UDT
Undersea Defence Technology
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Echo System

Machine learning methods for classification of sonar targets

N. Amoroso, L. Bellantuono, M. Ricci

#UDT2019

Agenda

- Project and goals
- Machine Learning approach
- Features extraction
- Random Forest classifier
- Classification accuracy
- Conclusions and perspectives

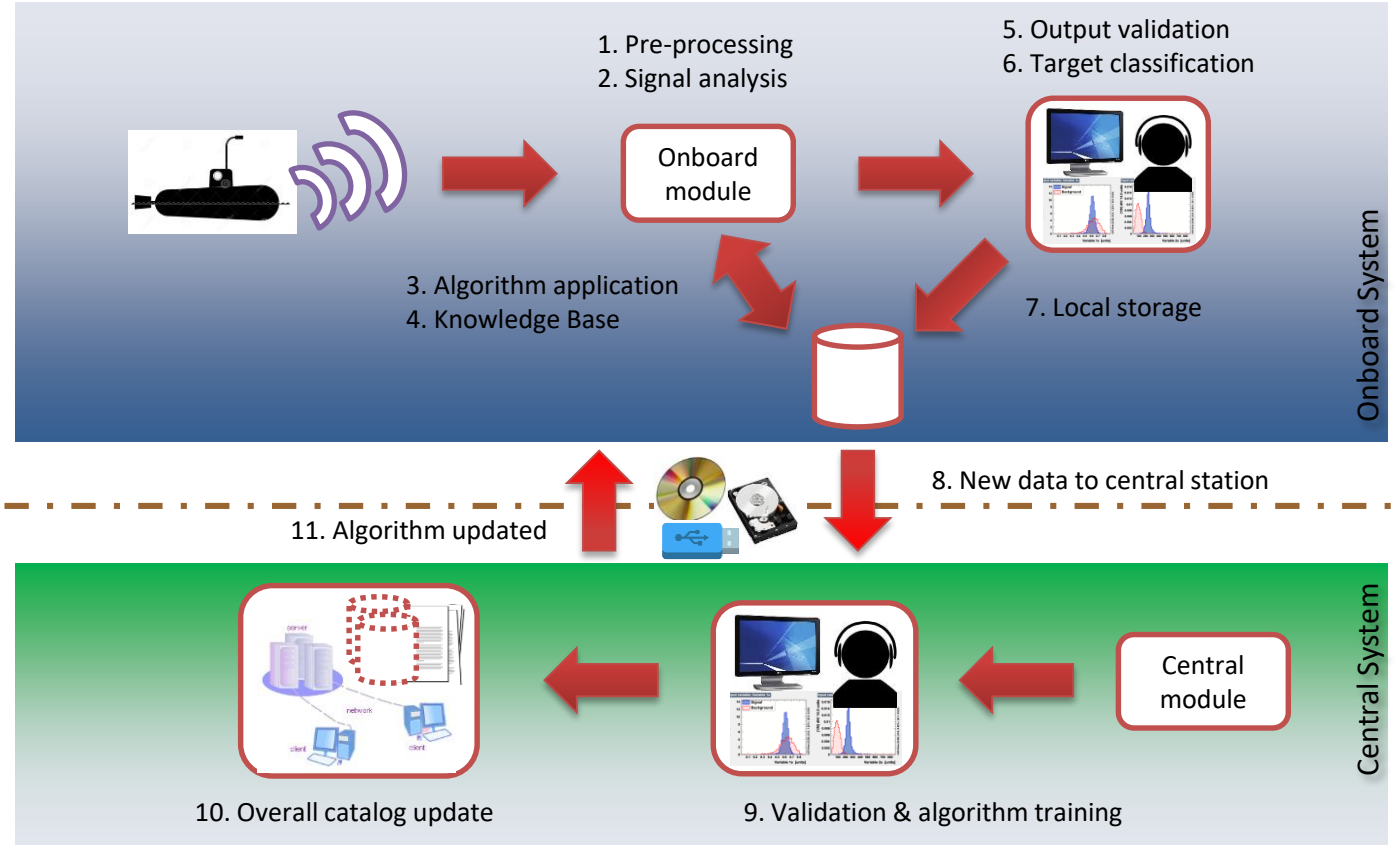
echo
SONAR SENSORS SYSTEM

Project and goals

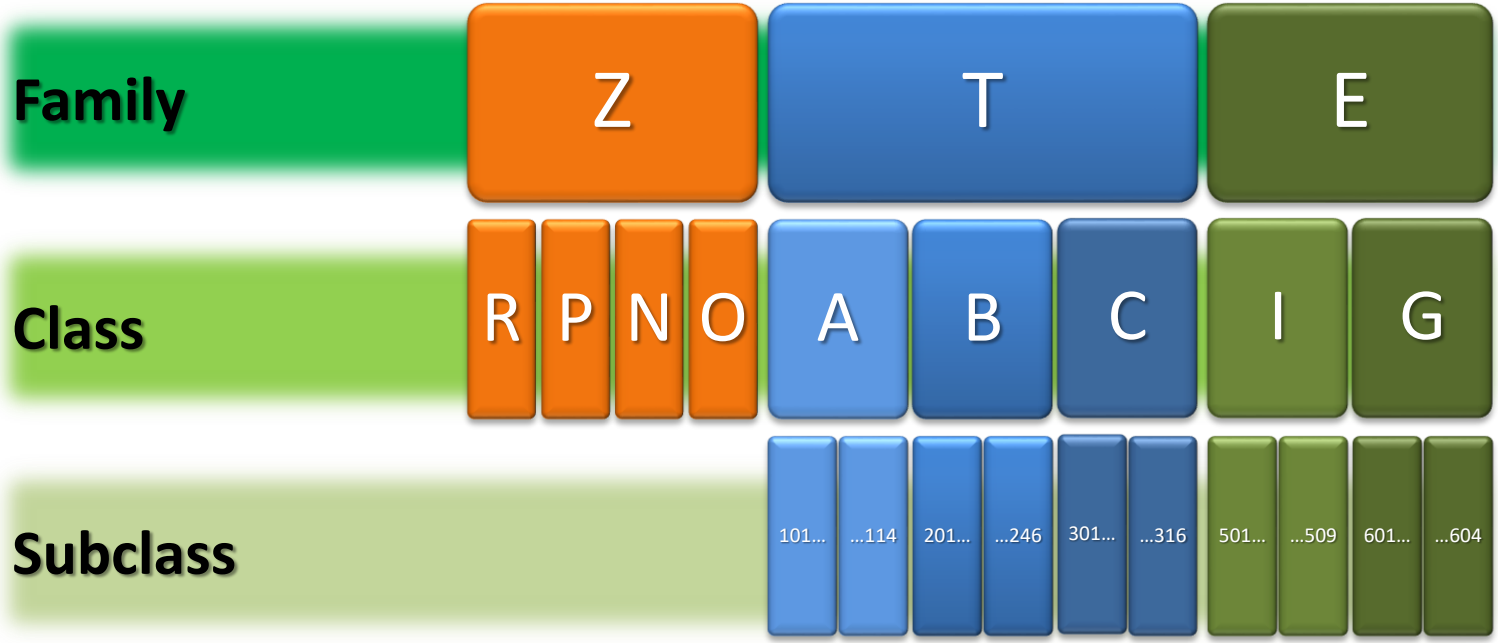
Provide a Decision Support platform, able to:

- ✓ process audio tracks acquired in an underwater environment
- ✓ establish the type of detected target
- ✓ provide the operator with the results of the processing, for its verification and validation

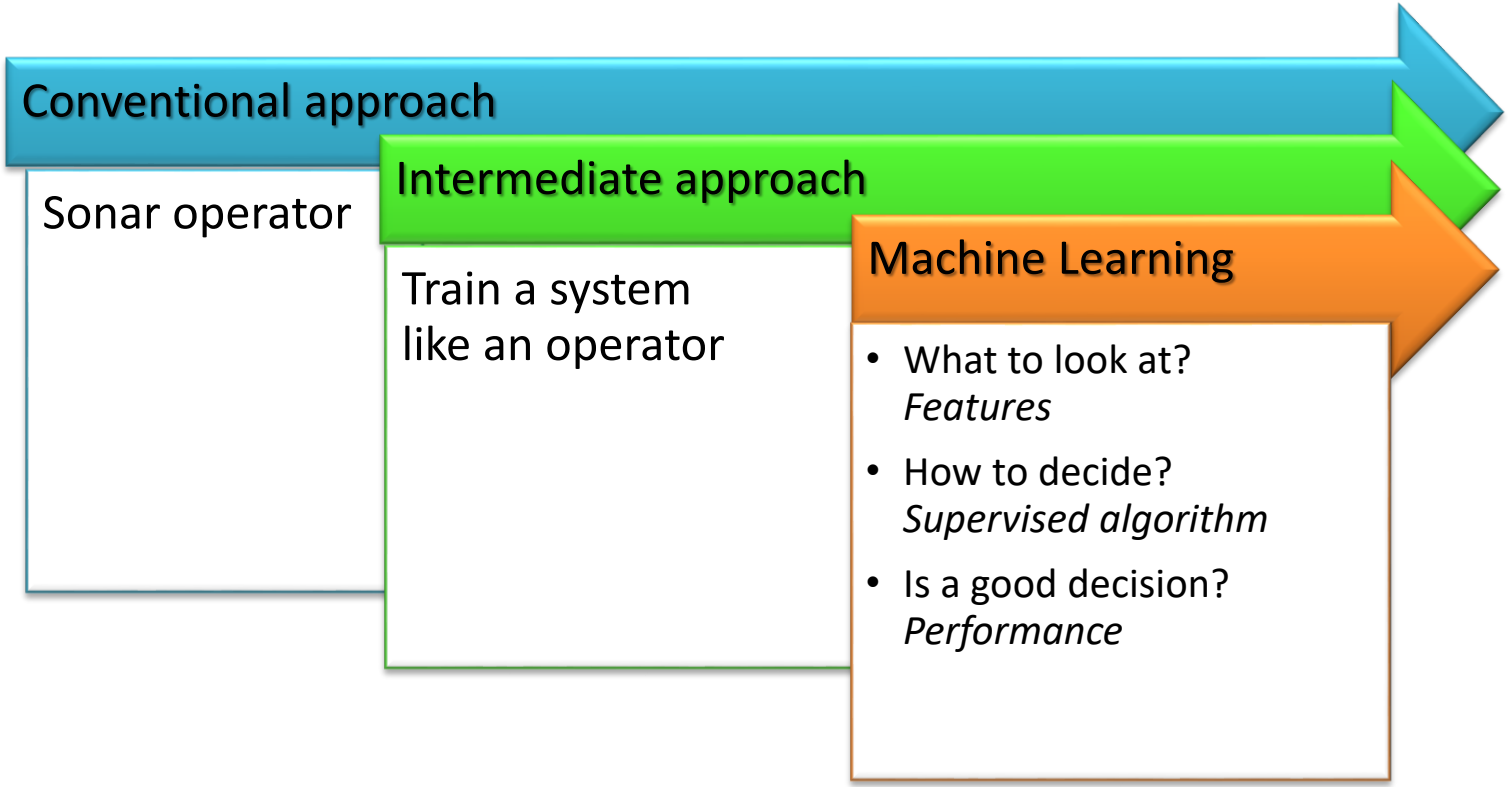
Project vision



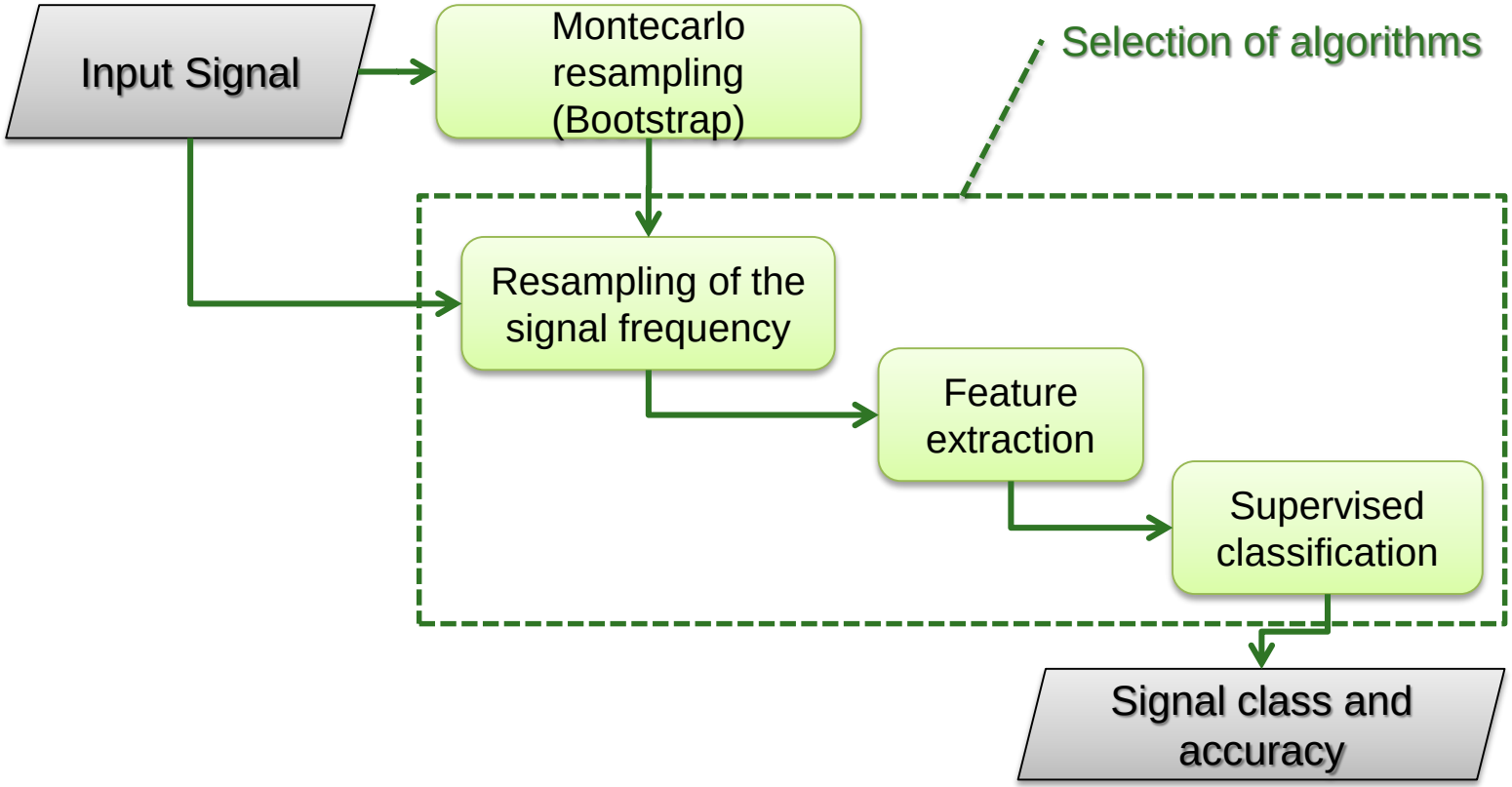
Families, Classes and Subclasses



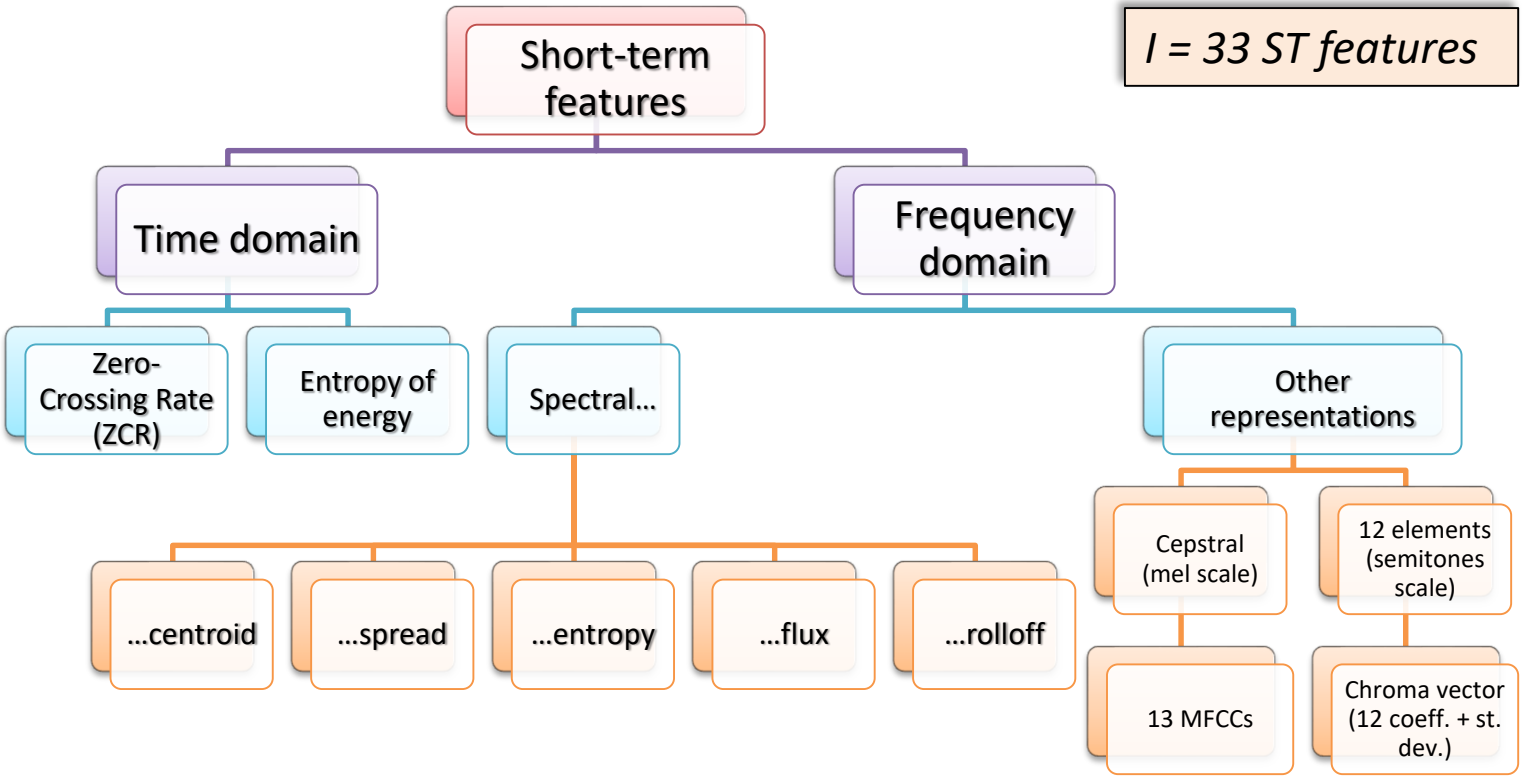
Machine Learning Approach



Flow chart

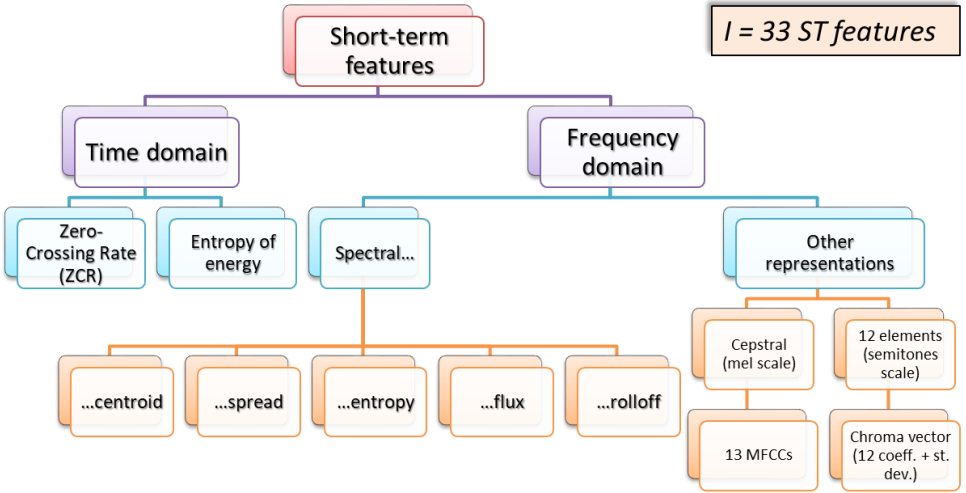

Input Signal
Montecarlo resampling (Bootstrap)
Selection of algorithms
Resampling of the signal frequency
Feature extraction
Supervised classification
Signal class and accuracy

Short-term (ST) features



Mid-term (MT) features

Statistical indicators extracted from the distribution of each ST feature on the whole signal



I = 33 ST features

- mean
- standard deviation (std)
- std/mean
- skewness
- Fisher kurtosis
- median
- 25th percentile
- 75th percentile
- max
- min

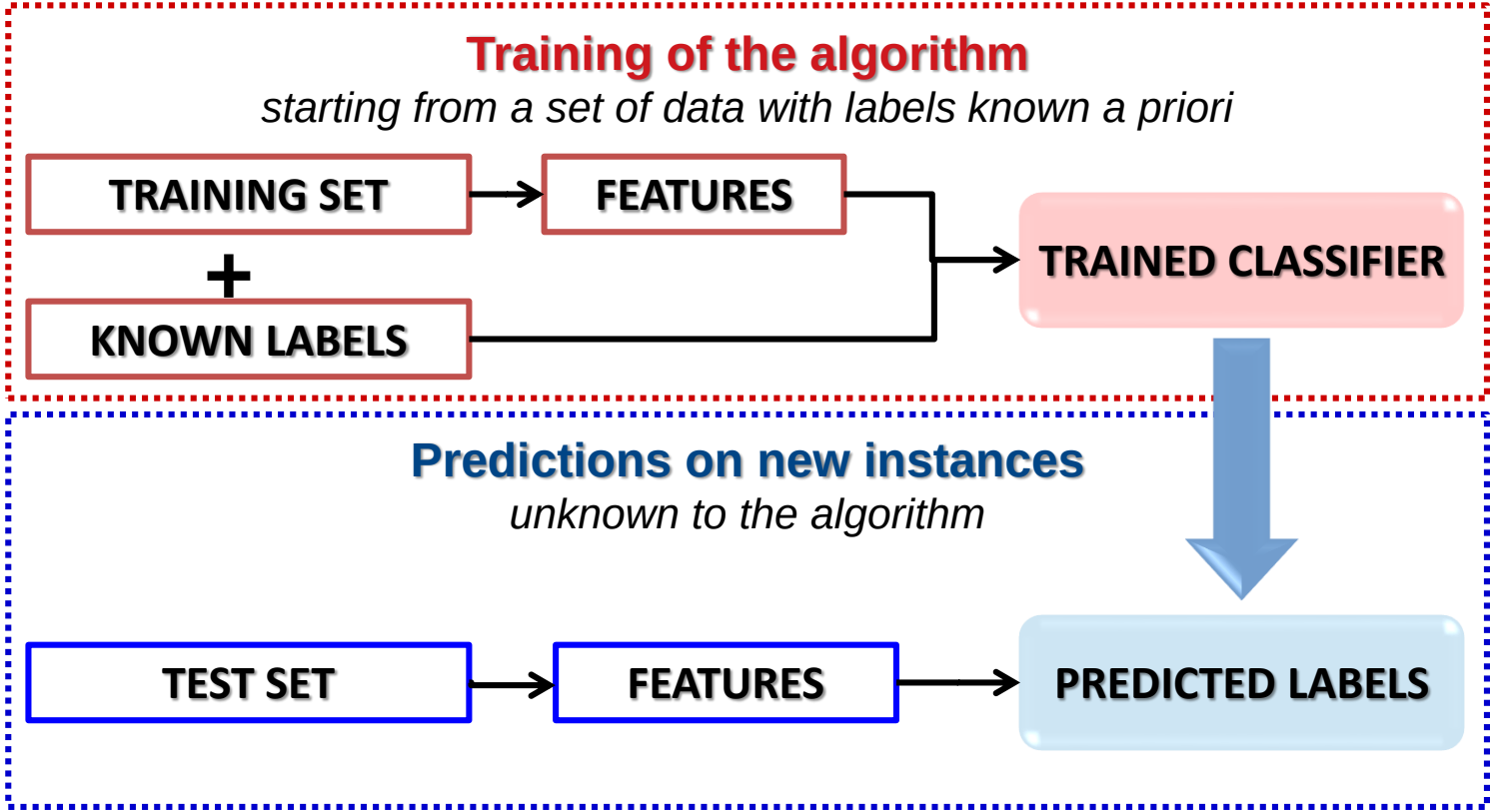
I = 33 ST features

M = 10 statistical indicators

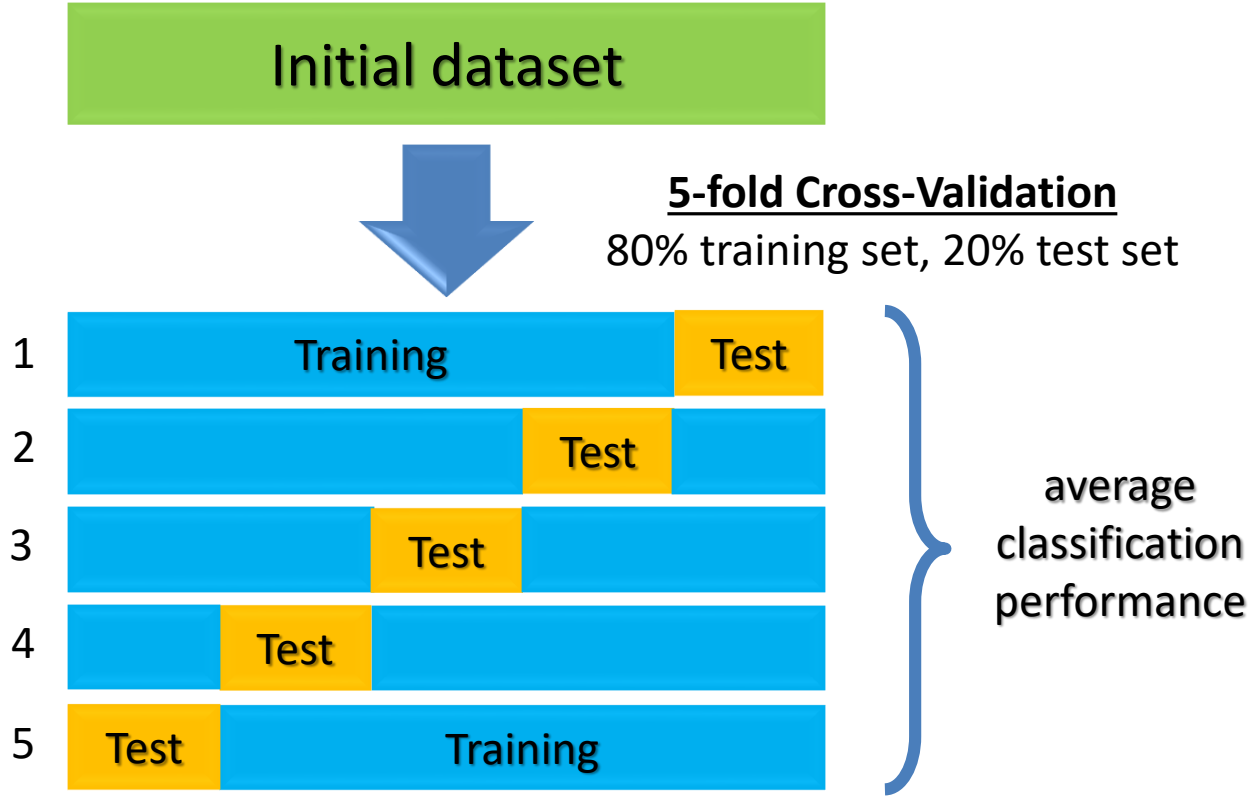
I x M = 330 MT features

Giannakopoulos T (2015) pyAudioAnalysis: An Open-Source Python Library for Audio Signal Analysis. PLoS ONE 10(12): e0144610

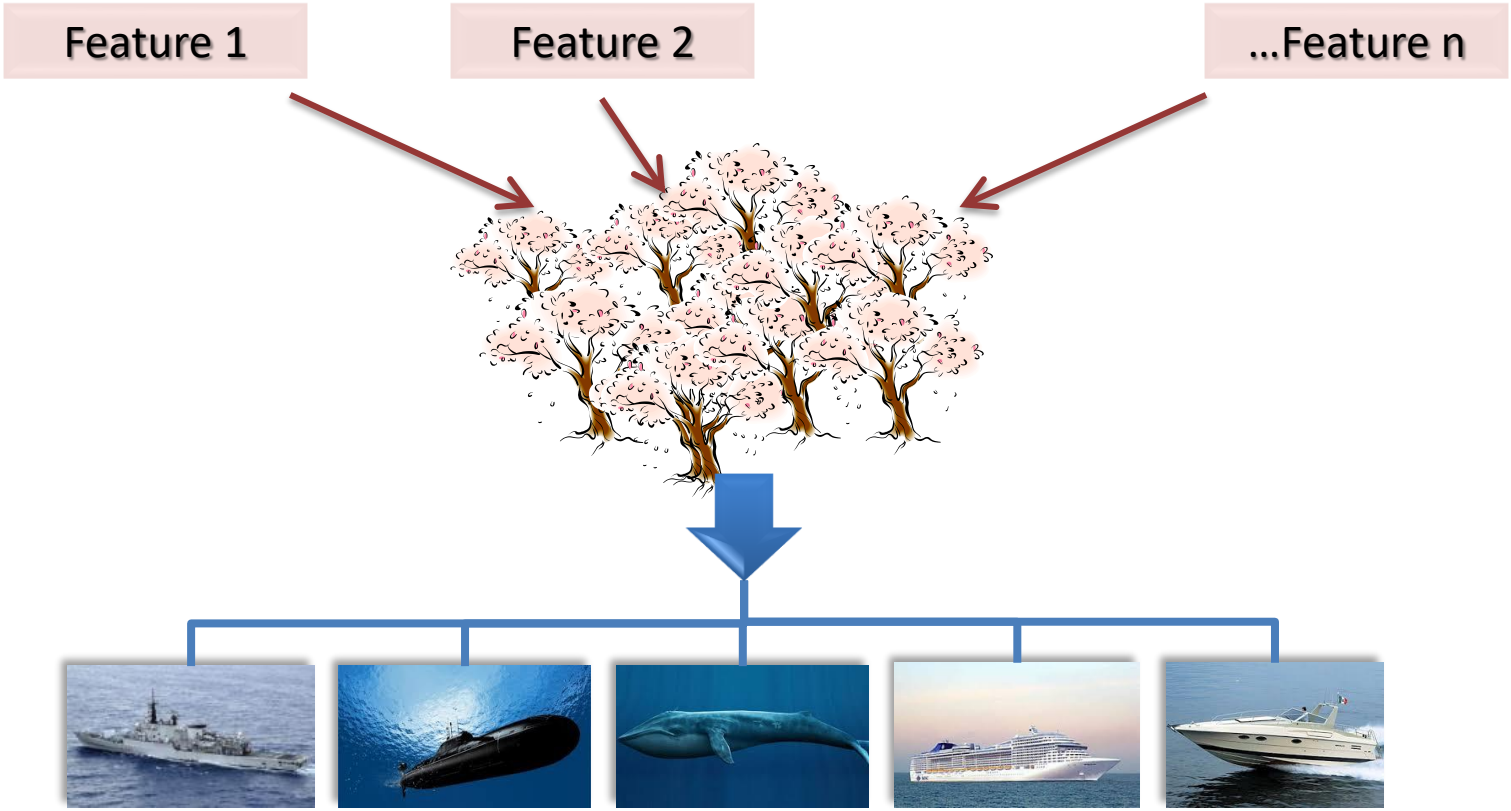
Supervised learning



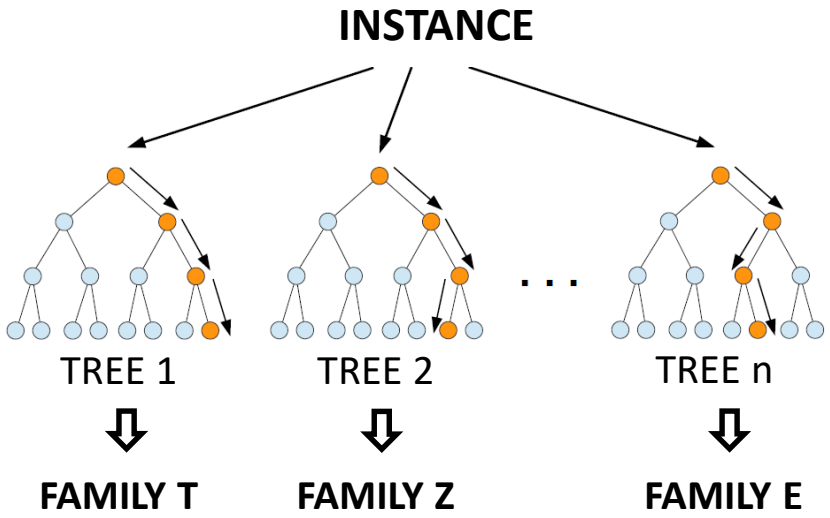
Cross-Validation



Random forest



Random forest & classification probability



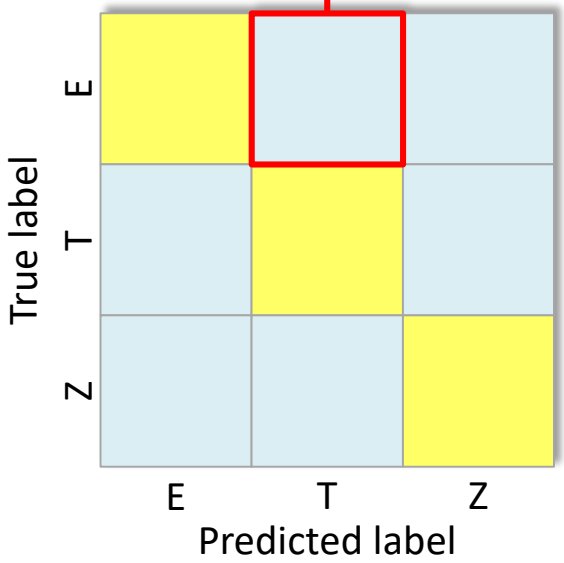
The test instance is classified by combining the output of trees with majority voting

Output not recognized if:

$\max(p_E,p_T,p_Z) <$ fixed treshold

Confusion Matrix

Matrix summarizing the classification output



of **E** classified as **T**

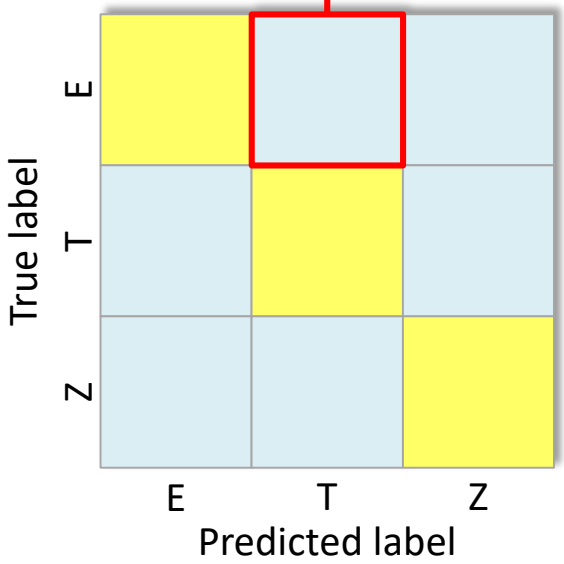
Principal diagonal
# of correctly classified tracks

Other cells
# of wrongly classified tracks

Sum of the confusion matrix elements → # of test instances

Normalized Confusion Matrix

Matrix summarizing the classification output



% of **E** classified as **T**

Principal diagonal
% of correctly classified tracks
for each family (row)

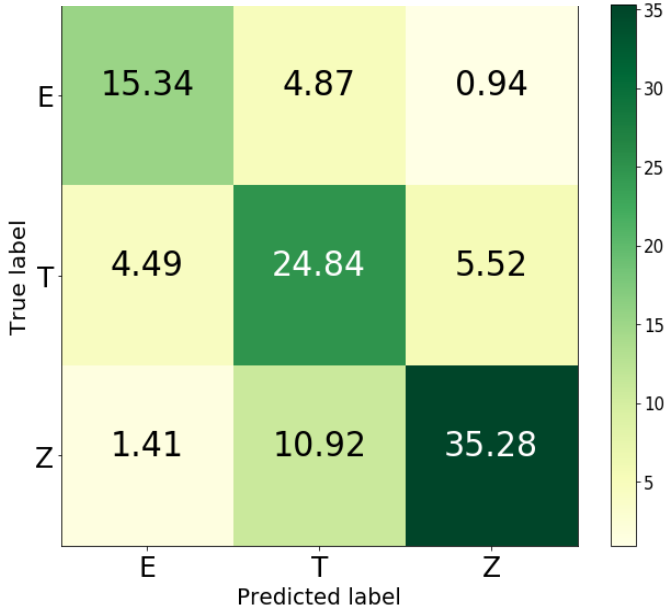
Other cells
% of wrongly classified tracks
for each family (row)

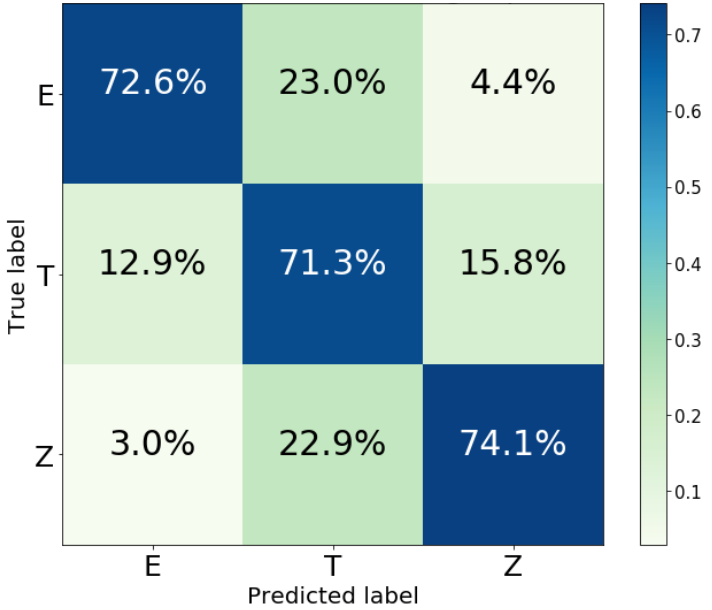
Sum of the elements in a row = 100 % → # of tracks in the corresponding family

Classification results on families

Output not recognized if $\max(p_E,p_T,p_Z) < 0.4$

500 executions: 103.61 tracks classified and 4.39 not recognized, on average





Conclusions and perspectives

- In this study we focused on the classification in families of marine self-propelled vehicles, motivated by the need to minimize the decisional error on the most general category, to avoid invalidating classification at the deeper levels (classes and subclasses)

- We aim at designing a multilayer algorithm, which should perform classification at all levels, yielding a confidence level for each decision.

- A possible improvement of the model is based on extracting features from only the most informative portion of each signal, e.g. at minimal distance from the target (CPA point) or maximum signal to noise ratio.

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Thank you for your attention

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