Deteksi Anomali Menggunakan *Deep Learning* Berbasis LSTM pada Data Operasional Pipa Gas Alam

Muhammad Rieza Fachrezi[1], Dr. Aditya Firman Ihsan, S.Si., M.Si.[2], Widi Astuti, S.T., M.Kom.[3]

[1,2,3]Fakultas Informatika, Universitas Telkom, Bandung
[1]riezacornelis@students.telkomuniversity.ac.id, [2]adityaihsan@telkomuniversity.ac.id,
[3]widiwdu@telkomuniversity.ac.id

Abstrak

Industri minyak dan gas alam merupakan sektor yang krusial dalam kehidupan sehari-hari. Insiden yang tidak diinginkan dalam sektor ini dapat berdampak signifikan pada sektor rumah tangga. Oleh karena itu, sistem peringatan dini otomatis diperlukan untuk mendeteksi kesalahan dalam jaringan pipa yang menghubungkan titik produksi dan pemrosesan. Metode deteksi anomali dapat digunakan untuk mengatasi masalah ini. Salah satu model yang cocok untuk deteksi anomali *unsupervised* adalah model *Long Short-Term Memory* (LSTM) berbasis *deep learning*. Penelitian ini bertujuan untuk mengimplementasikan model deteksi anomali berbasis LSTM pada data operasional *time-series* dari titik pengamatan yang terletak di dalam hilir, yang terdiri dari 17 fitur yang dapat digunakan dan 8.736 baris data, mewakili data selama satu tahun. Pemilihan model melibatkan pengoptimalan *hyperparameter* (misalnya *dropout, regularizer, layer,* dan *batch size*) menggunakan *Mean Squared Error* (MSE) melalui *3-fold cross validation,* menghasilkan 10 kandidat model. Model dengan performa terbaik kemudian dilatih menggunakan data pelatihan. Setelah pelatihan, model LSTM merekonstruksi data *time-series* asli untuk menghitung skor anomali berdasarkan metrik jarak *Euclidean*. Skor ini menentukan anomali menggunakan ambang batas yang ditetapkan dari distribusi skor anomali. Interpretasi manusia memvalidasi kemampuan model untuk secara akurat mengidentifikasi anomali dalam dataset. Persyaratan infrastruktur untuk penerapan di dunia nyata juga dibahas, dengan fokus pada penggunaan metode *edge computing* untuk meningkatkan kemampuan deteksi anomali secara *real-time*.

Kata kunci : deteksi anomali, LSTM, minyak dan gas bumi

Abstract

The oil and natural gas industry is a crucial sector in our daily lives. Unwanted incidents in this sector can significantly impact the household sector. Therefore, an automatic early warning system is necessary to detect errors in the pipeline network connecting production and processing points. Anomaly detection methods can be used to overcome these problems. One model suitable for unsupervised anomaly detection is the deep learning Long Short-Term Memory (LSTM) model. This research aims to implement an LSTM-based deep learning anomaly detection model on time-series operational data from an observation point situated within the sink, which consists of 17 usable features and 8,736 data points, representing a year's worth of data. Model selection involves optimizing hyperparameters (e.g., dropouts, regularizers, layers, and batch sizes) using the Mean Squared Error (MSE) through 3-fold cross-validation, resulting in 10 model candidates. The best-performing model is then trained using the training data. After training, the LSTM model reconstructs the original time-series data to calculate anomaly scores based on the Euclidean distance metric. These scores determine anomalies using a set threshold derived from the distribution of anomaly scores. Human interpretation validates the model's capability to accurately identify anomalies within the dataset. Infrastructure requirements for real-world applications are also discussed, focusing on the use of edge computing methods to enhance real-time anomaly detection capabilities.

Keywords: anomaly detection, LSTM, oil and natural gas

1. Introduction

The oil and natural gas industry is an essential industry since oil and gas is an energy intermediary used by the industrial sector all the way to the household sector [1]. The distribution of oil and gas must therefore be efficient and accurately measured using measuring devices so that supervision and evaluation can be carried out if harmful things occur because the impact can be felt by almost everyone.

The process of oil and gas distribution requires pipelines that connect from upstream to downstream. Of course, the installed pipes have the possibility of unwanted things happening, such as pipe leaks, failure of measuring instruments, or measuring sensor errors. Therefore, a reliable system is needed that can be utilized as an automatic early warning in case of such events.