IBM Watson

Travel and Transportation in the Cognitive Era

NUTC

2016

Definition of Terms

Machine Learning is a set of techniques typically taught in **Artificial Intelligence (AI)** courses at university. AI is part of **Computer Science.**

Artificial Intelligence (AI) is the study of intelligence in machines. (see https://en.wikipedia.org/wiki/Artificial_intelligence)

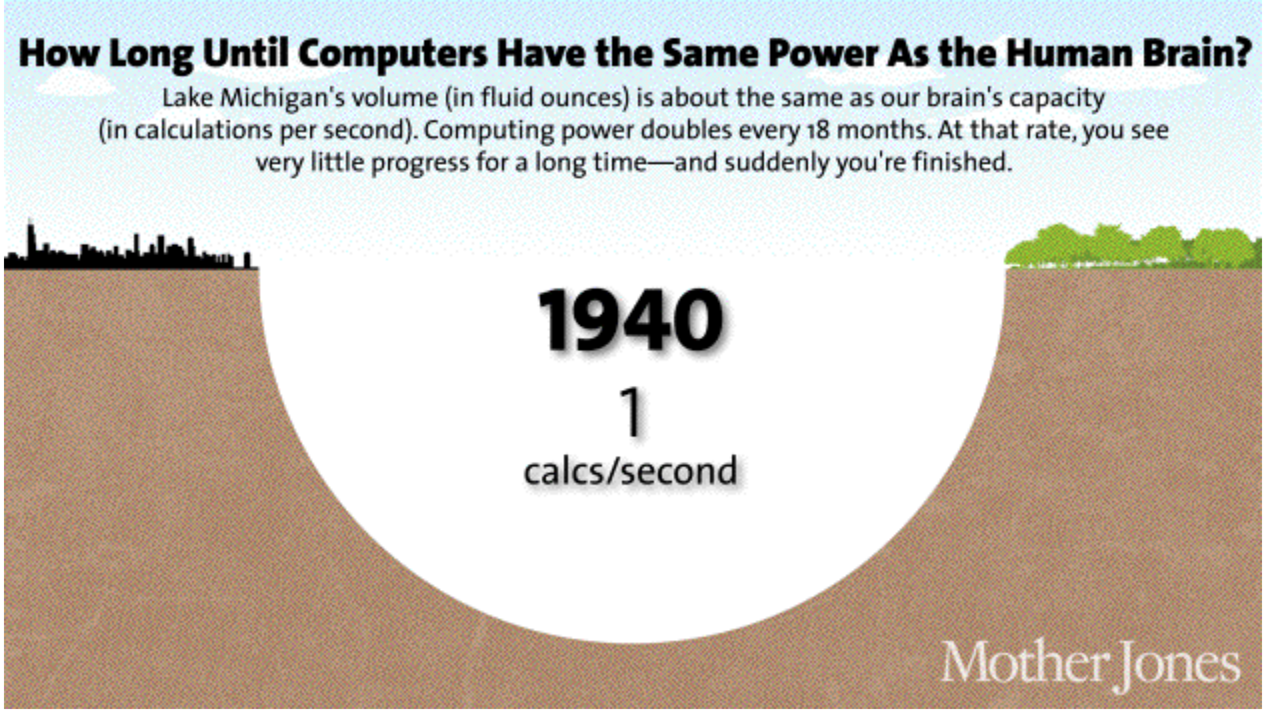
Besides AI, other building block disciplines include **HCI (Human-Computer Interaction)** and **CSCS (Computer Supported Collaborative Work)**, etc.

AI provides some, but not all of the building blocks, for what IBM refers to as **Cognitive Computing.**

IBM is interested in augmenting intelligence of people in business and society – through the simulations of human thought processes – using self-learning algorithms that use data mining, pattern recognition and natural language processing

Jim Spohrer, IBM Director, Understanding Cognitive Systems

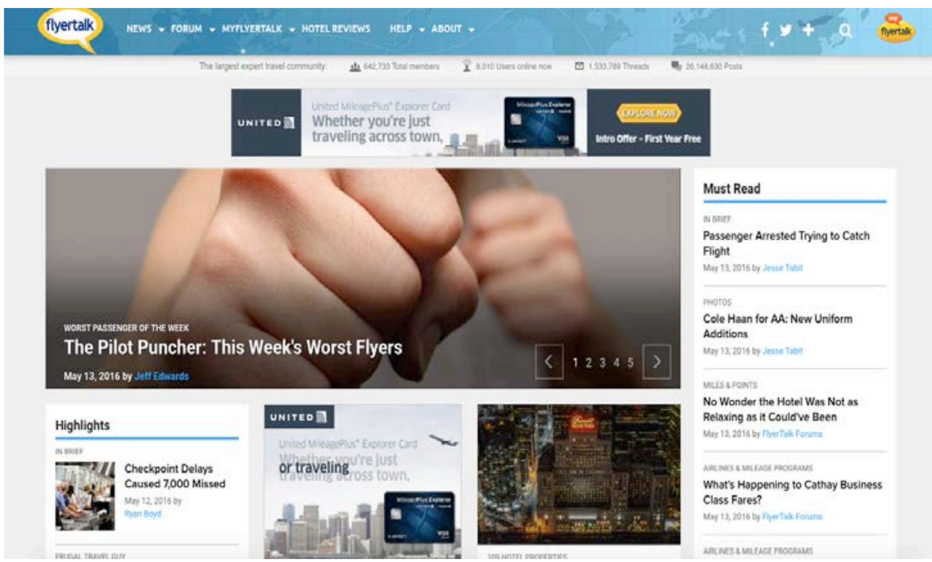
How fast is Artificial Intelligence approaching?



What might it look like?

10 Terabytes of commercial aircraft and engine data every **30 minutes**

800K Facebook status updates & Tweets every **30 seconds**



20 million+ passenger posts on FlyerTalk since its inception

26 billion weather forecasts per day

Traditional systems and databases are inadequate

80% of the world's data is unstructured
20% can be understood by traditional computer systems
90% was created in the past two years

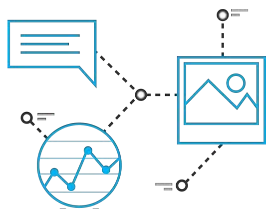
…Text, speech, video, photos, music, sensors, and more

Big

Doesn't describe it…..

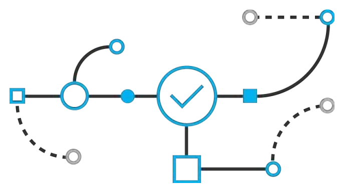
Unstructured
Streamed
Non-linear
Decentralized
Disconnected
Non-discrete

Three capabilities differentiate cognitive systems from traditional programmed computing systems…



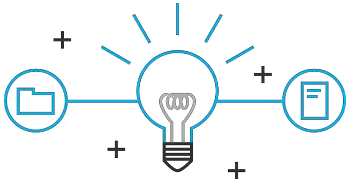
Understanding

Cognitive systems understand like humans do.



Reasoning

They reason. They understand underlying ideas and concepts. They form hypothesis. They infer and extract concepts.



Learning

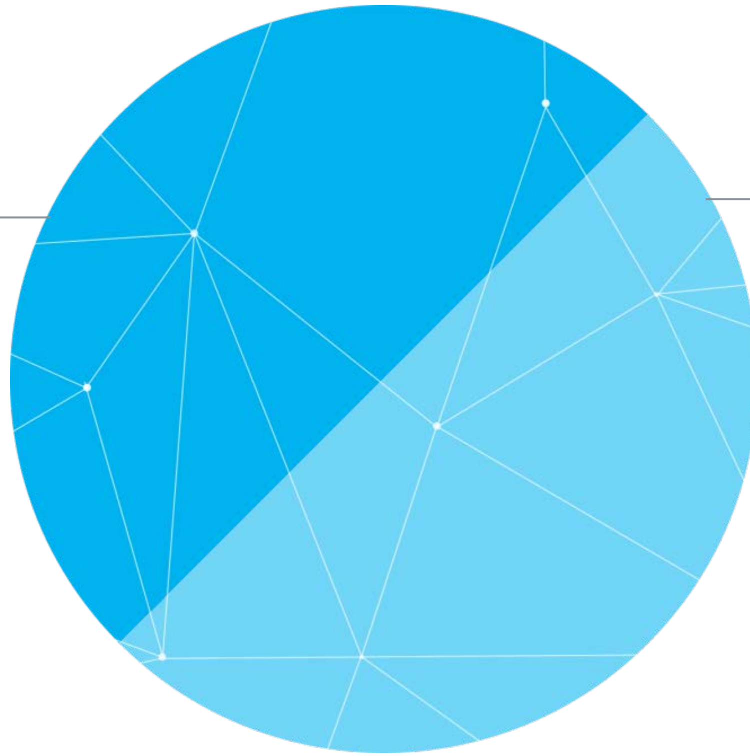
They never stop learning getting more valuable with time. Advancing with each new piece of information, interaction, and outcome. They develop “expertise”.

…. allowing them to interact with humans.

Cognitive systems are creating new partnerships to enhance human expertise

Humans excel at:

Common sense
Morals
Imagination
Compassion
Abstraction
Dilemmas
Dreaming
Generalization



Cognitive Systems excel at:

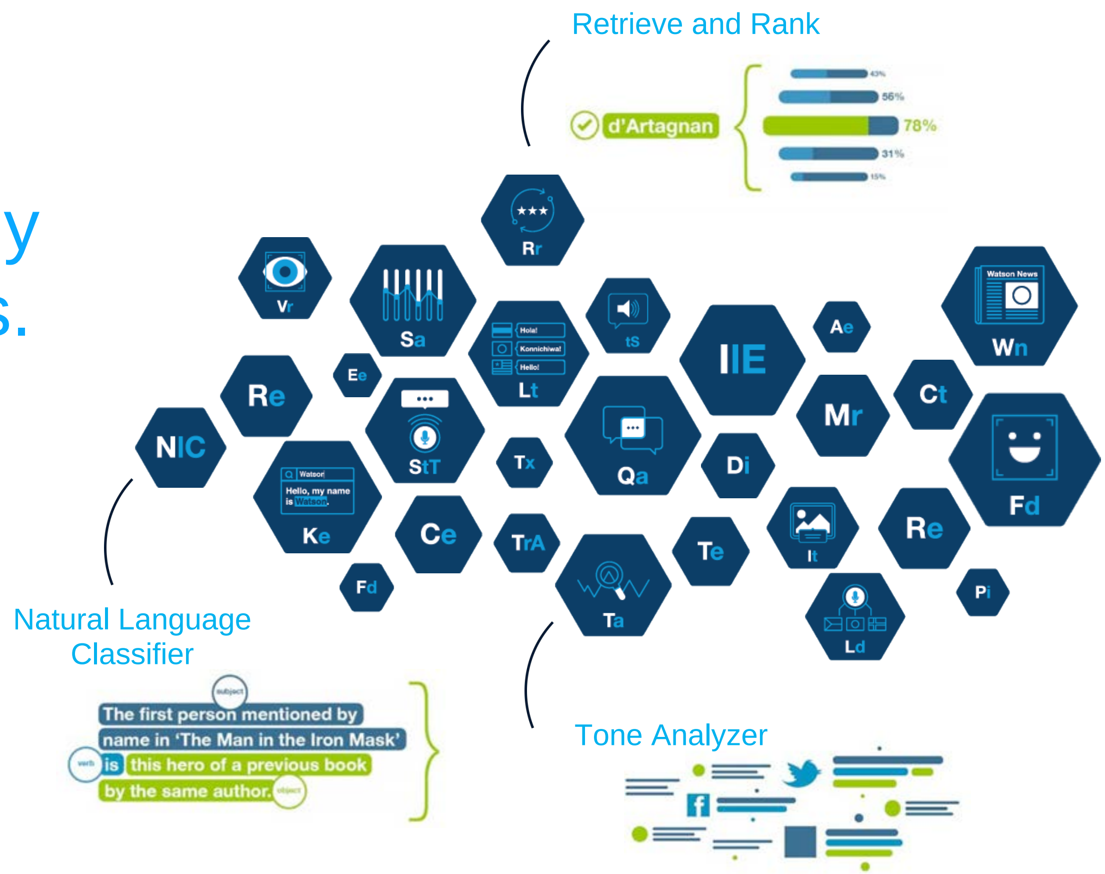
Locating knowledge
Pattern identification
Natural language
Machine learning
Eliminating bias
Endless capacity

Cognitive systems discover, assimilate and understand data and information

Data, information, and expertise

Reports	Patents	Forecasts
Images	Legislation	College classes
Social media	Regulation	Video libraries
Maps	Newspapers	News libraries
Weather	Blogs & Wikis	Health data
Internal documents	Economic reports	Sensors Machine Logs

...and then leverage Watson APIs to apply cognitive capabilities.

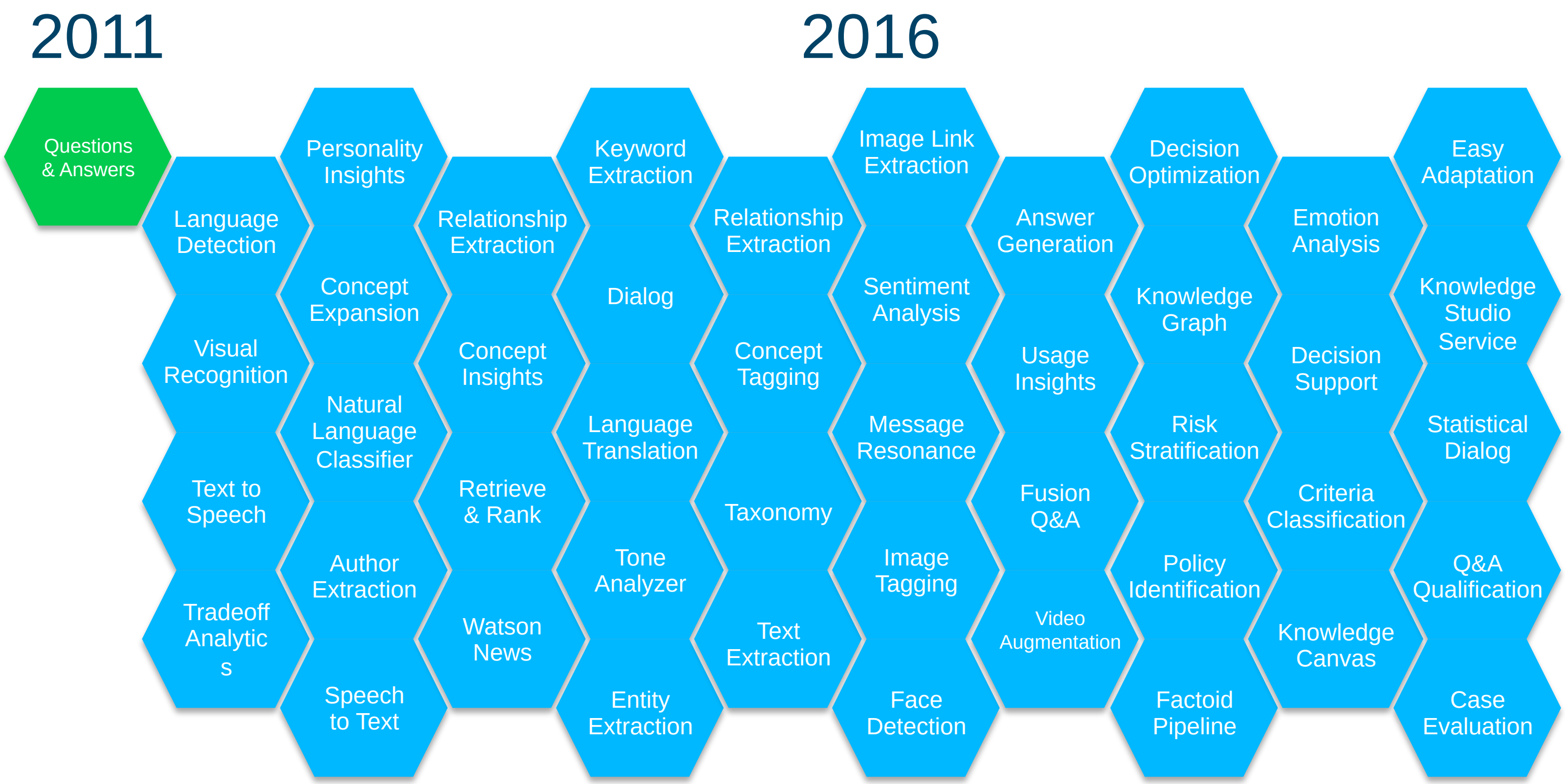


- **Natural Language Classifier API** enables developers without a background in machine learning or statistical algorithms to create machine-learning, natural language interfaces for their applications.

- **Tone analyzer** uses linguistic analysis to detect and interpret emotional, social, and writing cues

- **Retrieve and rank** helps users find the most relevant information for their query by using a combination of search and machine learning algorithms to detect "signals" in the data. – cognitive building blocks – to leverage capabilities including relationship extraction, personality analysis, tone analysis, concept expansion, and trade-off analytics, among others.

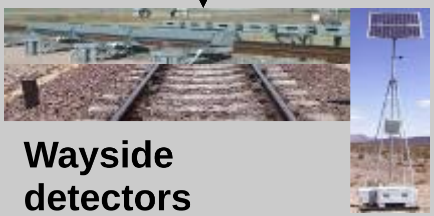
IBM Watson™ is a portfolio of APIs on the cloud in Bluemix



Easy access, modular capabilities, rapid development, modest cost

Detector Analytics - Rail

Moving from Reactive to Predictive



Wayside detectors

Alarms

Network Operations Center – Alarm Actions

1. Stop the train
2. Slow orders
3. Keep an eye on this one.
4. Pull this car at next station
5. Pull this car at end of trip

Predictive Model Based on Historical Data Mining

Data mining, Machine Learning, Predictive Modeling and Failure Analytics

Long Term – time series analysis

Multi- Detector analysis

List of “suspect equipment”

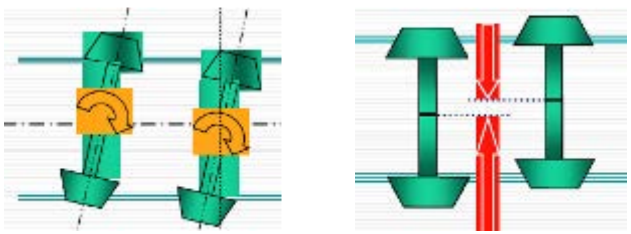
Railyard train formation

We are putting a safer train on the track

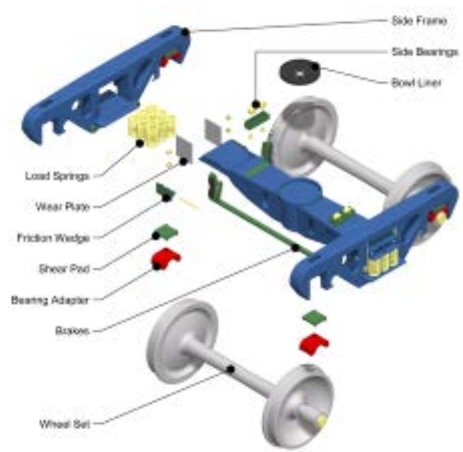
Mech. – Existing Sensors for Train Condition Monitoring – from independent vendors

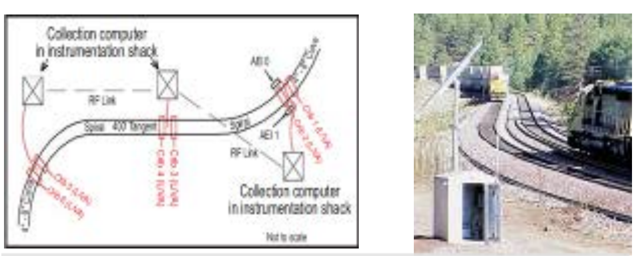
Machine Vision Detector

Wheel Impact Load Detector



Optical Geometry Detector





Truck Performance Detector

Acoustic Bang Detector

Hot Box Detectors
Warm Bearing Detectors
Hot Wheel / Cold Wheel Detectors

Value Proposition –
Composite Detector Analysis (Level 1 Warm Bearing Alarm Prediction)

Goal	Approach	Deliverable & some results
Detect anomalous warm bearing earlier	**Support Vector Machine & Random Forests algorithms** **Implemented on Big Data Platform (fast running time and std. pattern for analytics implementation)**	*__Deliverable:__* • Modified algorithm to detect and score anomalous warm bearings earlier • Software Specification to realize the Implementation of the algorithm on Big Data Platform • Architectural Recommendation for standard Pattern for repeatable analytics on Big Data Platform *__Validation:__* *__Results (**2-Days** in advance):__* True positive rate: ~10% / False positive rate: ~0.016%

Addressing Analytical Challenges – A Rail Example

Big Data:

- The data needing to be processes is in the 10s-100s of TB or more

Noisy Data:

- Missing data, incorrect values, missing values
- Custom algorithms to impute missing value

Extremely Imbalanced Sample:

- Historically there are only ~1000 sensors that have alarms
- But around 900,000 unique equipment identifiers in the data
- Statistical techniques for sample replication

Low False Positives:

- 20 out of 150,000 alarms

Hard to Predict:

- Equipment goes in and out of service

Simple Rules Preferred

- But simple rules may not work in such complete data
- Original method developed for simplification of ML algorithm output

Addressing Business Challenges

Industry Expertise:

- Leveraging internal SME's, assets + ecosystem

Unavailable or Inaccurate Cost Data:

- Presenting a set of recommendations with nuanced trade-offs

Client Organizational and Process Challenges:

- Working closely with clients and acting as intermediary to overcome client organizational silos

Setting Goals and Problems to be addressed

- Controlling scope is important but controlling work-flow and planning is equally important.

Distrust of 'black-box" analytical models:

- Simplifying the analytics output and presenting them in industry accepted terms.

Streamline operational efficiency with Watson for Mechanical and Engineering events

- Source all structured & unstructured data on an asset or repair functions in one place, enabling field workers to quickly find relevant policies, procedures, and product details
- Analyze past repairs, thousands of logs and other documentation for new insights that would drive additional efficiencies
- Routine turnaround and overnight checks to rectify non-routine log entries and the most complex in-service repairs

Unstructured Data Feeds

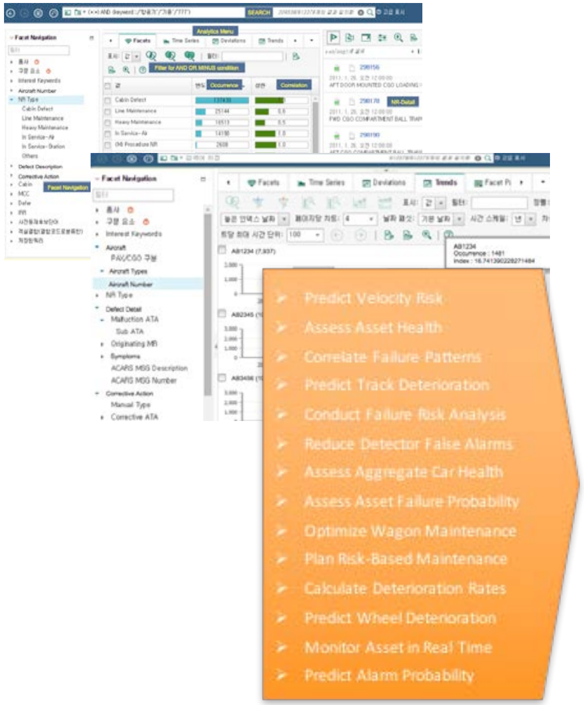
- Geometry or Ultrasonic Cars
- Visual and Electronic Inspections
- Signals
- Detectors
- ATC, ERTMS and PTC Wayside devices
- Communications
- Bridges, Tunnels, Culverts
- MOW equipment
- Locomotive and Car Inspections
- Depot maintenance
- Car Repair billing
- Drones

Watson Explorer

Analyze, visualize, and discover insight in structured and unstructured data through NLP and content mining

Data is transformed into structured format through text mining and other capabilities

Dashboards & Analysis



Line Maintenance – Airlines

Korean Airlines

Current Pain Points for Line Maintenance

- Currently, NR logs consist of unstructured inputs and there is a wealth of information that is currently inaccessible
- Natural language notes mean that seat component separation, text errors, acronyms and other issues prevent the data from being meaningful
- Expertise takes time to build, and Junior Mechanics do not have access to the same knowledge base as individuals with 10+ years of experience
- Typically, a lack of any consolidated views between NR data and other ERP data like man-hour, material, stock and etc.
- Mismatch between malfunction and corrective action ATA's mean that faults are not always properly diagnosed and add time and extra steps to the maintenance process
- Line Maintenance can be highly unpredictable and often causes unexpected delays, along with an unknown resolution time – driving poor customer experience during a delay

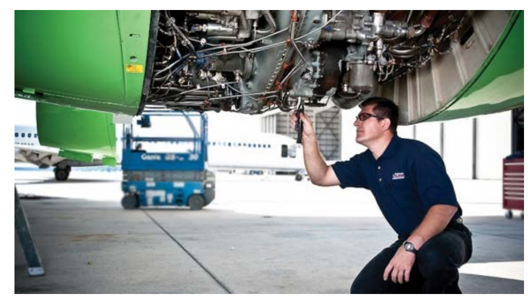
Line Maintenance

Enhance the maintenance process with unstructured data, natural language search, and additional analytics to:

- enable the mechanics of better diagnostics
- resolve maintenance faster
- to inform parts planning
- overall predictive maintenance
- when considering operations and how long an aircraft will be delayed.

Data Inputs: Unstructured + Structured

- NR Maintenance Logs (Non-Routine Maintenance Data, Component Part Maintenance Data)
- ERP System (Material Data, Man/Hour Data, etc.)
- Part Numbers, Inventory, ACMS, Skills Database, User Manuals, or other feeds



Solution

- Watson Explorer (Content Analytics, UI, Analytics Miner, 360 View, Foundational Engine Server)
- Additional analytics capabilities

Line Maintenance: How it works

Unstructured NR Data

NR No : 2950896

NR Summary : DURING TAXI, F/CTL FLAP SYS2 FAULT APPEAR

AC Type / AC No. : 330 / AB8276

Malfunction ATA / Corrective Action ATA : 27-51, 27-51

Corrective Action : MAINT MSG:275134, ACCORDING TO TSM 27-51-00-810-880-A, REPLACED NO.2 SFCC AND THEN SYS OP' CHECKED NORMAL PER AMM TASK 27-51-34-400-801-A AND REMOVED PLACARD

Message No. : 275134

Request Date : 2014-05-04

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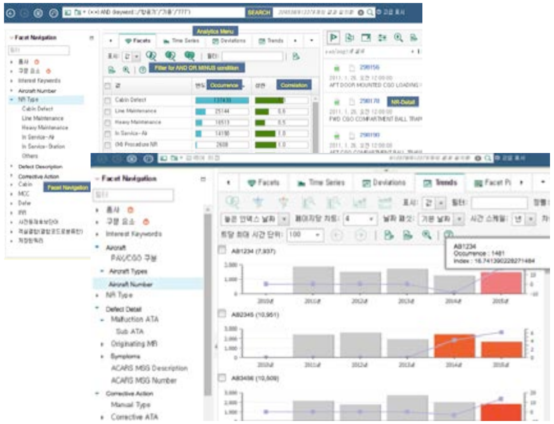
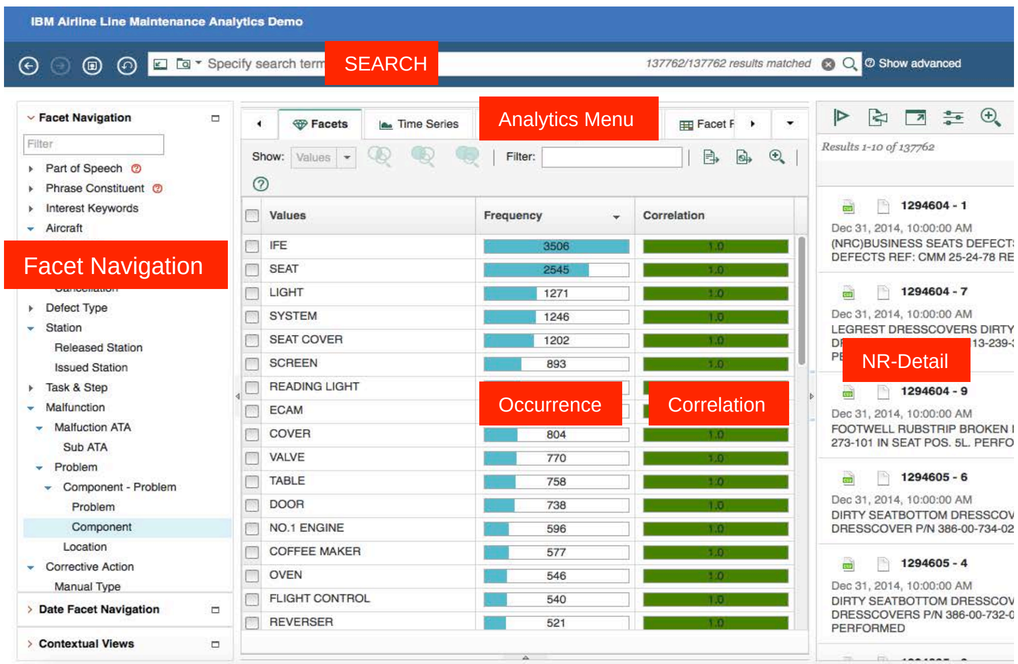


Defect Insights / Analytics



Full Scope

Power mining view with various built-in facets for unknown insight discovery and custom facets for known language patterns in unstructured data:

- User Interface is fully customizable by job role and functions
- Multi-dimensional analysis such as search, classification, and correlation for fault history
- This includes what is the best fix, along with a confidence score, by aircraft type, aircraft number, fault, ATA code, and etc.
- Allows for additional insights based on time-series, cabin, man-hours, delay, part number, etc.

Detailed Benefits

Maintenance Planning and Education Side:

- Provide various insight from details in maintenance log : occurrence, trend, correlations, frequency, etc.
- Able to find repeating defects in detail patterns of symptoms.
- Able to find wrong maintenance, over maintenance, etc.
- Able to revise job manuals for wrong way of maintenance which causes repeating defects
- Able to revise education plan for workers

Maintenance Worker Side:

- Quickly find best practice for given work order/defects easily by searching for log with descriptive search -> reduce time to find best practice and prevent potential delay or cancel of flight
- Higher standard of maintenance skills of worked with high quality tools for maintenance knowledge -> overcome the trend of reduced experienced worker.
- Focus on maintenance quality and speed without looking up complex ATA code set. Instead, let text analytics tool do automatic micro segmentation(classification) of defects using NLP (aka reverse engineering. -> prevents error or mistake of human/unexperienced

Common for each enterprise users: Maintenance Planning, Engineering/Workers, CxO:

- Holistic 360-degree view linked with unstructured insight and structured data for each role player can help them to do their job better with speed

IBM Cognitive Computing Curriculum

I Introduction

To be relevant, any curriculum needs to evolve over time and cannot only con
but must be brought to life through the ways the content is taught and learned.
this one cannot fulfill this alone, but it can inform and set a starting point for e
prioritize and structure the learning content.

In this white paper, we develop a point of view on the most relevant areas and
cognitive computing. The ongoing technological revolution that this area drive
practically all aspects of our social and economic life. Consequently, the need
almost ubiquitous and ranges from teaching the most basic competencies in us
technology to educating the future developers and visionaries of cognitive con
between lies the large space of teaching the next generation of practitioners in
professions -- doctors, journalists, lawyers, sociologists, bankers, designers, ar
themselves -- on best practices and most beneficial ways how they can integra
technologies to augment and complement their work.

The level of knowledge of the internal workings of cognitive technology obvic
accordingly. In this paper, we start with a curriculum for the future designers c
systems, from an applied mathematics and computer science point of view. La
this structure may also serve as a starting point for the cognitive side of an inte
curriculum. Alternatively, it can also serve to set the requirements for cognitiv
"major," whereby another discipline (biology/medicine, material science, soci
psychology, design, journalism, etc) complements and specializes the curricul
(the requirements for the minor are then to be set by the other discipline).

II Curriculum for Future Designers and Developers of Cogniti

We begin with a proposal for a comprehensive cognitive curriculum as it coul
colleges and universities throughout the world. The target for this curriculum a
computer science students who want to learn how to build cognitive systems. (
have exactly one of the following categories: Foundational, Core, Elective, or
All but the three foundational courses are partitioned into five cognitive areas:

Learning | Reasoning | Perception | Interaction | Knowled

A meaningful requirement for an undergraduate cognitive program would be t
foundational and core courses must be covered, plus three elective or graduate
at least two of the five cognitive areas. A graduate program should require at l
or graduate level courses in at least three different areas, whereby one area mu
completely (i.e. all elective and graduate courses in that area must be taken).

Course List

In the following we propose a list of courses, including a short list of topics co
their classification by area (learning, reasoning, perception, interaction and kn
(foundation, core, elective, and graduate).

Foundations

A: Introduction to Programming
B: Mathematical Foundations, with special focus on experimental analysis
C: Theory of Programming

Learning

11: Introduction to Machine Learning | Core | Probabilities, HMMs, Bayesian Learning, Graphical Models, Regression, Lasso, Naive Bayes, Decision Trees, Neural Networks (http://www.cs.ubc.ca/~nando/340-2012/lectures.php), Human Interpretable Models

12: Optimization | Elective | Solving systems of non-linear equations, Non-linear optimization for unconstrained and constrained minimization problems, Stochastic Gradient Descent, Limited-Memory BFGS, Hessian free techniques, Regularization

111: Advanced Machine Learning | Graduate | Ensemble Learning, Inference in Factor Graphs, Expectation-Maximization, Restricted Boltzmann machines, Object recognition, Word and Document Modelling, Auto-Encoders, Collaborative Filtering, Recurrent Neural Networks, Non-linear Dimensionality Reduction, Data Bias and Data Attacks on Learning

Reasoning

21: Fundamentals of Decision-Making | Core | Search & Heuristics, Game Playing, Linear Programming, Mathematical Modelling, Constraint Satisfaction, Satisfiability, Scheduling, Reasoning, Planning, Uncertainty & Probability, Sequential Decision Making, Human Understandable Explanations
22: Advanced Decision-Making | Elective | Common-sense Reasoning, Case-based Reasoning, Bayesian Inference, MDPs, Value Iteration, Policy Iteration, POMDPs, Dynamic Programming, Stochastic Dynamic Programming, Linear Programming & Optimization
121: Modeling Decision Making | Graduate | Planning Representations, Decision-Theoretic Models (MDPs/POMDPs), Reinforcement Learning, Bayesian Models, Bayesian Learning, Statistical Models, Statistical Relational Learning.

Perception

31: Introduction to Computer Vision | Core | cameras and optics, segmentation, visual recognition, stereo matching; motion estimation and others (http://cs.brown.edu/courses/cs143/)
32: Introduction to Computational Linguistics | Core | component modules comprising the field of computational linguistics including morphology, syntax, semantics, discourse; linguistics, statistical and machine learning approaches
33: Introduction to Machine Translation | Elective | Covers range of approaches to machine translation including direct, transfer, interlingua methods & statistical, hierarchical, syntax models & neural network machine translation

131: Deep Learning for Visual Recognition | Graduate | Convolutional Neural Network Architectures for visual analysis, Deep Networks for Spatial Localization / Object Detection, Convolutional neural networks for Video Analysis, and others (http://cs231n.stanford.edu/syllabus.html)

132: Advanced Theory and Practice of Machine Translation | Graduate | In depth study of statistical machine translation and hands-on experience on system building (i.e. implementation)

Microsoft Word 97 - 2004 Document

Questions?