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# Hybrid GNN Based Machine Learning Forecasting Model For Industrial IoT Applications

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**Abstract :** Background: According to World Bank national accounts data, the estimated global manufacturing value-added output in 2020 was 13.74 trillion USD. These manufacturing processes are monitored, modelled, and controlled by advanced, real-time, computer-based systems, e.g., Industrial IoT, PLC, SCADA, etc. These systems measure and manipulate a set of physical variables, e.g., temperature, pressure, etc. Despite the use of IoT, SCADA etc., in manufacturing, studies suggest that unplanned downtime leads to economic losses of approximately 864 billion USD each year. Therefore, real-time, accurate detection, classification and prediction of machine behaviour are needed to minimise financial losses. Although vast literature exists on time-series data processing using machine learning, the challenges faced by the industries that lead to unplanned downtimes are: The current algorithms do not efficiently handle the high-volume streaming data from industrial IoTsensors and were tested on static and simulated datasets. While the existing algorithms can detect significant 'point' outliers, most do not handle contextual outliers (e.g., values within normal range but happening at an unexpected time of day) or subtle changes in machine behaviour. Machines are revamped periodically as part of planned maintenance programmes, which change the assumptions on which original AI models were created and trained. Aim: This research study aims to deliver a Graph Neural Network(GNN)based hybrid forecasting model that interfaces with the real-time machine control systemand can detect, predict machine behaviour and behavioural changes (anomalies) in real-time. This research will help manufacturing industries and utilities, e.g., water, electricity etc., reduce unplanned downtimes and consequential financial losses. Method: The data stored within a process control system, e.g., Industrial-IoT, Data Historian, is generally sampled during data acquisition from the sensor (source) and whenpersistingin the Data Historian to optimise storage and query performance. The sampling may inadvertently discard values that might contain subtle aspects of behavioural changes in machines. This research proposed a hybrid forecasting and classification model which combines the expressive and extrapolation capability of GNN enhanced with the estimates of entropy and spectral changes in the sampled data and additional temporal contexts to reconstruct the likely temporal trajectory of machine behavioural changes. The proposed real-time model belongs to the Deep Learning category of machine learning and interfaces with the sensors directly or through 'Process Data Historian', SCADA etc., to perform forecasting and classification tasks. Results: The model was interfaced with a Data Historianholding time-series data from 4flow sensors within a water treatment plantfor45 days. The recorded sampling interval for a sensor varied from 10 sec to 30 min. Approximately 65% of the available data was used for training the model, 20% for validation, and the rest for testing. The model identified the anomalies within the water treatment plant and predicted the plant's performance. These results were compared with the data reported by the plant SCADA-Historian system and the official data reported by the plant authorities. The model's accuracy was much higher (20%) than that reported by the SCADA-Historian system and matched the validated results declared by the plant auditors. Conclusions: The research demonstrates that a hybrid GNN based approach enhanced with entropy calculation and spectral information can effectively detect and predict a machine's behavioural changes. The model can interface with a plant's 'process control system' in real-time to perform forecasting and classification tasks to aid the asset management engineers to operate their machines more efficiently and reduce unplanned downtimes. A series of trialsare planned for this model in the future in other manufacturing industries.

**Keywords :** GNN,Entropy,anomaly detection,industrial time-series,AI,IoT,Industry 4.0,Machine Learning
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