AI for Process Optimization, Reliability and Safety

Kathy Shell
Executive VP of Process Safety & Strategic Client Partnerships
aeSolutions

Jaidev Amrite
Head of Product, DeepNLP
SparkCognition
Kathy Shell, P.E.

- Executive VP, Process Safety & Strategic Client Partnerships
- Professional ChE, AIChE Fellow
- AIChE CCPS Technical Steering Committee Member, S&H Division Member
- Texas A&M Mary Kay O’Connor Process Safety Center: Steering Team Member, Harry West Memorial Service Award Recipient (2008 and 2015), Trevor Kletz Merit Award (2019)
- International Society of Automation Excellence in Leadership Award (2016)
- AIChE S&H Division: Walton-Miller Lifetime Achievement Award (2020)
- Process Safety Consultant, Corporate Strategist, Leadership Training and Mentoring, Global and Site Management System Consultant, Lead Auditor, Incident Investigator, PHA/LOPA Facilitator
- BS ChE, University of Akron
Jaidev Amrite
Head of Product - DeepNLP
jamrite@sparkcognition.com
512 739-8285

- Masters in Computer Engineering from GeorgiaTech
- Led product development in Web, IoT and Embedded Systems at National Instruments, Microsoft and Larsen & Toubro
- Highly interested human-centered design of technology
- STEM education for children and young adults with FIRST, Hyperloop and Girl Scouts
- Early-stage startup investor and entrepreneur
Presentation Outline

• AI Vision for Process Safety
• AI and the Subject Matter Expert
• Maximizing Production & Improving Safety
• Proactive Health, Safety and Environment (HSE) Management
• Applying AI in your own Organization
• Open Discussion
What is your AI Vision for Process Safety

Advanced Automation
Safe Process Optimization
Intelligent MOC

IPL Demand/Cause
Tracking/ML
Preemptive Loss of Control
Predictive Maintenance

Safe Work Locations
Bypass Management

Smart Operating Procedures
Human Performance Factors
Training Simulation & Feedback
Operating Discipline

Incident Investigation
Lesson Learning
Emergency Response, Evacuation and Rescue

Process Safety Metrics
Predictable Performance
AI and the Subject Matter Expert

In Industrial Environments, AI is augmenting SMEs to unlock higher quality and productivity

How AI Creates Value from Big Industrial Data:

- Operationalizes organizational information and tribal knowledge
- Surfaces patterns and insights in large volumes of data
- Enables SMEs to focus on high value decisions
Maximizing Production & Improving Safety

OIL & GAS UPSTREAM

One supermajor calculated that if they improved platform availability across their fleet by one percent, they could net an annual uplift in production of ~$300M.

PROBLEM
• Complexity in streaming data and managing alerts
• Inefficiencies around manually maintaining model accuracy

RESULTS/ROI

1-4% or ~$30M
Annual Improved Production

9 days
Failure Forewarning

Once deployed across fleet, the AI-powered solution will contribute a total economic impact of ~$800M annually.
Simple Rules? Not for Complex Assets

Rules based thresholding, even with complex combinational logic is insufficient to capture system states

• Several 100 -1000s of moving parts in complex interaction
• System state drifts with operation, condition and environment
• Very few failures to learn from
• 500 - 3000 sensors/tags per asset
• 40-60 complex assets per production platform
• False positives are expensive to address for unmanned platforms
Novel Techniques to Analyze Time Series Data

Data Preprocessing
- Scaling
- Imputation

Data Filtering
- System mode filter
- Normal filter

Data for mode of interest (e.g., ON/OFF system mode)

Test Data
- Normal data

Training Data

Models
- NBM Model
- Clustering Model

Model Validation on Test Data

Run new model

Tune Hyper-parameters
Prescribing Optimal Maintenance for Aircraft Faults

INDUSTRIAL CONGLOMERATE

For commercial airlines, a one- or two-hour AOG delay can cost between $10K-150K per instance, not to mention damage to the airline’s reputation.

PROBLEM
- Isolating a root cause can take hours
- Extracting value from PDFs and long technical manuals is difficult
- Tribal knowledge is lost as experienced personnel retire or leave

RESULTS

73% (38.6K) Unnecessary subsystem replacements found

120K (18 yrs.) Work orders’ worth of tribal knowledge captured

The prescriptive recommender reduced root cause analysis effort by 90%, resulting in a 20-min. decrease of aircraft on the ground (AOG) per incident.
KS2  How did you create the Work Orders worth of tribal knowledge Value?
Kathy Shell, 5/13/2021

KS3  Can we draw a corollary to manufacturing; Possibly. Consider applications across a facility or major unit operation where extracting and digitalizing degradation indicators enables a prioritized maintenance plan for an unplanned or planned outage.
Kathy Shell, 5/13/2021
Troubleshooting can take hours, even for experienced maintainers

Fault 34-21

Perform Procedure for Fault D2
Replace Panel
Check Wiring
Perform Procedure to Isolate Wiring
Replace Receiver
Replace Receiver
Replace User Interface
Check Wiring
Perform Procedure to Isolate Wiring
Replace LRU
Perform Replacement based on test results
Replace Receiver
Check Wiring
Perform Procedure to Isolate Wiring
R2 PSU
Perform Procedure to Isolate Wiring

Troubleshooting can take hours, even for experienced maintainers
Extracting Actionable Prescriptions from Maintenance Records

Maintenance records are not “natural language”

IT WAS PERFORMED IR FAILURE IAW FIM 34-21 TASK 803 REV 60, STEP E, ITEM 1 AND WAS PERFORMED ADIRS BITE PROCEDURE IAW FIM 34-21 TASK 801 REV 60, STEP B, ITEM 1-E AND WAS FOUND MAINTENANCE MESSAGE ( 34-21002 - IR FAILURE ) AND ( 34-21007 - ADIR DATA INVID ) AND ( 34-21020 - ADR FAIL ). IT WAS PERFORMED INSPECTION IN ADIRU LH AND FOUND WATER ON ADIRU AND WAS REPLACED ADIRU LH IAW AMM 34-21-01/401 REV 60. IT WAS PERFORMED NEW ADIRS BITE PROCEDURE IAW 34-21 TASK 801 REV 60, AND MAINTENANCE MESSAGE DOES NOT SHOW ON THE CDU, THE STATUS CODE DOES NOT SHOW IN ISDU AND THE FAULT LIGHT ON THE MSU DOES NOT COME ON, AND WAS CORRECTED THE FAULT.

IT WAS FOUND FAULT CODE [34-21002 (IR FAILURE)] IAW FIM 34-21 TASK 801 REV. 60, PERFORMED FIM 34-21 TASK 803 REV. 60, REPLACED ADIRU IAW AMM 34-21-01/401 REV. 60, SYSTEM OK IAW AMM 34-21-00-710-801 REV. 60.

IT WAS PERFORMED IR FAILURE IAW FIM 34-21 TASK 803 REV 60, STEP E, ITEM 1 AND WAS PERFORMED ADIRS BITE PROCEDURE IAW FIM 34-21 TASK 801 REV 60, STEP B, ITEM 1-E AND WAS FOUND MAINTENANCE MESSAGE ( 34-21004 - ALIGN FAULT ). IT WAS PERFORMED ALIGN FAULT IAW FIM 34-21 TASK 805 REV 60, STEP F, ITEM 2 AND WAS PERFORMED STEPS FROM THE CDU AGAIN TO ENTER THE PRESENT POSITION AND THE STATUS CODE DOES NOT SHOWS ON THE ISDU AND CORRECTED THE FAULT. FLT 5617 ASSUMED BY ACFT PA-GAT.

- Fault Code
- Symptom
- Procedure Reference
- Effectiveness
- Corrective Action
Proactive Health, Safety and Environment (HSE) Management

GAS PROCESSING AT NATIONAL OIL COMPANY

In 2019, 48 O&G companies (and contractors) reported 21,899 days of work lost through injuries

PROBLEM

• Safety function is typically poorly staffed with 1-2 Safety Supervisors per plant
• HSE management is "retroactive", learning from historical incidents
• Truly catastrophic incidents are rare, limiting learning opportunities

RESULTS

1.3% High Severity Risks
Correctly identified LOTO as root cause for high severity electrical risk despite minimal examples

2000+ Observations
Automatically evaluated with 75%+ accuracy

The HSE solution enables SMEs to train/fine tune models and automates weeks of manual work in minutes
What do you want to convey with this. As stated, it really isn't a problem. From our earlier conversations, maybe incident learning must come from lower Tier events.

Kathy Shell, 5/13/2021
Natural Language Challenges
Operational records are functional and terse with high variability

Functional Language
"received a cwp diagnosis for ee. ee was termed on 1/23/2013."

Non-standard grammar and vocabulary
"we have chemical store that contain different kind of chemical that we handle it in the area, employee may expose to them at any time, There is no CHB around that location for any craft to know the hazard of that chemicals."

Terse
"Plug chute alarm"

Spelling/Typographical errors
"Box glass breaking."
"LADDER FOR PZV ON AIR RECEIVER TANK WHIT OUT SAFETY GUARD"

Technical jargon/colloquialisms
"breakers shut without LOTO"
"Several breakers found in OFF position and not locked"
"Breaker in OFF position but it was not locked and tagged out"

Keywords/ontologies and Off-the-shelf language models are ineffective on operational records
Natural Language Analysis of “Observations”

Observations
- Safety Violations
- Employee Suggestions
- Unsafe Conditions

Risk Analysis

Time-based Patterns

Language Similarity

Historical Reports
- Root Cause Analysis
- Incident Reports
- Near Misses

Alert Hazard Types by Location
- Utilities Unit
- Recovery Unit
- Compression Unit
- Heat & Gas Treatment Unit

Observation Risk Trends

Alerts by Alert Type
- Slip, Trip, Fall
- Contact with Chemical
- Fire & Explosion
- Collision
- Electric
- Hazardous Conditions

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Getting Started with AI in your Organization

1. Explore un-utilized/underutilized data sources in high cost/tedious/critical processes
2. Consult SMEs to understand current process, gaps, desires
3. Utilize development accelerators from discovery → operationalization – DS is an iterative process

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Common Source</th>
<th>Application</th>
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</thead>
<tbody>
<tr>
<td>Time series sensor data for vibration, temperature, strain, pressure,</td>
<td>OSI PI</td>
<td>Predictive Maintenance</td>
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<tr>
<td>current, voltage etc.</td>
<td></td>
<td></td>
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<tr>
<td>Maintenance records</td>
<td>Maximo, Oracle</td>
<td>Prescriptive Maintenance</td>
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<tr>
<td>Safety observations, MOCs, PHA Recs, Incident Records</td>
<td>SAP/Custom/Excel</td>
<td>HSE Management Incident Anticipation</td>
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<tr>
<td>Service tickets – disruptions, IT requests, call centers</td>
<td>SAP, EMC2, JIRA, ORACLE</td>
<td>Operational Analytics, Business Process Automation</td>
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Thank you for your attention!

Kathy.shell@aesolutions.com
614-595-0619

jamrite@sparkcognition.com
512 739-8285