Machine Learning at the Extreme: Teaching AI to Sail

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Machine Learning at the Extreme: Teaching AI to Sail

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Trigger Racing
Director and Skipper

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T-DAB
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WisConT
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Data Scientist

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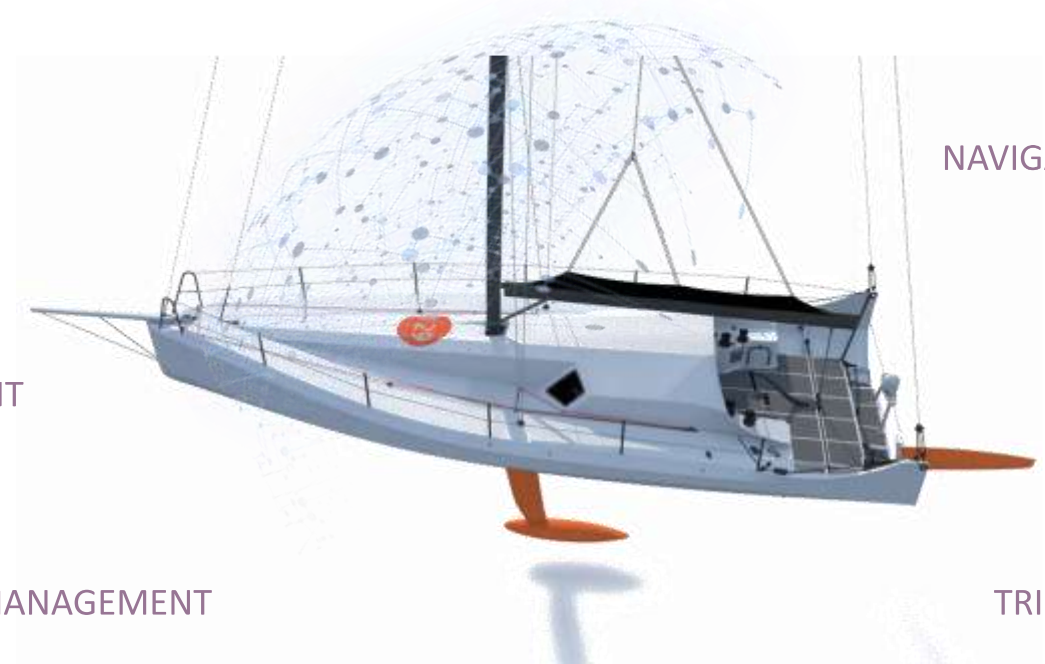
THE DATA ANALYSIS BUREAU
WisCONT 云图智联
TRIGGER RACING
Imperial College London

MEDIA + COMMS

PHYSICALITY

PROBLEM SOLVING

NAVIGATION AND STRATEGY



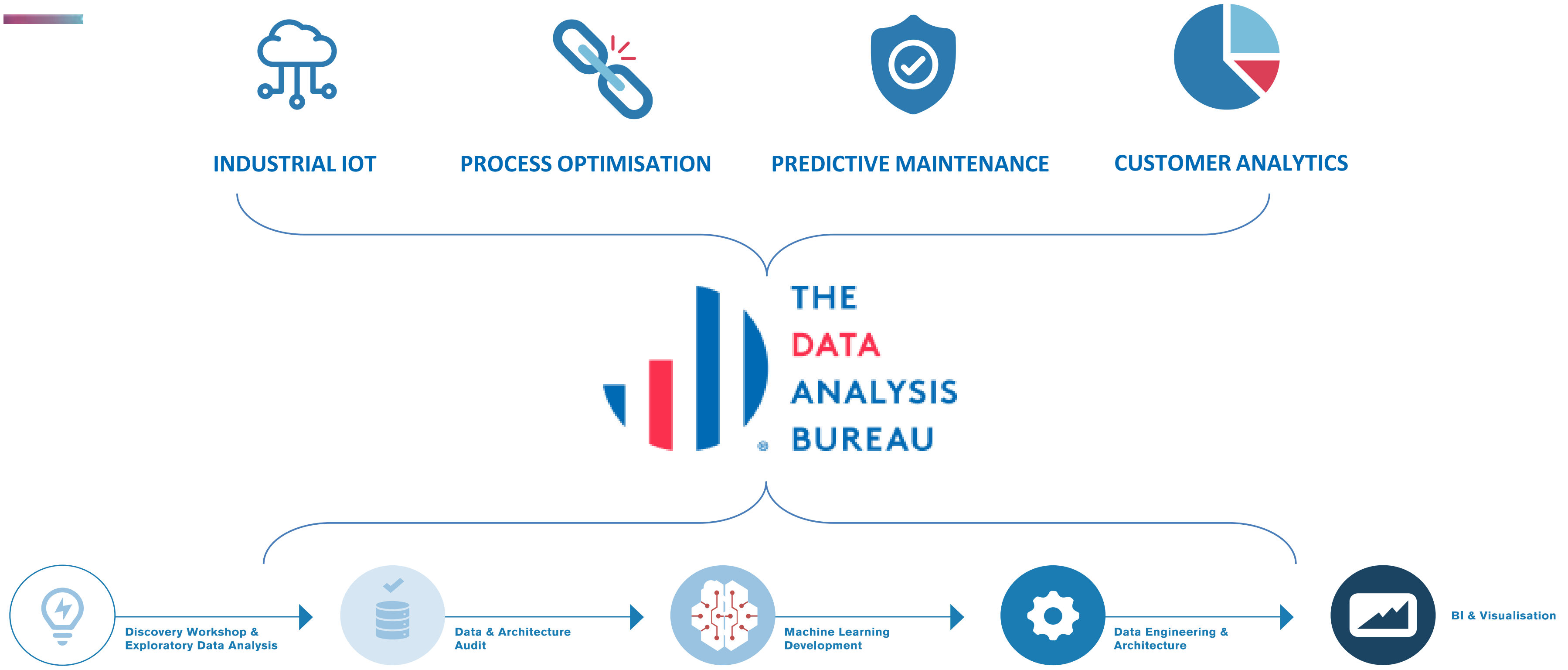
PERSONAL MANAGEMENT

MANOEUVRES

SYSTEM MANAGEMENT

TRIM AND SET UP

Sailing friends thinking about ML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Data & Architecture Audit
Machine Learning Development
Data Engineering & Architecture
BI & Visualisation

THE DATA ANALYSIS BUREAU

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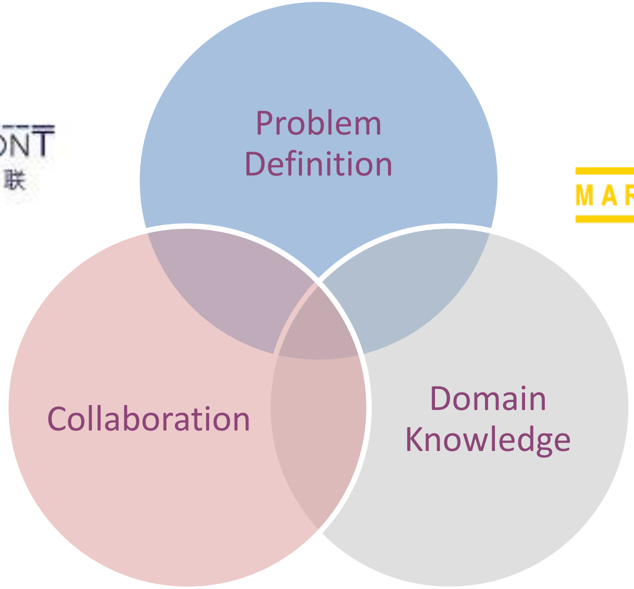
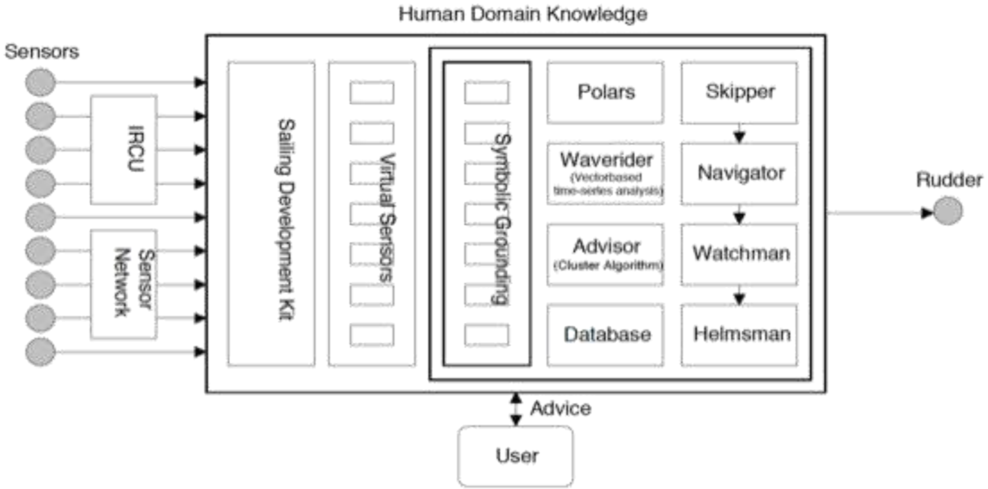


nke MARINE ELECTRONICS

Imperial College London

TRIGGER RACING

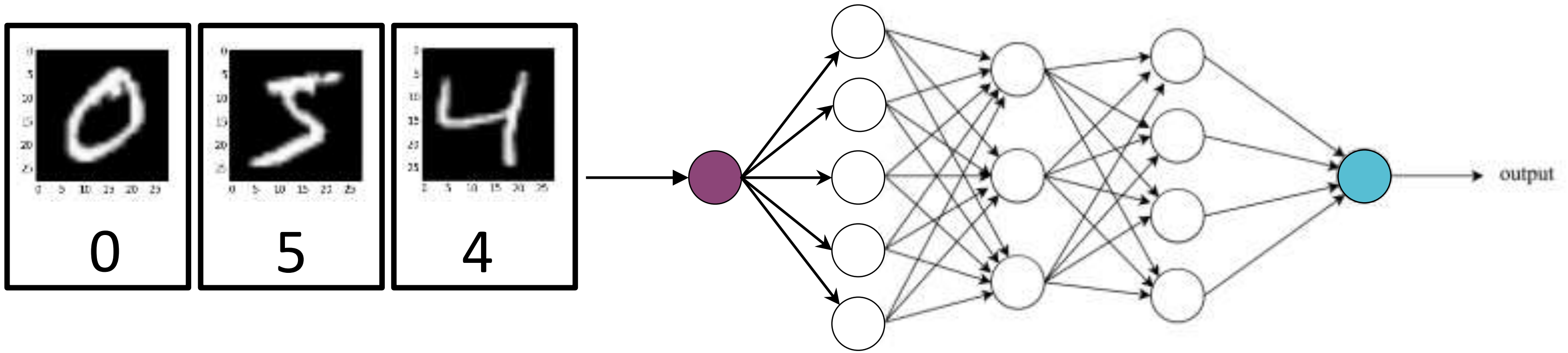
RoboSail Sailingteam



[3] AI on the Ocean: the RoboSail Project – M. L. van Aartrijk, C. P. Tagliola, P. W. Adriaans

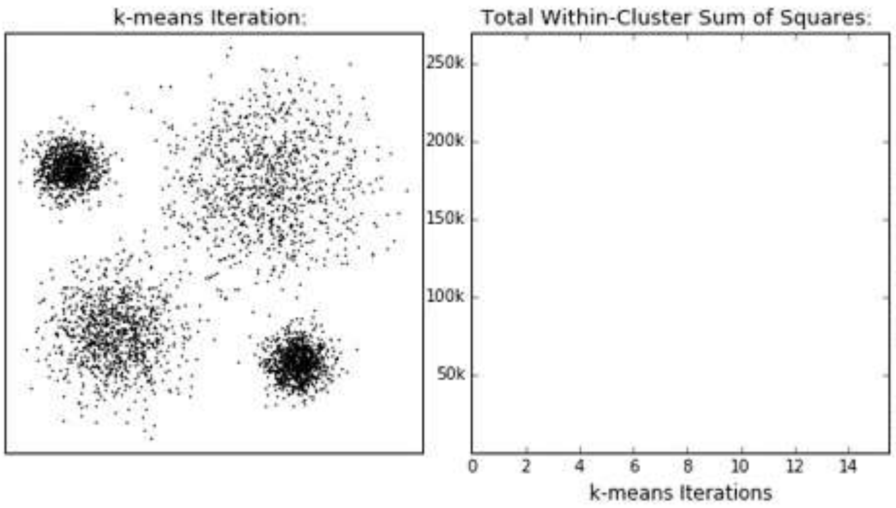
Types of Machine Learning

Supervised ML – learning by example



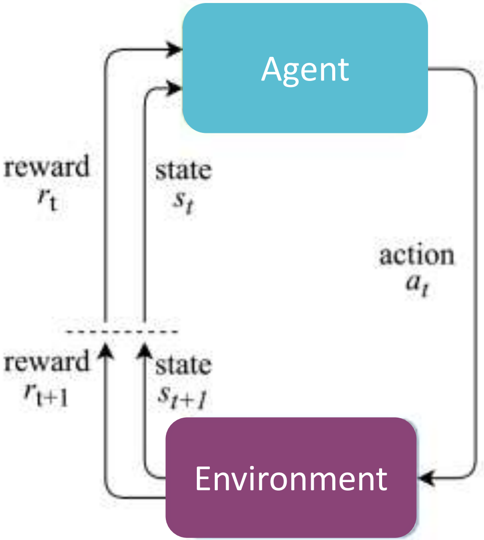
Types of Machine Learning

Unsupervised ML – finding the structure of data



Types of Machine Learning

Reinforcement Learning – Free interraction with the environment



- The concept is derived from animal behaviour
- Agent is given all the actions it could perform and is placed in the environment which would reward him for choosing better actions

Types of Machine Learning

Reinforcement Learning – Free interraction with the environment

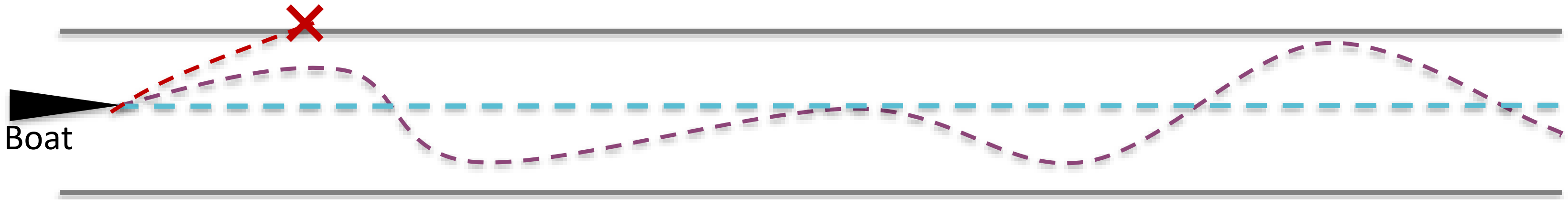
dit: DeepMind

Defining Reinforcement Learning for Sailboat Steering

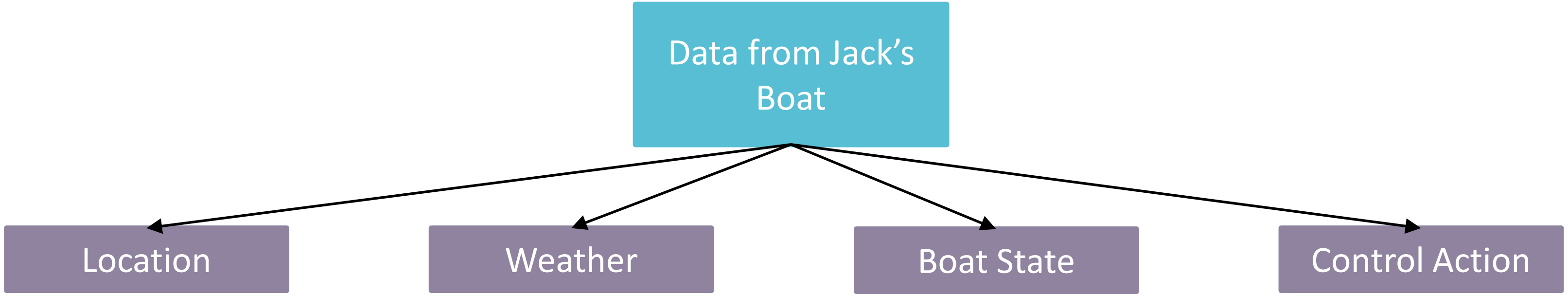
Difficulty of Sailing as an RL 'game':

- There are changes of the environment out of our control – weather
  - Can be anticipated, but cannot be influenced
  - Can have both positive and negative effects
- Rudder movement is continuous
- Rudder steering is not the only, in fact, not even the main action

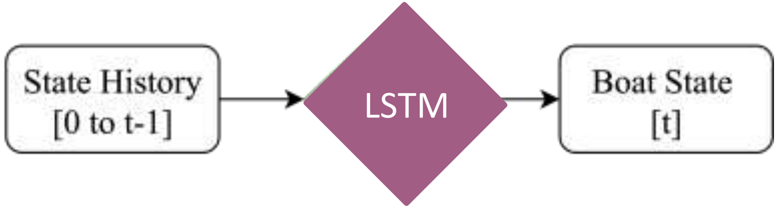
Objective:
Keep the boat on the course chosen by Jack while minimising the drag



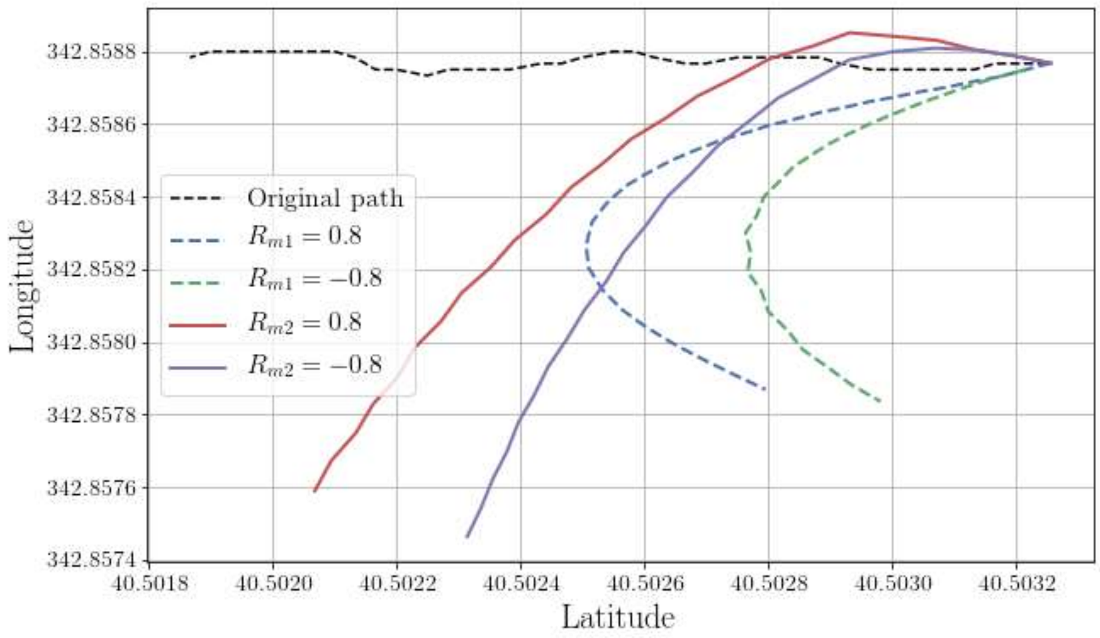
Defining Reinforcement Learning for Sailboat Steering



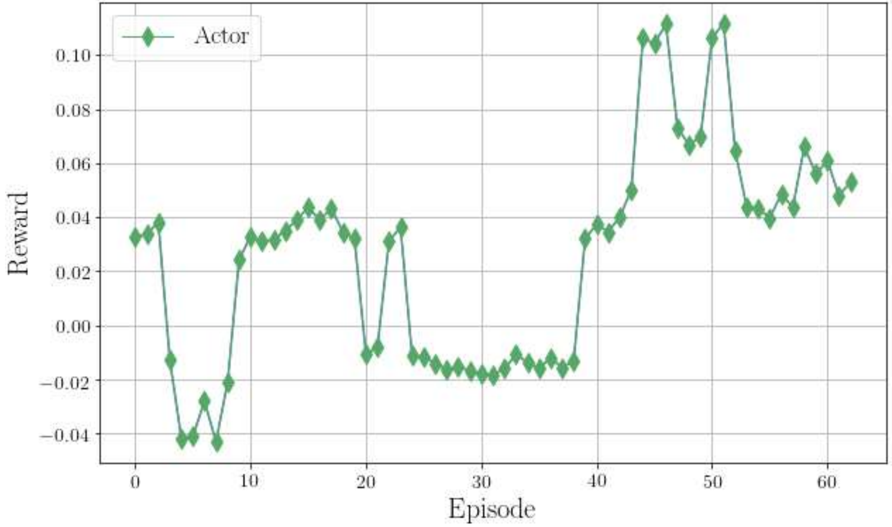
Recurrent Neural Network
(LSTM) – based state estimator

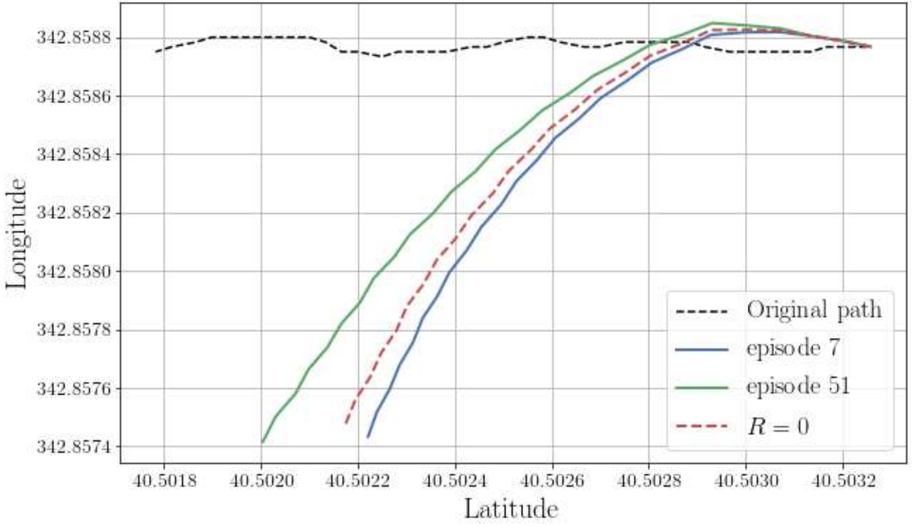


Digital Twin of Concise 8



Deep Deterministic Policy Gradient





Defining Supervised Learning for Sailboat Steering

The general objective is to predict the optimal rudder angle.

Here, the supervised learning approach is based on the following assumption:
The optimal rudder angle is the one that would have been chosen by Jack Trigger.

Using (labeled) historical data of Jack Trigger in race navigation and supervised learning models like recurrent neural networks, it is possible to predict the rudder angle that would have been chosen by Jack Trigger

Objective:
Given the actual state of the boat and thanks to historical data,
predicting the rudder angle that would have been chosen by Jack Trigger for t+1

Dataset Presentation

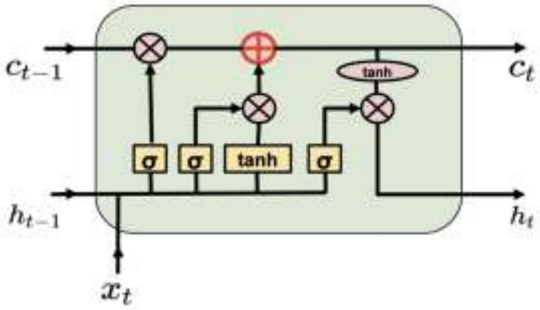
Feature Name	Feature Description	Range	Applied Normalization
Air_temp	Temperature of the air	[0,30]	Min-Max
AWA	Apparent Wind Angle	[-180,180]	Cos and Sin
AWS	Apparent Wind Speed	[0,50]	Min-Max
Current_direction	Direction of the current	[0,360]	Cos and Sin
Current_speed	Speed of the current	[0,15]	Min-Max
Heading_Mag	Magnetic heading of the boat	[0,360]	Cos and Sin
Heading_True	True heading of the boat	[0,360]	Cos and Sin
Heading_ov_ground	Heading over ground of the boat	[0,360]	Cos and Sin
Latitude	Latitude	[-90,90]	Max-Abs
Longitude	Longitude	[-180,180]	Cos and Sin
Yaw	1^{st} Tait-Bryan angle	[-180,180]	Cos and Sin
Pitch	2^{nd} Tait-Bryan angle	[-20,20]	Max-Abs
Roll	3^{rd} Tait-Bryan angle	[-60,60]	Max-Abs
Speed_ov_ground	Speed over ground	[0,25]	Min-Max
Speed_ov_surface	Speed over surface	[0,25]	Min-Max
TWA	True Wind Angle	[-180,180]	Cos and Sin
TWD	True Wind Direction	[0,360]	Cos and Sin
TWS	True Wind Speed	[0,40]	Min-Max
VMG	Velocity Made Good	[0,25]	Min-Max
Rudder	Rudder Angle	[-50,50]	Max-Abs

- DRHEAM CUP 2018 – Double-handed professional race
- 64 hours – 20 Features
- 95% of the Rudder has been done by Jack Trigger and his teammate

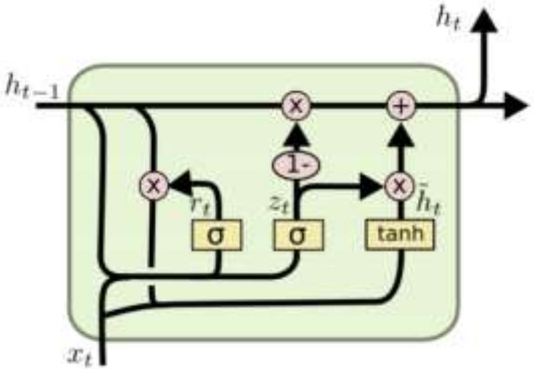
Supervised Learning Model

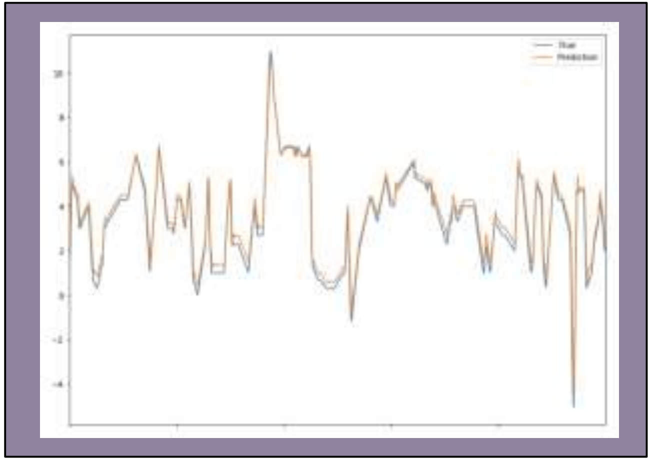
Data Cleaning (Tack Detection…)
Feature Normalisation
Long Short-Term Memory vs Gated Reccurent Unit
Bayesian Optimisation to set hyperparameters
Evaluation of performances

LSTM

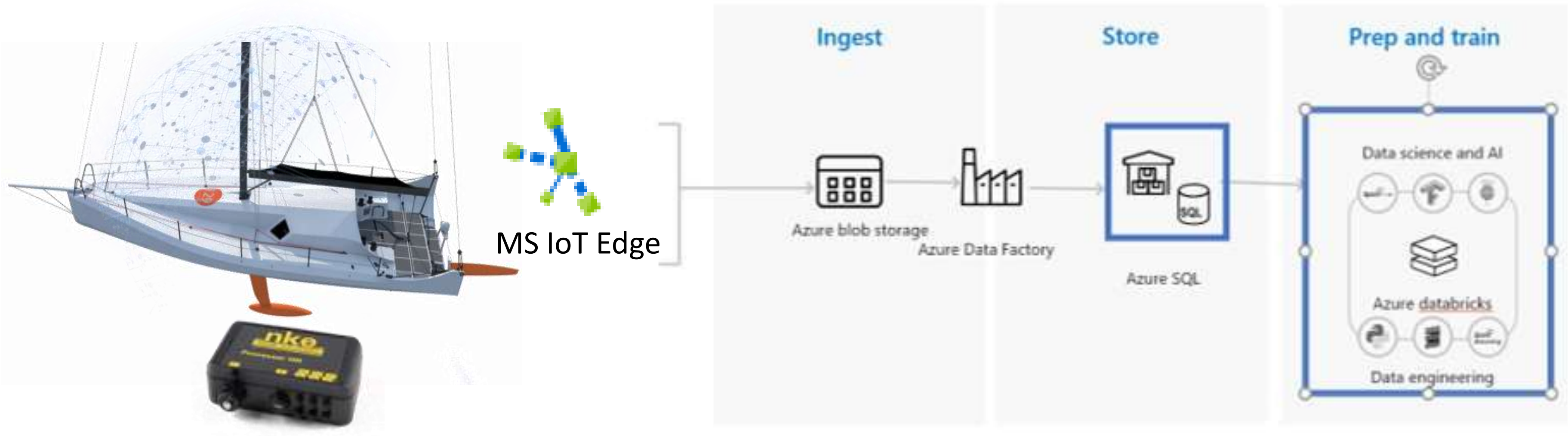


GRU





Testing
RMSE
1.096 °


MS IoT Edge
Ingest
Store
Prep and train
Azure blob storage
Azure Data Factory
Azure SQL
Data science and AI
Azure databricks
Data engineering

Project Thanks and Acknowledgements

Professor Julie McCann

Professor Pieter Adrians

NKE Marine Electronics

Microsoft (UK)

Imperial College London

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Microsoft

Any Questions?

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