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PULSAR: PRESCRIPTIVE OPTIMIZATION AND ARTIFICIAL INTELLIGENCE APPLIED TO BOTTLENECK REDUCTION IN MANUFACTURING

Vitor Hugo Furtado[1]*, Rodrigo Otávio Ribeiro Hagstrom[2], Claudio Olivio Piotto[3]
[1]*Centro Universitário UniSENAI Campus Jaraguá do Sul*
[2]*Universidade de São Paulo - Instituto de Matemática e Estatística*
[3]*Centro Universitário UniSENAI Campus Jaraguá do Sul*

1. Introduction

The complex manufacturing industry, especially the textile and forest-based sectors, frequently operates in a scenario of "informational darkness". Despite the vast adoption of passive recording systems, such as Enterprise Resource Planning (ERPs) and Warehouse Management Systems (WMS), industries face severe limitations in transforming data into prescriptive decisions in real time.

In practice, machine sequencing, raw material breakdown, and dispatch prioritization depend on manual spreadsheets and human intuition, generating "mix friction", factory idleness, delays, and order cancellations due to a lack of systemic components. Aiming to fill this "prescriptive void", this article aims to present the development and initial validation of the PULSAR engine, an Engine-as-a-Service (EaaS) solution that integrates Expert Artificial Intelligence and Operations Research [1] to dynamically orchestrate the shop floor (Fig. 1), dictating "what to produce" and "in what sequence". The solution aligns with the Engineering and Industrial Technologies axis, promoting resource efficiency and sustainability.

2. Experiment

For the structuring and validation of the prescriptive algorithm, a qualitative-descriptive methodology with an exploratory approach was adopted. Data collection was divided into two fronts. Primary sources involved in-depth interviews and direct observations in the factory environment with logistics managers, dispatch coordinators, and Production Planning and Control (PCP) analysts from industries located in the hubs of Jaraguá do Sul and Caçador (SC). Secondary sources included the extraction of anonymized real data from legacy reports (SAP), dispatch dashboards, and sectoral sizing studies (FIESC and IBÁ) [3, 4].

Based on this diagnosis, the Operations Research and Artificial Intelligence algorithms were modeled in the PULSAR engine to cross-reference simultaneous constraints (inventory, deadlines, humidity) and generate optimal prioritization routing, culminating in the validation of the Minimum Viable Product (MVP) in a controlled environment with real industrial data (Fig. 2).

3. Results and Discussion

The application of the MVP in the textile ecosystem demonstrated the empirical efficacy of mathematical modeling and Expert AI. By replacing heuristic sequencing (based on intuition) with PULSAR's automated prescription, a drastic reduction in picking time and distance was observed, mitigating the excessive displacement of operators. Furthermore, intelligent prioritization reduced dock blockages and raised the indicator for complete and timely deliveries, known as On Time In Full (OTIF). Reflecting the architectural robustness (open-source cloud) and the scalability of the algorithm, the same logic of optimized constraints was validated as applicable to the timber hub of Caçador (SC).

In this forest-based context, the technology prescribes the optimal log breakdown to maximize volumetric yield (over-run), promoting the responsible use of finite raw materials. Additionally, predictive sequencing minimizes idleness in the drying kilns, reducing the waste of thermal energy derived from biomass.

Finally, it is concluded that the prescriptive engine breaks the paradigm of passive legacy systems. The results indicate that the transition from operational chaos to mathematical predictability, orchestrated by Data

*vitor.furtado@edu.sc.senai.br

Intelligence, not only recovers profit margins eroded by invisible inefficiencies but also acts directly in mitigating socio-environmental liabilities. The solution provides manufacturing with the foundations for an Industry 4.0 aligned with global demands for competitiveness and sustainability.

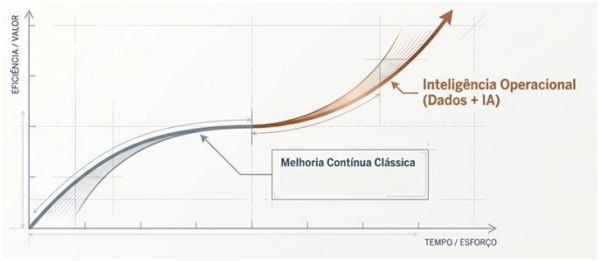

Fig. 1. *Continuous Improvement vs. Operational Intelligence*

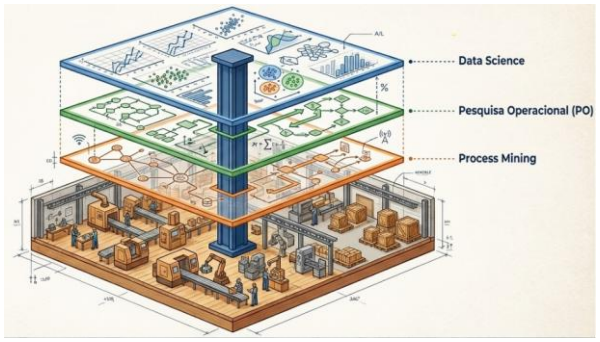

Fig. 2. *Logical architecture of the Digital Twin and orchestration flow of the prescriptive engine connected to the shop floor.*

4. Referências

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*vitor.furtado@edu.sc.senai.br