

<u>Self-Healing' Infrastructure</u>: Machine Learning for Proactive Infrastructure Inspection, Maintenance & Repair (IMR) Diagnostics

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 To detect and extrapolate generalized patterns from complex **Machine Learning** 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. 1000 PATTERN RECOGNITION DECISION TREES FUZZY LOGIC DATA MINING The set of the set Statistical Associative Rule Learning Bayesian Belief Nets (BBN) Classification Linear classifiers Genetic Programming **Regression Trees** Neural Networks COST CONTRACTOR Inductive Logic Support Vector Machines Optimal directions **Boosted Trees** Reinforcement Learning Clustering **Random Forests** Geometric No. of Concession, and Concession, Name Optimize infrastructure integrity and reduce overhead by **Self-Healing Infrastructure** 2 improving IMR diagnostic accuracy and efficiency... I. HISTORICAL Example: II. AGGREGATED III. MACHINE IV. INFORMATION V. ONGOING VI. IMR Planning & DATASET LEARNING DATA **Oil Pipeline** FUSION Prioritization METRICS <u>A,B,n</u> ((**ף**)) Aggregate Condition Data Corrosion Fatique A: Sensor - Stress/cracking Data Deformation Dents - Buckles Aggregate Hiahlv Machine training IMR planning via - Delaminations Continual probability heterogeneous B: Inspection - Faulty welds process improvement multi-criteria distribution case - Other dataset data analvsis metrics process exceptions. dataset X Past Decisions ONGOING n: Other Comparative - X1: Defect type DIAGNOSTICS data - X2: Severity Best of Class - X3: Potential **Technique** consequence Neural Network - X4: Degradation Decision Tree speed - Pattern Rec. - X5: Rectification Bayesian New prescribed X: Expert - Xn: Other Sensor Expert diagnostics classifications. Data Diagnosis **Ongoing quality assessment & improvement** Gated project milestones demonstrating evolving levels of machine-based **Pilot Process** decision efficacy via quantifiable integrity & efficiency improvements... STAGE 2: Advanced Approach (6 weeks) STAGE 1: Proof-of-Concept (1 week) STAGE 3: Implemented Pilot (3 months) Support from internal data expert & diagnostician Selection & implementation of advanced ML method Support from internal data expert <u>RESULT</u>: Neural Network results demo proving ability of ML to produce inform Support from executive, data expert & diagnostician Operational pilot of advanced ML implementation RESULT: Working ML-based continual improvement RESULT: Results showing comparative performa proving ability of IVIL to pro-targeted diagnostic guidance against historical expert judgment; indication of next diagnostics process for IML planning guidance steps required for pilot implementation **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.