PERANCANGAN SISTEM PREDIKSI WORK-IN-PROGRESS MANUFAKTUR BAJA MENGGUNAKAN PENDEKATAN ARSITEKTUR DECOUPLED *MACHINE LEARNING*

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ABSTRAK

Dalam konteks studi kasus, Work-in-Progress (WIP) merupakan keluaran produksi yang belum mencapai kategori Prime, tetapi masih dapat diproses ulang. Penelitian ini bertujuan merancang dan mengevaluasi purwarupa sistem prediksi dan pemantauan WIP pada manufaktur baja menggunakan pendekatan arsitektur decoupled machine learning. Penelitian menggunakan Design Research Methodology dengan mengolah laporan produksi semi-terstruktur melalui prapemrosesan berbantuan manual, pembentukan observasi tanggal–profil, alokasi WIP harian, pencegahan data leakage, dan pembagian data secara kronologis. Lima model regresi dibandingkan, dengan Extra Trees terpilih sebagai model terbaik dengan RMSE 177,37 ton, MAE 110,00 ton, dan R^2 0,102 pada 24 observasi pengujian serta mengungguli baseline mean dan baseline median. Model dioperasionalkan melalui adapter layer, layanan API, antrean pekerjaan asinkron, worker inferensi, artefak model, basis data, dan antarmuka web. Pengujian fungsional mencakup kontrak data dan adapter, lifecycle prediksi asinkron, keterlacakan model, dan rekonsiliasi. Validasi terbatas oleh tiga praktisi memperoleh rata-rata 3,86 dari skala 4. Purwarupa berhasil mengoperasionalkan model prediksi WIP, sedangkan hasil prediksi tetap diposisikan sebagai estimasi awal, bukan dasar tunggal keputusan operasional.

Kata Kunci: *Work-in-Progress*; manufaktur baja; *machine learning*; *arsitektur decoupled*; Extra Trees.

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ABSTRACT

In the context of the case study, Work-in-Progress (WIP) refers to production output that has not reached the Prime category but can still be reprocessed. This study aims to design and evaluate a WIP prediction and monitoring prototype for steel manufacturing using a decoupled machine learning architecture. The research adopts the Design Research Methodology and processes semi-structured production reports through manual-assisted preprocessing, date–profile observation construction, daily WIP allocation, data leakage prevention, and chronological data splitting. Five regression models were compared, with Extra Trees selected as the best-performing model, achieving an RMSE of 177.37 tons, MAE of 110.00 tons, and R^2 of 0.102 on 24 test observations, while outperforming the mean and median baselines. The model was operationalized through an adapter layer, API services, an asynchronous task queue, an inference worker, model artifacts, a database, and a web interface. Functional testing covered data contracts and adapters, the asynchronous prediction lifecycle, model traceability, and reconciliation. Limited validation by three practitioners produced an average score of 3.86 out of 4. The prototype successfully operationalized the WIP prediction model, while predictions remain preliminary estimates rather than the sole basis for operational decisions.

Keywords: *Work-in-Progress*; steel manufacturing; *machine learning*; *decoupled architecture*; Extra Trees.