



Data Mining (Big Data Analytics)

Andrew Kusiak
Intelligent Systems Laboratory
2139 Seamans Center
The University of Iowa
Iowa City, IA 52242 - 1527
andrew-kusiak@uiowa.edu
<http://user.engineering.uiowa.edu/~ankusiak/>
Tel. 319-335 5934
Fax. 319-335 5669

What is Data Mining?

A PROCESS

- Domain understanding
- Data selection
- Data cleaning, e.g., data duplication, missing data
- Preprocessing, e.g., integration of different files
- Pattern (knowledge) discovery
- Interpretation (e.g., visualization)
- Reporting

Illustrative Applications

General category

- Prediction of equipment faults
- Determining a stock level
- Process control
- Fraud detection
- Genetics
- Disease staging and diagnosis
- Decision making

pharmaceutical Applications

Manufacturing
Service industry
Healthcare
Pharmaceuticals

What is Knowledge Discovery?

Process



Learning



Knowledge



E.g., Excel, Access,
Data Warehouse

Learning Systems (1/2)

- Classical statistical methods
(e.g., discriminant analysis)
- Modern statistical techniques
(e.g., k -nearest neighbor, Bayes theorem)
- Neural networks
- Support vector machines
- Decision tree algorithms
- Decision rule algorithms
- Learning classifier systems

Knowledge
discovery

Black box tools



Learning Systems (2/2)

- Association rule algorithms
- Text mining algorithms
- Meta-learning algorithms
- Inductive learning programming
- Sequence learning



Neural Networks

Definition

- Based on biology
- Inputs transformed via a network of simple processors
- Processor combines (weighted) inputs and produces an output value
- Obvious questions: What transformation function do you use and how are the weights determined?

Types of Decision Trees

- CHAID: Chi-Square Automatic Interaction Detection
 - Kass (1980)
 - n-way splits
 - Categorical variables
- CART: Classification and Regression Trees
 - Breimam, Friedman, Olshen, and Stone (1984)
 - Binary splits
 - Continuous variables
- C4.5
 - Quinlan (1993)
 - Also used for rule induction

Text Mining

- Mining unstructured data (free-form text) is a challenge for data mining
- Usual solution is to impose structure on the data and then process using standard techniques, e.g.,
 - Simple heuristics (e.g., unusual words)
 - Domain expertise
 - Linguistic analysis
- Presentation is critical

Yet Another Classification

Examples

- Supervised
 - Regression models
 - k-Nearest-Neighbor
 - Neural networks
 - Rule induction
 - Decision trees
- Unsupervised
 - k-means clustering
 - Self organized maps

Supervised Learning Algorithms

Characteristics

- kNN
 - Quick and easy
 - Models tend to be very large
- Neural Networks
 - Difficult to interpret
 - Training can be time consuming
- Rule Induction
 - Understandable
 - Need to limit calculations
- Decision Trees
 - Understandable
 - Relatively fast
 - Easy to translate into SQL queries

Knowledge Representation Forms

Examples

- Decision rules
- Trees (graphs)
- Patterns (matrices)

DM: Product Quality Example

Training data set

Product ID	Process param 1	Test_1	Process param_2	Test_2	Quality D
1	1.02	Red	2.98	High	Good_Quality
2	2.03	Black	1.04	Low	Poor_Quality
3	0.99	Blue	3.04	High	Good_Quality
4	2.03	Blue	3.11	High	Good_Quality
5	0.03	Orange	0.96	Low	Poor_Quality
6	0.04	Blue	1.04	Medium	Poor_Quality
7	0.99	Orange	1.04	Medium	Good_Quality
8	1.02	Red	0.94	Low	Poor_Quality



The University of Iowa

Intelligent Systems Laboratory

Decision Rules

Rule 1. IF (Process_parameter_1 < 0.515) THEN (D = Poor_Quality);
[2, 2, 50.00%, 100.00%][2, 0][5, 6]

Rule 2. IF (Test_2 = Low) THEN (D = Poor_Quality);
[3, 3, 75.00%, 100.00%][3,0][2, 5, 8]

Rule 3. IF (Process_parameter_2 >= 2.01) THEN (D = Good_Quality);
[3, 3, 75.00%, 100.00%][0, 3][1, 3, 4]

Rule 4. IF (Process_parameter_1 >= 0.515) & (Test_1 = Orange) THEN
(D = Good_Quality);
[1, 1, 25.00%, 100.00%][0, 1][7]

Data Mining Result



The University of Iowa

Intelligent Systems Laboratory

Decision Rule Metrics

Rule 12

IF (Flow = 6) AND (Pressure = 7)
THEN (Efficiency = 81);

[13, 8, 4.19%, 61.54%] [1, 8, 4] ← No of supporting objects

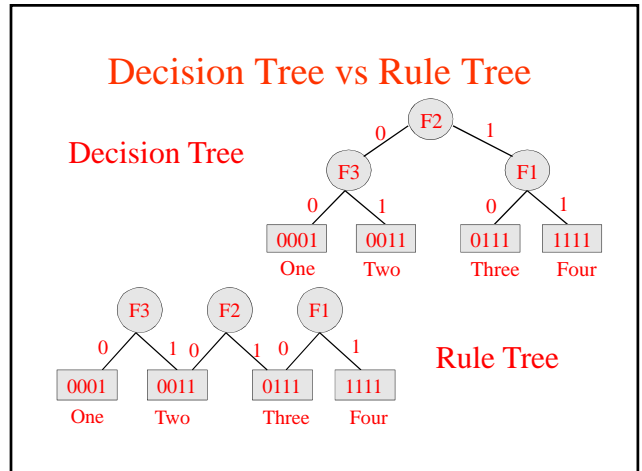
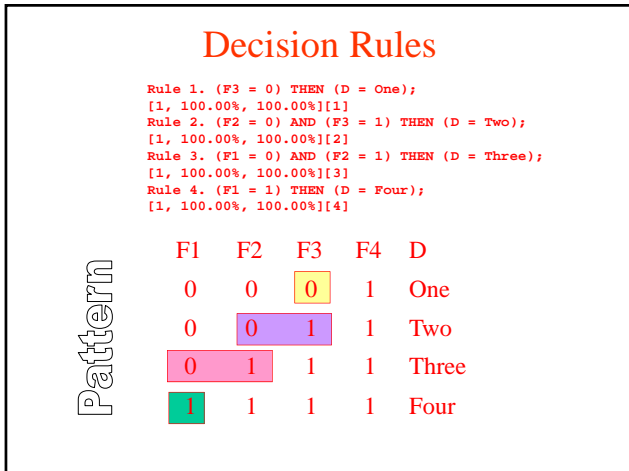
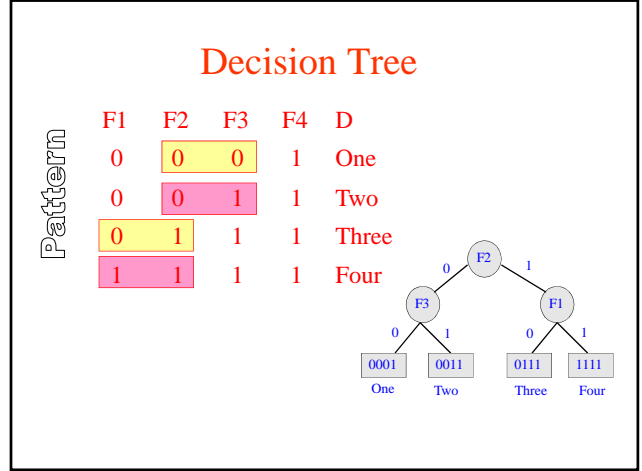
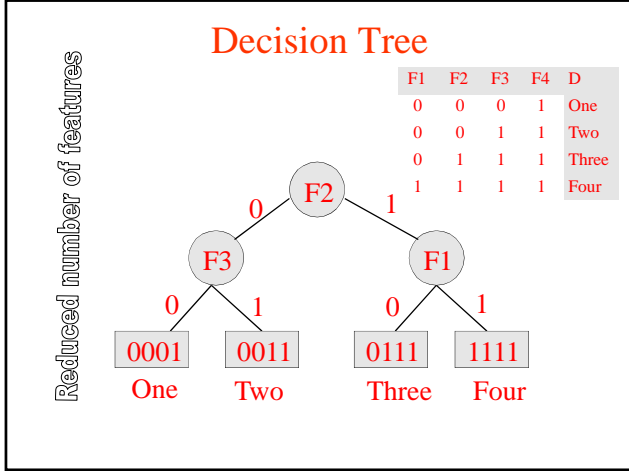
Support Strength Relative strength Confidence

[{ 524 },
{ 527, 528, 529, 530, 531, 533, 535, 536 },
{ 525, 526, 532, 534 }]

Supporting objects

Definitions

- **Support** = Number of objects satisfying condition of the rule
- **Strength** = Number of objects satisfying condition and the decision of the rule
- **Relative strength** = Number of objects satisfying condition and the decision of the rule/The number of objects in the class
- **Confidence** = Strength/Support



Important Class of Algorithms

Decision Rule Algorithms

Rough Set Theory

Identify **unique features of an object** rather than **commonality among all objects**

Individual object vs population based approach

Use of Extracted Knowledge

Given - 0 1 -

Decision Making

F1	F2	F3	F4	D
0	0	0	1	One
0	0	1	1	Two
0	1	1	1	Three
1	1	1	1	Four

Match - 0 1 -

Result

OR

Traditional Modeling

Data Set → **Single Model** (All features)

Example

- Regression analysis
- Neural network

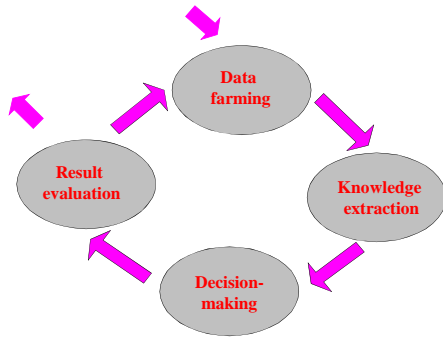
Data Mining

Data Set → **Models** (Subset of features)

Example

- Rules
- Decision trees
- Patterns

Data Life Cycle



Data Mining Standards

- Predictive Model Markup Language (PMML)
 - The Data Mining Group (www.dmg.org)
 - XML based (DTD)
- Java Data Mining API spec request (JSR-000073)
 - Oracle, Sun, IBM, ...
 - Support for data mining APIs on J2EE platforms
 - Build, manage, and score models programmatically
- OLE DB for Data Mining
 - Microsoft
 - Table based
 - Incorporates PMML

Summary



- Data mining algorithms support a new paradigm: Identify what is unique about an object
- DM tools to enter new areas of information analysis