Predictive and Prescriptive Maintenance
Outline
A summary for this presentation

Maintenance Programs
Overview of the most adopted maintenance programs

Prediction/Prescription Analytics
What is Prediction/Prescription Analytic and why it is important
Use Cases
Description of use cases applied in the energy and automatic machines sectors

Our Software Solution
Presentation of the Synapse Maintenance Suite

Our Team
Brief presentation of the team and its awards.

Our Portfolio
Overview of our main past and current projects
Maintenance expenses are almost as big a part of a building’s budget as energy costs.

Maintenance costs consume nearly as much of a typical facility’s operating budget as utility costs and amount to more than one-third of the total operating expenses.
Failures:

- Unexpected breakdowns
- Unplanned downtime
- Production loss
- Secondary failures
- Inefficient use of the staff resources
- Unneeded maintenance.
"Too many companies inaccurately think that maintenance consists solely of waiting for an asset to go down, and then fixing or replacing it."

Reid Paquin, Research Analyst,
Manufacturing and Product Innovation & Engineering (PIE)
Reactive Maintenance

Advantages

• Low cost
• Less staff

Disadvantages

• Frequent unplanned downtime of equipment.
• Increased labor cost, especially if overtime is needed.
• Cost involved with repair or replacement of equipment.
• Possible secondary equipment or process damage from equipment failure.
• Inefficient use of staff resources

“Referring to reactive maintenance as ‘maintenance’ is a misnomer; it should really just be called ‘repair.’”
Preventive Maintenance

**Advantages**
- Flexibility allows for the adjustment of maintenance periodicity.
- Increased component life cycle
- Estimated 12-18% costs savings over reactive programs

**Disadvantages**
- Unplanned downtime of equipment.
- Unneeded Maintenance.
- Labour Intensive
Predictive Maintenance

Advantages
- Increased component operational life/availability.
- Decrease in equipment or process downtime.
- Decrease in costs for parts and labor.
- Estimated 30-40% costs savings over reactive programs

Disadvantages
- Increased investment in diagnostic equipment.
- Increased investment in staff training.
Maintenance Programs Costs in Power Generation

- Reactive: $18 per USD/hp per annum
- Preventive: $13 per USD/hp per annum
- Predictive: $9 per USD/hp per annum

Piotrowski, J., Pro-Active Maintenance for Pumps
Predictive Maintenance

- **75%** Breakdown reduction
  A well-orchestrated predictive maintenance program tends to eliminate the equipment failures.

- **45%** Downtime reduction
  A predictive maintenance program reduces the downtime of the devices.

- **30%** Maintenance cost reduction
  Surveys show that in some specific areas, the savings can be even **10X** return on investment.

- **25%** Production increase
  The reduction of the failures implies the increase in production continuity.

Source: Roland Berger Strategy Consultants, Survey 2014
Human intervention in decisions

Source: Gartner 2013
Industrial adoption of data analytics

Value & Complexity

Inform

Descriptive Analytics
What happened?

Diagnostic Analytics
Why did it happen?

Examples

- Plant operation report
- Fault report
- Sales reports
- Service statistics

Analyse

Predictive Analytics
What will happen?

- Load forecasting
- Fault prediction
- Price forecasts
- Demand forecasts

Act

Prescriptive Analytics
What shall we do?

- Self-learning systems
- Control optimization
- Load balancing
- Production re-planning

Current penetration across all industries (according to Gartner 2013)

99% Adopted by vast majority but not all data
30% Adopted by minorities
13% Still few adopters
3% Very few early adopters

Source: SAP
Interactive prescriptive analytics

Batch prescriptive analytics

Predictive analytics

Near real-time processing

Data visualization

Data streams

Distributed DBMS (noSQL)

PLANT DATA

ASSET MGT

PREMISE DATA WH

WEATHER DEMAND
Use Case: **Fault Prediction**

**Data streams**
- coming from 120 sensors sampled every 20 seconds

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**Data preprocessing**
- Divided per machine average/variance per minute/hour
Use Case: Fault Prediction

Predicts:
- Time to fault/probability of fault
- Which sensors are representative
Use Case: **Fault Prediction**

**Machine Learning Classification/Regression**

There are Machine Learning methods that enable to identify the most representative values.

Decision trees/random forests

- Attribute values: sensors and sensor values
- Class: fault/no-fault
- Decision trees identify the most informative sensors
- Sometimes low accuracy
Use Case: **Fault Prediction**

Deep Learning can Help!

**Auto-encoders** are neural networks that learn a representation of the input and is able to **reconstruct** it.

![Auto-encoder diagram](http://www.asimovinstitute.org/neural-network-zoo/)
Use Case: Fault Prediction

Auto-encoders

Number of hidden units lower than input features
- Feature selection
- Dimensionality reduction

Number of hidden units larger than input features
- Parameter induced sparsity
- Discover non-linear relations in data that are not easily captured by statistical methods
Use Case: Fault Prediction

Deep Learning can Help!

Compared to ML method using average and variance on a time windows

10-20% Accuracy improvement
Use Case: **Fault Prediction**

Beside predictions, we need an optimization component being able to exploit predictions to

- optimally plan maintenance intervention
- define optimal production/maintenance plans
- define maintenance crews shifts
- define optimal operations conditions to decrease fault probabilities
PLANT DATA
Static data on plant config. Asset Mgt

TEMPORAL SERIES
Production data per component/plant

HISTORICAL MAINTENANCE DATA
Processes/costs/Time/loss

MARKET DATA
Demand/Energy cost Predictions

DATA LAYER

SOLVING COMPONENT
Output Maintenance Plans

MAINTENANCE PLANS VISUALIZATION

Stochastic Multi-Criteria Optimization Model

OBJECTIVE FUNCTIONS
Maintenance costs
Breakdowns
Downtime
Production

FAILRE MODEL
For plant/component
Temporal model for failure prediction with confidence levels

COST MODEL
For plant/component
Function that links intervention plan with corresponding cost

PRODUCTION MODEL
For plant/component
Function that links intervention plan with production losses

MARKET MODEL
Demand profile
Cost of energy

Machine Learning

MODEL INTEGRATION

Machine Learning

MODEL OUTPUT
Maintenance Plans

MODEL VISUALIZATION

BDSS
The Synapse Maintenance Suite

- Synapse
  - Proprietary AI Based Framework
- SYNAPSE PREDICTION ENGINE
  - Failures Prediction
- SYNAPSE MONITORING SYSTEM
  - Real Time Anomaly Detection
- SYNAPSE INTELLIGENT SCHEDULER
  - Maintenance and Production Plan
The Synapse Maintenance Suite

**Synapse Monitoring System**

**Anomaly Detection**

**Predict failures**

**Synapse Prediction Engine**

**Optimal maintenance and production plan**

**Synapse Intelligent Scheduler**
The Team

Alessio Bonfietti
Co-founder, CEO
PhD Computer Engineering

Federico Caselli
Co-founder, Project Manager
Computer Engineering

Raffaele Ianniello
Co-founder, CTO
Computer Engineering

Michele Lombardi
Co-founder
Assistant Professor

Michela Milano
Co-founder
Full Professor

Alessandro Bosi
Stakeholder, Chairman
Entrepreneur, Engineer
The Team

Team creation: 2008

Expertise: Artificial Intelligence, Machine Learning, Combinatorial Optimization, Distributed Systems

Awards:
1 Best Italian AI Researcher Award
2 Best Italian PhD Thesis in Artificial Intelligence

Grants:
1 Research Grant and
1 Award from Google
It is time to change the world of industrial maintenance with (Artificial) Intelligence.