. DMV forwards the signed JSON to KSI verifier for integrity verification.
- 4. For all data, data model and KSI signature are both checked.
- 5. Any issues for integrity checking are reported to the user of NAIADES platform.

Future of data integrity





Credit: xkcd (https://xkcd.com/2582/)

• Importance of data is increasing, including for AI

- Critical infrastructure operations
 - Water
 - Energy
 - Finances
 - Health
 - Automotive
 - Supply chain
 - Space





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External Speaker





Marc Ribalta
EURECAT





Sewer sediment deposition prediction using Machine Learning

Marc Ribalta, EURECAT



The SCOREwater project



 SCOREwater focuses on enhancing the resilience of cities against climate change and urbanization by enabling a water smart society.



SCOREwater in Amersfoort will focus on improving the detection of flash floods while reducing environmental impacts through:

- · Prediction models and early warning systems for flash floods;
- decision-tool (case-based reasoning) for reducing environmental impact considering risks, economic, operational and environmental information.

BARCELOMA CASE 2 SEWAGE

SCOREwater in Barcelona will focus on reducing wastewater management problems with the vision of improving public health:

- · Predicting sewer clogging User behavior profiling and analysis;
- correlate behavior with water quality measurements, and subsequent actions to mitigate health risks and hazardous events.



CÖTERORG

SCOREwater in Göteborg will focus on managing water pollution in the industrial sector by:

- The prediction of water pollution based on the combination of meteorological data and water quality sensors;
- predictive maintenance of local water treatment equipment.



Sediment deposition in sewers



The accumulation of sediment reduces the volume of water that can be carried in a pipe.

Pipe blockages/failures may happen, producing retentions or flooding in the city.

To ensure this is not happening, preventive routines are carried to clean and maintain the pipes.

Preventive routines suppose an economic expenditure of millions of euros each year.

The aim of our solution is to create a predictive maintenance model, using machine learning, that works as a support system to improve the maintenance schedules and therefore reduce the cost.







Sources: Wikipedia, Sediment desposition in Toronto, London Sewer

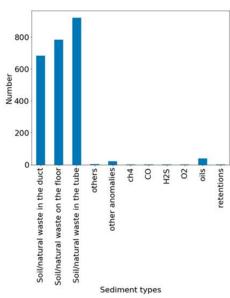
Data features identification

Webinar Series

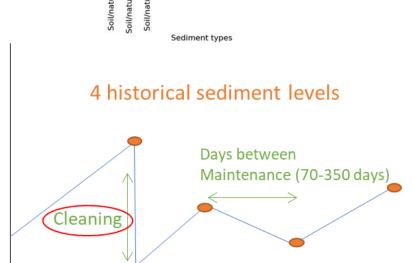
Sediment Data

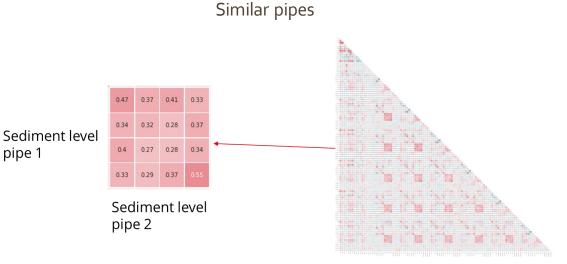
Two generic type of features:

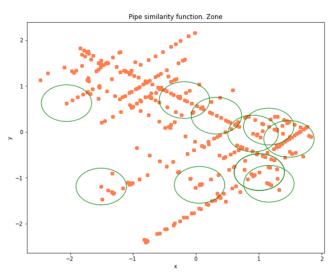
- Physical sewer pipe features
- Dynamic features that change over time



pipe 1







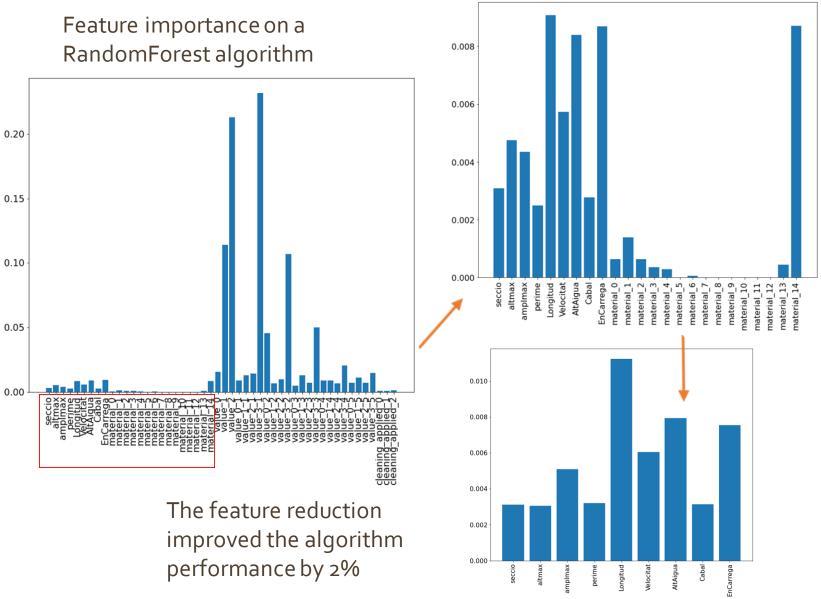
Data model and objective predictions

Feature	Description	Туре
Pipe section	The pipes section metric	Physical
Perimeter	The perimeter of the section	Physical
Length	Length of the sewer section	Physical
Section width	Width of the section	Physical
Section height	Height of the section	Physical
Mean water height	The mean water height during the dry season	Physical
Mean velocity	Mean velocity of the residual water during the dry season	Physical
Meanflow	Mean flow of the residual water during the dry season	Physical
Material	The material of the section walls	Physical
Sediment level lags 1 to 3	Sedimentation level in 3 different timestamps	Dynamic
Days between maintenances	Days between the sedimentation level gathering	Dynamic
Mean of daily total rain lags 1 to 3	Mean of daily rain between maintenance routines	Dynamic
Standard deviation of rain value lags 1 to 3	Standard deviation of the daily rain value between maintenance routines	Dynamic
Cleaning applied	Indicates if cleaning was applied during the maintenance session	Dynamic
Physical features of nearer sections	The physical features already explained, but for all the 5 near sections	Physical
Dynamic features of nearer sections	The dynamic features already explained, but for all the 5 near sections	Dynamic



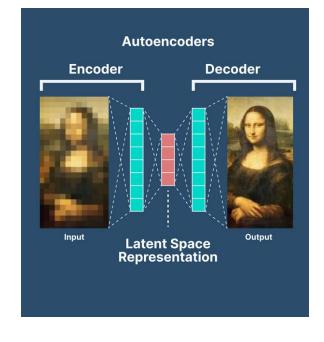
Problem: Only 1900 registers available, but a lot of features to be used

The reduction of variables



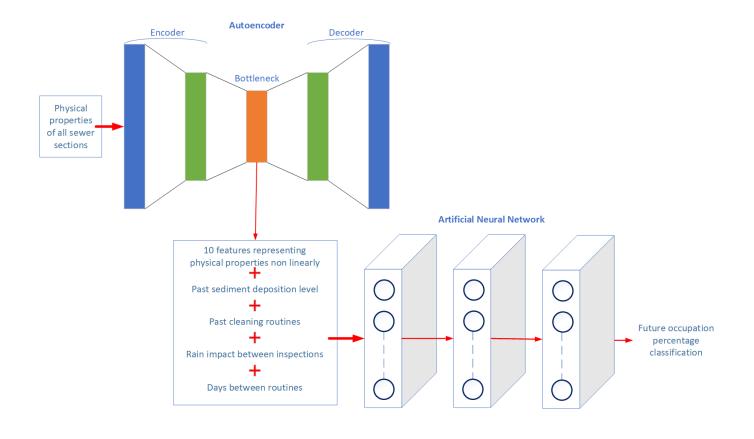


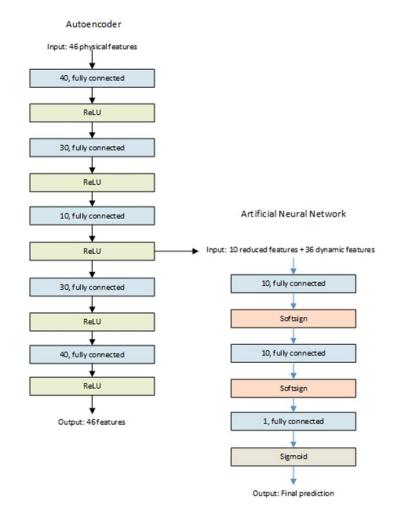
Idea: Use Autoencoders to reduce feature dimensions



Overall architecture



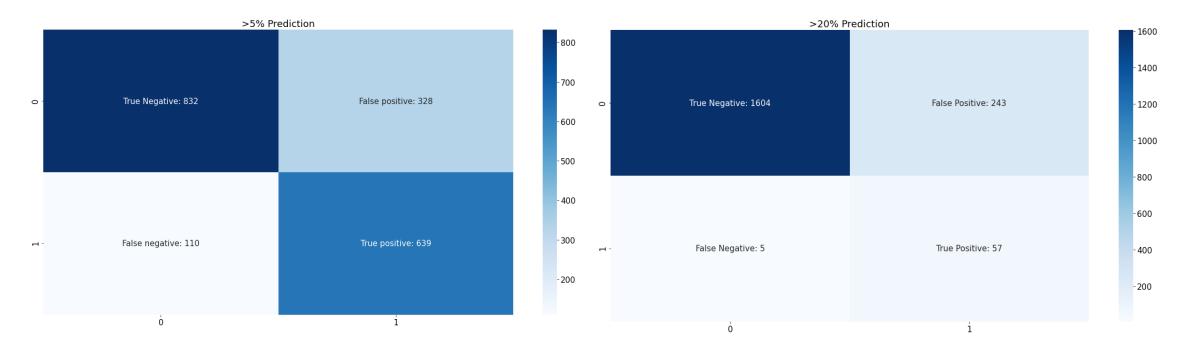




Results



Classification type	Specificity	Sensitivity	Accuracy
>5%	74%	81%	76%
>10%	78%	77%	79%
>15%	87%	82%	86%
>20%	87%	85%	87%







Panel discussion & wrap-up







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