DCdetector: Dual Attention Contrastive Representation Learning for Time Series Anomaly Detection

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Background and Challenges

- Lack of Labeled Data: Anomalies are usually rare without many labels. Systems are in steady state in major cases.
- Imbalance: The number of anomalies is much smaller than the normal one. For example, in the financial system.
- Noise Interference: Time-series data may be affected by noise that may mask the true anomaly signal.
- Complex Patterns: Typical anomalies are often complex (wind turbines operate in different modes and conditions).
- Multi-dimensional Features: Models should consider temporal, multidimensional and non-stationary features.
- Explanatory and Interpretable: In some application scenarios, explanatory and interpretable results for anomaly detection are needed to better understand why an anomaly was flagged and to be able to take action accordingly.

Related Works

Reconstructed-based problem: The raw time series has a mixture of normalities and anomalies with noise. So it is difficult to train a high quality encoder for reconstruction based models.

Experiment and Main Results

- Datasets & Baselines: 6+1 benchmarks, 26 baselines
- Evaluation Criteria: 10 metrics (F1, Affiliation, VUS)
- Performance on Parameter Sensitivity
- Time-Cost and Memory Usage
- Visual Analysis

Conclusion and Highlight

- Architecture: A contrastive learning-based dual-branch attention structure
- Channel independence patching is proposed to enhance local semantic information
- Multi-scale structure in the attention module can reduce information loss during patching
- Optimization: An effective and robust loss function is designed based on the similarity of two branches
- Model is trained purely contrastively without reconstruction loss, reducing distractions from anomalies
- Performance: DCDetector achieves SOTA performance in 7 benchmarks with 10 metrics, compared with 26 baselines