# Supervised Transfer Learning Framework for Fault Diagnosis in Wind Turbines

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**Abstract.** In Germany, electricity from renewable energy sources is primarily generated from wind energy [1]. To support the EU's renewable energy targets, it is important to reduce wind turbine downtime and prevent damage. This can be achieved through condition monitoring and intelligent fault diagnosis, which increases the energy yield.

Supervised learning is a method for performing intelligent fault diagnosis on wind turbines. In literature, numerous solutions based on supervised learning are available [2, 3, 4]. However, these solutions typically focus solely on diagnosing faults in one particular machine, resulting in the development of a separate model for each machine. With an increasing amount of wind turbines, there's also a need for more and more specialized staff members (diagnostics) which monitor the outputs of an increasing amount of machine learning models. Furthermore, to achieve accurate diagnostic results with this approach, a large dataset is required, wherein each fault to be detected must have occurred on each machine. Such a dataset is often not available. As a result, only a general statement can be made whether a system has anomalies. Subsequently, a manual analysis is required to identify the exact defect, which increases the diagnostic teams' workload even more. An automated intelligent fault diagnosis solution is therefore needed, in order to reduce the manual effort.

To this end, we propose a *supervised transfer learning framework for fault diagnosis in wind turbines*. Our database includes data from various wind farms and turbines of different types.

SCADA data are typically used for condition monitoring in wind turbines. In general, the term SCADA stands for "Supervisory Control and Data Acquisition" and refers to the monitoring and control of technical processes using data that originates from sensors, actuators and other field devices and is sent to a control system. Among other things, process variables such as temperature, pressure and similar values are recorded. Each recorded 10-minute window is aggregated into four scalar values: minimum, maximum, standard deviation and average.

The SCADA data feature space has been transformed into an anomaly score feature space by applying several simple anomaly detection models. This provides an anomaly score for each wind turbine component. A higher anomaly score corresponds to a more severe anomaly. We use these anomaly scores as input to our metamodel, which we train for fault diagnosis.

We conducted an extensive evaluation using popular supervised classifiers like Random Forest (RF), Light-GBM and Multi-Layer Perceptron (MLP) as metamodels.

We trained our metamodel on specific wind turbines and transferred this model to similar wind turbines, i.e, the prediction quality of our trained models was measured on similar wind turbines which are part of the test data.

The best performing model is able to classify faults with a high degree of accuracy, which is a significant asset to the diagnostic team.

**Keywords:** Condition Monitoring, Wind Turbines, Anomaly Detection, Fault Detection, Fault Diagnosis, Transfer Learning

## References

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