GSRAW 2018
Machine Learning
Space Ground System Working Group

Move the Algorithms; Not the Data!

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Adoption of machine learning and “artificial intelligence” is about at this stage

—the BEGINNING!
Key messages:

• Ground System ML/AI is not a unique “Space” Challenge – It’s a IT, Data Management, Analytics challenge

• Move the Algorithms – not the Data
  – Moving Data creates Platform Sprawl: Architecture Complexity, Duplicated Data, Data Latency, Data Consistency Issues, Security Exposures, and Duplicated Storage, Backup, Systems, etc/etc

• Leverage Commercial Technology – Private R&D Investment in ML is Several Orders of Magnitude more than Government investment in this field.
  – And it’s Moving Fast

• Evolve towards a combined data management + advanced analytics environment that can analyze data, perform machine learning and essentially “think”

• Don’t throw away historical Data – That’s Training Data!

• Operational ML/AI Solution must enable *Timely Deployment* of Analytic Models
Example of Machine Learning in Industries

• Financial
  – Enterprise Risk Management,
  – Financial Crime and Compliance
  – Credit Score/analysis
  – Customer Relationship/marketing
  – Customer Insight

• Retail B2C
  – Market Basket Analysis
  – Event Based Marketing
  – Purchased X – Recommend Y
  – Customer Segmentation
  – Customer Loyalty
  – Sales Predictions

• Industrial
  – Predictive Fault Monitoring

• Health Care
  – Illness pattern analysis
  – Patient Care & Quality Analysis

• Human Capital Management (HCM)
  – Employee turnover, performance prediction and “What if?” analysis

• Government
  – Threat Detection
  – Cyber/Trend Analysis
  – System Failure prediction
  – Computer Vision
  – Sentiment Analysis

• IT Infrastructure
  – IDAM: Real-time security and fraud analytics
  – Autonomous Database
  – Customer Support: Predictive Incident Monitoring
What is Machine Learning, Data Mining, Predictive Analytics?

*Automatically* sift through large amounts of data to find hidden patterns, discover new insights and make predictions

- Identify most important factor (*Attribute Importance*)
- Predict some customer behavior (*Classification*)
- Predict or estimate a value (*Regression*)
- Find profiles of targeted people or items (*Decision Trees*)
- Segment a population (*Clustering*)
- Find fraudulent or “rare events” (*Anomaly Detection*)
- Determine co-occurring items in a “baskets” (*Associations*)

**CLASSIFICATION**
- Naive Bayes
- Logistic Regression (GLM)
- Decision Tree
- Random Forest
- Neural Network
- Support Vector Machine
- Explicit Semantic Analysis

**CLUSTERING**
- Hierarchical K-Means
- Hierarchical O-Cluster
- Expectation Maximization (EM)

**ANOMALY DETECTION**
- One-Class SVM

**TIME SERIES**
- Holt-Winters, Regular & Irregular, with and w/o trends & seasonal
- Single, Double, Exp Smoothing

**REGRESSION**
- Linear Model
- Generalized Linear Model
- Support Vector Machine (SVM)
- Stepwise Linear regression
- Neural Network
- LASSO

**ATTRIBUTE IMPORTANCE**
- Minimum Description Length
- Principal Comp Analysis (PCA)
- Unsupervised Pair-wise KL Div
- CUR decomposition for row & AI

**ASSOCIATION RULES**
- A priori/ market basket

**PREDICTIVE QUERIES**
- Predict, cluster, detect, features

**SQL ANALYTICS**
- SQL Windows, SQL Patterns, SQL Aggregates

**FEATURE EXTRACTION**
- Principal Comp Analysis (PCA)
- Non-negative Matrix Factorization
- Singular Value Decomposition (SVD)
- Explicit Semantic Analysis (ESA)

**TEXT MINING SUPPORT**
- Algorithms support text type
- Tokenization and theme extraction
- Explicit Semantic Analysis (ESA) for document similarity

**STATISTICAL FUNCTIONS**
- Basic statistics: min, max, median, stdev, t-test, F-test, Pearson’s, Chi-Sq, ANOVA, etc.

**R PACKAGES**
- CRAN R Algorithm Packages through Embedded R Execution
- Spark MLlib algorithm integration

**EXPORTABLE ML MODELS**
- C and Java code for deployment

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* OAA (Oracle Data Mining + Oracle R Enterprise) and ORAAH combined
* OAA includes support for Partitioned Models, Transactional, Unstructured, Geo-spatial, Graph data, etc.

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Potential ML/AI Ground System Resiliency Use Cases

• Premise of the Working Group
  – Platform Telemetry Analysis
  – Anomaly Detection/Prediction

• Global Ground System
  – Optimized Worldwide Comm Planning/Scheduling
  – Constellation Orbital Management
  – Anomaly Analysis/Prediction
    • MOC, Backup MOC, Comm Relay & Tracking Sites
    • Uplink/Downlink RF System Fault
    • Pedestal System
    • IT Fault Analysis/Prediction
  – WX degradation/re-plan Prediction

• Ground Facility
  – Anomaly Detection
    • Power Plant, Cooling, etc

• Product Processing
  – Automated Exploitation
  – Anomaly Detection

• Human Element
  – Employee turnover, performance prediction and “What if?” analysis
Summary

• Machine learning, predictive analytics & “AI” have become *must-have* capabilities

• Separate islands for data management and for data science don’t work

• *Move the Algorithms, Not the Data!*

• Need to evolve towards a combined data management + advanced analytics environment that can analyze data, perform machine learning and essentially “think”

• *Leverage Extensive Commercial R&D and Investment*
  – Avoid Opportunity Costs of duplicating COTS capabilities
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