Prescriptive Analytics: Introduction

INCOSE WMA Tutorial
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- **126 million** – The number of blogs on the Internet (as tracked by BlogPulse).
- **27.3 million** – Number of tweets on Twitter per day (November, 2009)
- **350 million** – People on Facebook.
- **50%** – Percentage of Facebook users that log in every day.
- **4 billion** – Photos hosted by Flickr (October 2009).
- **2.5 billion** – Photos uploaded each month to Facebook.
- **12.2 billion** – Videos viewed per month on YouTube in the US (November 2009).
- **924 million** – Videos viewed per month on Hulu in the US (November 2009).

A Useful Distinction

• Big Data
  – Collection, management and processing of large quantities of complex structured and unstructured data

• Data Analytics
  – Extracting value from data by using formal analysis to:
    • Find patterns
    • Understand meaning of patterns
    • Make predictions
    • Recommend decisions
Driving Forces

- Unprecedented data availability
- Intense competition
- Culture of constant improvement
- Changing customer demographic
- Expanding customer expectations
Why Analytics?

• Competitive differentiator
  – Individualized customer experience
  – Faster and better service
  – Cost effective processes

• Increasingly pervasive
  – Do you remember life without your computer? Your cell phone? The web?
  – Soon it will inconceivable to do business without analytics
Analytics Value Chain

Increasing Value

Curate
- Collect, store, manage, clean, process data

Summarize
- Provide tables, charts and other summaries

Describe
- Identify meaningful patterns in data

Predict
- Understand causal relationships to predict future scenarios

Prescribe
- Create the future through informed, value-driven choices

Analytics: Descriptive / Predictive / Prescriptive
Increasing Value

Curate
- Collect, store, manage, clean, process data

Summarize
- Provide tables, charts and other summaries

Focus of Today’s Tutorial
- Identify meaningful patterns in data

Prescribe
- Create the future through informed, value-driven choices

Analytics: Descriptive / Predictive / Prescriptive
Descriptive Analytics

• Identify patterns in data
• Common categories of analytical methods
  – Data visualization methods
  – Data transformation
  – Outlier detection
  – Data mining methods
  – Clustering
  – Exploratory identification of trends and patterns
Predictive Analytics

• Analyze data to make predictions
  – Identify and formally verify patterns in data
  – Understand cause and effect relationships
  – Extrapolate patterns to future

• Common categories of analytical methods
  – Regression analysis
  – Time series models
  – Machine learning methods
Prescriptive Analytics

• Suggest actions to decision maker based on descriptive and predictive analytics
  – Frame the problem
  – Identify candidate actions
  – Predict consequences of actions
  – Assess value of consequences
  – Suggest highest value actions

• Common categories of analytical methods
  – Optimization
  – Simulation
Analytics Supports Better Decisions

• Example: FedEx
  – Package scans and active sensors in high-value packages provide data on shipments
  – Events are analyzed in real time and shipments rerouted in case of problems
  – Analytics are used to identify and respond to customer service issues

• Example: Petroleum industry
  – Analytics improves problem diagnosis, improves maintenance and repair policies, reduces cost and prevents catastrophic failures
  – Analytics helped ConocoPhillips predict ice floe movement and extend the drilling season by weeks
Decisions and Models

• A model is a representation of a system that can be used to answer questions about the system
  – “All decisions are based on models… and all models are wrong.” – John D. Stearman
  – “All models are wrong but some are useful” – George Box

• Models are constructed from:
  – Past data on the system
  – Past data related to the system
  – Judgment of subject matter experts
  – Judgment of experienced model builders
Models in Engineering

• Engineers design a system by:
  – Building a model to represent the system they want to design
  – Manipulating the model
  – Using behavior of the model to
    • Predict behavior of the system
    • Evaluate and compare alternative design options

• Types of representation
  – Physical
  – Mathematical
  – Computer
  – Verbal

• Examples
  – Wind tunnel and model airplane
  – CAD model of a bridge
  – Computer simulation of traffic flows on highway network
  – Linear program model for inventory planning
  – Bayesian spam filter
Human Decision Makers and Models

- People are good at:
  - Identifying what objectives are important
  - Identifying what features are relevant
  - Identifying relationships
  - Generating options

- People need support to:
  - Bump out of pre-conceived ideas and established conventions
  - Integrate large numbers of factors
  - Combine numerical and statistical information with judgment
  - Perform tedious bookkeeping
  - Coordinate among multiple actors

- Effective models produce **understandable rationale** for recommendations
Cognitive Tools
(von Winterfeldt and Edwards)

- We would never start a construction project without tools
- We should not make important decisions without effective cognitive tools
- Cognitive tools can assist with:
  - Problem structuring
  - Elicitation of human judgmental inputs
  - Organizing and displaying relevant data
  - Aggregating inputs to produce
    - Predictions of outcomes for options suggested by decision maker
    - Recommendations of options for decision maker to consider
  - Understanding strengths and weaknesses of candidate solutions
  - Selecting a solution
  - Justifying the selected solution
  - Implementing the selected solution
- Prescriptive analytics gives us cognitive tools
Functional Components of a DSS

- Model Management
- Knowledge Engine
- Dialogue Management
- Data Management
- Repository of Models
- External Data Sources
- User & External Environment
Decision Support Trends

- IT is increasingly pervasive
- Computer hardware is increasingly smaller and more powerful
- Systems are increasingly interconnected
- The Web is interwoven into all aspects of life
- Demand for usable, flexible, powerful decision support will continue to grow
- Decision support is increasingly embedded into consumer and business products
- User expectations are exploding
Data Analytics at GMU

• Graduate certificate program starts Fall 2013
  – Broad overview of value chain for Big Data Analytics
  – Framework for methodologies to organize, visualize, analyze, and generate value from data
  – Interdisciplinary

• MS program awaits state approval

• Prescriptive analytics
  – Course in certificate program
  – Track in MS program

http://volgenau.gmu.edu/graduates/GraduateCertificateDataAnalytics.php
Schedule

9:00  Introduction
9:30  Modeling Decision Problems
10:15 Break
10:30 Model-Based Systems Engineering and Prescriptive Simulation
11:15 Optimization Methods for Prescriptive Analytics
12:15 Conclusion
Enjoy the Tutorial!