Machine learning for optimization of pump operation under transients in hydraulic turbine rigs

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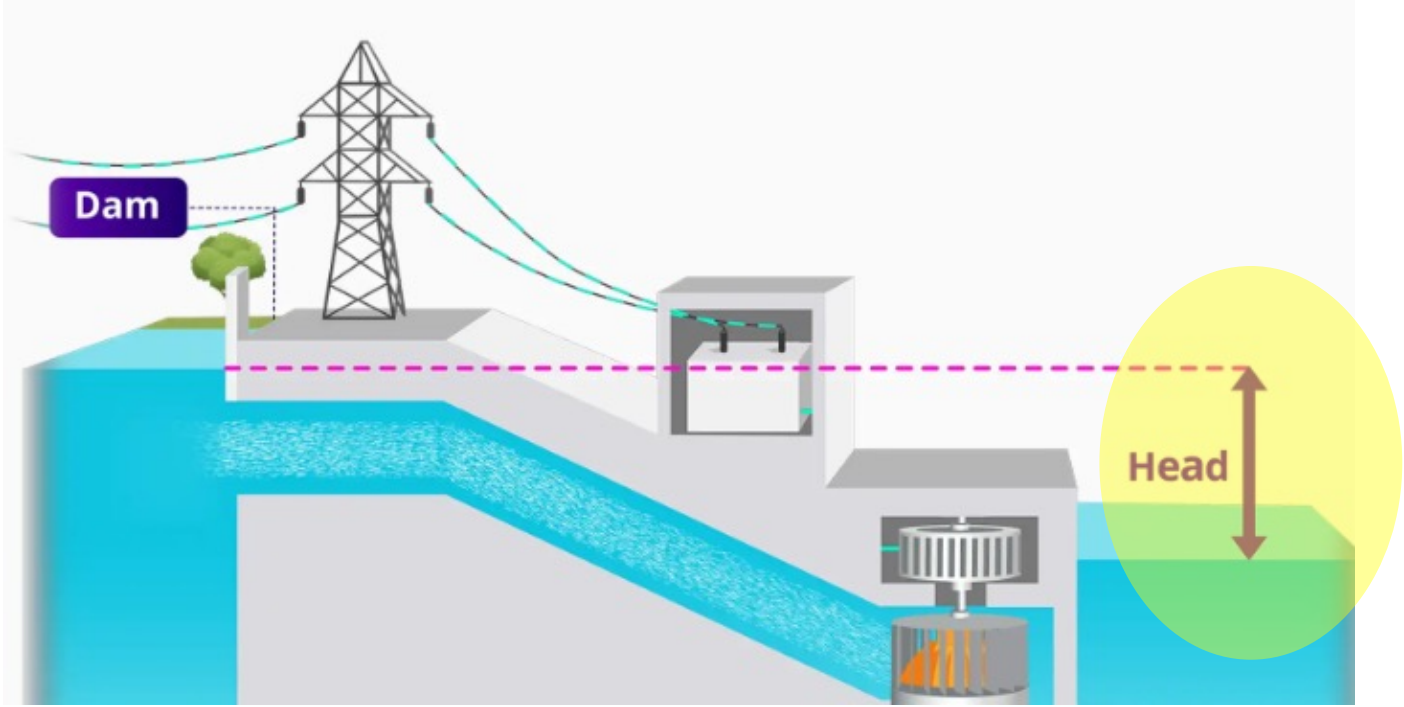
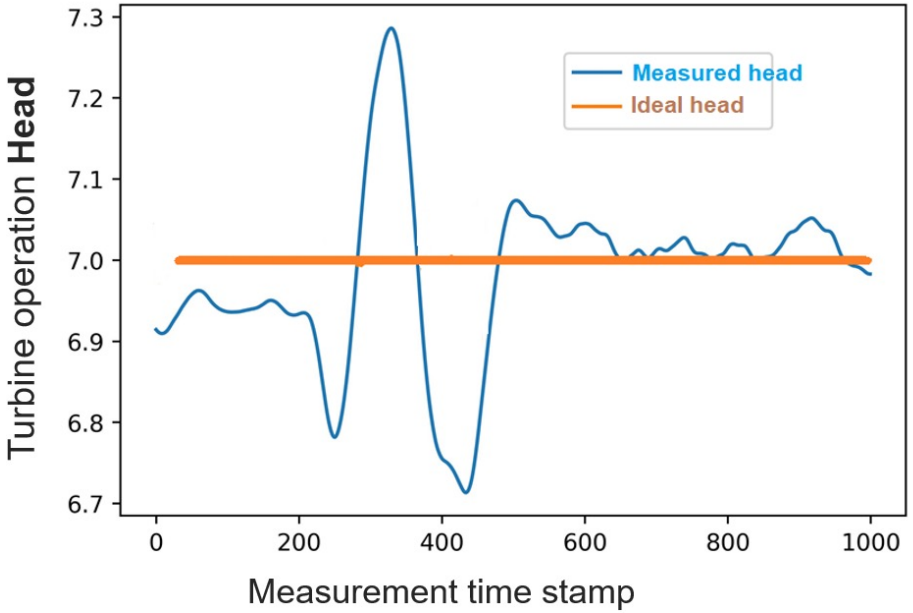
Background and motivation



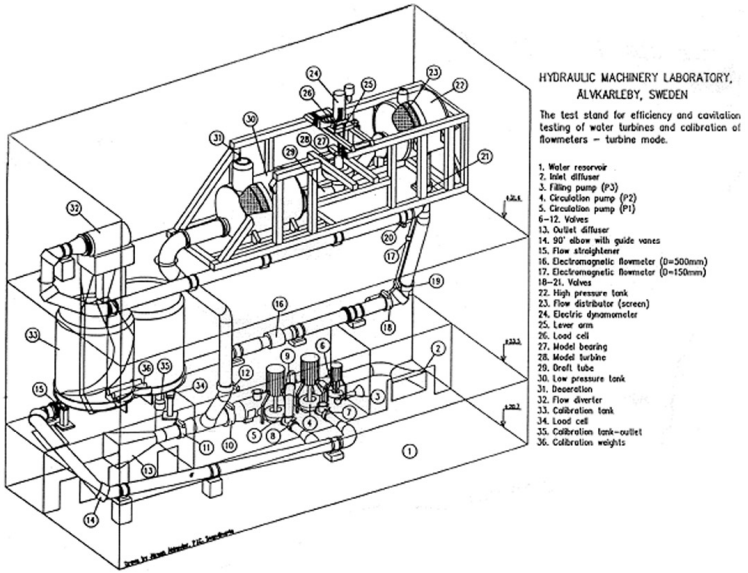
Background and motivation



Head variation due to transient operations:

- Start up phase
- Stop phase
- Normal operations with load variation caused by
  - ✓ Cavitation
  - ✓ Change of guide vane
  - ✓ Change of turbine pitch,
  - ✓ …

Background and motivation



Objectives of this pilot-project

- **Overall objective**
  - Explore AI/ML applications for Swedish hydropower industry
- **As a pilot project**
  - Machine learning → model turbine operational performance
  - Start up phase, design optimal control method → stable head operations
  - Optimizing PID parameters with machine learning

Method (1): Machine learning model

- Machine learning turbine model: Artificial neural network (ANN) $h_t = h(n_p, \alpha, \ldots)$

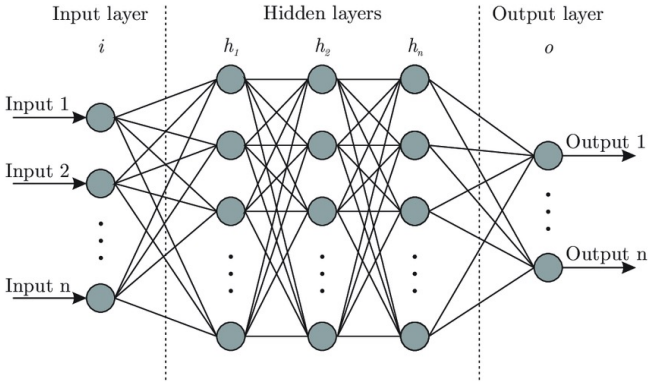
Pump 1 speed,

Pump 2 speed,

Guide open,

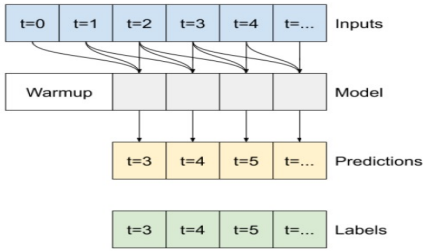
Tank pressure,

….



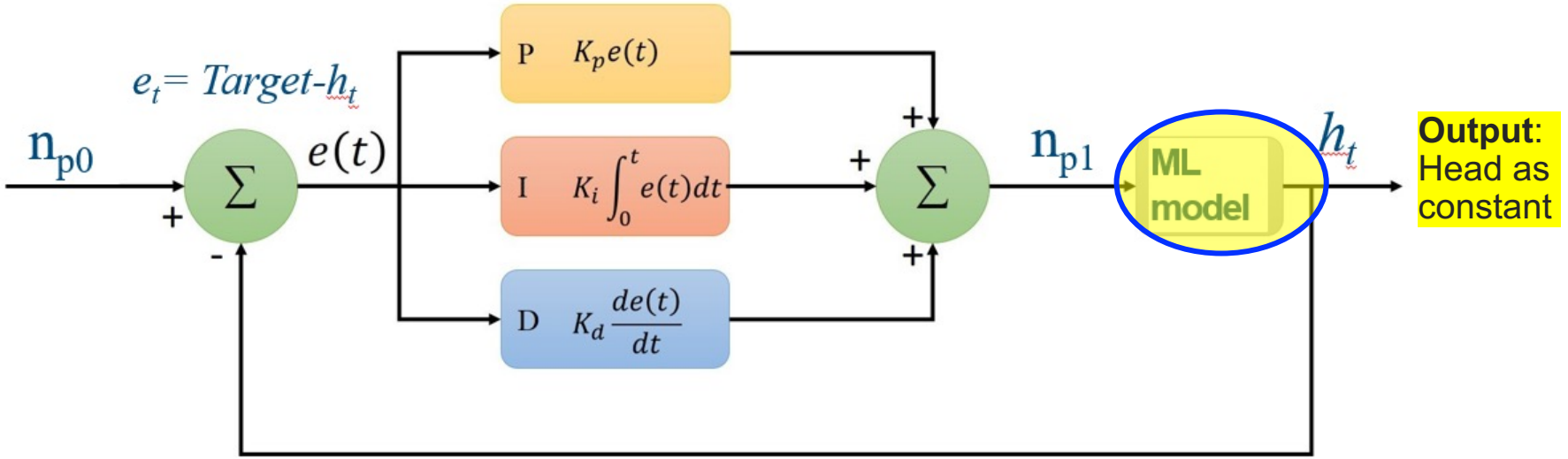
Static turbine head

Convolutional Neuron Network



Dynamic turbine head in time series

Method (2): optimal control design

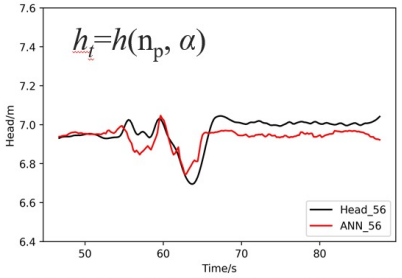


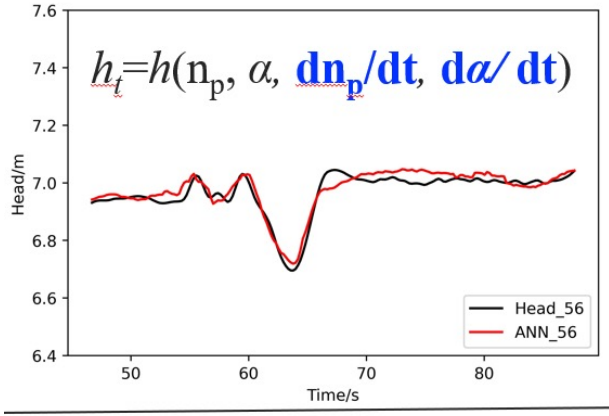
Optimizing the pump operations for the Vattenfall test facility

Some results: model

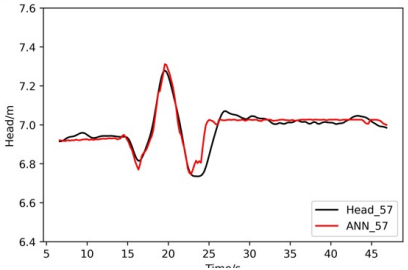
- 57 test cases from Vattenfall
  - 1-55 for training the model
  - 56-57 for testing the model

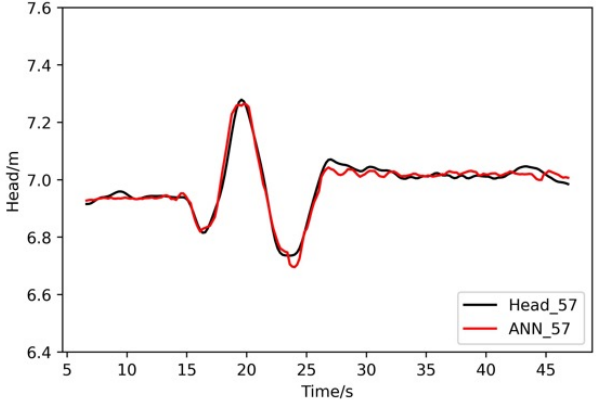
Data_56





Data_57

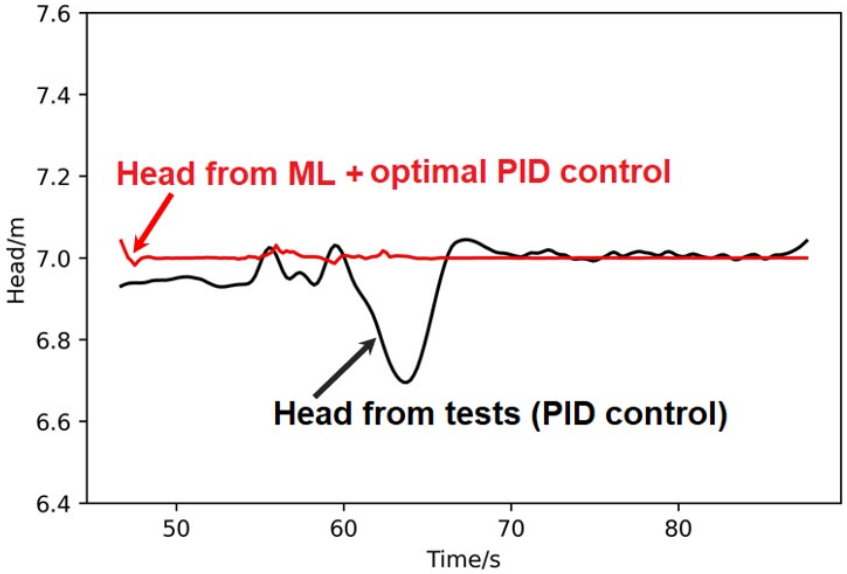




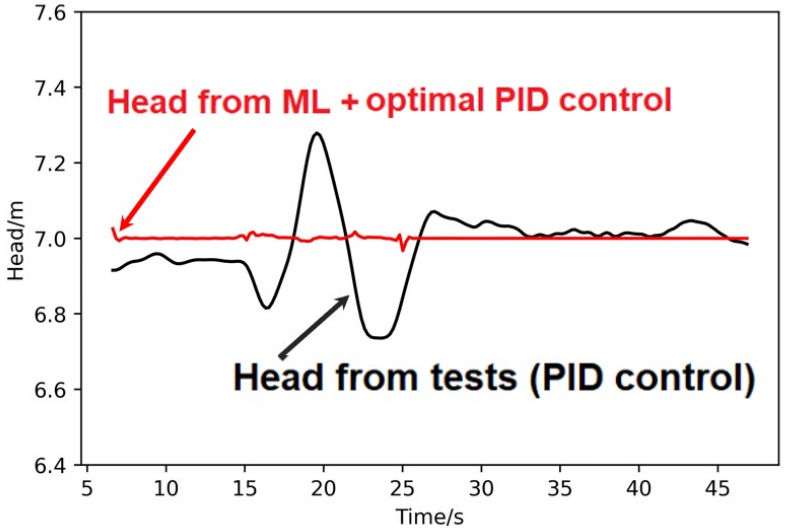
1, Model behaves good if only measured features used;

2, almost perfect prediction by considering the time gradients

Some results: control

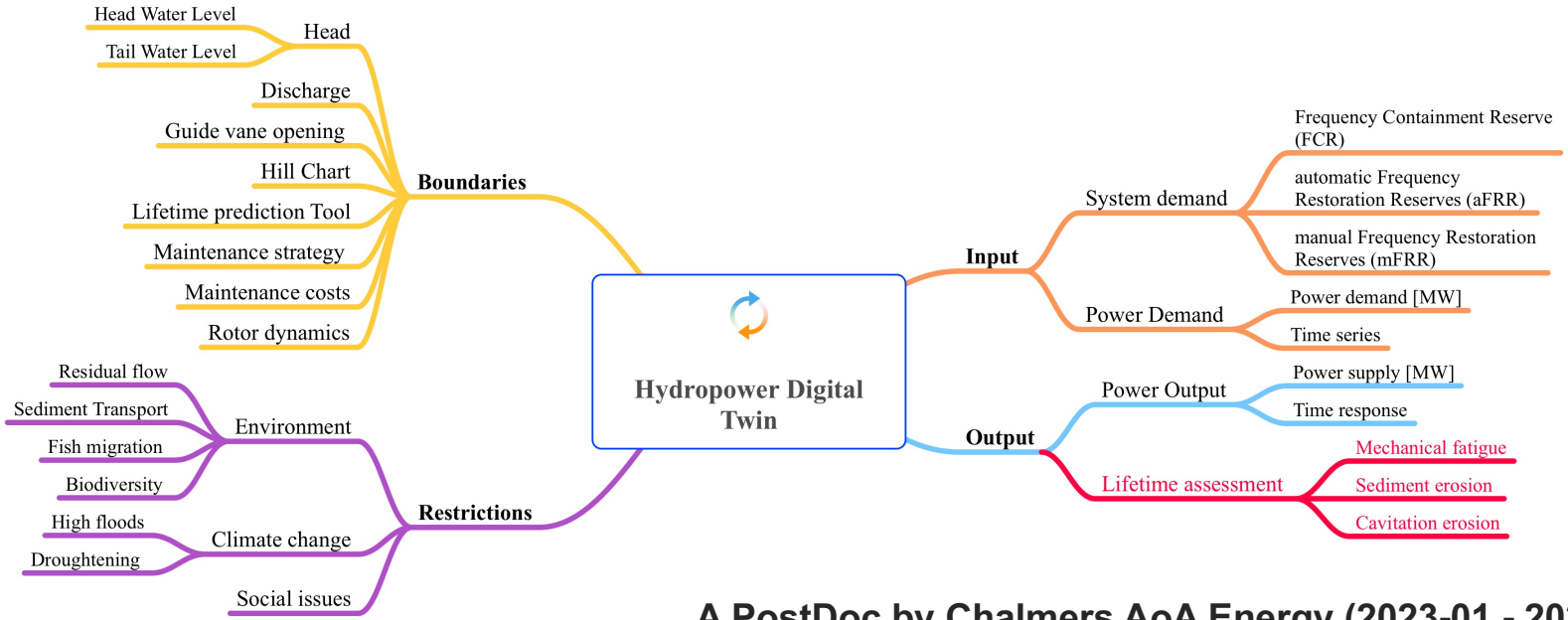


Control for case no. 56



Control for case no. 57

Future work: Hydropower digital twin



A PostDoc by Chalmers AoA Energy (2023-01 - 2024-12)

- Skellefteå Kraft AB and Vattenfall AB
- More partners to help with data…

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