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Coordenação de Pós-Graduação em Engenharia de Sistemas

Proposta de Dissertação de Mestrado

Área:	Cibernética
Linha de Pesquisa:	Modelagem e simulação de sistemas inteligentes e embarcados
Título Provisório:	An Automated Machine Learning Framework for Explainable Anomaly Detection in Industrial Process Control Loops
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Descrição:

Process industries such as oil, gas, chemicals, and energy generation rely on complex plants where hundreds or even thousands of process variables are continuously monitored and controlled. Ensuring reliability in these environments requires effective detection of anomalies in control loops, as deviations can compromise safety, reduce efficiency, and increase costs. However, the scale and interdependence of variables make it challenging to identify abnormal conditions and diagnose their root causes using traditional monitoring techniques [5].

The research community has proposed several directions to address this problem. Invariant rules have been used to automatically capture temporal relationships among process variables, providing real-time anomaly detection with high accuracy [1]. Swarm intelligence has inspired approaches that model dynamic systems as communication networks, where anomalies are identified through changes in system topology [2]. Unsupervised projection techniques have demonstrated the ability to detect faults in control loops without requiring labeled fault data, providing visual tools for expert interpretation [3]. At the hardware level, lightweight anomaly detection mechanisms, such as cumulative sum (CUSUM) regression, have been integrated into programmable logic controllers, showing the feasibility of embedding security functions directly in industrial controllers [4]. More recently, measurement-based machine learning models have been proposed to analyze process data rather than network traffic, proving more robust against stealthy attacks that mimic normal communication patterns [7]. Deep learning approaches such as DAICS also achieve high performance in industrial environments, although their lack of interpretability limits adoption in real operations [6].

Building on these advances, this project proposes the development of an automated machine learning (AutoML) framework for anomaly detection in industrial process control loop systems, enriched with explainability features. The framework will tackle three main challenges: (i) the automatic grouping of process variables into meaningful subsets based on their interactions, (ii) the design of AutoML pipelines capable of generating accurate anomaly detection models without the need for specialized data science expertise, and (iii) the integration of explainable AI techniques to highlight which instruments, actuators, or parameters are most associated with detected anomalies. This will allow engineers and maintenance professionals not only to be alerted to anomalies but also to understand their likely causes and act effectively.

Do Candidato: Engenharia de Controle e Automação, Engenharia de Computação, Engenharia Eletrônica, Engenharia Mecânica, Engenharia de Materiais, Bacharelado em Física, Engenharia Física, e áreas afins.

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