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Modelado Inteligente de Sistemas
Intelligent Modelling of Systems

Dr. Ignacio J. Turias Domínguez (Research Group Leader)
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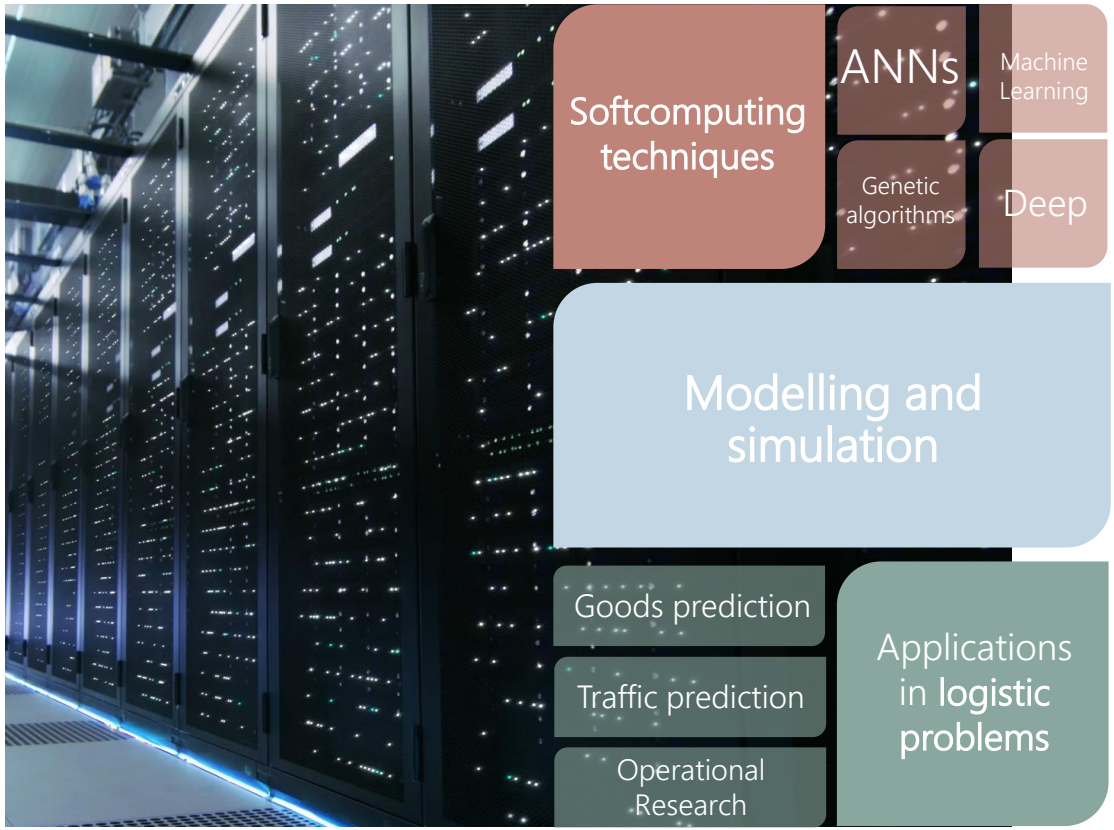
MIS Intelligent Modelling of Systems

Research



Softcomputing techniques

ANNs

Machine Learning

Genetic algorithms

Deep

Modelling and simulation

Goods prediction

Traffic prediction

Operational Research

Applications in logistic problems

Applications in industrial problems

Data Analytics

Support decision tools

Soft sensoring / Digital twins

Industry 4.0

Applications in environmental problems

Prediction of atmospheric pollution

Fusion data in sensoring networks

etc

Applications in medicine

Deep Learning

Omics

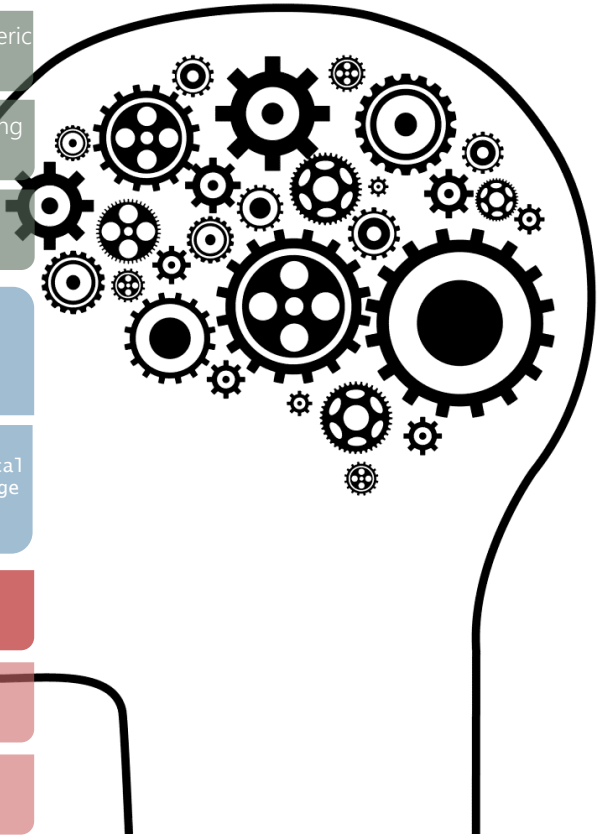
Survival Analysis

Biological Knowledge

Objectives

How to solve problems using soft computing techniques

How to model and simulate processes



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Ignacio J. Turias

INTELLIGENT MODELLING OF SYSTEMS

The importance of data in Ports 4.0: Case study of air pollution analysis with Machine Learning techniques.

Dra. María Inmaculada Rodríguez García.

Degree in Civil Engineering.

Master's Degree in Civil Engineering.

Master's Degree in Logistics and Port Management.

PhD in Energy and Sustainable Engineering.

FPI Universidad de Cádiz

12 de marzo de 2024

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Puerto de Algeciras

International Staff Week

PAIDI · TEP · 024

Intelligent Modelling of Systems

Hyperspectral Technology

Pattern recognition, image processing and machine learning

Dr. Ignacio J. Turias Domínguez (Research Group Leader) ignacio.turias@uca.es

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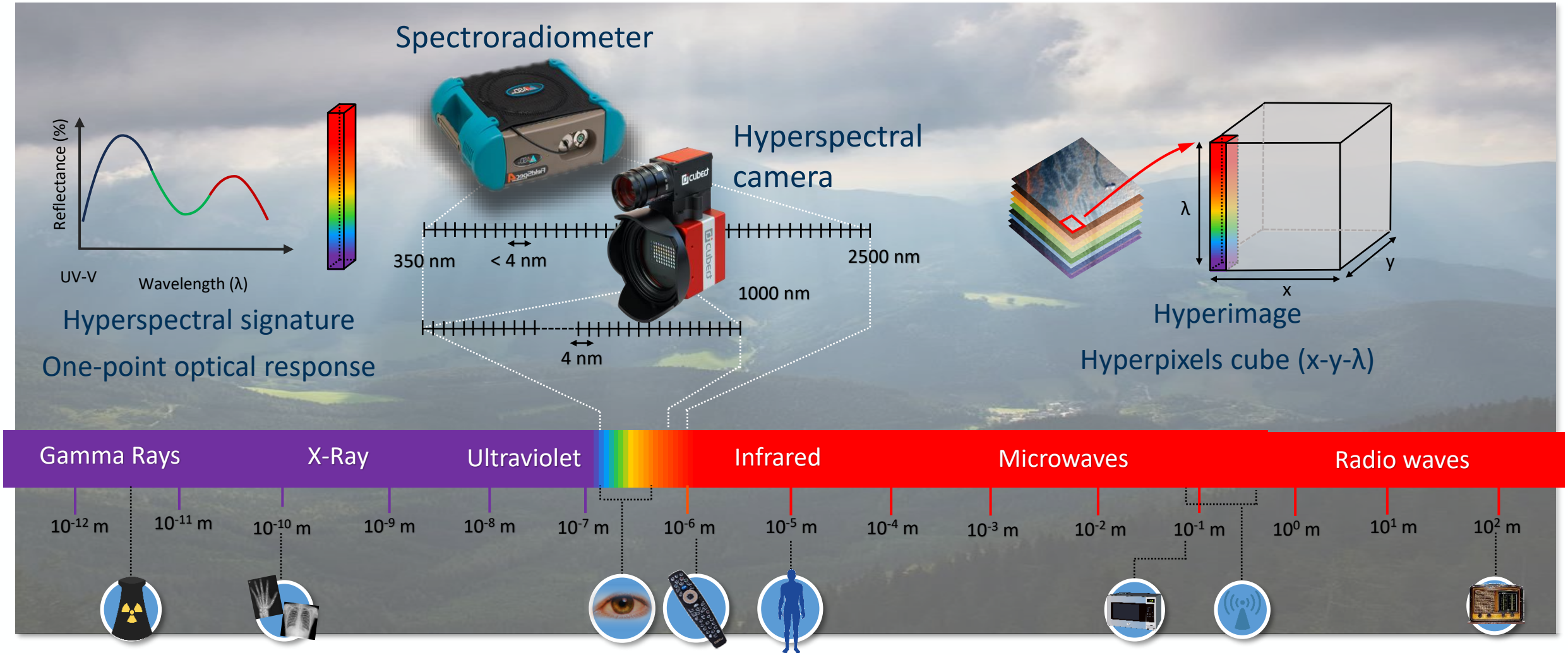
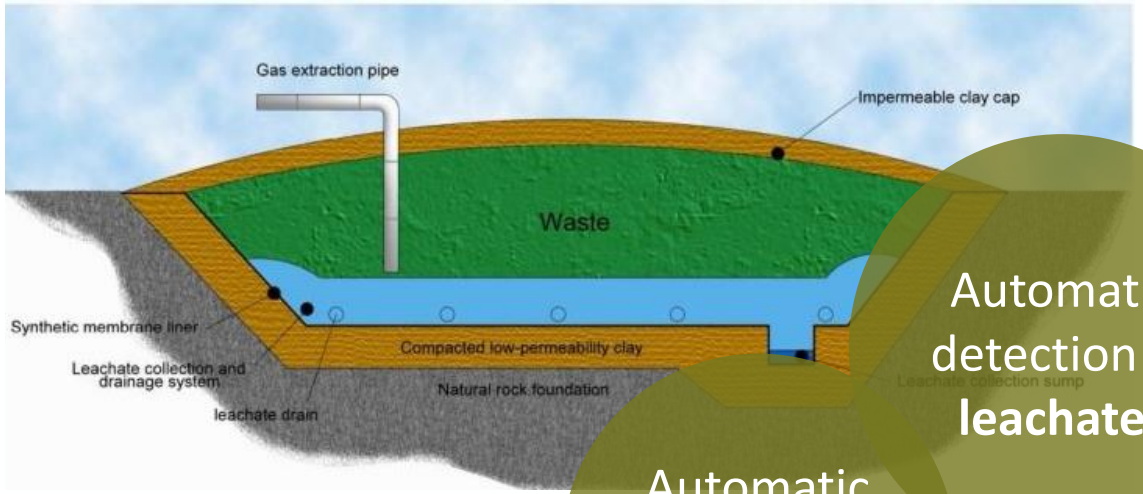
Hyperspectral Technology




Hyperspectral Technology
Problem Solving
· Landfill Safety ·
· Water Protection·
Mahine & Deep learning

Research line I: Landfill Safety

Civil Engineering Projects – Project ARCGISA-FCTA (2021-2023): Use of HSI and RPA in intelligent management of urban waste landfills



Automatic detection of **leachates**

Reduction of slope slides

Automatic detection of **gases**

Reduction of potential explosions

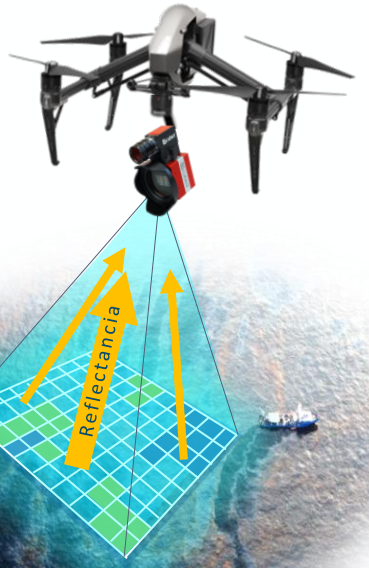
Research line II: Water protection- Oil spills monitoring

Industrial Projects - CEIMAR Project 23-24 (in progress): Hyperspectral monitoring of oil spills in marine and river waters with ML

Hyperspectral signatures library

Hyperimages dataset

Machine & Deep learning



Vs

Research line II: Water protection- Oil spills monitoring

Industrial Projects - CEIMAR Project 23-24 (in progress): Hyperspectral monitoring of oil spills in marine and river waters with ML

Journal of Marine Science and Engineering
MDPI

Article

Oil Spill Classification Using an Autoencoder and Hyperspectral Technology

María Gema Carrasco-García [1,*], María Inmaculada Rodríguez-Gar
David Elizondo [3] and Ignacio José Turias Domínguez [2]

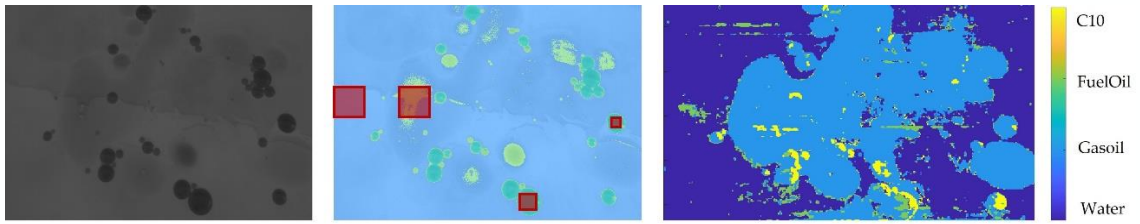
Published

LOGIC JOURNAL of the IGPL
OXFORD ACADEMIC

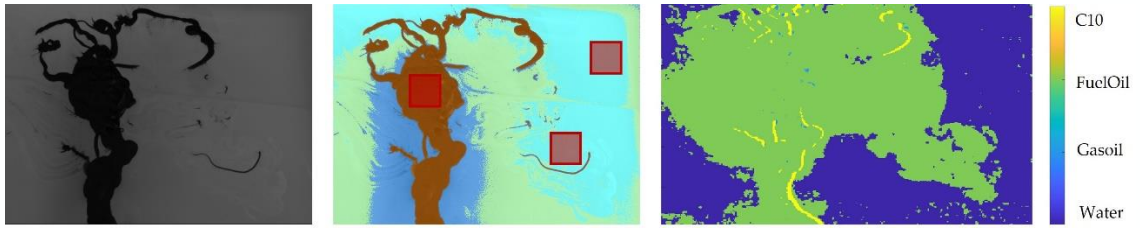
Hyperspectral imaging and artificial neural networks for oil spills automatic detection

María Gema Carrasco-García[1]
María Inmaculada Rodríguez-Garcí
Javier González-Enrique[1]
Juan Jesús Ruiz-Aguilar[1]
José Manuel Alcantara Pérez[2]
Ignacio J. Turias Domínguez[1]

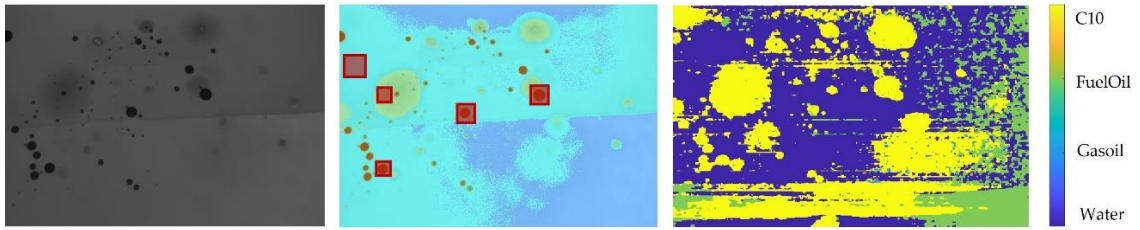
Special issue (under review)



100% Water – 100% Gasoil



91% Water – 90% Fuel oil



99% Water – 92% C10

International Staff Week

Intelligent Modelling of Systems

- Hyperspectral Technology -

Thank you for your attention

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BAHÍA DE ALGECIRAS: Puerto de Algeciras

Description of the study area → industrial center, airport, port of Algeciras (the 4th most important port in Europe).Complexity of the area → meteorology

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Puerto de Algeciras

The Port of Algeciras → Logistics

Coordination and optimization of all flows of materials, information and personnel of the company, from the initial procurement of raw materials, through production, storage and distribution of goods and services to consumption by the end customer.

"Si los 80 fueron tiempo de calidad y los 90 de reingeniería, los 2000 serán tiempo de velocidad."

Bill Gates, 1999
Business @ the speed of thought.

Velocidad = Distancia / Tiempo → Para aumentar la velocidad debe reducirse el tiempo → Operaciones ágiles

Union of all the companies involved in the production, distribution, handling, storage and marketing of a product and its components.

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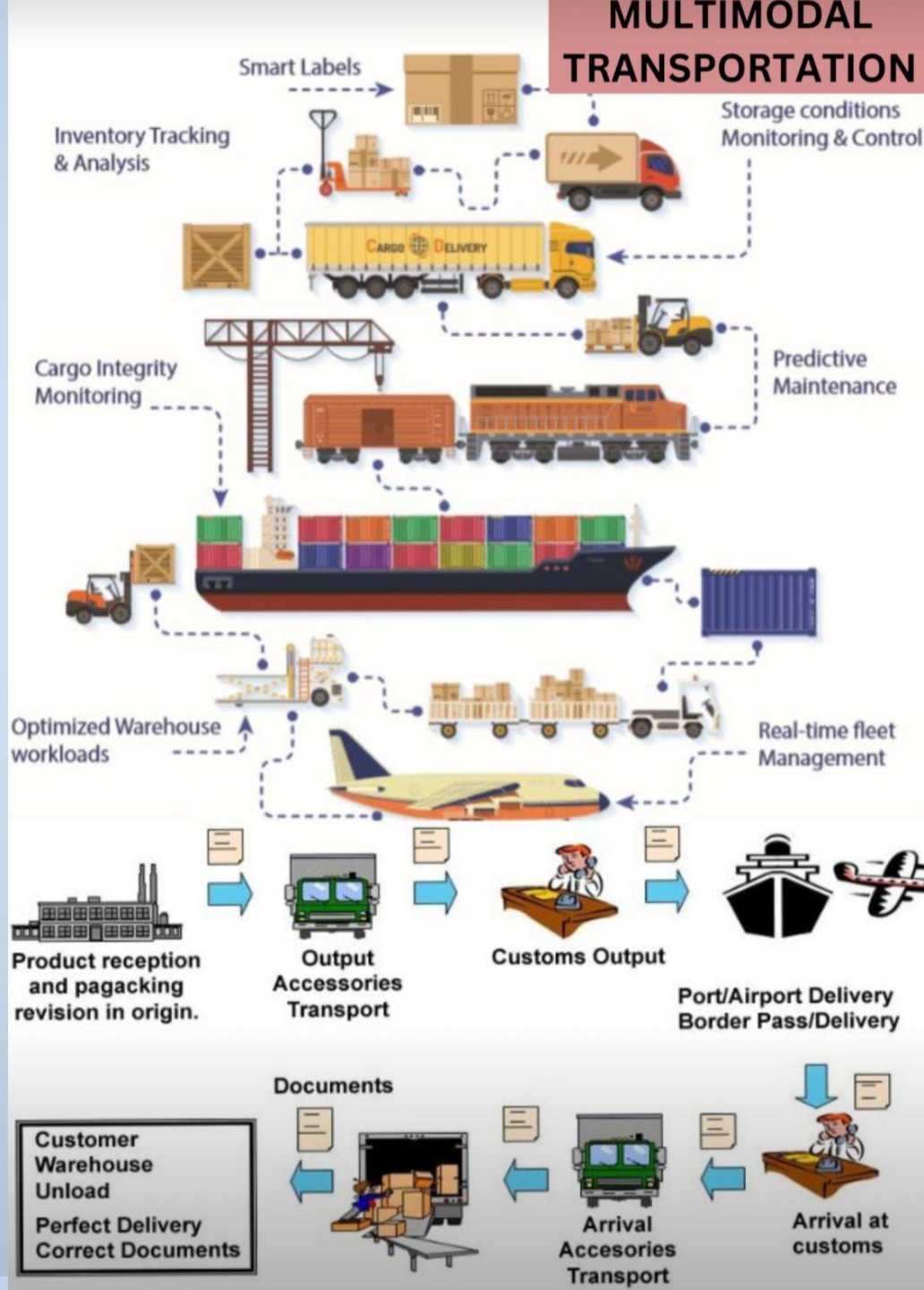
The Port of Algeciras → Logistics

Objetivos logísticos:

- Minimize costs
- Improve service levels
- horten response time

Eliminate activities that do not add value



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The Port of Algeciras

- **Infrastructure and Operations/ traffic and volume:**
- Container traffic → more than 100 million tons in 2023
- Bulk and liquid cargo
- Carga rodada (roro → roll on-roll off)
  - Passenger traffic
  - Cruises
  - Strategic location

Receipt of more than 90,000 ships per year →

⬆ Air pollution in the Bay

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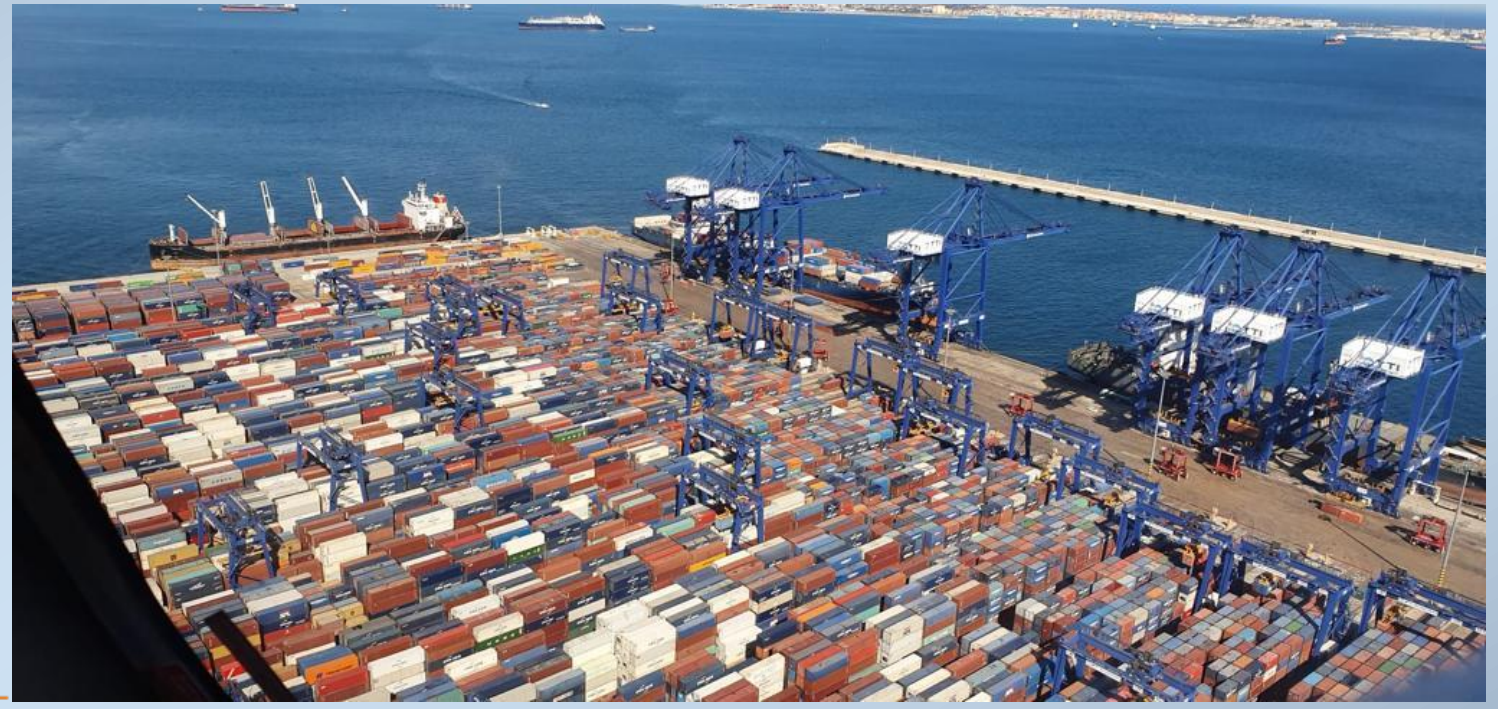
Puerto de Algeciras

The Port of Algeciras

- **Container terminals:**
  - Maersk and TTI Algeciras → Advanced automated technology for efficient container handling
- **Conectividad:**
  - Land, sea and rail connections



Maritime connectivity between Europe, Africa and the Americas. Its advanced infrastructure, strategic location and operational capacity make it one of the most important and active ports in the world.

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Puerto de Algeciras

The Port of Algeciras

The Port of Algeciras

- Increased pollution levels
- Prediction to take preventive and evasive measures
- Urban pollution
- Industrial emissions
- Meteorological variables
- Human health problems

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Strait of Gibraltar

The Impact of Shipping in the World

Cargo transported by sea represents more than 85% of the Cargo transported in general

Maritime transport is responsible for less than 3% of responsible for less than 3% of CO_2 emissions to the atmosphere.

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Puerto de Algeciras

Strait of Gibraltar

The Impact of Shipping in the World

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DETERMINACIÓN DEL EFECTO DEL TRÁFICO MARÍTIMO EN LA ESTIMACIÓN DE LA CALIDAD DEL AIRE DE UNA CIUDAD-PUERTO

ANALYSIS OF THE EFFECT OF MARITIME TRAFFIC ON THE ESTIMATION OF AIR QUALITY IN A PORT-CITY

UCA Universidad de Cádiz

TESIS DOCTORAL

María Inmaculada Rodríguez García

Grado en Ingeniería Civil y Máster en Ingeniería de Caminos, Canales y Puertos

Programa de Ingeniería Energética y Sostenible

2023

Puerto de Algeciras

INTRODUCTION

DATABASE

Hourly data → ANNEX I

Hourly immissions of:

Pollutants: SO_2 , O_3, NO_x , NO, $PM_{2.5}$, $PM_{10,}$ $NO_{2,}$ C_8H_{10} , CO, C_7H_8 , C_6H_6.

- Contaminants most related to maritime traffic:
- **Study pollutants:** SO_2 , NO_x , NO, $PM_{10,}$ $NO_{2.}$

Some characteristics: acid rain, chronic respiratory and cardiac diseases, cancer.

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UCA Universidad de Cádiz Puerto de Algeciras MIS

INTRODUCTION

DATABASE

Meteorological data: Rainfall RF (l/m2), temperature T (ºC), atmospheric pressure AP (hPa), solar radiation SR (W/m2), relative humidity RH (%), wind speed WS (km/h), wind direction WD (degrees).

Vessel databases: hours of vessel arrivals and departures in the Bay → a gross tonnage/hour in the Bay (GT/h).

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Puerto de Algeciras

MIS

Doctoral thesis

- **Hourly weather data from:**
  - Wind speed (km/h)
  - Wind direction
  - Solar radiation
  - Temperature
  - Atmospheric pressure
  - Rainfall
  - Relative humidity

Tabla 2. Estaciones meteorológicas.

Código	Descripción
W1	La Línea
W2	Los Barrios
W3	CEPSA 10 m de altura
W4	CEPSA 15 m de altura
W5	CEPSA 60 m de altura

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Puerto de Algeciras

Doctoral thesis

- DETERMINACIÓN DEL EFECTO DEL TRÁFICO MARÍTIMO EN LA ESTIMACIÓN DE LA CALIDAD DEL AIRE DE UNA CIUDAD-PUERTO

Tabla 1. Situación de las estaciones

Monitoring station	Code
EPSA Algeciras	1
Campamento	2
Los Cortillijos	3
Esc. Hostelería	4
Col. Los Barrios	5
Col. Carteya	6
El Rinconcillo	7
Palmones	8
Est. San Roque	9
El Zabal	10
Economato	11
Guadarranque	12
La Línea	13
Madrevieja	14
Est. Los Barrios	15
Est. Puente Mayorga	16

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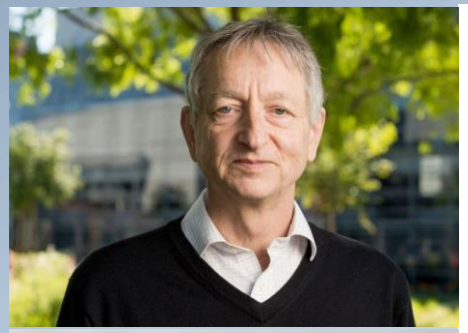
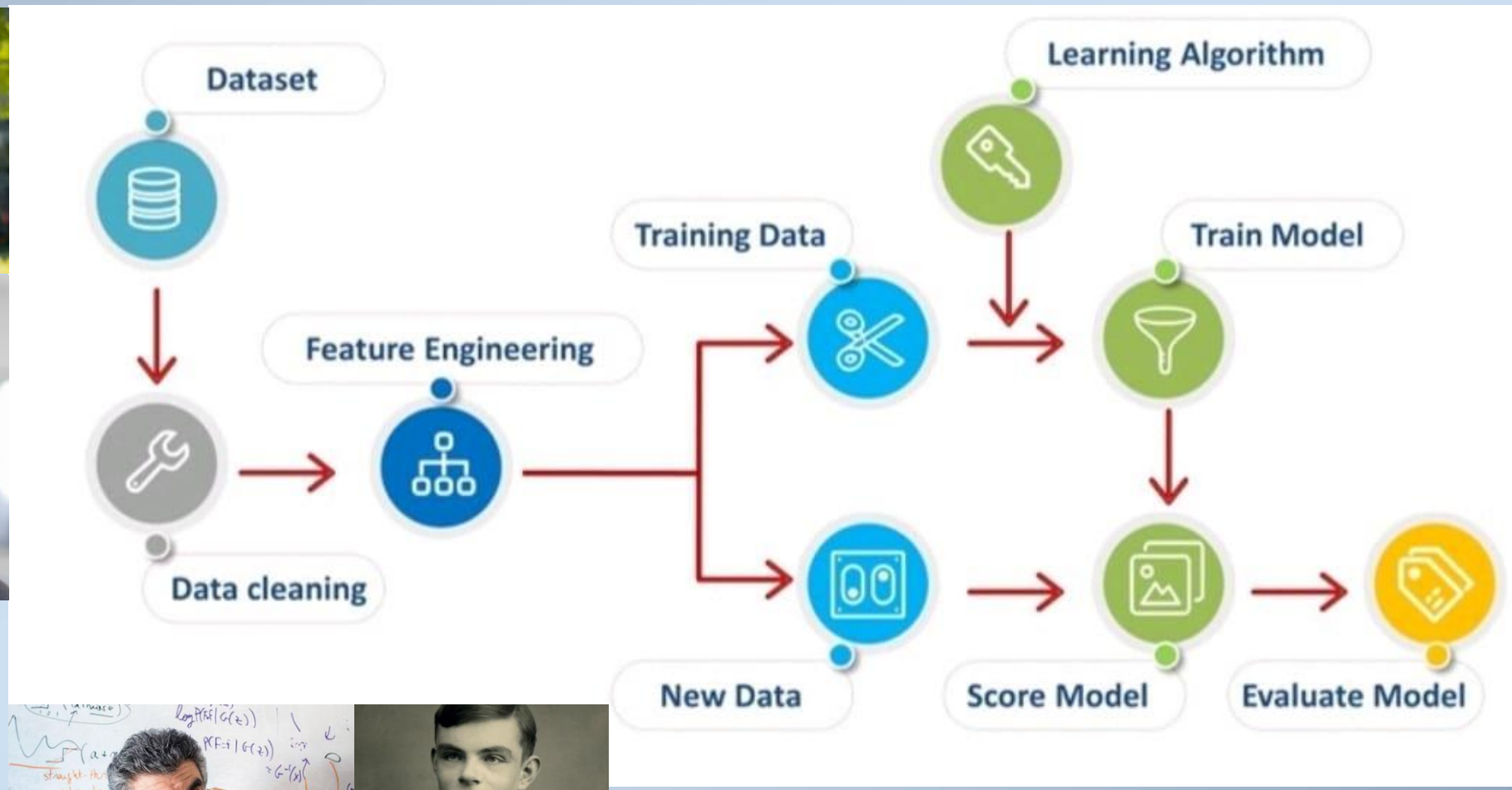
Puerto de Algeciras

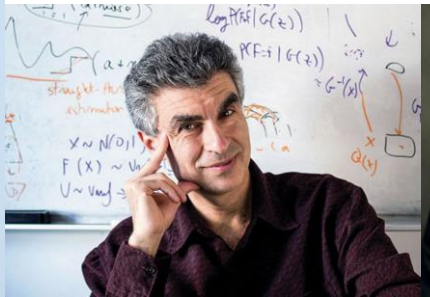
Tesis doctoral

- DETERMINACIÓN DEL EFECTO DEL TRÁFICO MARÍTIMO EN LA ESTIMACIÓN DE LA CALIDAD DEL AIRE DE UNA CIUDAD-PUERTO

Machine Learning → data analysis







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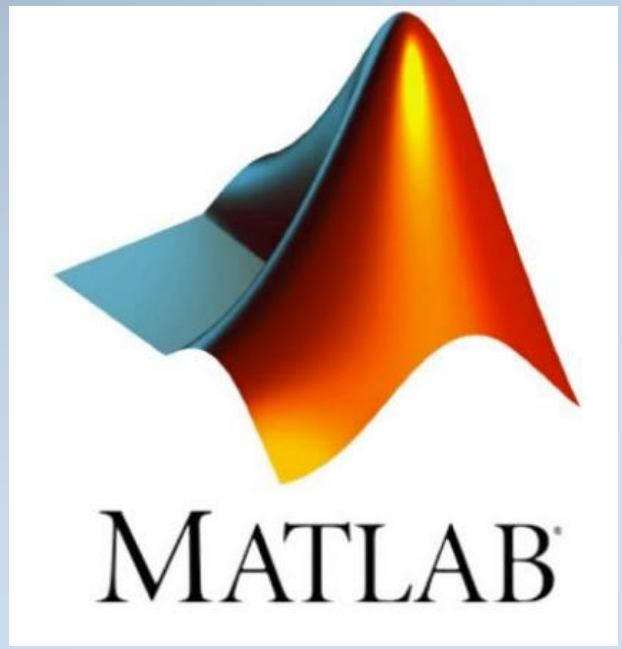
Machine Learning →Software



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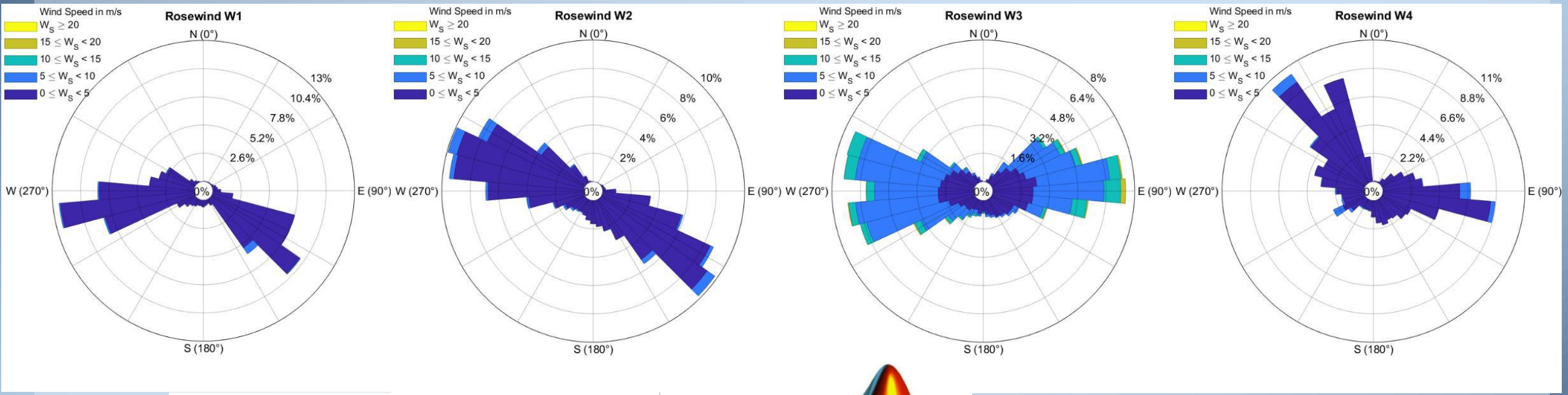
Machine Learning → data analysis




```
load database.mat;
WS_2017a2019 = database(:, [107:110]);
WD_2017a2019 = database(:, [111:114]);

direccion = WD_2017a2019;
velocidad_km_h = WS_2017a2019; % velocidad en km/h tal como viene en la base de datos
velocidad = WS_2017a2019*1000/3600; %velocidad en m/s

Options = {'anglenorth', 0, 'angleeast', 90, 'labels', {'N (0°)', 'E (90°)', 'S (180°)', 'W (270°)'}, ...
    'freqlabelangle', 45,  "vWinds",[0 5 10 15 20], ...
        "lablegend", "Wind Speed in m/s"};
```

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MATLAB

Puerto de Algeciras

Data analysis

- **Phases**
  1) Preprocessing
  2) Feature extraction and selection
  3) Regression, classification, prediction
  4) Post-processing: comparison of results and validation of models

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Puerto de Algeciras

INTRODUCTION

OBJECTIVES

Objetivos principales:

- Contrast whether computational intelligence techniques help to:
  - Study air quality between the port and the city (immissions) .
  - Study air quality with meteorological situations.
  - Study air quality with ships (port operations) → diesel combustion.

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INTRODUCTION

Particular objectives: **OBJECTIVE**

- **Design multivariate regression models for each pollutant-station** → Most relevant variables.
- **Design indirect estimation models for each pollutant-station** → as a virtual sensor: Imputation of missing values.

- **Obtain reliable predictions.Predict if high pollution level situations will occur** → European Directive 2008/50/CE.
- **Make predictions with deep learning** → Long-Short Term Memory (LSTM).

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DOCTORAL THESIS

DESCRIPTION

Preliminary phase: Pre-screening of data and imputation of missing data (ANNs).

Three phases were developed to analyze air quality:

Phase 1: Air quality diagnosis.

Phase 2: Estimation-Prediction of air quality.

Phase 3: Air Quality Time Series Prediction.

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PHASE 1: AIR QUALITY DIAGNOSIS.

This phase involved an in-depth analysis of air pollution in the two main cities of the Bay of Algeciras (Spain): Algeciras and La Línea. An extensive database of air pollutant concentrations and meteorological measurements was collected through a monitoring network installed throughout the region from 2010 to 2015. The concentration parameters contain nitrogen dioxide (NO2), sulfur dioxide (SO2) and particulate matter (PM10). The analysis was developed in two monitoring stations (Algeciras and La Línea) performing the studies of each pollutant in each of the two monitoring stations.

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Puerto de Algeciras MIS

PHASE 2: ESTIMATION-PREDICTION OF AIR QUALITY.

To obtain reliable estimates of concentrations of maritime traffic-related pollutants (SO2, PM10, NO2, NOX and NO) in a port city, Algeciras. The three scenarios analyzed are the locations of the Parque de los Alcornocales and the cities of La Línea and Algeciras. These scenarios allow us to compare the results. The objective is to predict future air quality levels of the main pollutants related to maritime traffic in the Bay of Algeciras as a function of other pollutants, meteorological variables and a ship database.

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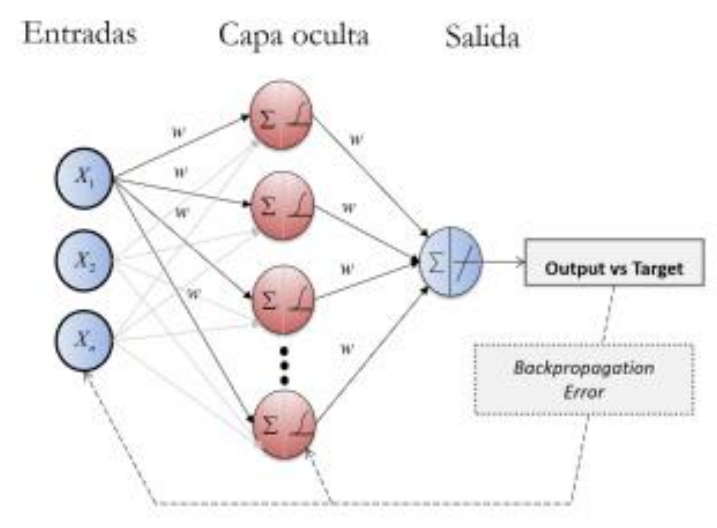
Puerto de Algeciras MIS

FASE 2. METODOLOGÍA

- **Métodos basados en *Machine Learning*. Redes neuronales artificiales (ANNs)→ Estimación, predicción, regresión múltiple no lineal.**

- **Redes Neuronales Artificiales (ANNs) → Tipos**
  - Capa oculta con 10, 25 y 100 neuronas
  - Dos capas ocultas con 10x10 neuronas
  - Tres capas ocultas de 10x10x10 neuronas



Esquema principal y ecuación de una red neuronal de una capa oculta.

$$\hat{y}_i = G\left(\sum_{i=1}^{N} w_i \left(f\left(\sum_{i=1}^{N} w_i \cdot x_i\right)\right)\right)$$

Expresión analítica de una red neuronal artificial típica de dos capas

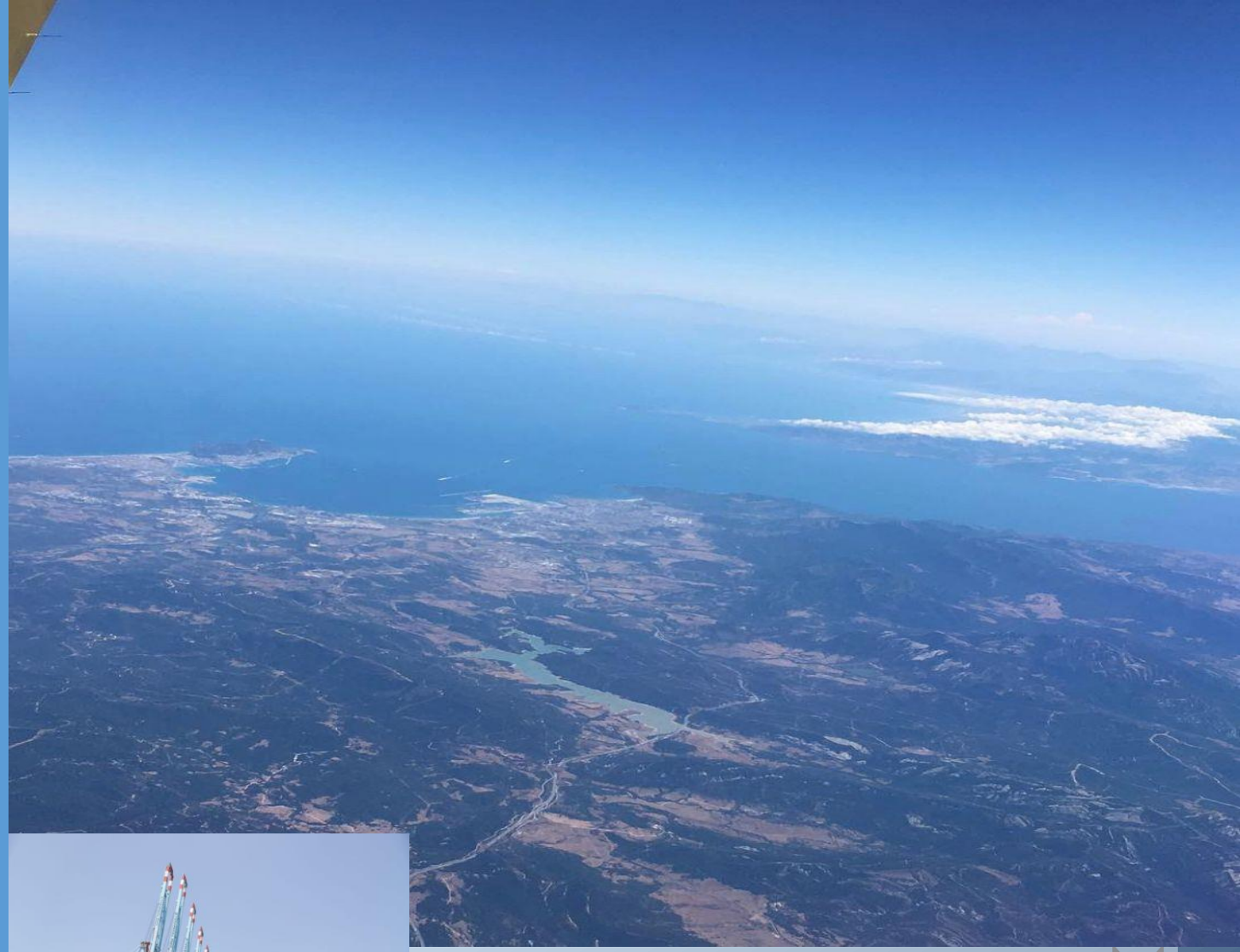
Hornik, K., Stinchcombe, M., and White, H. (1989). Multilayer feedforward networks are universal approximators. *Neural Networks*, 2(5), 359-366. https://doi.org/10.1016/0893-6080(89)90020-8

FASE 2. RESULTADOS variables top-10 ALGECIRAS

SO_2 Algeciras concentraciones diarias		PM_{10} Algeciras concentraciones diarias		NO_2 Algeciras concentraciones diarias		NO_X Algeciras concentraciones diarias		NO Algeciras Estación monitorización	
Variable	**Estación monitorización**	**Variable**	**Estación monitorización**	**Variable**	**Estación monitorización**	**Variable**	**Estación monitorización**	**Variable**	**Estación monitorización**
SO_2(t)	Algeciras	PM_{10}(t)	Algeciras	NO_2(t)	Algeciras	NO_x(t)	Algeciras	NO(t)	Algeciras
WD	W1 (La Línea)	Tolueno	Puente Mayorga	WD	W1 (La Línea)	WD	W5 (CEPSA 60 m altura)	RF	W3 (CEPSA 10 m altura)
NO	Alcornocales	WS	W4 (CEPSA 15 m altura)	NO_X	Los Barrios	WS	W4 (CEPSA 15 m altura)	NO	Cortijillos
O_3	Cortijillos	PM_{10}	Alcornocales	RF	W2 (Los Barrios)	NOX	Los Barrios	Benceno	Campamento
NO_2	Algeciras	NO_2	Algeciras	O_3	Algeciras	PM_{10}	Palmones	NO_2	Algeciras
$PM_{2.5}$	Economato	PM_{10}	La Línea	PM_{10}	Rinconcillo	O_3	Algeciras	SR	W4 (CEPSA 15 m altura)
SO_2	Los Barrios	PM_{10}	Carteya	NO_2	Cortijillos	NO_2	Algeciras	Tolueno	Cortijillos
SO_2	Alcornocales	PM_{10}	Palmones	NO_X	Algeciras	NO_X	Cortijillos	PM_{10}	Palmones
SO_2	Palmones	$PM_{2.5}$	Alcornocales	WS	W4 (CEPSA 15 m altura)	WD	W1 (La Línea)	NO	Rinconcillo
PM_{10}	Palmones	PM_{10}	El Zabal	WD	W5 (CEPSA 60 m altura)	NO	Algeciras	O_3	Algeciras

PHASE 3: TIME SERIES PREDICTION OF AIR QUALITY.

During the period 2017-2019, a database of 131 variables was recorded to predict air quality at Algeciras station using LSTM models. Four different approaches have been developed to perform SO2 and NO2 1h and 4h predictions at Algeciras. The first one uses the remaining 130 exogenous variables. The second uses only the time series data without exogenous variables. The third approach is to use an autoregressive array of time series as input and the fourth is similar using the time series together with wind and ship data.The third approach also uses exogenous variables such as the ship database and wind information (direction and speed).



PHASE 1-2. CONCLUSIONS

Air quality estimation-prediction

- Para concretar más, los contaminantes PM10, SO2 se predicen mejor con clasificadores tipo árbol en todos los casos y estaciones.
- Los óxidos de nitrógeno tienden a predecirse mejor con redes neuronales.

PHASE 3. CONCLUSIONS

Air quality prediction

- Winds have been shown to affect the movement of pollutants in the Bay.

- Citizens need to know air quality.
- The LSTMs method has proven to be an effective tool for the prediction of air pollutants.
- On the other hand, it has been additionally demonstrated that the use of lagged information with an autoregressive data input scheme is an effective tool for the prediction of atmospheric pollutants.

PRODUCCIÓN CIENTÍFICA

1. **Air pollution relevance analysis in the bay of Algeciras (Spain)**
    1. https://link.springer.com/article/10.1007/s13762-022-04466-4
2. **Long Short-Term Memory Approach for Short-Term Air Quality Forecasting in the Bay of Algeciras (Spain)**
    1. https://www.mdpi.com/2071-1050/15/6/5089
3. **Forecasting air pollutants using classification models: a case study in the Bay of Algeciras (Spain)**
    1. https://link.springer.com/article/10.1007/s00477-023-02512-2
4. **Air Pollution PM_{10} Forecasting Maps in the Maritime Area of the Bay of Algeciras (Spain)**
    1. https://www.mdpi.com/2077-1312/12/3/397

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Puerto de Algeciras

- **THANK YOU VERY MUCH FOR YOUR ATTENTION**

inma.rodriguezgarcia@uca.es

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Puerto de Algeciras

INTERNATIONAL STAFF WEEK 2024

Intelligent Modelling of Systems PAIDI TEP 024

Modelling and Simulation in Transportation and Logistics

Adriana Pabón Noguera

Research Project

Container traffic in the colombian Caribbean. An approach to the competitiveness study of the Port of Santa Marta

Doctoral Program: Management and Conservation of the Sea

PRODUCTIVITY

Optimal use of resources

EFFICIENCY

Meet objectives/goals with the least amount of resources

COMPETITIVENESS

Offer a good/service with higher quality than its competitors

Geographical context of Santa Marta, Colombia

Santa Marta
Dpto.de Magdalena
Colombia

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Main Objective

The assessment of the competitiveness factors of activities related to Container traffic in the Port of Santa Marta - Colombia, through an integrated technical-economic for evaluating the perception of the different agents involved in the port phase of containerization (containerized)

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Main competitiveness factors assessed

1. Geographic location
2. Physical conditions
3. Port Terminal Infrastructure and Superstructure
4. Operating conditions
5. Port costs and quality of services
6. Logistics Offer (Impor/Expor)
7. Hinterland and Foreland connections

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Stages of the investigation

Background analysis

Survey instrument design

Other quialitative and quantitative Data searching

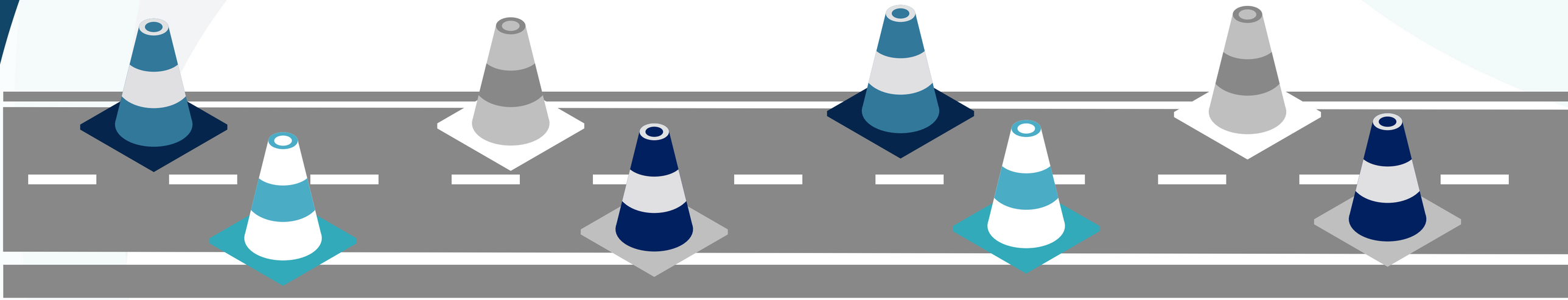
Survey instrument application

Data analysis, based on the Economic Model

Data análisis, based on the Multicreria Decision Model

Discussion/Doctoral Thesis

Publications



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Present and future of the port context

Big Data and AI

Standardization and massive data collection, Changes in decisión, Making demand predictions

Digital Twin

Simulation, Prediction, Analysis real time

Port planning

Continuous process improvement

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Santa Marta and its Maritime Port as an object of study

Tourism potential

Agroindustrial economic development potencial

Multimodal Logistics Platform potencial

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Santa Marta and its Maritime Port as an object of study

- Competitive Port in accordance with the demands of international markets
- Exporting Port, not importing
- First port in Colombia in Reefer type Containers. Controlled atmosphere
- Possibilities for growth and optimization of its Container Terminal
- Improve positioning as a Port of colombian agriculture

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The container and the Container Terminal as an object of study

Solide Bulk

Decrease in the use of coal.

Liquid Bulk

Petroleum Derivatives (export) and Palm Oil (decrease and limitation in large markets)

Bulk cargo and other goods

In the future they will travel in containers. Increase in container traffic in the future

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THANKS

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aulp

sea·EU EUROPEAN UNIVERSITY OF THE SEAS

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uca. ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA DE ALGECIRAS

INTERNATIONAL STAFF WEEK
Research and Technology Transfer at ASET

SEA EU European University of the Seas

Machine learning for predicting neurodevelopmental impairments in very preterm infants

Early-Stage Researcher 7: Arantxa Ortega Leon

Supervisors: Ignacio Turias, Daniel Urda

The PARENT project has received funding from the European Union's Horizon 2020 research and innovation programme under the Maria Sklodowska-Curie – Innovative Training Network 2020, Grant Agreement N° 956394

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Politecnico di Torino 1859 1906

gpi

7HC

INiBICA Instituto de Investigación e Innovación Biomédica de Cádiz

icometrix

UCA

KU LEUVEN

TOELT AI

Univerza v Ljubljani

Bambino Gesù Ospedale Pediatrico

neus™ eye-tracking neurodiagnostics

The PARENT project has received funding from the European Union's Horizon 2020 research and innovation programme under the Maria Sklodowska-Curie – Innovative Training Network 2020, Grant Agreement N° 956394

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Systematic review: ML techniques for the prediction of NDI.

Brain injury prediction using clinical data

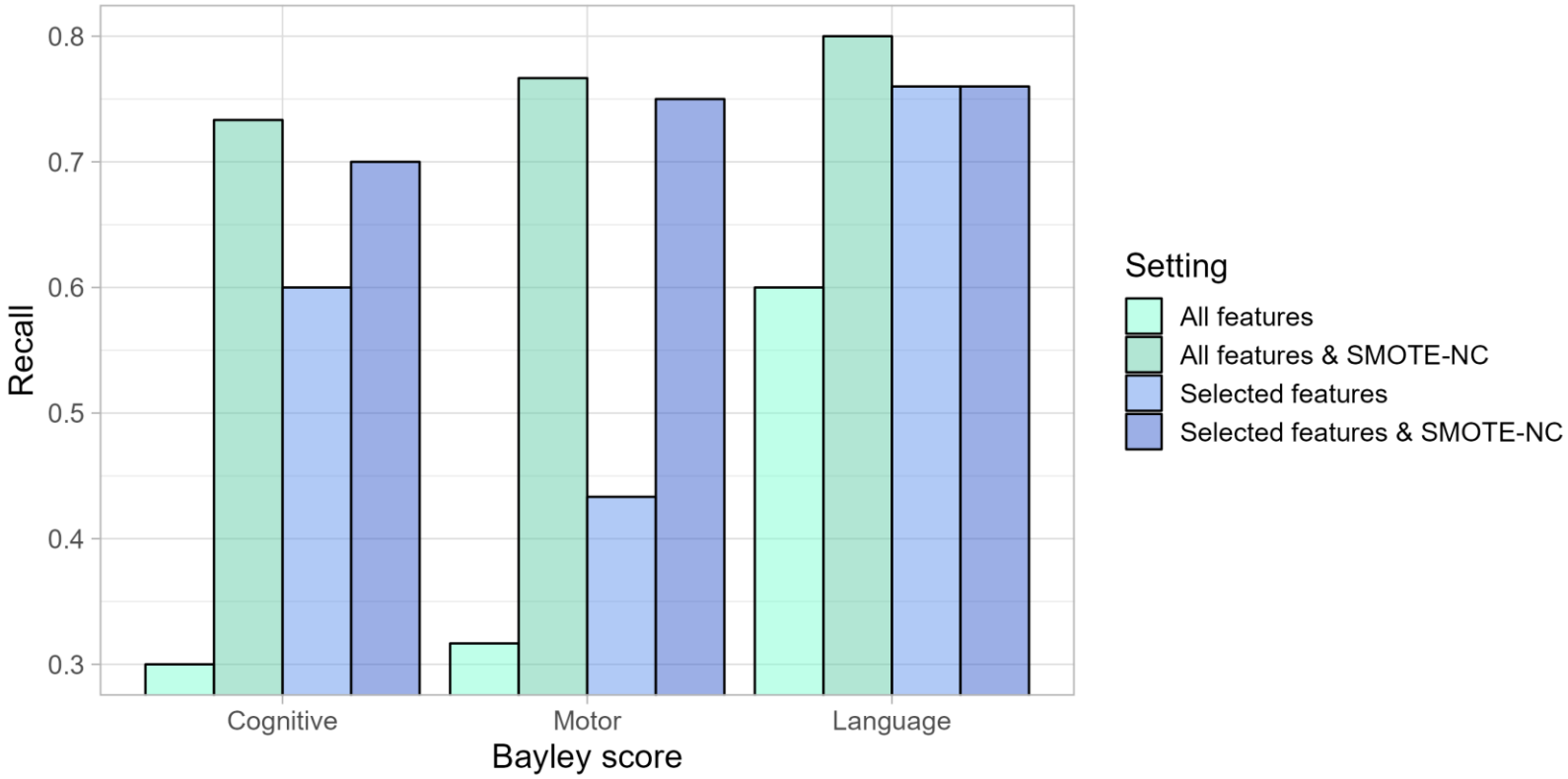
NDI prediction using clinical data

NDI prediction using total brain volume

Association of neonatal glycemia with clinical outcomes

microRNA diffuse white matter injury

Neurodevelopmental impairments prediction in premature infants based on clinical data and machine learning techniques



Best prediction setting: All features and SMOTE-NC which the highest recall in the three cases.

Best model performance: Logistic Regression for cognitive impairment. K-nearest neighbours for motor and language impairment.

Feature selection didn't improve notably results. Juul et al. (2023) stated that even by applying advanced methods the field is still not able to predict complex long-term outcomes such as the Bayley score using clinical data.

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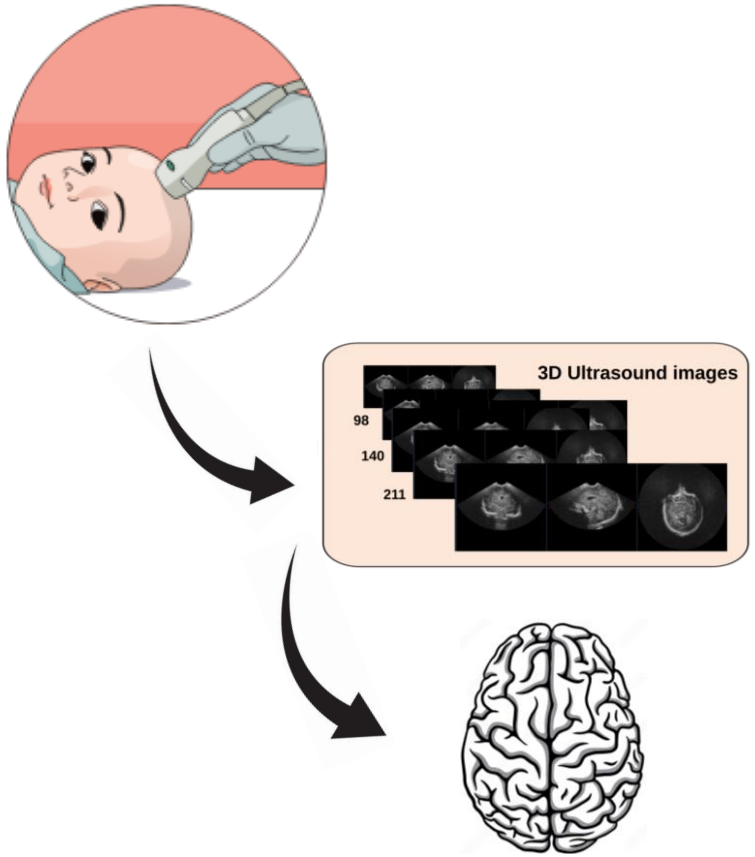
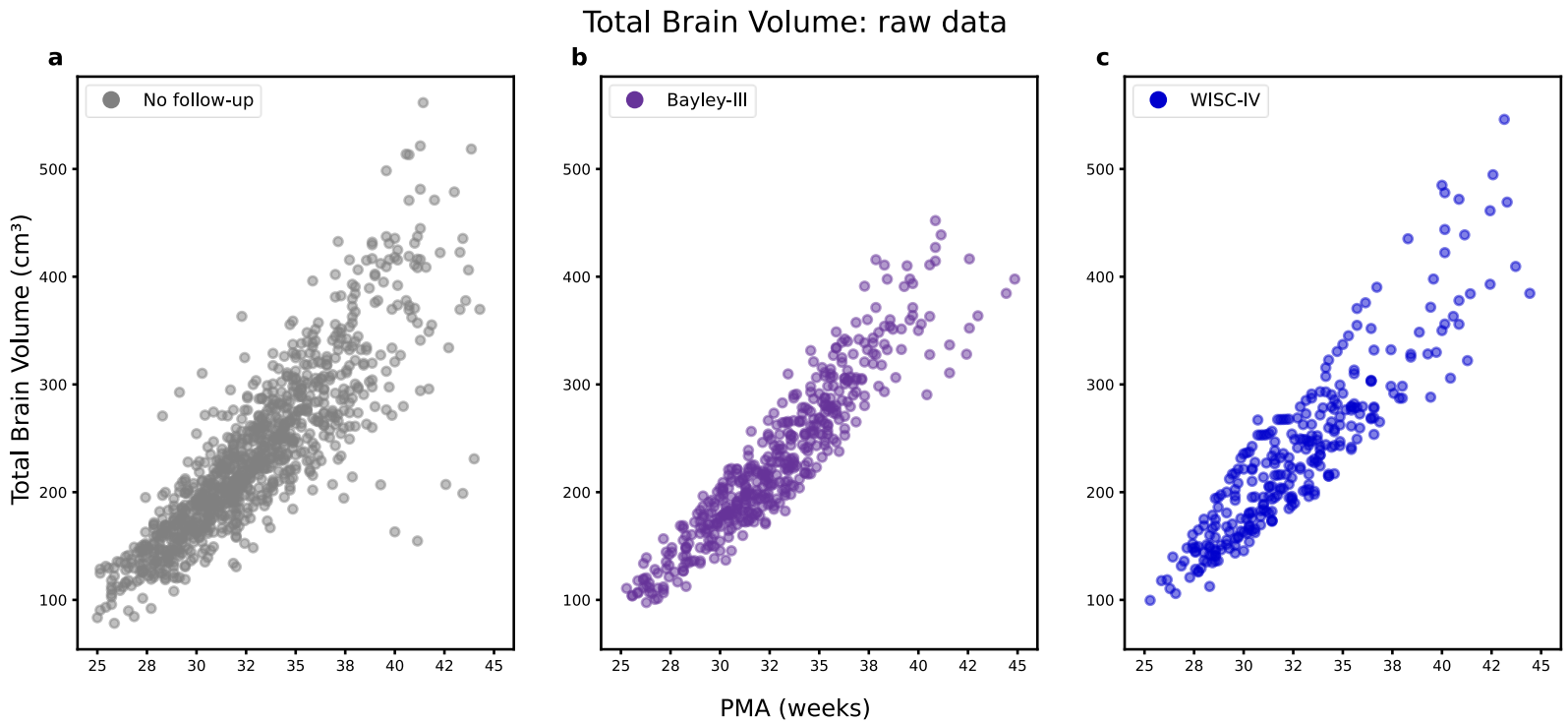
Enhancing Knowledge Extraction from Longitudinal Data Using Gaussian Process Modeling





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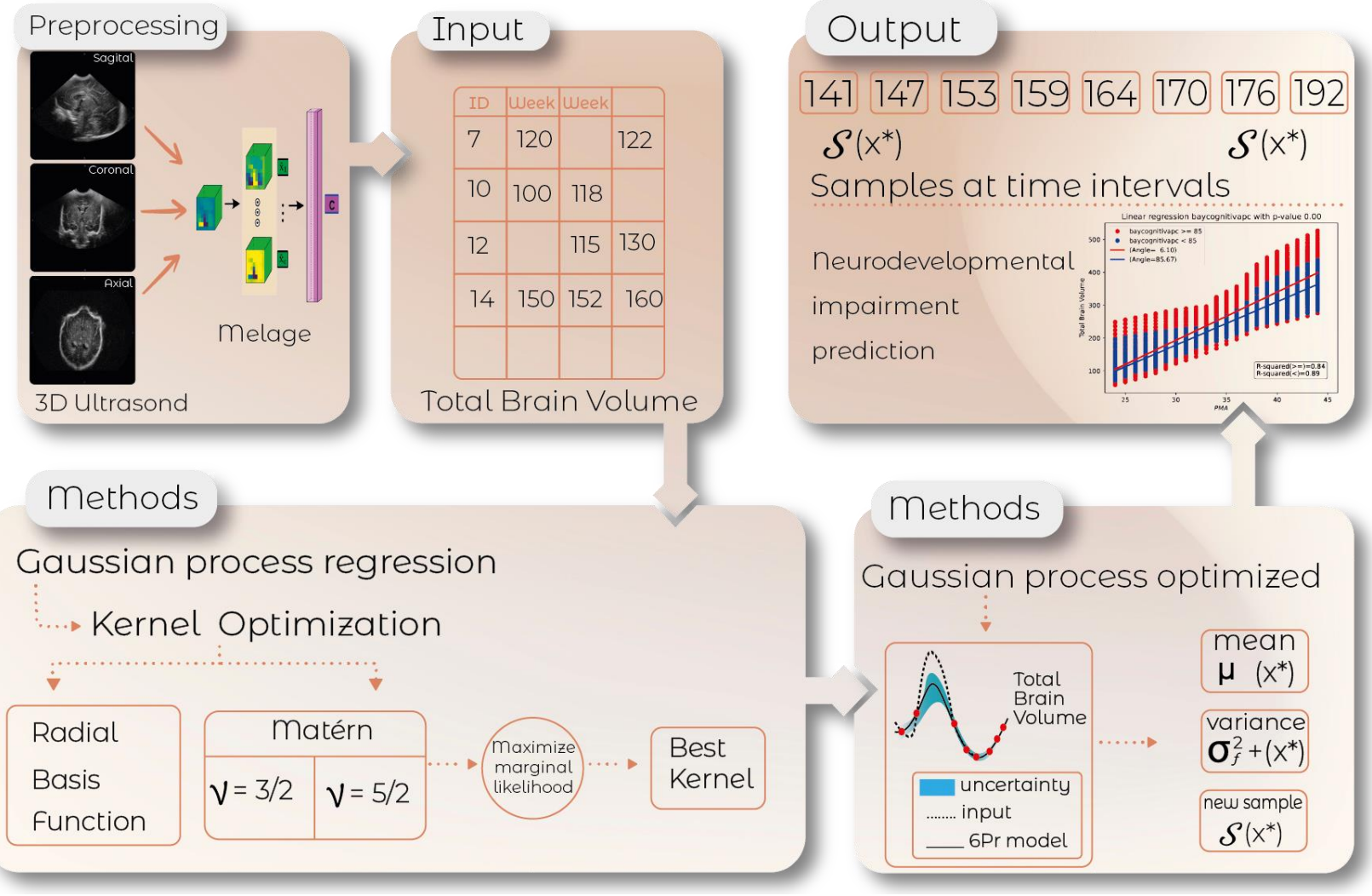

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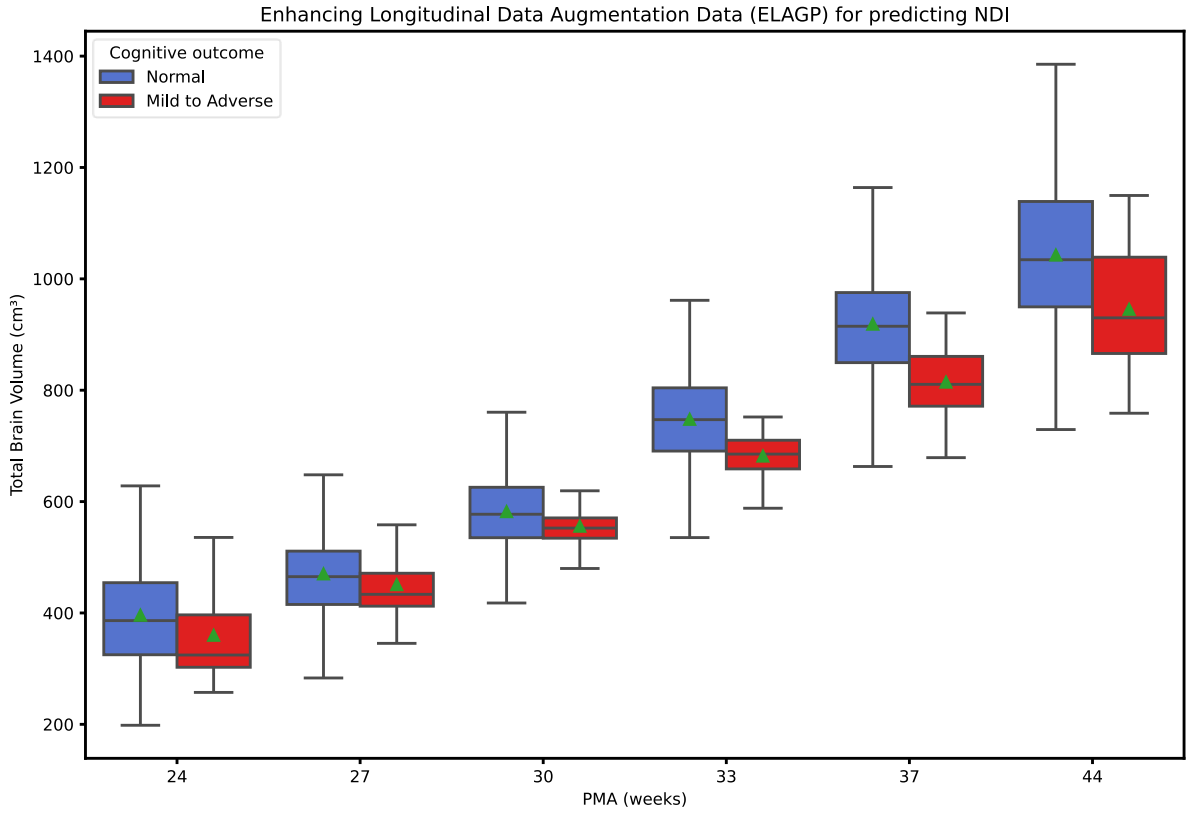
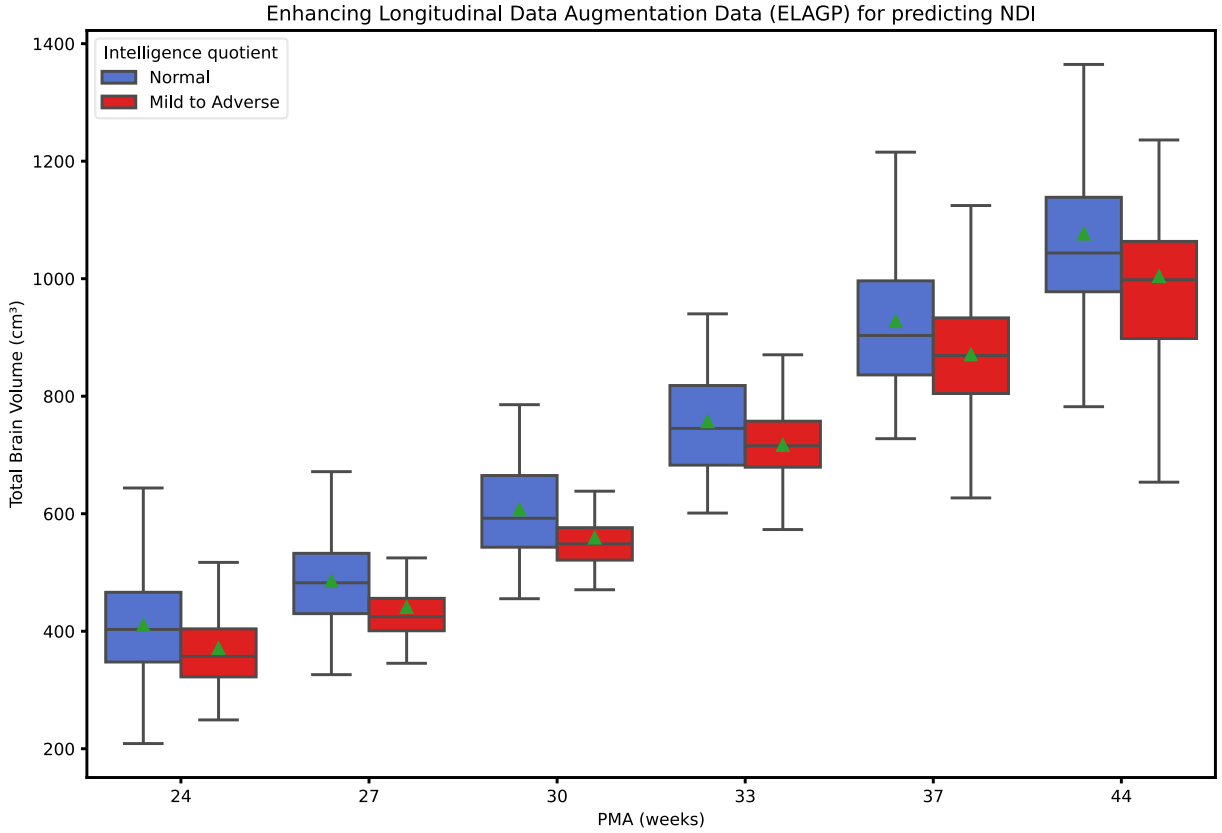
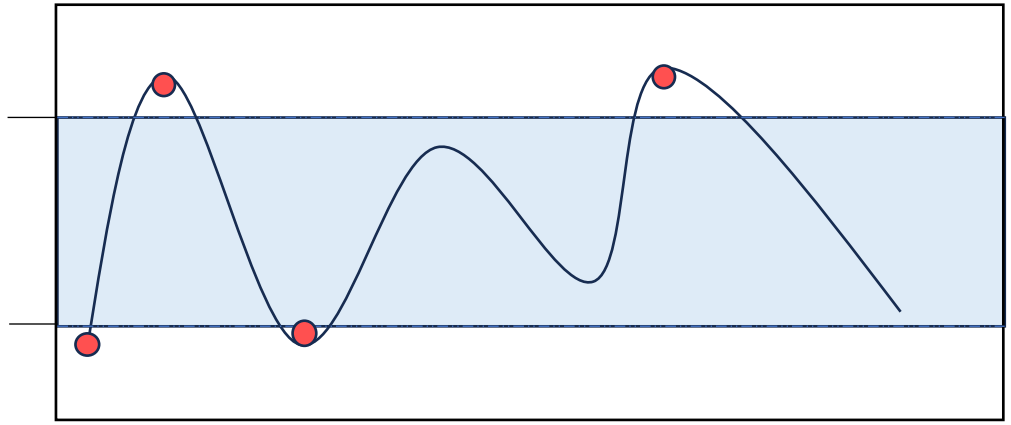


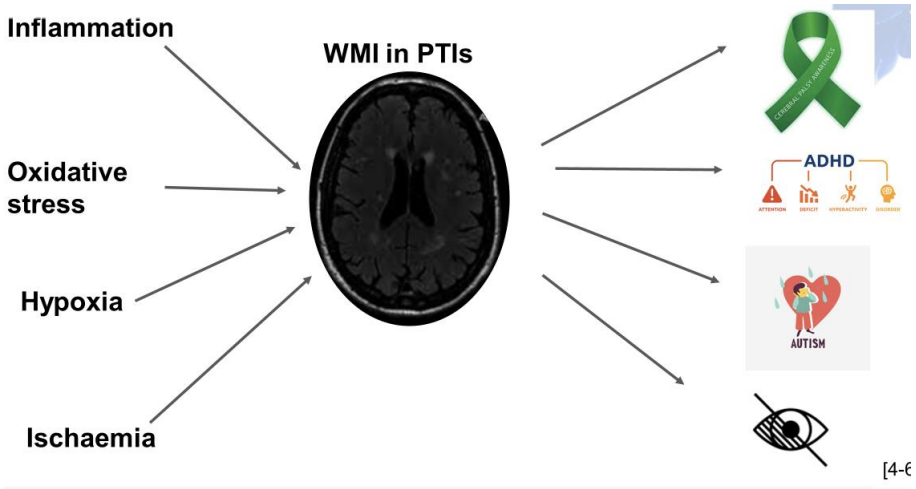


Association of neonatal glycemia with clinical outcomes

Hyperglycemia

Hypoglycemia





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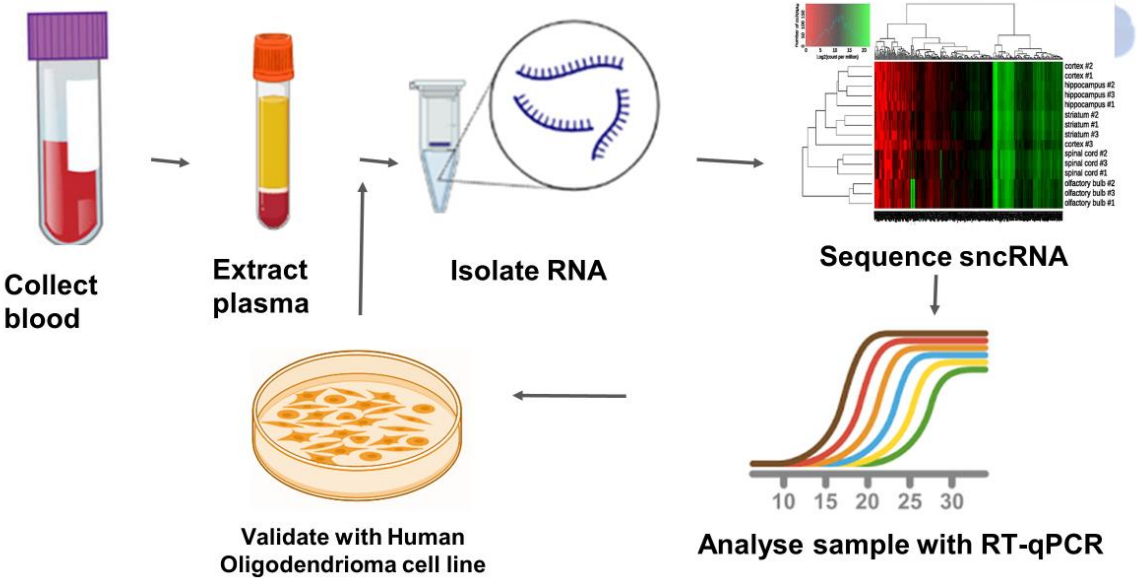
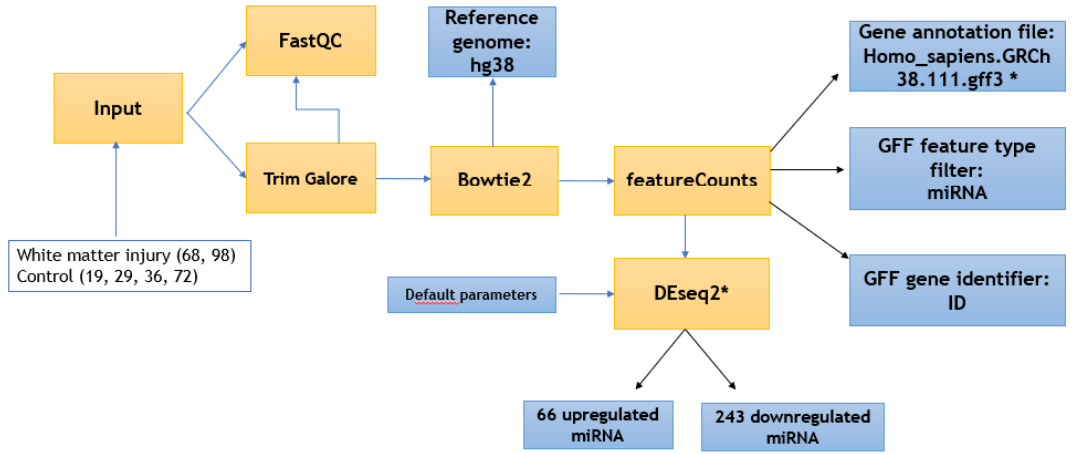
Biological experiments/ Liquid Biomarker Discovery



miRNA analysis pipeline: Control vs White matter injury



Thanks for your attention!