‘Self-Healing’ Infrastructure: Machine Learning for Proactive Infrastructure Inspection, Maintenance & Repair (IMR) Diagnostics

INFORMS CONFERENCE ON BUSINESS ANALYTICS & OPERATIONS RESEARCH

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Goals: Machine Learning (ML) integrity diagnostics for physical infrastructure Inspection, Maintenance and Repair (IMR) planning, resulting in measurable quality improvements and IMR process cost reductions associated with infrastructure management. ML captures expert organizational knowledge by codifying dynamic judgment, creating a virtuous cycle for continual diagnostic process improvement.

Keywords: *Data Integration & Management, IMR Resource Optimization, Diagnostic Process Improvement*

① Machine Learning

To detect and extrapolate generalized patterns from complex data sets and to adapt subsequently to new circumstances…

Operations Research (OR)-based approach for ‘training’ computer systems to classify patterns in complex datasets, allowing for the automation of expert decision making. Established efficacy in numerous industries for lowering costs and error rates related to high-overhead expert diagnostics. Research has evidenced improvements in fault diagnostics for complex infrastructure where error margins are slim, human error rates are high, and rectification is costly. Resulting predictive analytics for infrastructure management suggests automation of diagnostics for proactive IMR and subsequent repair planning prioritization.

PATTERN RECOGNITION

- Statistical
- Linear classifiers
- Optimal directions
- Geometric

FUZZY LOGIC

- Associative Rule Learning
- Genetic Programming
- Inductive Logic
- Reinforcement Learning

DATA MINING

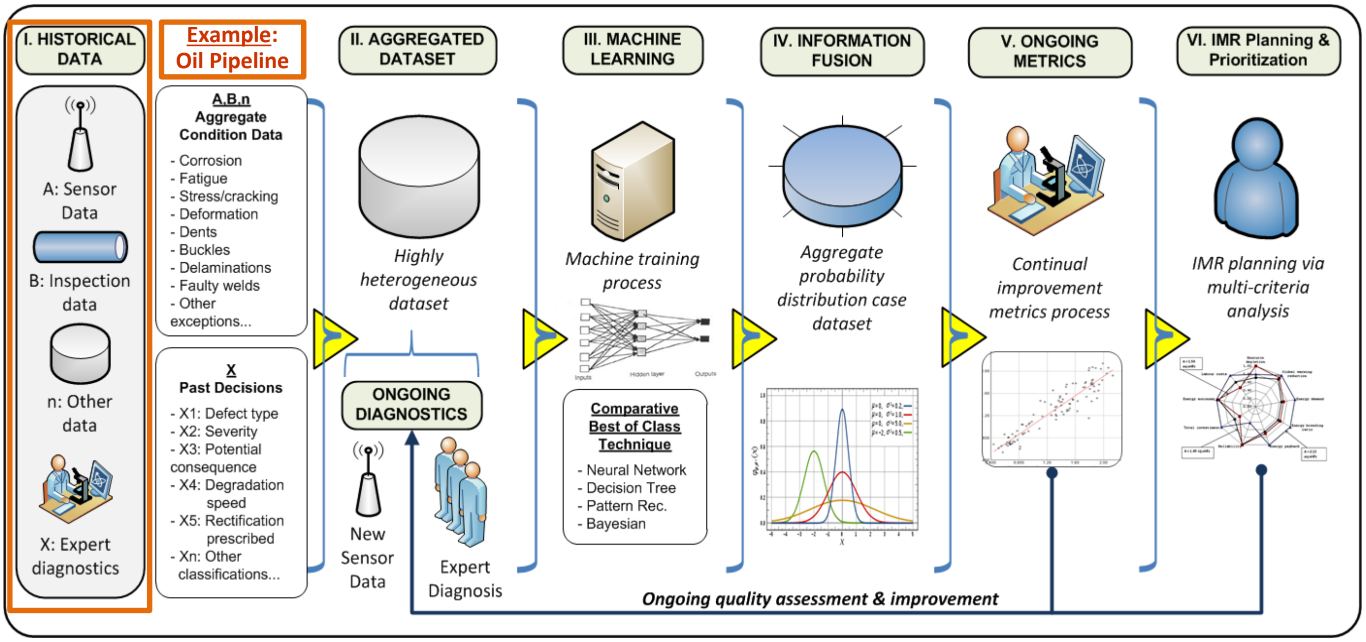
- Bayesian Belief Nets (BBN)
- Neural Networks
- Support Vector Machines
- Clustering

DECISION TREES

- Classification
- Regression Trees
- Boosted Trees
- Random Forests

② Self-Healing Infrastructure

Optimize infrastructure integrity and reduce overhead by improving IMR diagnostic accuracy and efficiency…

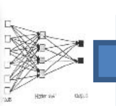


③ Pilot Process

Gated project milestones demonstrating evolving levels of machine-based decision efficacy via quantifiable integrity & efficiency improvements…

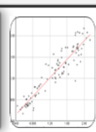
STAGE 1: Proof-of-Concept (*1 week*)

- Support from internal data expert
- RESULT: Neural Network results demo proving ability of ML to produce informed, targeted diagnostic guidance



STAGE 2: Advanced Approach (*6 weeks*)

- Support from internal data expert & diagnostician
- Selection & implementation of advanced ML method
- RESULT: Results showing comparative performance against historical expert judgment; indication of next steps required for pilot implementation



STAGE 3: Implemented Pilot (*3 months*)

- Support from executive, data expert & diagnostician
- Operational pilot of advanced ML implementation
- RESULT: Working ML-based continual improvement diagnostics process for IML planning guidance

Conclusions and Outlook: Based on existing research and evidence from implementations in several industries, there is promising support for a targeted Machine Learning IMR process pilot to improve the accuracy of diagnostics and to reduce infrastructure management costs. Staged pilot would involve: a) aggregation of heterogeneous diagnostic data set, b) ‘training’ via targeted ML technique and c) assessing resulting guidance via comparative expert analysis. Pilot acceptance evolves into a continual improvement-oriented pilot implementation.