University of South-Eastern Norway

Anomaly detection in sensory data and automatic tuning of CIP time parameter

using Deep Learning and setup of OPC DA-UA gateway communication.

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Objectives:

The purpose of this study was to create an anomaly detection application to detect error in sensory data from an industrial plant and tune time parameter for CIP (Cleaning-in-place) stations using deep learning. Furthermore, setup the OPC DA-UA gateway between the OPC Server workstation 26 to workstation 5 with the deployed application for transferring of data between workstations and applications located on the local network of the plant.

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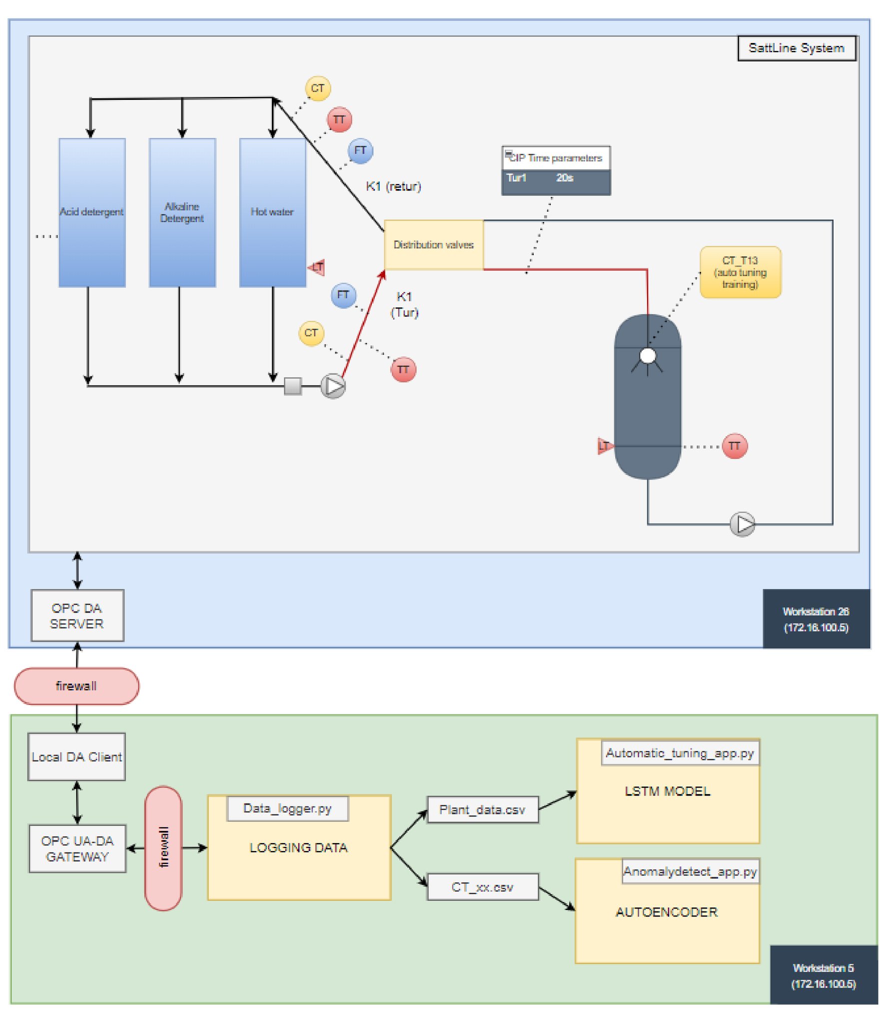
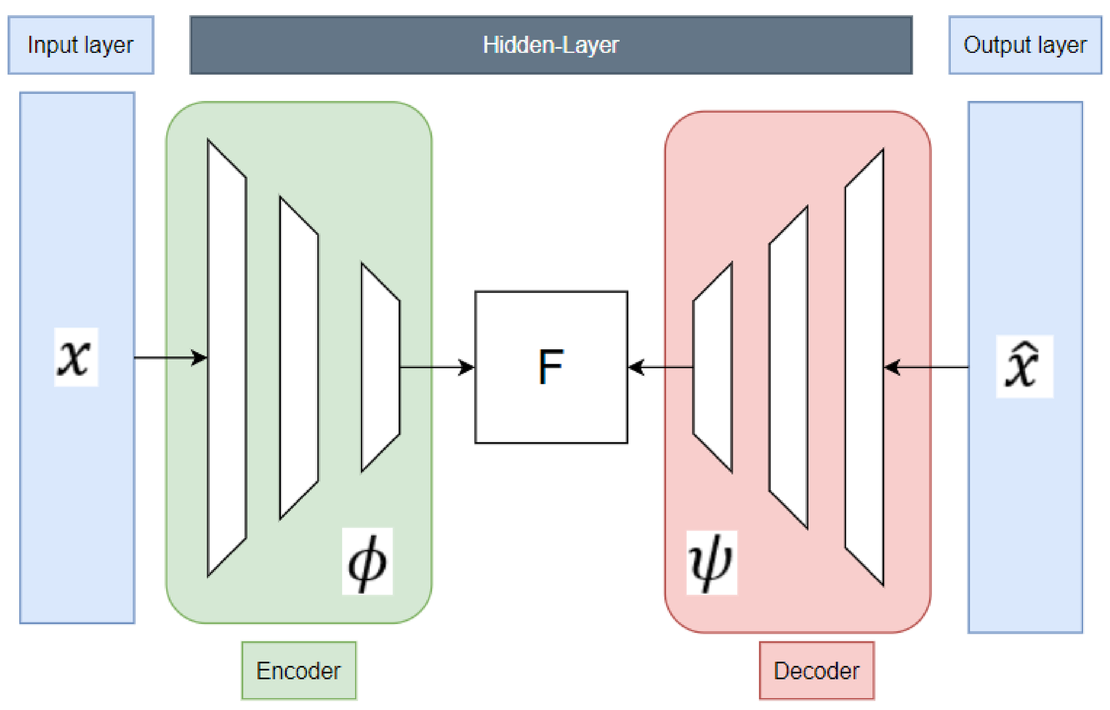


Autoencoder

The main use-cases for autoencoders have previously been information retrieval and dimension reduction applications. The use of autoencoders has been changing recently, and the method has been implemented in a variety of applications.

The autoencoder reduces the dimensionality of input data into lower latent space during the encoding procedure. The lower latent spaces have more correlated variables where the difference between abnormal and normal data is significant compared to the original dimensions The decoder reconstructs the encoded data back to the original dimensions for the output layer.



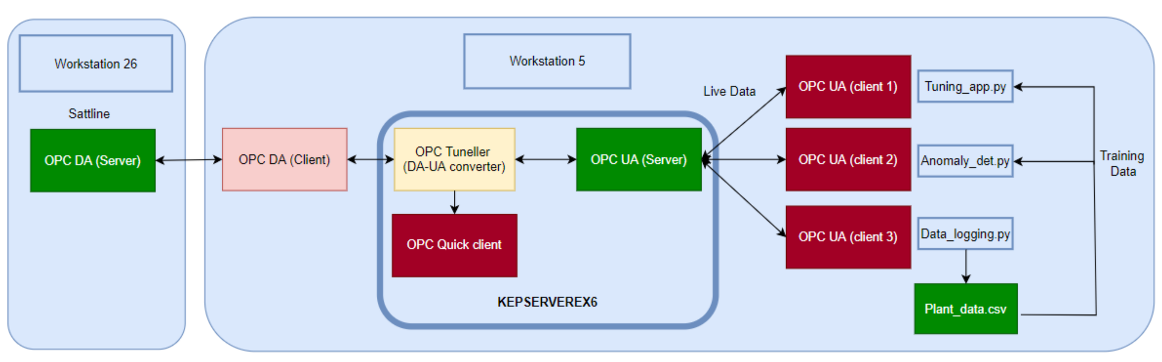
LSTM Neural Network

Long-short-term-memory networks have commonly been assigned the abbreviation "LSTM." This neural network is a distinctive RNN (Recurrent Neural Network) architecture with the capacity for learning dependencies over larger periods. The design of LSTMs is explicitly composed to avert limitations regarding long-term dependencies. Remembering information over larger periods is intrinsic for LSTM networks. This makes it a viable option for predictions of future values based on the inputted data. A multilayered LSTM has been implemented for the tuning application as seen in the model architecture below.

Layer (type)	Output Shape
lstm_3 (LSTM)	(None, 15, 64)
dropout_3 (Dropout)	(None, 15, 64)
lstm_4 (LSTM)	(None, 15, 64)
dropout_4 (Dropout)	(None, 15, 64)
lstm_5 (LSTM)	(None, 64)
dropout_5 (Dropout)	(None, 64)
dense_2 (Dense)	(None, 32)
dense_3 (Dense)	(None, 1)

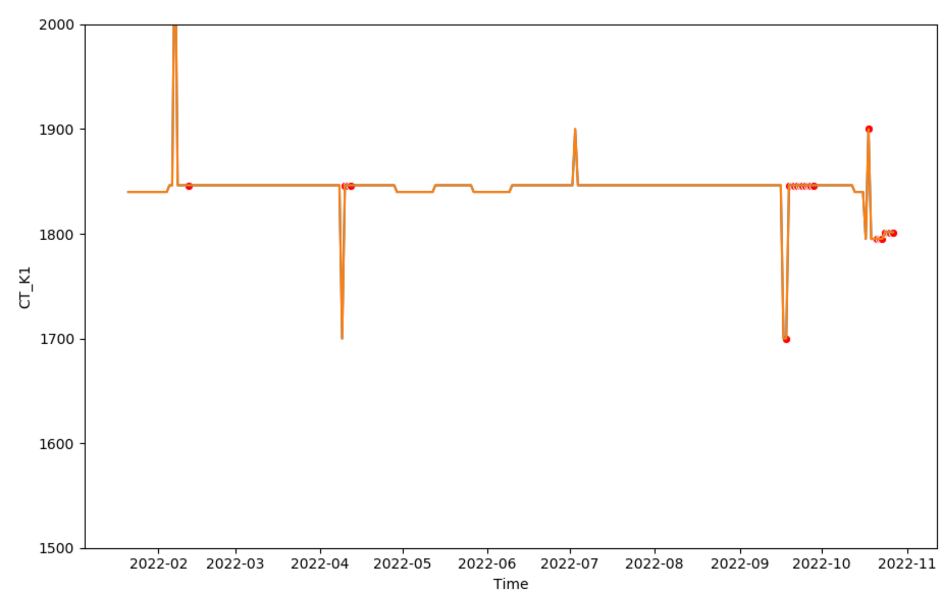
OPC DA-UA Gateway

The industrial plant is previously set up with multiple workstations for monitoring and control purposes. Workstation 26 is assigned to gather data from the plant using classical OPC DA (Data Access) communication. KepserverEX6 is implemented during this project for communication between the server workstation and the workstation assigned for the program applications (workstation 5). A local DA client is set up for a local connection to the server workstation. The KepServer is connected to the local client to provide OPC UA (Unified Architecture) communication possibilities for the logging, anomaly detection, and tuning application. The OPC UA standard provides great interoperability and safety using the TCP communication protocol.



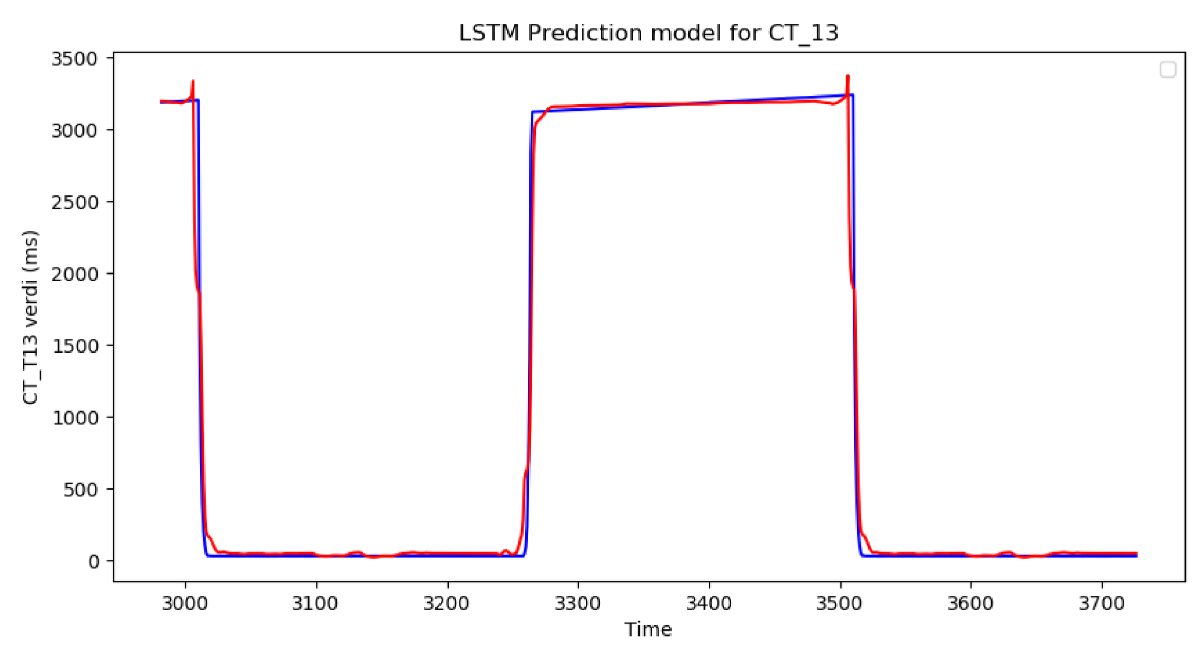
Anomaly Detection

A vast number of neural network approaches are available for a variety of purposes. The autoencoder approach is chosen in this project for the detection of error and malfunction in a conductivity transmitter located on the plant. Time series data for a conductivity transmitter in the CIP station is logged into the autoencoder model and the reconstructed output from the autoencoder is used to calculate the reconstruction error between the input data and output data. Datapoints with higher reconstruction error than a specified threshold are automatically detected as anomalies in the dataset.



Tuning of CIP parameter

The LSTM neural network model is deployed for predicting measurements for a conductivity transmitter located on the inlet of the washing object. The training of the model is based on time-series data from the transmitter and other relating measurements in the CIP station. This enables the model to forecast future values of the transmitter based on the relating measurements which relieve the industrial plant managers from deploying conductivity transmitters on every object that has to be cleaned. The forecasting is further used for calculating and tuning the time frame for the washing liquids to reach the inlet of the tank from the CIP station based on the forecasted values. The figure below shows predictions for the transmitter compared to actual time-series data.



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