THE INDUSTRIAL SOFTWARE REVOLUTION BEGINS NOW
AV-24
Advanced Analytics for Predictive Maintenance

“Big Data” Meets Equipment Reliability and Maintenance

Paul Sheremeto
President & CEO
Pattern Discovery Technologies Inc.
Pattern Discovery Technologies Inc.

• Core competency in data mining and predictive analytics
• Developers of Production Intelligence – an analytic framework to manage and analyze data in complex industrial processes and equipment
• Primary focus on:
  • Process analytics – continuous improvement (oil and gas)
  • Equipment reliability and maintenance in manufacturing and utilities
  • Mobile equipment for mining operations
• Partnership agreements with Wireless Sensor Networks, Isaac Instruments, Draeger Safety, Meir Soft Tissue Solutions, OSIsoft, Invensys
• Joint Venture partnership in Beijing, China

www.patterndiscovery.com
Production Intelligence Platform

APPLICATIONS
- Process Insight
- Asset Insight
- Energy Insight
- Environmental Insight

INSIGHT DELIVERY

DISCOVER*E ANALYTICS
- Association Discovery
- Clustering
- Classification
- Visualization
- Induction/Segmentation

ANALYTICAL CONTEXT
- Contextual Management Intelligence
- Contextual Performance Intelligence
- Contextual Operation Intelligence

INTELLIGENT ETL
- Signal Processing, Feature Selection, Natural Language Processing, Event Detection

DATA SOURCES
- Extract
- Profile
- Cleanse
- Link
- Merge
- Bundle
- Load

- Internal/External Structured Data
- Internal/External Unstructured Data
PDT’s Client Experiences

- EXON Mobil
- ConocoPhillips
- OPEC
- Ergon Energy
- Esso
- Imperial Oil
- Shell
- Teck
- ASM
- Lilly
- Vale
- Total
- Syncrude
- TransCanada
- Ontario Power Generation
- PotashCorp
- Canadian Natural
- Suncor Energy
- Alberta Research Council
- University of Toronto
- CertaPay
- Alberta Innovates Technology Futures
- Invensys
Formula for Failure

\[
\text{Failure} = \text{Latent Error} \times \text{Enabling Condition}
\]

Existing, hidden, ignored

Circumstance or strain
Formula for Failure

Failure = Latent Error × Enabling Condition

CMMS

Operational Historian

Maintenance Department

Engineering Department

What the *&@ is going on?

What the *&@ is going on?
Economics for Predicting Failure is Compelling

Reactive repair and maintenance work is 7 times more expensive than planned work.
Taking Advantage of Available Data

**Business**
- Environmental Energy
- ERP
- Procurement
- CMMS
- EAM

**Operations**
- Faults & Diagnostics Logs
- Sensors
- Historian
- PLC
- Predictive Analysis Historian
- Smart Sensor

**Challenges:**
- Access – isolated islands of data
- Formats – databases, text, historians, logs
- Too much data – overwhelming
- Time – everyone doing more with less
- Analysis – where to start – hypothesis?
- Tools – Excel spreadsheets
- Responsibility – who’s job is it anyway?

Raw Data
AssetInsight - Advanced Analytics for Equipment Reliability and Maintenance

**Business**
- Environmental
- Energy
- Procurement
- ERP
- CMMS

**Operations**
- Faults & Diagnostics Logs
- Sensors
- Historian
- PLC
- Predictive Analysis Historian
- Smart Sensor

**Pattern Discovery Production Intelligence Pattern Hub™**

**Pre-processing the data**
- Extract, Transform, Load (ETL)
- Natural Language Processing Engine
- Sort, Tag and Organize (schema)

**Analytics**
- Isolate Equipment Failures
- Advanced Signal Processing
- Time Aligned Co-occurrence
- Event Detection and Modeling
- High Order Association Discovery
- Rules and Models
- Fault Detection and Isolation

**Output**
- Slice and Dice
- Visualization
- Reports
- Dashboards
- Compare to Industry Benchmarks
- Predictive Models
- Real Time Comparison

**Patterns That Matter™**
**AssetInsight™ - Advanced Analytics for Equipment Reliability and Maintenance**

**Functional Hierarchy**

- **Economic Drivers**
  - Demand, forecasts, market variables

- **Production Data**
  - ERP Systems

- **Advanced Troubleshooting**
  - Knowledge Based Expert System

- **Diagnostic Input**
  - Predictive monitoring (online and occasional)

- **Operation Data**
  - Production History

- **EAM/CMMS Systems**
  - Maintenance History

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1. **Maintenance Program Effectiveness**
2. **Failure History**
3. **High Resolution Fault Detection**
4. **Advanced Troubleshooting**
5. **Decision Support System**
6. **Turnaround Planning**

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*Pattern Discovery Technologies Inc.*
Methods of Predicting Failures – Expert Driven

- Model from first principles
  - Understand critical parameters of an engineered model and measure those
  - Look for patterns that conform to design curve.
- Model against rules – supervised learning
  - Define normal operation
  - Develop rules for describing threshold violations – expert input
  - Signal upon condition violation
Methods of Predicting Failures - Statistical

- Linear regression
  - Primarily 2-D - Excel spreadsheet type comparisons
  - Assumes an hypothesis and look for correlation

- Normal probability distributions (Weibull)
  - Graphical plot of mean, mode, median and distance
  - Does not necessarily reflect current conditions

- Unsupervised learning techniques
  - Automatically extract features
  - Turn features into events
  - Discover patterns and rules
  - Use rules to trigger condition violation
Predicting Failure – Artesis

Combine modelling and feature extraction

Featured advertisement for:
AV-25 – Rotating Equipment Health
Thursday – 8:00am – Victor Lough
Predicting Failures from Operational Data

### Failure Reports

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Predictive Failure Modeling

- Normal Operation
- Immediate Failure
- Fundamental Failure

Sensor Values:
- Tag 12786 (Current)
- Tag 231123 (Temp)
- Tag 455672 (Air Pressure)
- Tag 88765 (VA)
- Tag 12786 (Tension)

Conditions At Time Of Failure:
- Tag 101
- Tag 24
- Tag 345
- Tag 35
- Tag 561
- Tag 67
- Tag 456
Predictive Failure Modeling
Event Detection and Correlation in Real Time
Event Detection and Correlation in Real Time
AssetInsight - Failure Modeling for Pipeline Integrity Risk Assessment - Case study #1

**The Problem:**

Predict the severity and location of Stress Corrosion Cracking (SCC) in a pipeline to minimize environmental risk and guide maintenance and repair activities.

Several factors combine to influence SCC

- Environmental conditions (soil type, drainage, temperature, exposure, etc.)
- Stress loading due to pressures, temperatures and flows (operational variables)
- Material properties (pipe material, coating, manufacturer, inclusions, welds, etc.)
- Prior maintenance and repair

**The Challenge:**

Can we understand the leading causes of SCC based on historical data, characterize the severity and predict the occurrences?
AssetInsight - Failure Modeling for Pipeline Integrity Risk Assessment - Case study #1

IF wall thickness between (6.35, 7.14) AND soil type is tilled waterways AND topographic pattern is leveled, THEN severity = 3

IF soil code is 4 AND topographic pattern is inclined, THEN severity = 2

Output – Predictive Models with Associated Rules for Interrogation and Interpretation

Cracking Risk Assessment of Pipeline Segments
The Problem:

Unexpected failures of heavy equipment costly to repair and severely impact production schedules.

Engine diagnostics and condition monitoring information available but difficult if not impossible to access and interpret.

Shrinking skilled labor pool - events detected should be linked to most likely causes for speedy resolution.

The Challenge:

Communications in underground environments.
Access to engine diagnostics and sensors
Correlating measured conditions and establishing patterns of events for early detection
AssetInsight - Heavy Equipment Monitoring for Potential Failure in Real Time - Case study #2
Hauling Equipment – Fuel Consumption – Case Study #3

Fuel Burn (L/hr) vs. Speed (km/h) Monthly Avg.

Fuel Burn (L/hr) vs. Avg. EFH (EFH km) Monthly Avg.

Metered Fuel Measurement
Monitoring Equipment Health

- **Maintenance Effectiveness**
- **Operational Data (Wonderware)**
- **Turnaround Maintenance**
- **Remaining Useful Life (RUL)**
- **High Resolution Detection and Troubleshooting**

**Session Av-17**

**Session Av-24**

**Session Av-25**

**Session Av-26**

**Pattern Hub™**

- Failures
- Marketplace Drivers
- Production Drivers
- Accuracy
- ERP
- Predictions
- CM
- Diagnostics
- Historian
- Sensors
- Patterns
- CMMS

**Accuracy**

**Session Av-20**
Contact and Product Information

Thanks Paul

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Thanks Stan

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The Industrial Software Revolution Begins Now