AI In Cement Manufacturing – Holistic Approach

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Agenda

- Holistic Approach

- Integration of AI Driven Models for PM and Safety

- General versus Targeted Approach

- Roadmap for Maximizing Returns on AI Investment

Predictive Power
Leveraging Digital Twins for Preventative Action

- Digital twins create a virtual representation of the pyro process
- Real-time data from sensors enables continuous monitoring
- Dynamic state simulation predicts potential issues before they occur
- Allows for planned maintenance during optimal times, minimizing disruption

Predictive Power
## Leveraging Digital Twins for Preventative Action
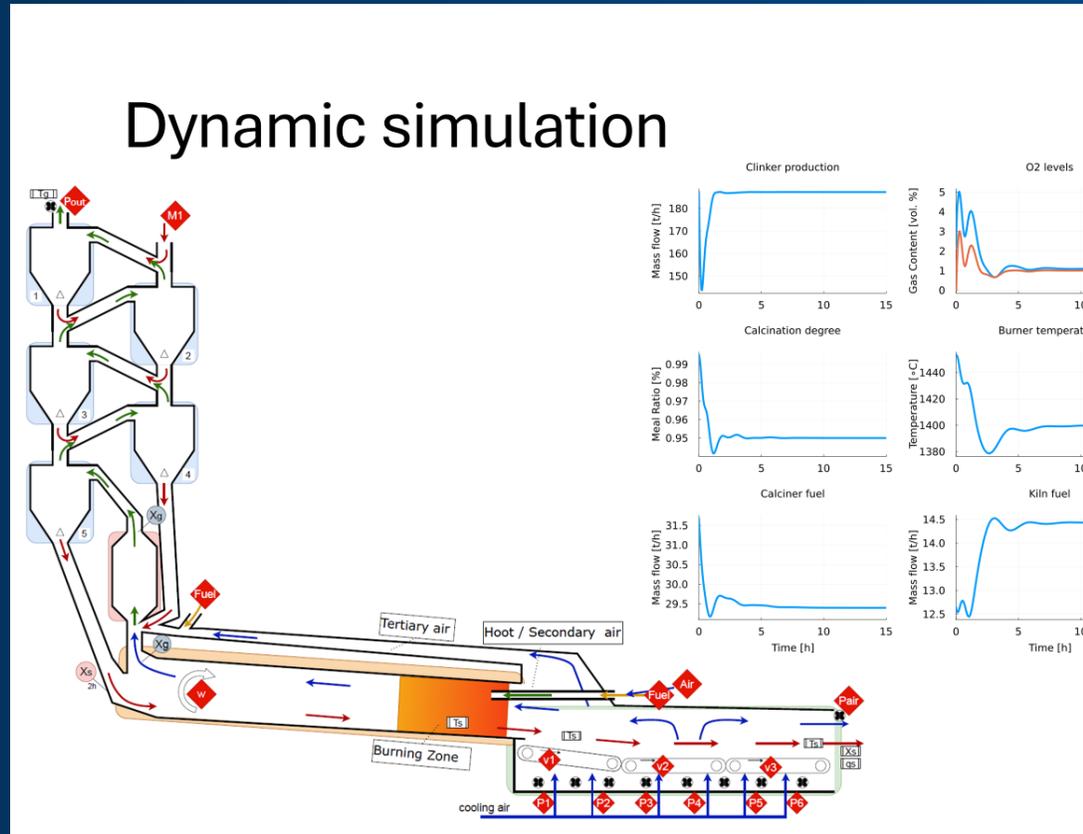
- **Clinker Production:**
  Monitor for deviations from expected output to identify potential blockages or inefficiencies

- **Calcination Degree:**
  Ensure optimal calcination for product quality and energy efficiency

- **Burner Temperature:**
  Track temperature fluctuations to prevent overheating or under-burning

- **Clinker Temperature:**
  Maintain stable clinker temperature for consistent product quality.

- **Fuel Efficiency:**
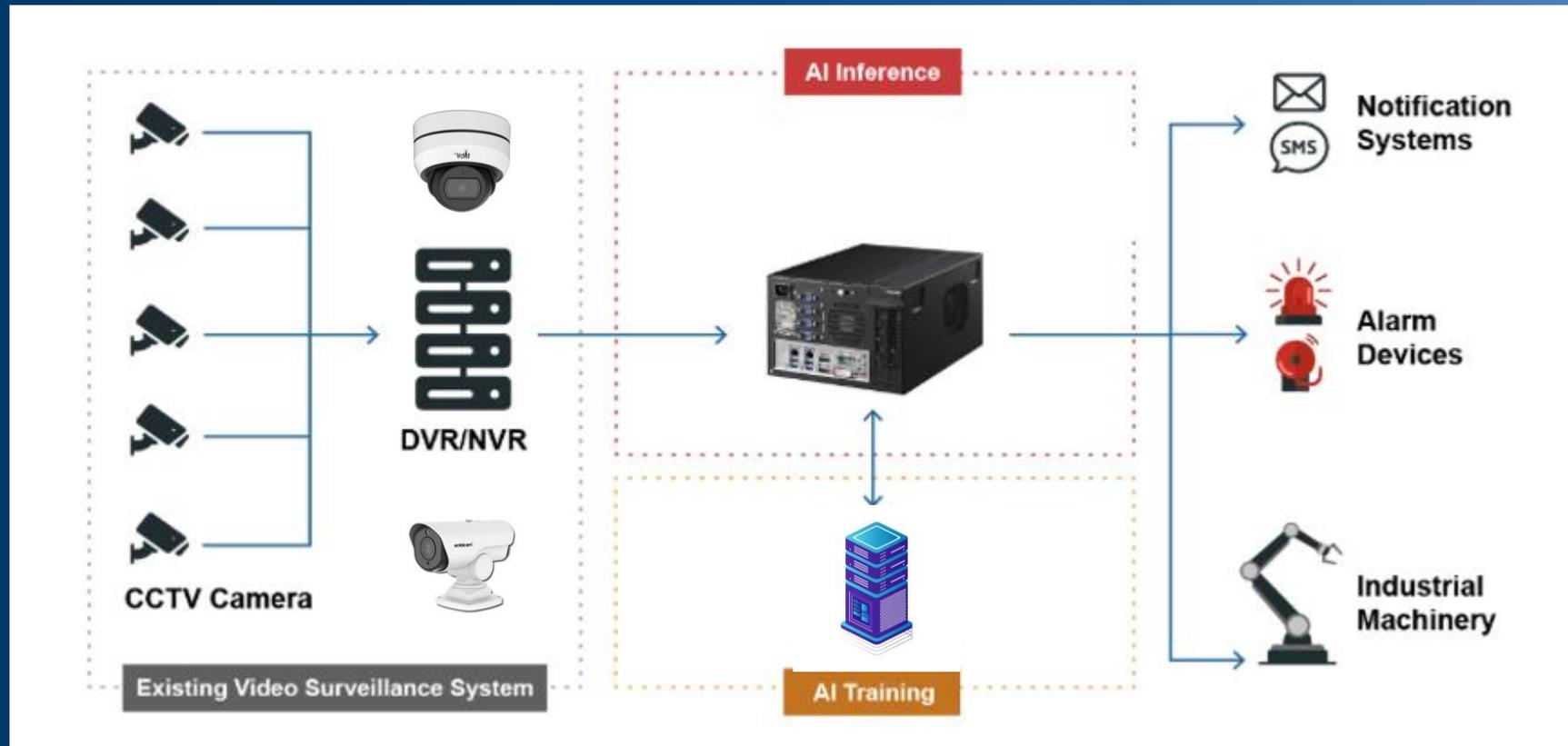 Analyze fuel consumption to optimize energy usage and identify potential issues.

Predictive Power
Machine Learning – Model Predictive Control
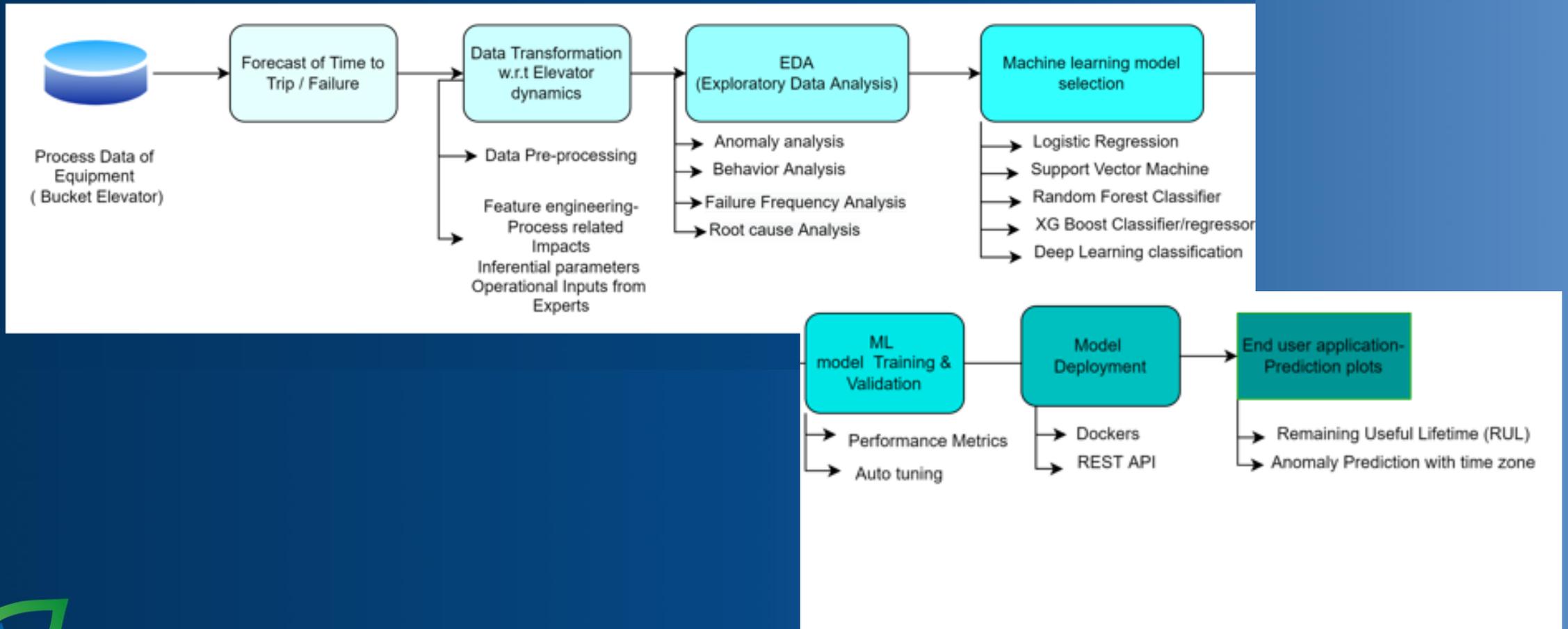
AI Powered Analytics for Safety

AI Powered Analytics for Safety

Computer Vision: Foundation - AI algorithms "see" and interpret the images and videos captured by cameras.

Deep Learning: Often, deep neural networks (a type of machine learning) are used to train the AI models. These networks learn complex patterns from vast amounts of data

Object Detection: Identifying and locating specific objects (people, vehicles, bags, etc.) within a video frame

Object Tracking: Following the movement of objects over time

Image Classification: Categorizing images or parts of images based on their content (e.g., identifying fire or smoke).

Facial Recognition: Identifying individuals based on their facial features

Optical Character Recognition (OCR): Extracting text from images (used in ANPR)

AI Monitoring Solutions
Work at Height Video Analytics

- Life Safety Ropes & PPE Detection
- Slips, Trips, and Almost Falls Detection
- Worker's Improper Means of Climbing Detection
- Missing Barricades Detection
- Forklift Operations

General versus Targeted Approach

- Holistic Process Optimization
  - General Overall Approach versus Targeted Process Focus
    - Nuanced domain expertise
    - Manage extreme high volatility
    - Specific measurement challenges of single asset
  - Example – model designed to optimize grinding power versus precise adaptation for min-min variations in material hardness

Partnerships for Process Control and Decarbonization

- Targeted Process Focus
  - PSD Control with Online Particle Sizer
    - Traditional QC versus Focused QC
    - Variations in material, changes in hardness and moisture to predict final product quality
    - Energy Optimization
  - Pyro Analysis with Kiln Analyzers
    - Predict chemical & thermal state of kiln before lab results
    - Integrate advanced sensors to predict quality – C_3S variance
    - Management of complex variables

Target Process Focus

Process Parameter	Traditional Control Loop (Reactive/High Latency)	AI-Driven Targeted Process Focus (TPF)	Core Benefit/Impact
PSD/Fineness Measurement	Retrospective lab analysis (Blaine fineness, hours);	Real-time optical particle analysis; continuous (minute-by-minute)	Guaranteed energy optimization; minimized over-grinding.
Clinker Chemical Quality	Post-analysis of final product; reliance on steady-state	Predictive modeling (thermal, chemical, operational) with hours of lead time.	Maximized cement strength consistency;
Alternative Fuel (AFR) CV	Manual blending ratios; lab checks for moisture/CV;	Vision AI analysis of composition and moisture; dynamic CV & combustion	Stable kiln operations; increased ESG compliance and EBITDA protection.[1]
Asset Monitoring	Time-based or condition-monitoring	Predictive intelligence detecting early failure signs (e.g., subtle vibration changes *before* power draw increase).[3]	Reduction in unplanned downtime; minimized excess power draw; optimized asset lifespan.

Sensor & Data

Targeted Pain Point	Required Sensor Inputs	Data Type	AI Function/Model Type	Operational Outcome
PSD Consistency	High-frequency optical particle analyzers, vibration sensors, VFD power draw.	High-frequency time series (Hz), 2D/3D image data.	Reinforcement Learning (RL), Predictive Maintenance.	Energy optimization; reduced maintenance risk.[3]
Clinker Phase (C3S) Prediction	Kiln exhaust gas analyzers, thermal imaging of burning zone, chemical lab results (historical and real-time).	High-dimensional, heterogeneous time series, spectral data.	Deep Learning Regression/Classification Models (XAI emphasis).[4]	Quality consistency; proactive adjustment of kiln kinetics.
AFR Dynamic CV Optimization	Vision AI cameras on feed belts, moisture meters, kiln temperature profiles.	Image recognition (composition), low-frequency time series (composition and moisture).	Computer Vision, Predictive Calorific Value Models.[5]	Maximized AFR utilization; stabilization of fuel-air ratios.[1]
Overall Process Stability	Hundreds of DCS setpoints, ID fan speed, raw feed rates, fuel flow meters.	Closed-loop control signals, dense process historian data.	Deep Learning Process Control (DLPC) Agents.	Steadier throughput; elimination of volatility.[1]

Roadmap for Maximizing Returns on AI Investment

- Data Management and Cultural Change
  - Investment Data Fidelity
    - Clean foundation from data quality from sensors and lab inputs.
  - Focus on Closed-Loop Deployment
    - Transition rapidly from open to closed loop recommendations
    - Allow AI system to write SP's directly to DCS
  - Mandatory Workforce Adaptation
    - Training& acceptance programs centered on AIAP model
    - Operators must understand and trust AI recommendations
    - Move to a constant optimized, data-driven environment

Thank You For Listening!

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