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MIAI Grenoble Alpes

Multidisciplinary Institute in Artificial intelligence

On the Physical Inference in Machine Learning approaches for the surveillance of hydraulic equipments

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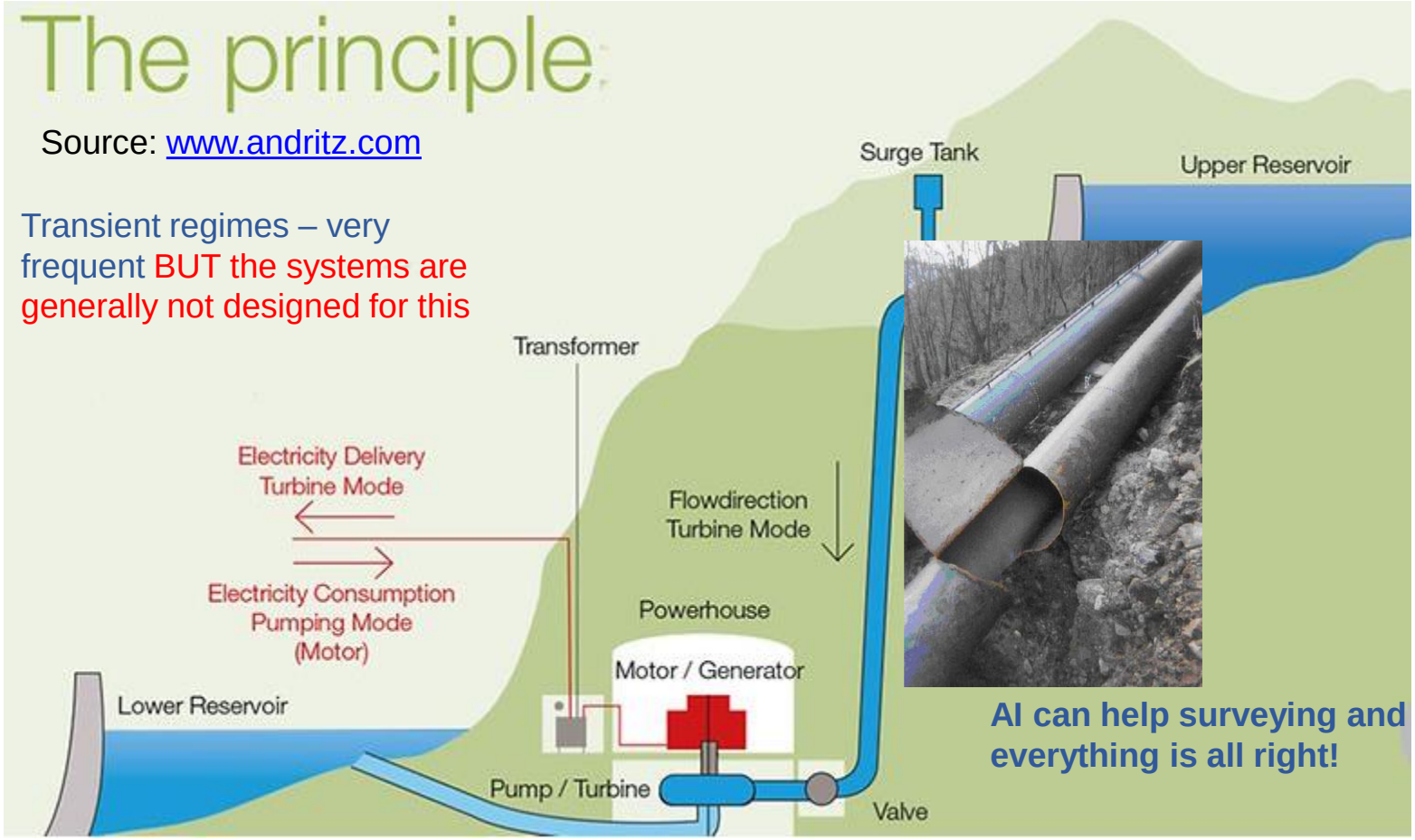
cnrs Grenoble INP UNIVERSITÉ Grenoble Alpes UMR 5216

Motivation – surveillance of hydro equipement

face to intermitent use of hydro electicity



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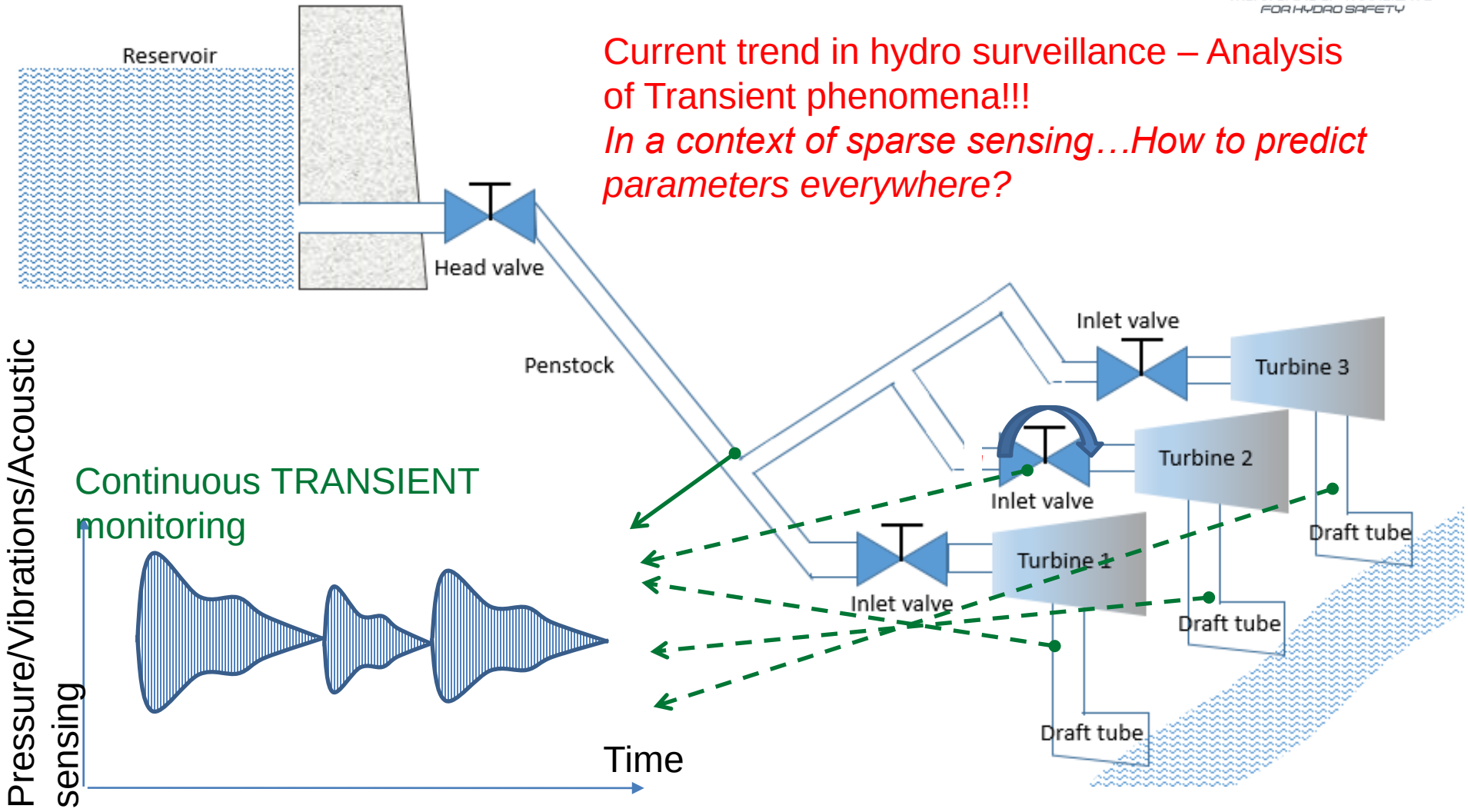
- Introduction – application context
- State of the Art in feature extraction in hydraulic surveillance
- Physical inference in Machine Learning
- Illustration
- Conclusions

Introduction (1)

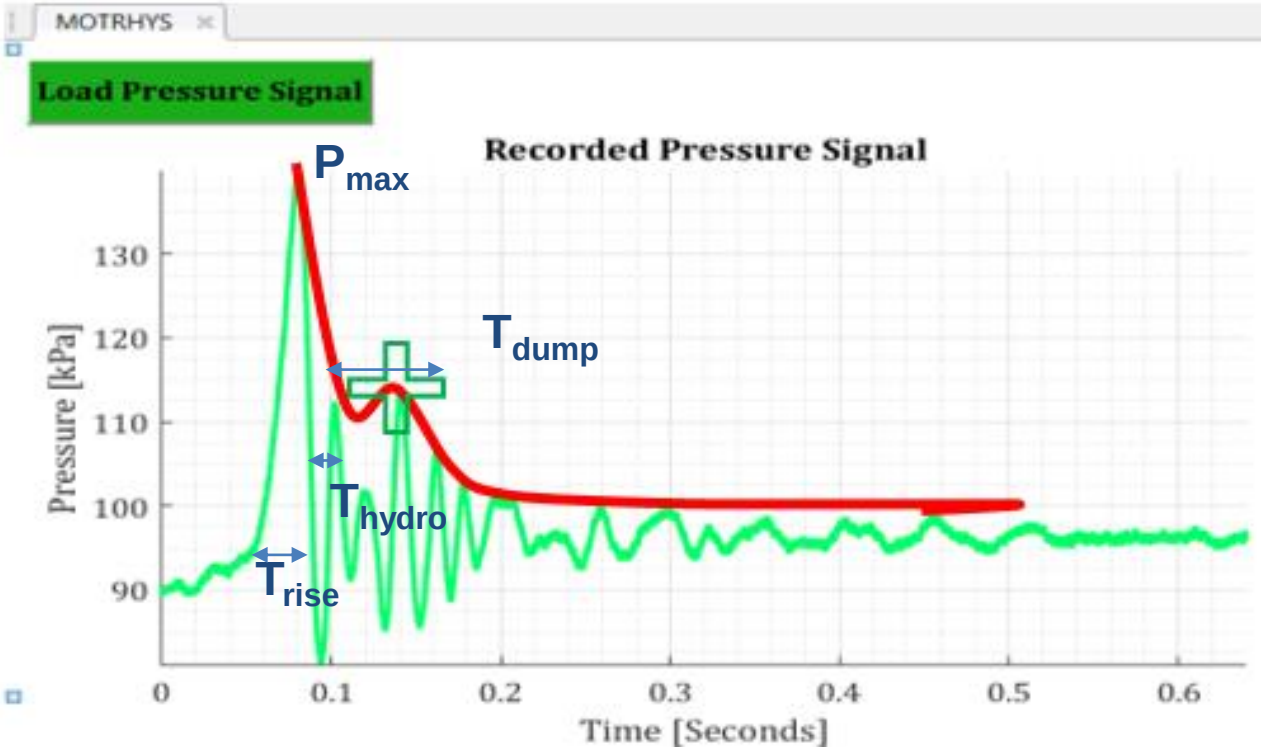


Current trend in hydro surveillance – Analysis of Transient phenomena!!!

In a context of sparse sensing…How to predict parameters everywhere?

Introduction (3)

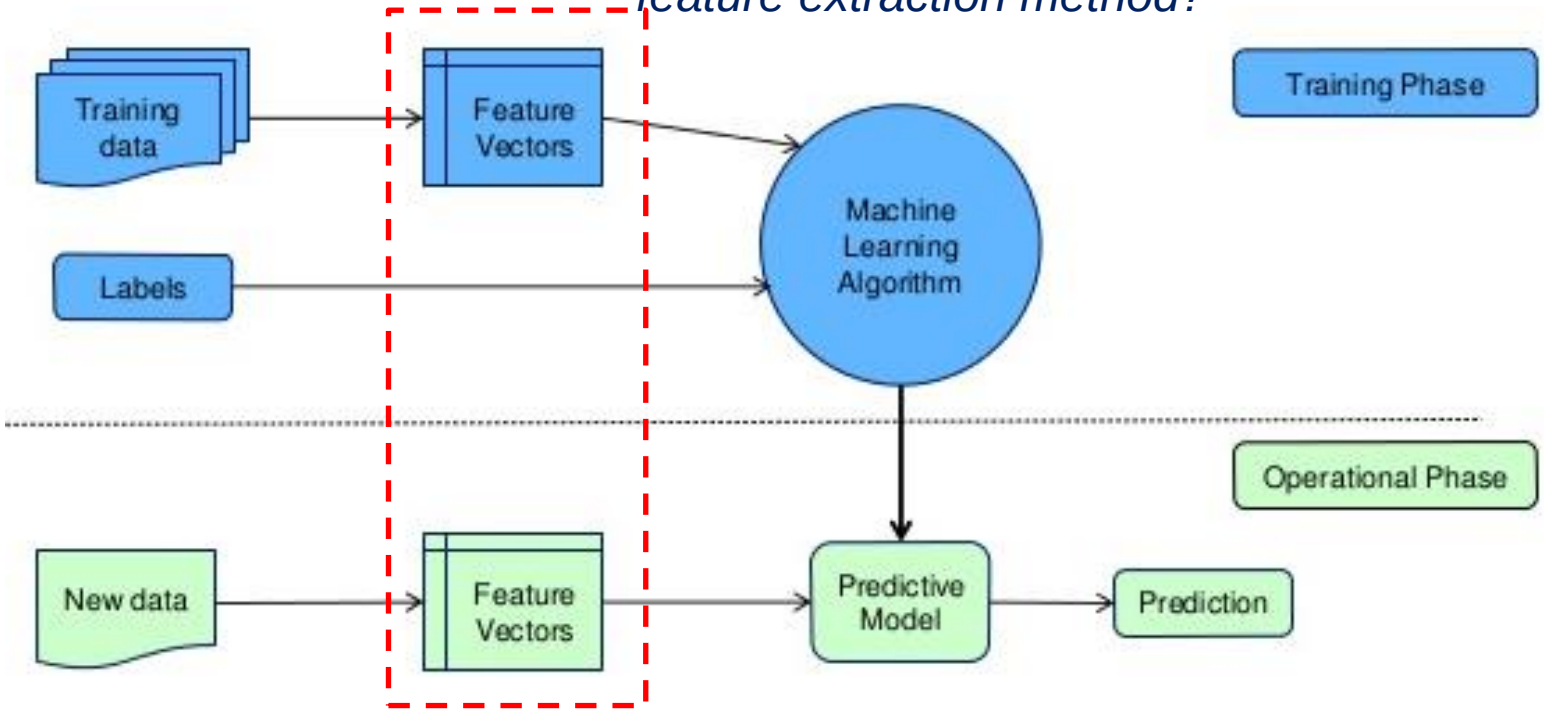
Transitory states – affect the pipe characteristics this is why is crucial to supervise them



NEED to classify these transients, knowing that they depend on the physical phenomena but on the state of circuits (aging, fatigue, corrosion,…).

Introduction (4)

Key point: how to design the appropriate feature extraction method?



Courtesy of https://www.slideshare.net/fredverheul/machine-learning-101-dkom-2017

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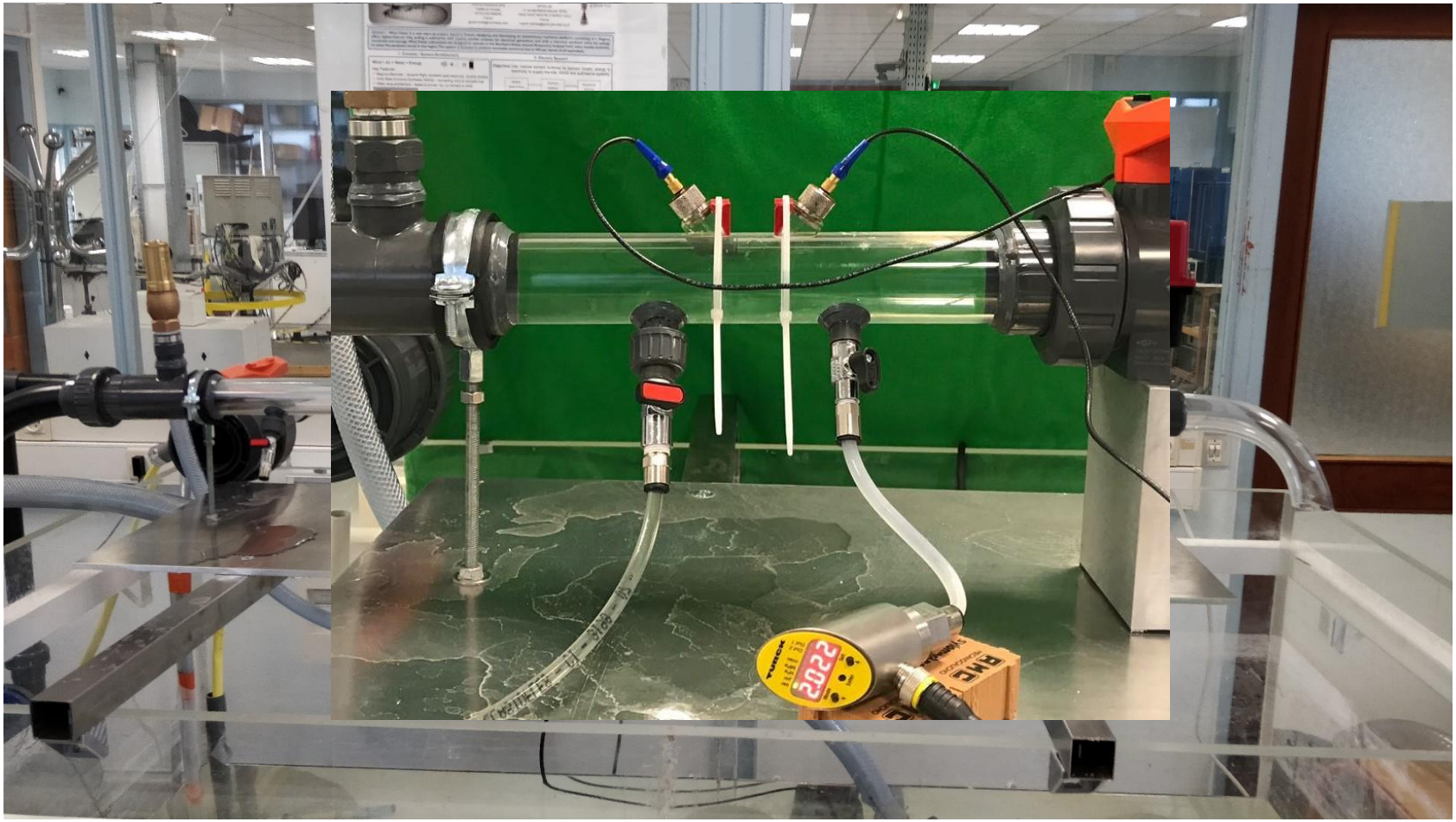
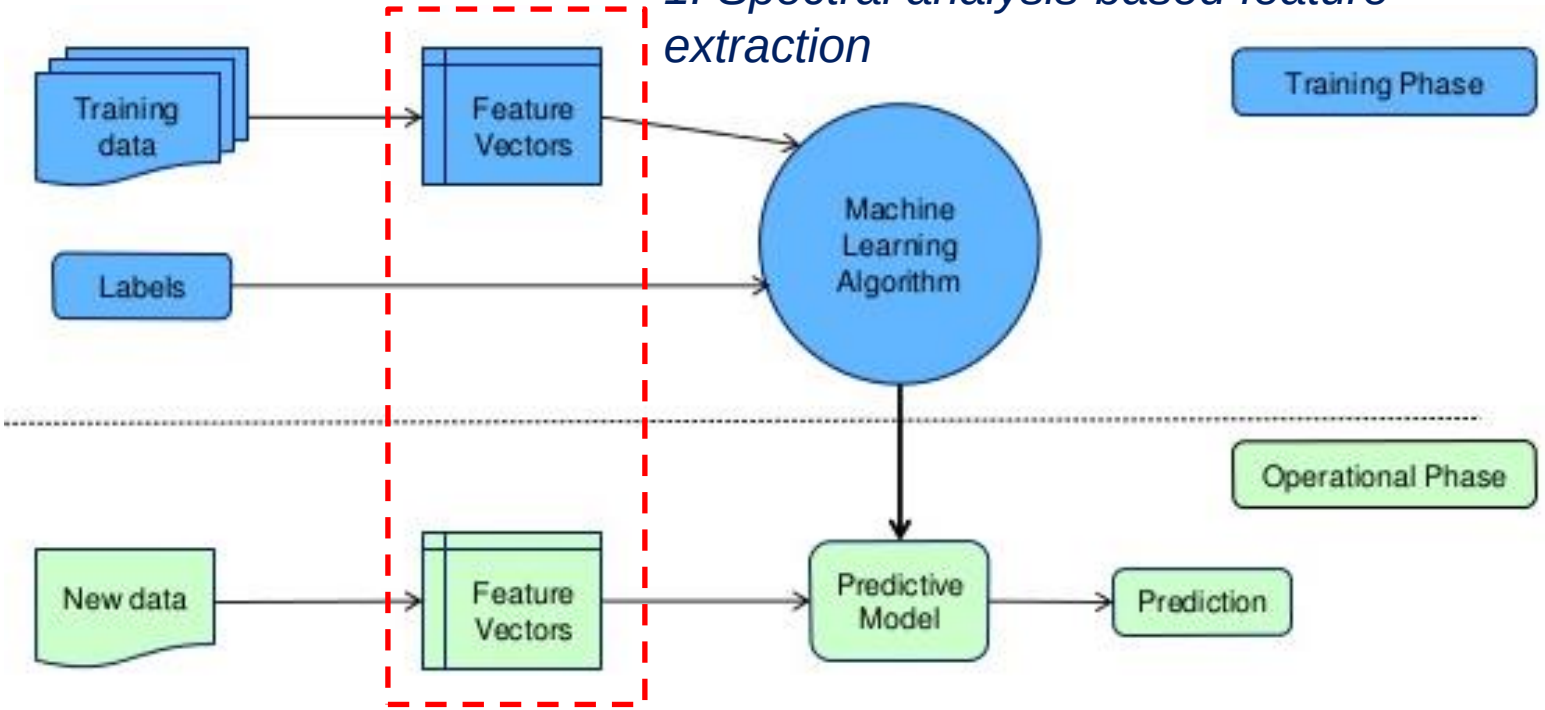
State of the Art (1) – Studied on a fully controlled reduced scale experimental facility



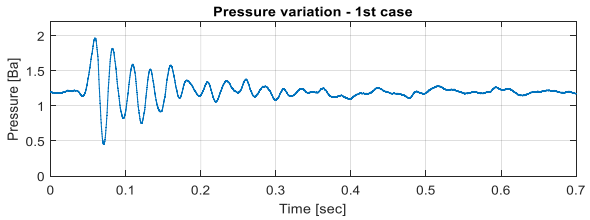
State of the Art (2)

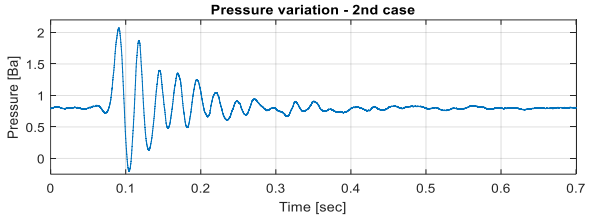
1. Spectral analysis-based feature extraction



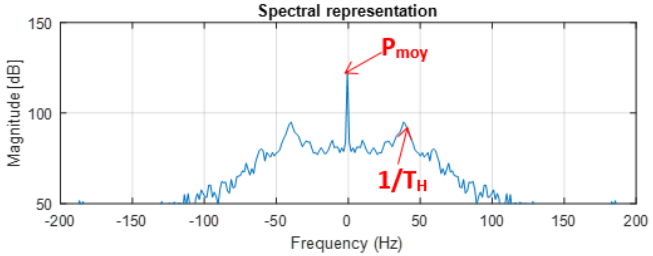
Courtesy of https://www.slideshare.net/fredverheul/machine-learning-101-dkom-2017

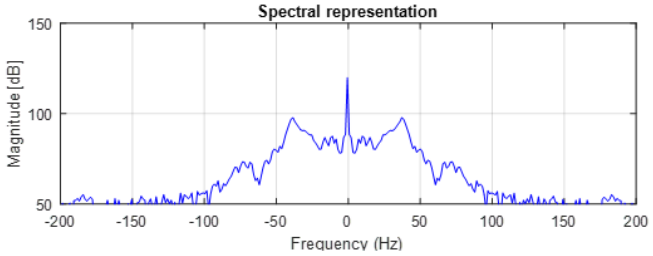
State of the Art (3) – Spectral analysis



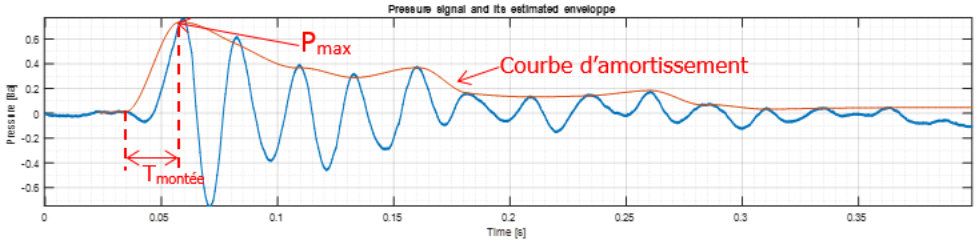


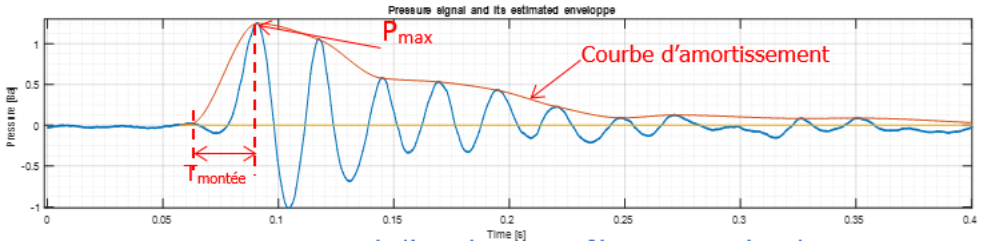
Fourier Transform





HUMAN intervention/setting required!





Spectral estimation/ Filtering

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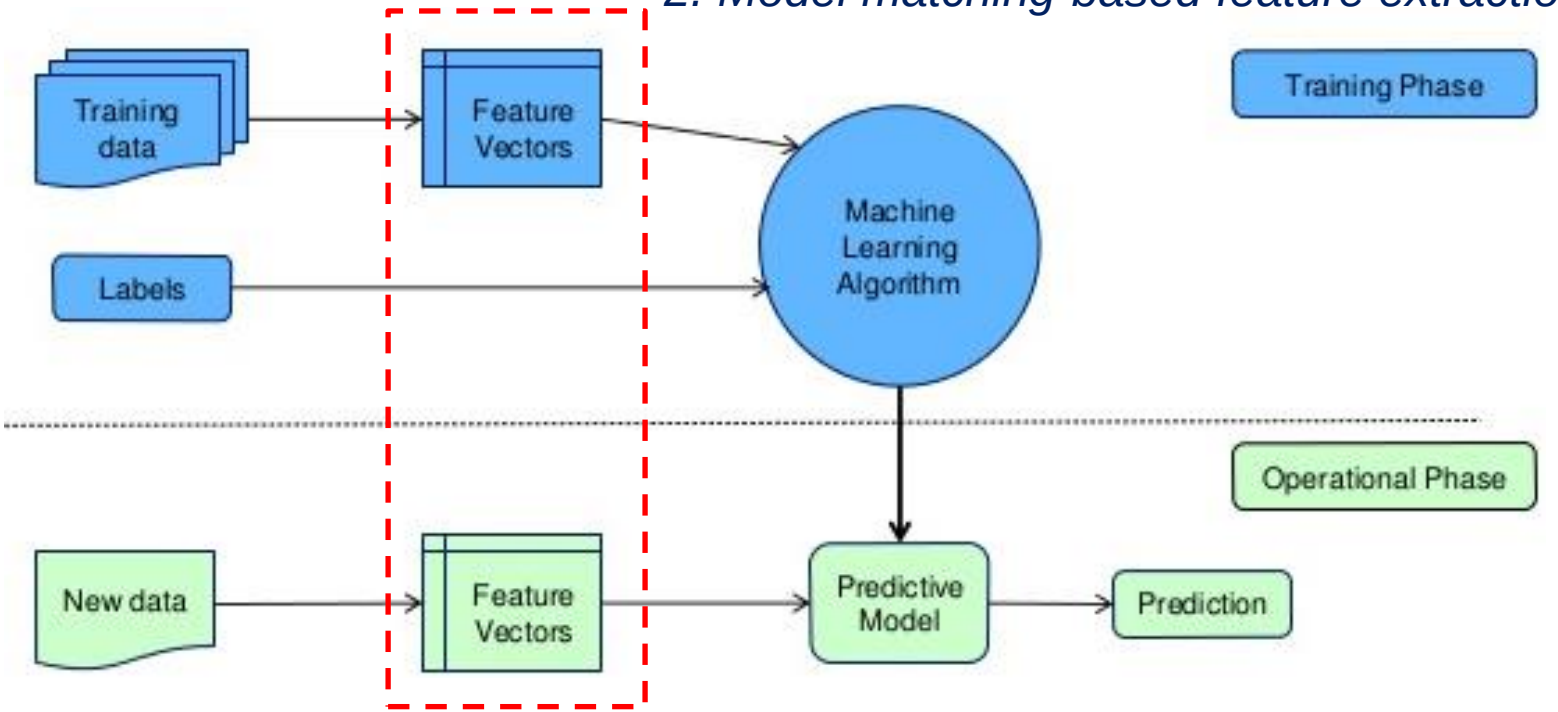
State of the Art (4)

2. Model matching-based feature extraction



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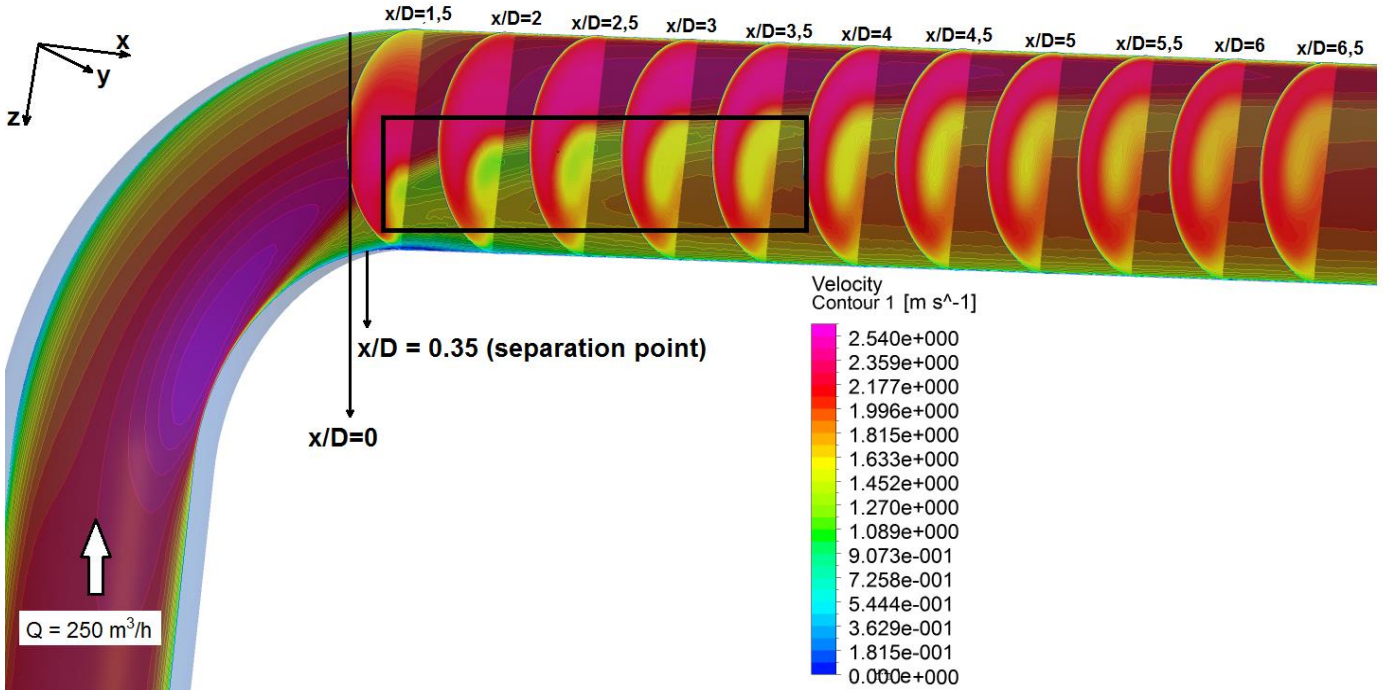
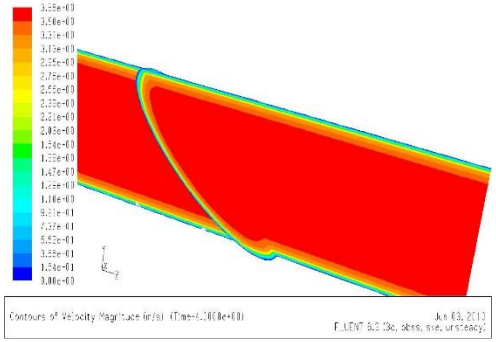
State of the Art (5)

Key element – modelisation using simulation software: Cosmos, Comsol, Fluent, Simsen…



State of the Art (5)

Model = pressure distribution for each *possible* real situation



CFD simulation

- Coordonées (x,y,z);
- Vitesses

Code C++
Sim_matrice.cpp

Interpolation spatiale bilinéaire

Augmenter la résolution spatiale

Algorithme de Bressenham

Définir les conditions initiales et aux limites sur des frontières circulaires, elliptiques ou rectangulaires

Définir comme condition initiale l'émission d'une sinusoide à haute fréquence

Discrétiser les équations avec la méthode des Différences Finies

La pression et la vitesse d'onde à la sortie

State of the Art (6)

MOTHYS
MONITORING OF TRANSIENTS FOR HYDRO SAFETY

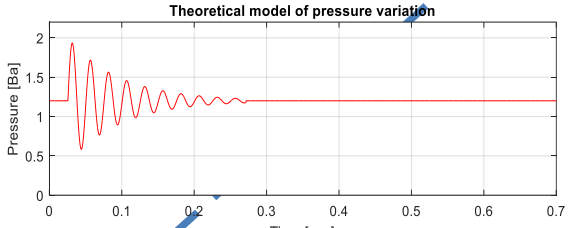
Models

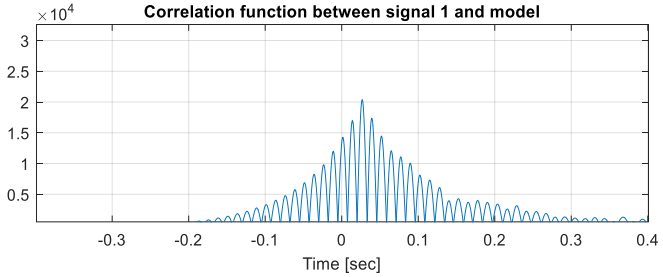
Test signals

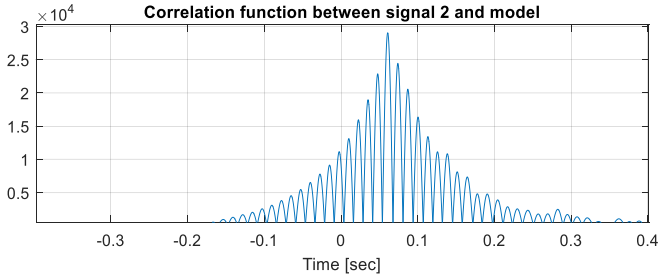
Matching process

NOT always realistic

NOT always available

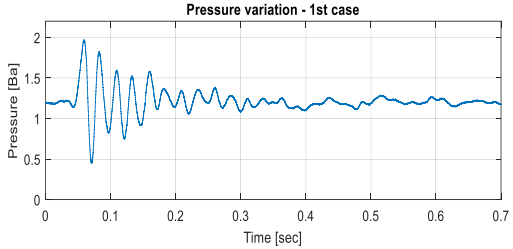


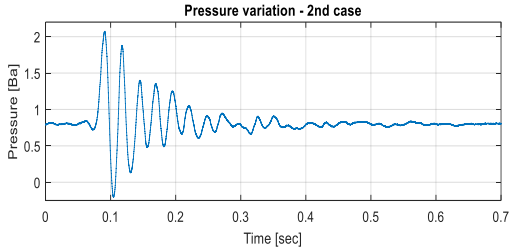




NOT discriminant !

Projection





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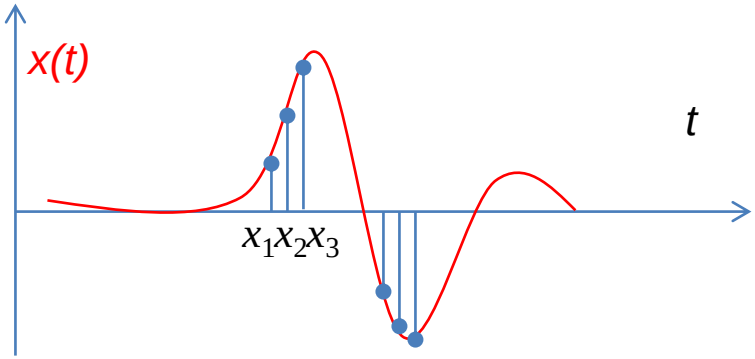
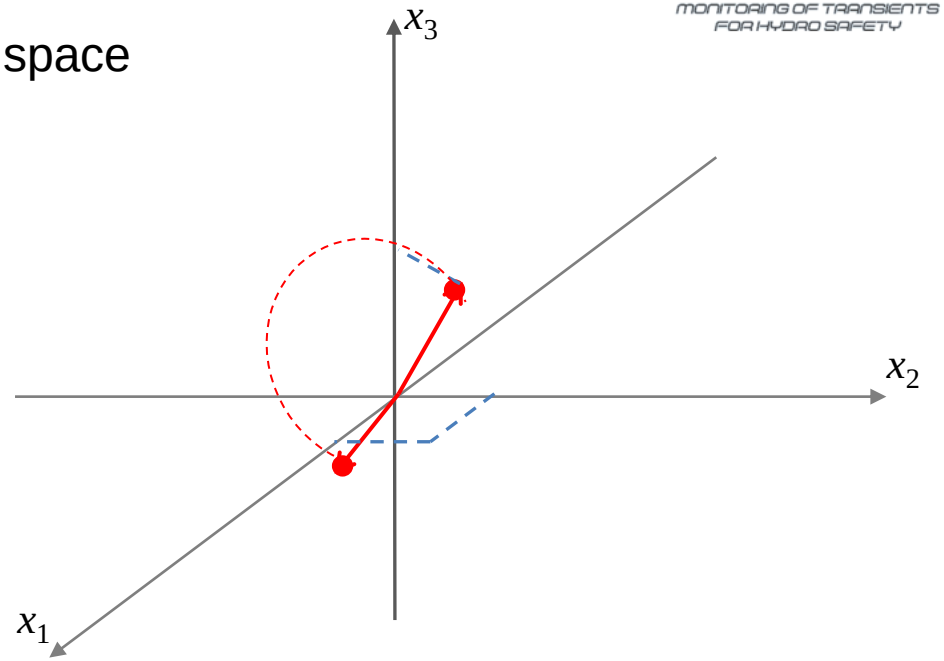
Physical inference (1)

First, need for a data driven representation space
PHASE DIAGRAM ANALYSIS



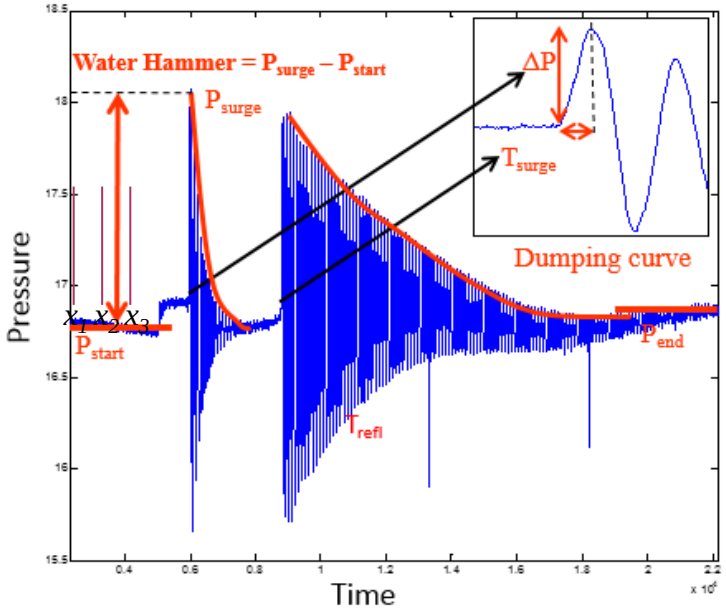


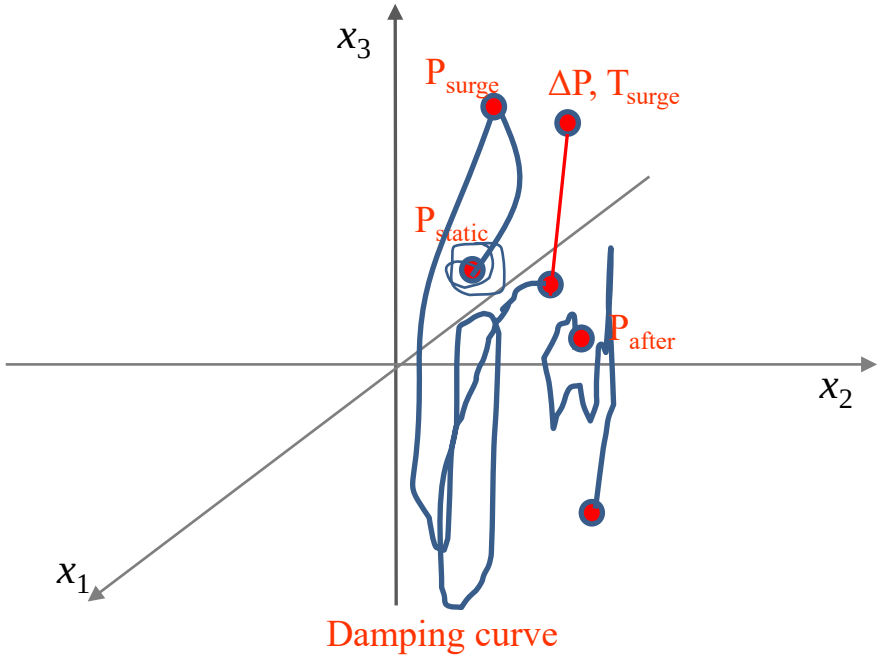
$$\alpha_i = \arccos\left(\frac{\overrightarrow{v_{[i]}} \cdot \overrightarrow{v_{[i+1]}}}{\left|\overrightarrow{v_{[i]}}\right| \cdot \left|\overrightarrow{v_{[i+1]}}\right|}\right)$$

$$IFL(k) = \frac{f_s}{2N_k}, \text{ where } N_k \mid \sum_{j=i}^{i+N_k-1} \alpha_j = \pi$$

Physical inference (2)

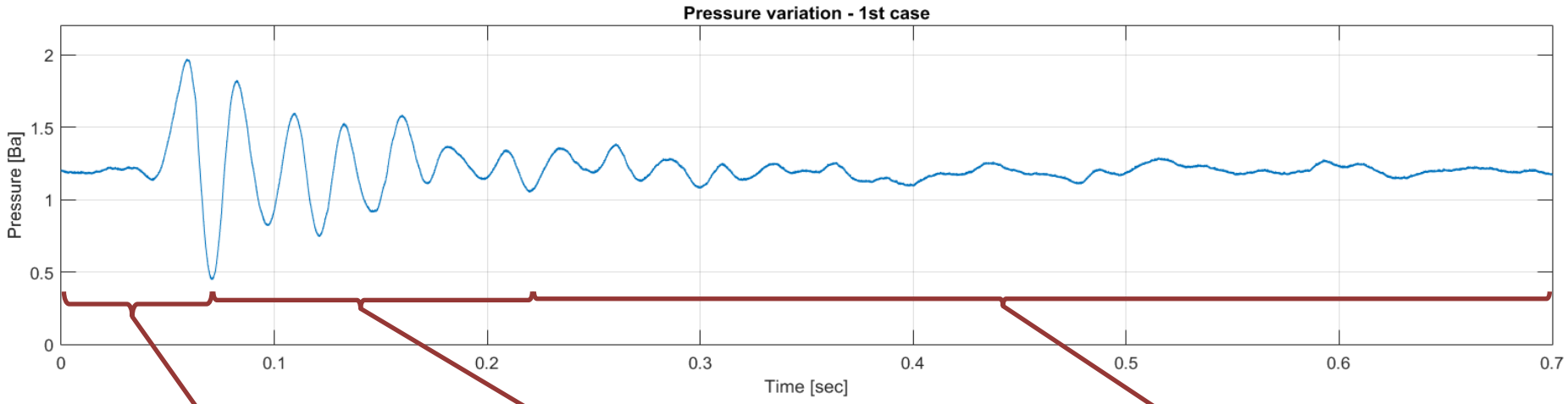
Second, infere physical parameter extraction

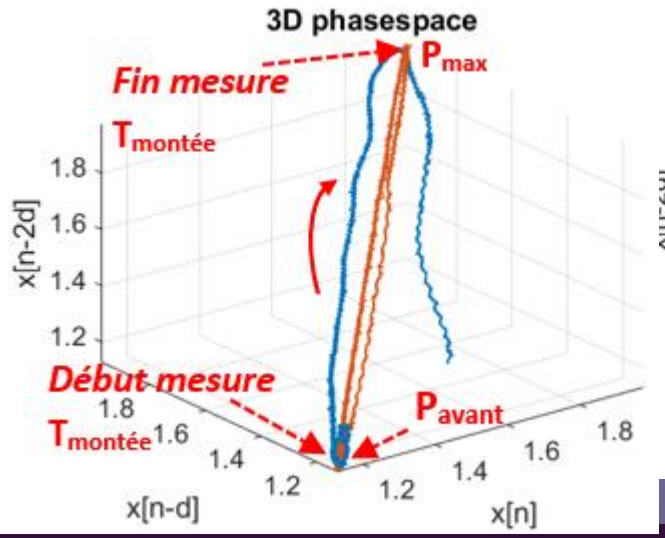


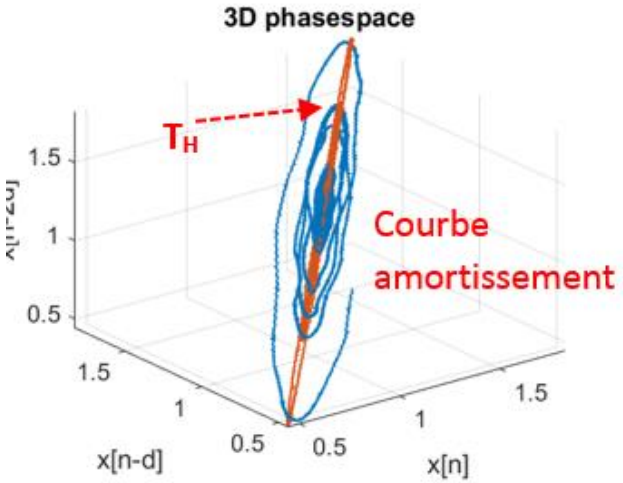


Physical inference (3)

Adaptive analysis to any context, no a priori knowledges required







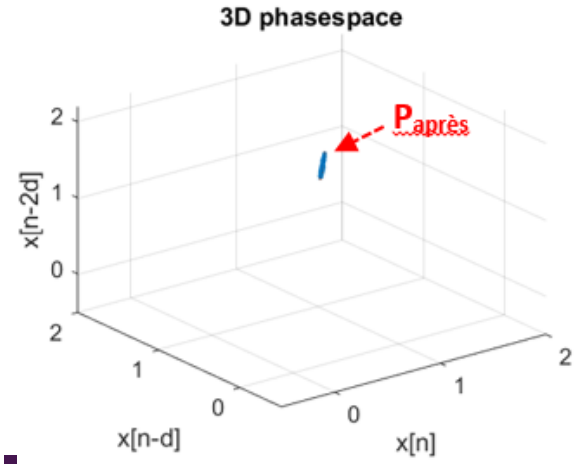


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Illustration (1) – Hydrosurge© software

Feature extraction data driven and transient adapted

Machine Learning

Supervise

Clustering

Reinforcement

Open conversion module, easy to adapt to different sensing units, in order to monitor TRANSIENTS

Predict/Asses an abnormal behaviour

On line system assessment/clustering

Long term/model evolution

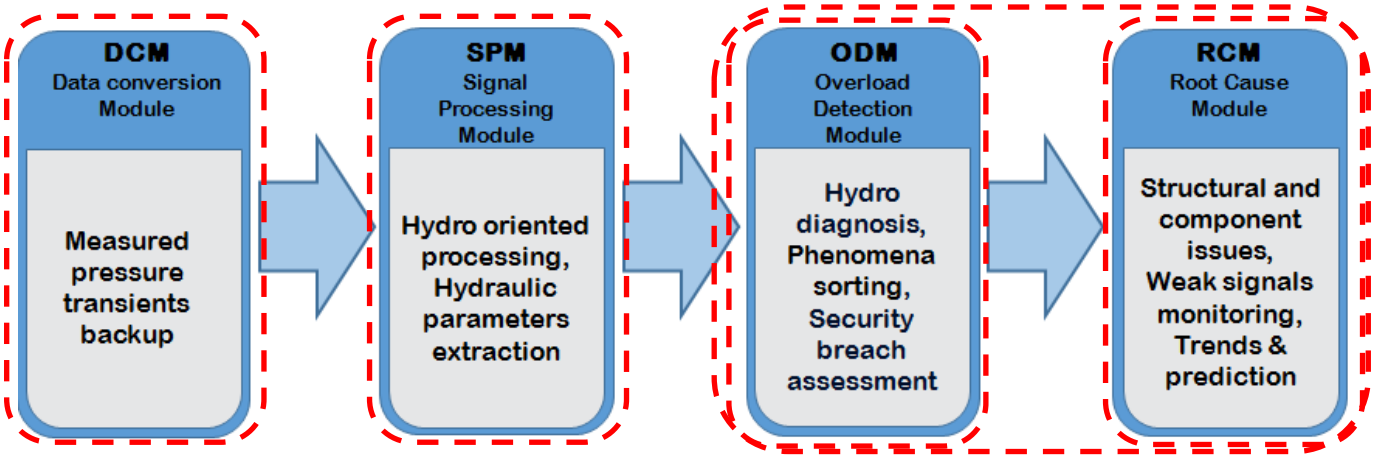
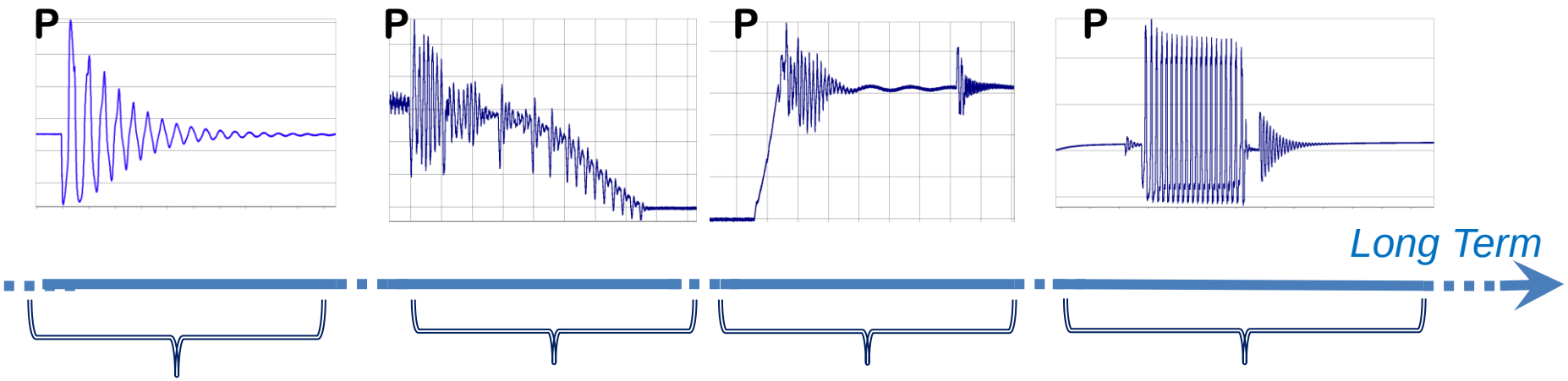


Illustration (2)

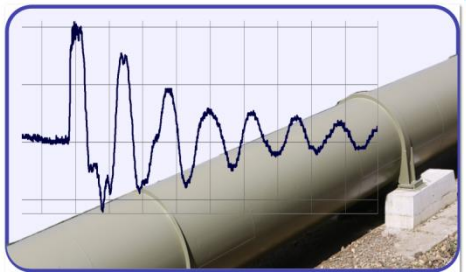


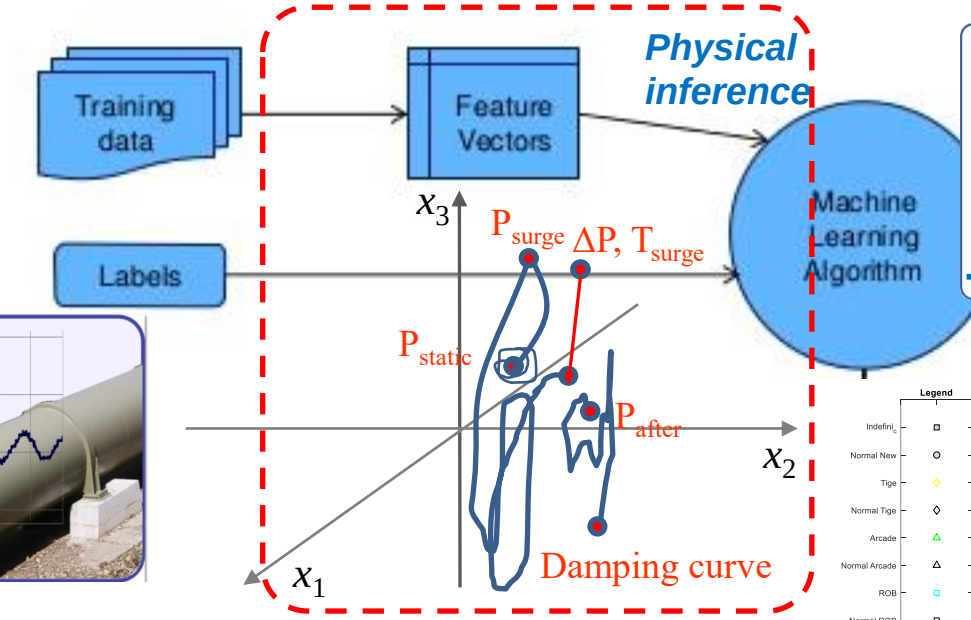
For ex. : Valve and bypass opening

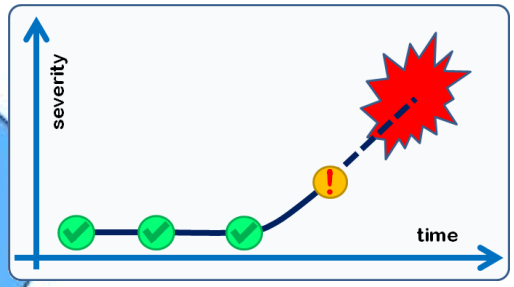
For ex.: Loading and Stop
(related to machine control)

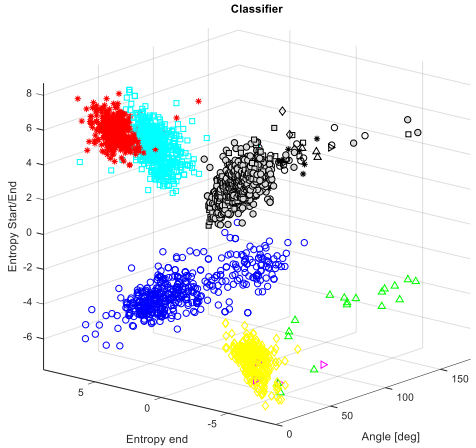
For ex.: Instability, resonance
(related to physical problems)

Illustration (3)









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Conclusions

- High interest for physical inference in machine learning process: three POC in progress
- Motrhys is partner with GE Hydro and won the 1st price at the Innovation contest (GE, 2018), in the theme Machine Learning

- This is just the beginning, partnerships highly suitable