Anomaly Detection on Gas Pipeline Operational Data Using Classic Seasonal Decomposition and Level Shift Anomaly Detection Architecture

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***Abstract*—Gas pipeline infrastructure is critical to energy distribution, but its operational existence is often threatened by anomalies such as leaks, malfunctions, and system disruptions. Early detection of these anomalies is critical to prevent safety hazards, operational inefficiencies, and economic losses. This paper proposes an anomaly detection framework using Classic Seasonal Decomposition and Level Shift Anomaly Detection methods for frequency selection and labeling processes, as well as LSTM and VAE-GAN algorithms for anomaly detection. The dataset consists of time-series sensor measurements, including pressure, temperature, energy flow rate, and gas composition. Classic Seasonal Decomposition isolates trend, seasonal, and residual components, enhancing periodic anomaly detection. Meanwhile, Level Shift Anomaly Detection identifies abrupt changes in data levels that signal critical events. LSTM leverages temporal dependencies to detect anomalies with high accuracy in data with strong sequential patterns, while VAE-GAN is effective in modeling complex data distributions and capturing anomalies in datasets with less obvious patterns. Experimental results demonstrate the effectiveness of the proposed approach, with model performance evaluated using F1-Score for each LSTM and VAE-GAN model. The proposed framework shows great potential for peering into real-time monitoring systems, improving operational efficiency, supporting data-driven decision making, and significantly reducing the risk of system failure.**

Keywords—Anomaly Detection, Gas Pipeline, Time Series Data, Classic Seasonal Decomposition, Level Shift Anomaly Detection, Deep Learning Models