AI Assisted Quality Prediction and Quality Control of Paint and Coatings

Uğur Yenier
Bultarda Türkiye
ugury@bultarda.com

AI Assisted Quality Prediction and Quality Control of Paint and Coatings

Why AI?

- Efficiency and Productivity
- Cost Reduction
- Data Analysis and Insights
- Predictive Maintenance
- **Quality Control**
- Innovation and Product Development
- Supply Chain Optimization
- Risk Management
- Regulatory Compliance

Challenges

- Data Quality and Availability
- Ethical Considerations
- Lack of Skilled Workforce
- Integration with Existing Systems
- Security Concerns
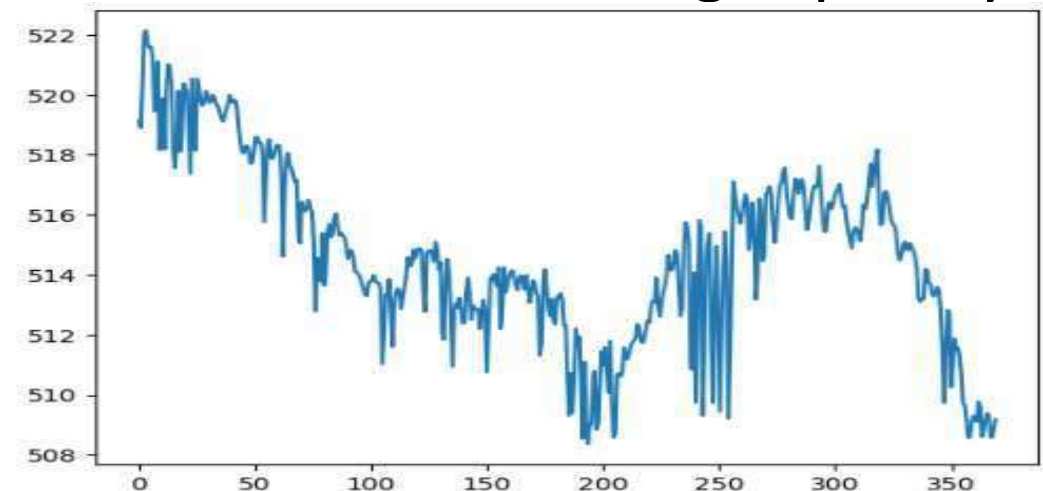- Computational Power
- Initial Investment

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AI 101

Model

- Machine learning model is a computer program that learns patterns from data and makes predictions or decisions without being explicitly programmed for the task.
    - Data Input
    - Learning Patterns
    - Training
    - Prediction/Decision

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**AI 101**   **Overfitting Problem**

- Model learns not only the underlying patterns in the training data but also captures the noise and random fluctuations present in that data
    - High Training Accuracy, Poor Generalization
    - Complex Models
    - Memorization vs. Generalization
    - Sensitivity to Training Data
    - Risk of Poor Performance on New Data

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Typical High Speed Dispersion

- Intermediary pigment concentration

- (r)Resin + (p)Pigment + (s) Solvent

- 2+ A/C motors

- 2+ independent agitators

- Additional sensors

Dissolver Motor

Scraper Motor

Scraper

Blade
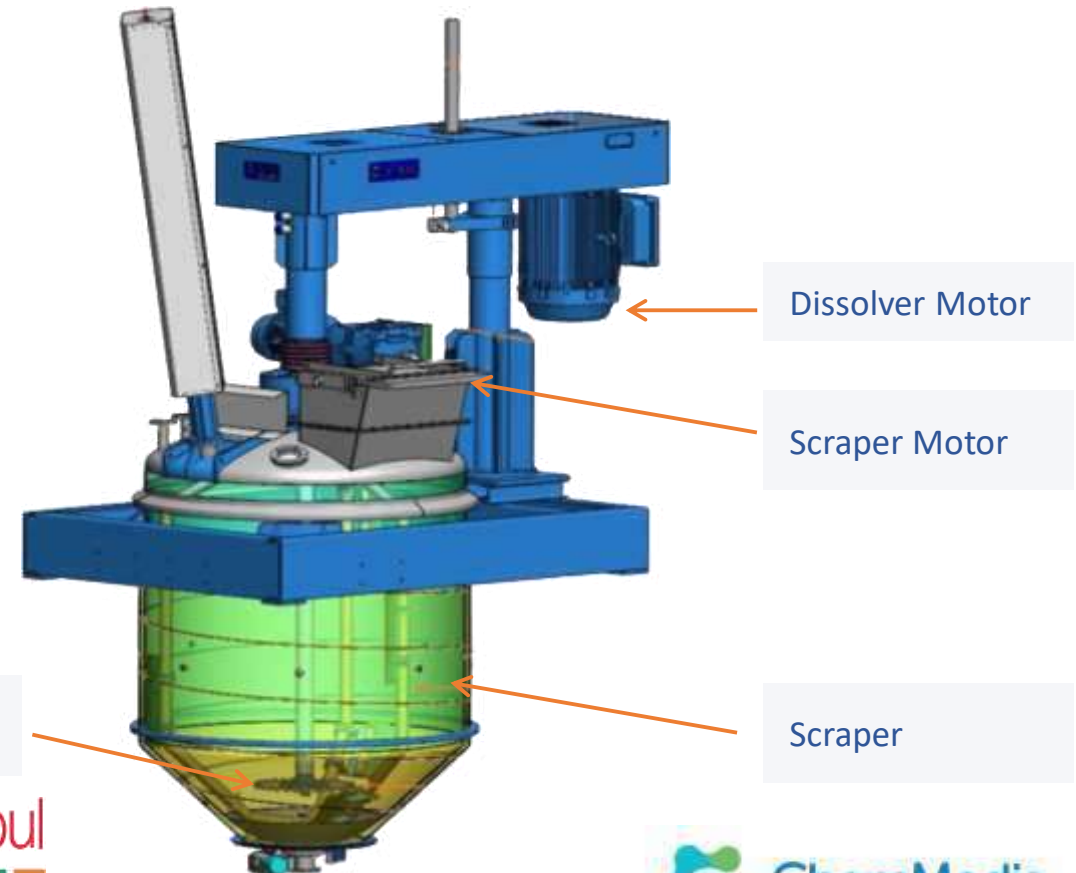
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Why High Speed Dispersion?

- High speed dispersion is one of the most common process in any paint & coating production
  - High energy consumption
  - Intermediary for multiple coatings
  - Minimal ingredients
 - High batch count per formulation
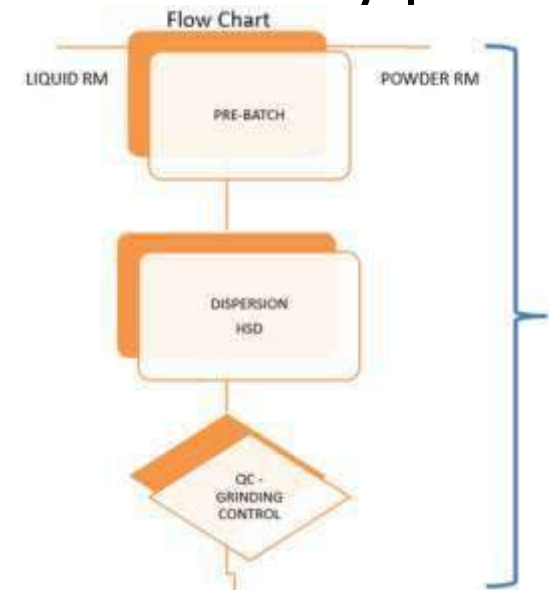
Flow Chart

LIQUID RM — POWDER RM

PRE-BATCH

DISPERSION HSD

QC - GRINDING CONTROL

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Modelling Dispersion

- There are significant sources of noise and random fluctuations in a typical dispersion process
  - Differences in feed patterns
  - Changes in raw materials
  - Influence of ambient factors
  - Changes in equipment behavior
  - Unpredictable human behavior

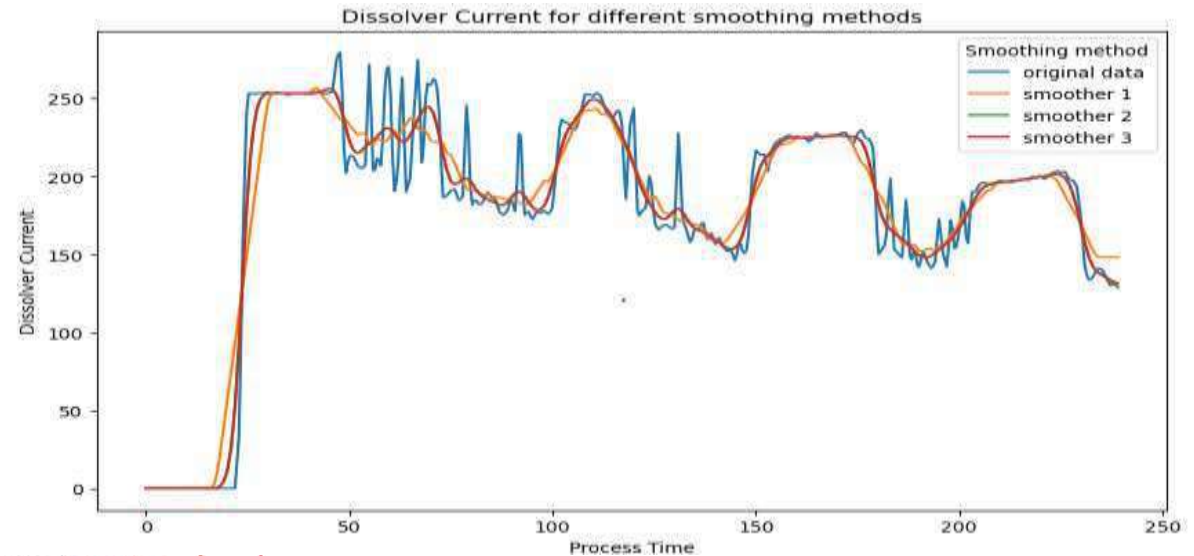**Overfitting Problem (single feature)**
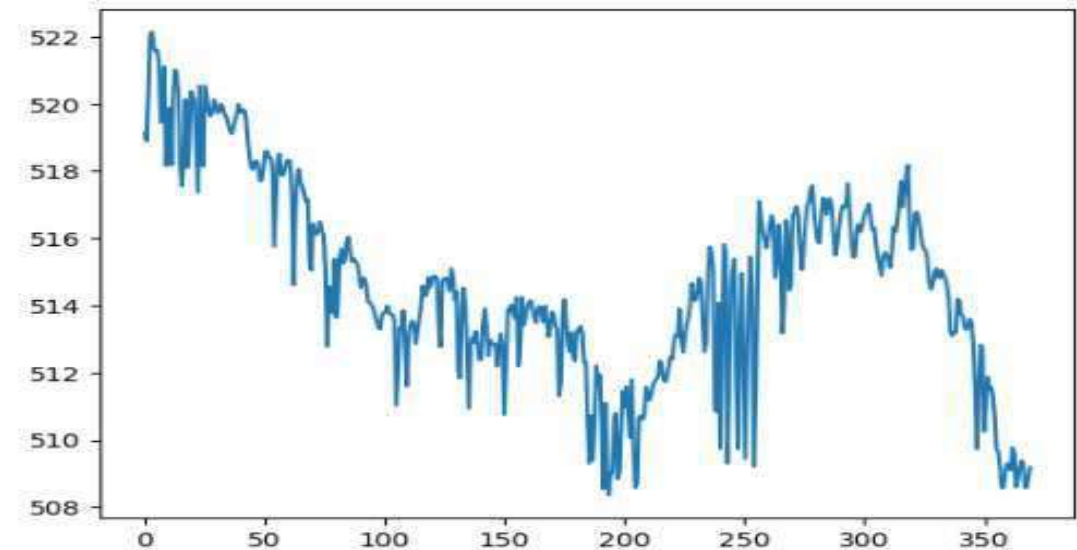
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Modelling Dispersion

Noise Reduction (single feature)

- Even though looks random to the human eye, AI model is able to isolate patterns vs noise
    - Motor input vs output
    - Temperature
    - Formulation card
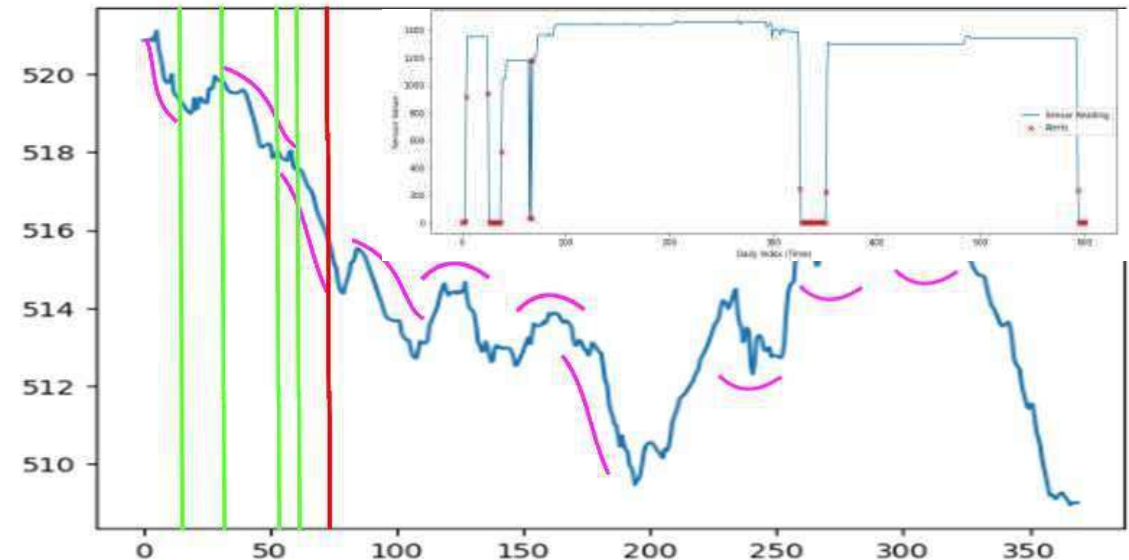   - Additional sensors
    - User interaction

Dissolver Current for different smoothing methods

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Modelling Dispersion

Pattern Recognition (single feature)

- Once the noise is reduced pattern recognition is run every second
  - System is already trained with results
  - 30 – 50 per formulation
  - 20+ typical process patterns
  - 30+ typical process errors

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Modelling Dispersion

- Correlation of features
  - Power
  - Torque
  - Speed
  - Shear force
  - Capasitive feedback
  - Temperature

How is it done?

- Thermodynamics
  - 0th – equilibrium
  - 1st – conservation of energy
  - 2nd – maximization of entropy
- Fluid Dynamics
  - Continuity equation
  - Conservation of momentum
  - Energy equation

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Results

Confidence Matrix

- Difference confidence in detection of incorrect vs correct paterns
  - Detecting anomalies is priority
  - Possible after a few minutes
    - Raw material issues
    - Agitation related issues
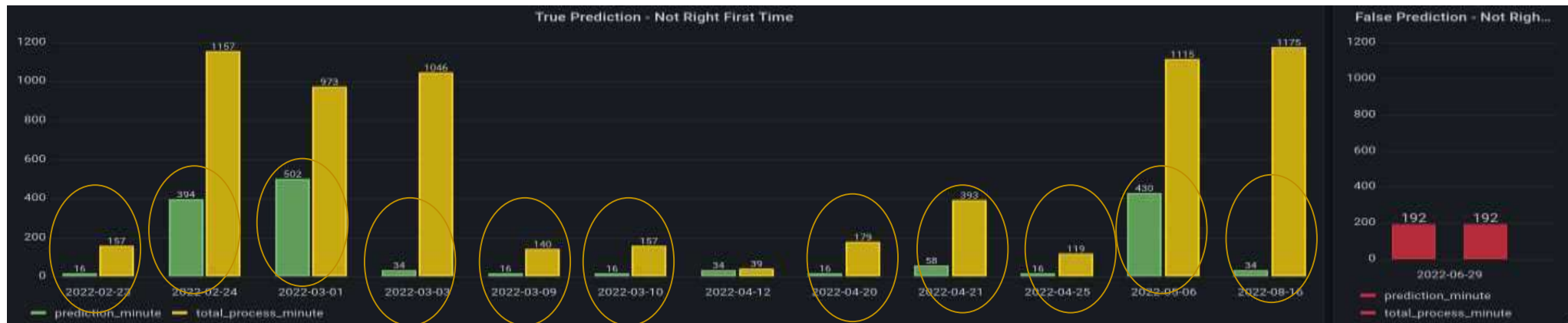   - Equipment failure
    - Sequence / feeding speed issues

	f1-score	support
0	0.72	8
1	0.82	18
weighted average	0.80	26

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Results   **Real life runs**

- Early detection of anomalies!

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Results

- Low hanging fruits
  - Batch time reduction & lower energy consumption
  - Immediate detection of mis-fed ingredient
  - Immediate detection of unexpected agitator behaviour
  - Waste reduction

- Current status
  - Confidence up to %80
  - Up to %40 reduction on dispersion cycles
  - Early detection of mis-fed ingredients

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Next Steps

- What is possible
  - **Create global fingerprints for standard formulations**
  - **Reduced energy consumption, waste, cycle times**
  - **Site / equipment benchmarking, optimization**
  - **Full automation!**

- Next goals
  - **Increase confidence to %90+, improve model**
  - **Pilot to scale up QC**
  - **Preventive maintanence**
  - **Site / Equipment comparison**