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Federated Transfer Learning for Condition-based Maintenance in Nuclear Power Plants

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The current fleet of nuclear power plants in the United States is transitioning from a time-consuming, labor-intensive, and cost-prohibitive preventive maintenance strategy to a condition-based predictive maintenance (PdM) strategy. A risk-informed PdM strategy will be discussed in the presentation. One of the aspects of the risk-informed PdM strategy is scalability, the presentation will focus on a first-of-a-kind federated transfer learning (FTL) framework [1] (Fig. 1) for the condition-based maintenance of a circulating water system. The FTL framework developed and presented here details how an aggregated model obtained under federated learning at one plant site can diagnose the same fault mode at a different plant site using transfer learning. The fault used for demonstration is waterbox fouling in the circulating water system. The FTL framework was verified using a multi-kernel adaptive support vector machine and an artificial neural network, details are in [1]. The results compare the performance of individual machine learning models with aggregated models as part of federated learning. In the case of transfer learning, the results of individual machine learning models are compared with transferred aggregated models with and without training on data from a new plant site. Finally, this paper presents some challenges associated with the FTL framework development.

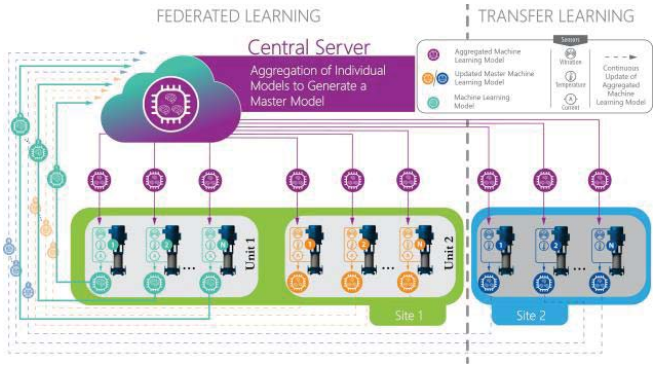

Fig. 1. FTL framework for PdM.

Keywords: Predictive maintenance, federated learning, transfer learning, support vector machines, artificial neural networks, circulating water system.

References

1. V. Agarwal et al. Scalable Technologies Achieving Risk-Informed Condition-Based Predictive Maintenance Enhancing the Economic Performance of Operating Nuclear Power Plants. Idaho National Laboratory, INL/EXT-21-64168, August 2021.