Data Mining as a Process

• Data mining involves many steps
  – Machine learning is only one aspect
  – Data exploration/understanding, evaluation, etc.
• This needs to be formalized so it is more science than art
  – Steps and tasks involved
• One approach: Process Model
  – Formalize steps
  – Document what is to be done at each step
Data Mining Process

• Cross-Industry Standard Process for Data Mining (CRISP-DM)
• European Community funded effort to develop framework for data mining tasks
• Goals:
  – Encourage interoperable tools across entire data mining process
  – Take the mystery/high-priced expertise out of simple data mining tasks

Why Should There be a Standard Process?

• Framework for recording experience
  – Allows projects to be replicated
• Aid to project planning and management
• “Comfort factor” for new adopters
  – Demonstrates maturity of Data Mining
  – Reduces dependency on “stars”

The data mining process must be reliable and repeatable by people with little data mining background.
Process Standardization

- CRoss Industry Standard Process for Data Mining
- SPSS/ISL, NCR, Daimler-Benz, OHRA
- Funding from European commission
- Over 200 members of the CRISP-DM SIG worldwide
  - DM Vendors - SPSS, NCR, IBM, SAS, SGI, Data Distilleries, Syllogic, Magnify, ...
  - System Suppliers / consultants - Cap Gemini, ICL Retail, Deloitte & Touche, …
  - End Users - BT, ABB, Lloyds Bank, AirTouch, Experian, ...

CRISP-DM

- Non-proprietary
- Application/Industry neutral
- Tool neutral
- Focus on business issues
  - As well as technical analysis
- Framework for guidance
- Experience base
  - Templates for Analysis
CRISP-DM: Overview

- Hierarchical Model

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CRISP-DM: Phases

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CRISP-DM: Phases

1. Business Understanding
   - Understanding project objectives and requirements
   - Data mining problem definition

2. Data Understanding
   - Initial data collection and familiarization
   - Identify data quality issues
   - Initial, obvious results

3. Data Preparation
   - Record and attribute selection
   - Data cleansing

4. Modeling
   - Run the data mining tools

5. Evaluation
   - Determine if results meet business objectives
   - Identify business issues that should have been addressed earlier

6. Deployment
   - Put the resulting models into practice
   - Set up for repeated/continuous mining of the data

Phases and Tasks

<table>
<thead>
<tr>
<th>Business Understanding</th>
<th>Data Understanding</th>
<th>Data Preparation</th>
<th>Modeling</th>
<th>Evaluation</th>
<th>Deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine Business Objectives</td>
<td>Collect Initial Data</td>
<td>Select Modeling Technique</td>
<td>Evaluate Results</td>
<td>Plan Deployment</td>
<td></td>
</tr>
<tr>
<td>Background</td>
<td>Initial Data Collection Report</td>
<td>Data Set</td>
<td>Assessment of Data Mining Results w.r.t. Business Success Criteria</td>
<td>Deployment Plan</td>
<td></td>
</tr>
<tr>
<td>Business Objectives</td>
<td>Describe Data</td>
<td>Select Data</td>
<td>Modeling Technique</td>
<td>Plan Monitoring and Maintenance Plan</td>
<td></td>
</tr>
<tr>
<td>Business Success Criteria</td>
<td>Data Description Report</td>
<td>Rationale for Inclusion / Exclusion</td>
<td>Modeling Assumptions</td>
<td>Produce Final Report</td>
<td></td>
</tr>
<tr>
<td>Situation Assessment</td>
<td>Explore Data</td>
<td>Clean Data</td>
<td>Generate Test Design</td>
<td>Final Report</td>
<td></td>
</tr>
<tr>
<td>Inventory of Resources Requirements, Assumptions, and Constraints</td>
<td>Verify Data Quality</td>
<td>Data Cleaning Report</td>
<td>Test Design</td>
<td>Final Presentation</td>
<td></td>
</tr>
<tr>
<td>Risks and Contingencies</td>
<td>Data Quality Report</td>
<td>Construct Data</td>
<td>Build Model</td>
<td>Review Process</td>
<td></td>
</tr>
<tr>
<td>Terminology</td>
<td>Select Data</td>
<td>Derived Attributes</td>
<td>Parameter Settings</td>
<td>Review of Process</td>
<td></td>
</tr>
<tr>
<td>Costs and Benefits</td>
<td>Verify Data Quality</td>
<td>Generated Records</td>
<td>Models</td>
<td>Determine Next Steps</td>
<td></td>
</tr>
<tr>
<td>Determine Data Mining Goal</td>
<td>Data Set</td>
<td>Integrate Data</td>
<td>Asses Model</td>
<td>List of Possible Actions</td>
<td></td>
</tr>
<tr>
<td>Data Mining Goals</td>
<td>Data Set Description</td>
<td>Merged Data</td>
<td>Model Assessment</td>
<td>Decision</td>
<td></td>
</tr>
<tr>
<td>Data Mining Success Criteria</td>
<td>Select Data</td>
<td>Format Data</td>
<td>Revised Parameter Setting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Produce Project Plan</td>
<td>Data Set Description</td>
<td>Reformatted Data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Plan Initial Assessment of Tools and Techniques</td>
<td>Select Data</td>
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<td></td>
<td>Verify Data Quality</td>
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<td>Construct Data</td>
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Phase 1: Business Understanding

- Business Understanding:
  - Statement of Business Objective
  - Statement of Data Mining objective
  - Statement of Success Criteria

Business Understanding

- Determine Business Objectives
  - Background, Objectives, Success Criteria
- Assess Situation
- Determine Data Mining Goals
  - Success Criteria
- Produce Project Plan
Business Understanding: Determine Business Objectives

Activities:
- Develop organizational charts identifying divisions, departments and project groups. The chart should also identify managers' names and responsibilities.
- Identify key persons in the business and their roles.
- Identify an internal sponsor (financial sponsor and primary user/domain expert).
- Is there a steering committee and who are the members?
- Identify the business units which are impacted by the data mining project (e.g., Marketing, Sales, Finance).

Problem area:
- Identify the problem area (e.g., Marketing, Customer Care, Business Development, etc.).
- Describe the problem in general terms.
- Check the current status of the project (e.g., Check if it is already clear within the business unit that we are performing a data mining project or do we need to advertise data mining as a key technology in the business?).
- Clarify prerequisites of the project (e.g., what is the motivation of the project? Does the business already use data mining?).
- If necessary, prepare presentations and present data mining to the business.
- Identify target groups for the project result (e.g., Do we expect a written report for top management or do we expect a running system that is used by naive end users?).
- Identify the users' needs and expectations.

Current solution
- Describe any solution currently in use for the problem.
- Describe the advantages and disadvantages of the current solution and the level to which it is accepted by the users.

Business Understanding: Assess Situation

- Inventory of Resources
- Requirements Assumptions & Constraints
- Risks and Contingencies
- Terminology
- Costs and Benefits
Business Understanding: Project Plan

- Stages of the project
  - Schedule
  - Resources
  - Dependencies
- Assessment of Tools and Techniques
- “Living Document”
  - Specific points for review/update

Business Understanding: Phase Report

- Background
- Business objectives and success criteria
- Inventory of resources
- Requirements, assumptions, and constraints
- Risks and contingencies
- Terminology
- Costs and benefits
- Data mining goals and success criteria
- Initial assessment of tools and techniques
Phase 2: Data Understanding

- Business Understanding:
  - Statement of Business Objective
  - Statement of Data Mining objective
  - Statement of Success Criteria

- Data Understanding
  - Explore the data and verify the quality
  - Find outliers

Data Understanding

- Collect Initial Data
- Describe Data
- Explore Data
- Verify Data Quality

Report at each stage
  - Capture information to ensure repeatability of process
Data Understanding: Data Description Report

- Format of data
- Quantity of data
- Identity of fields, other surface features

Does the data acquired satisfy requirements?

Data Understanding: Explore Data

- We’ve covered data exploration
  - Distribution, pairwise correlations, sub-populations
- Outcome
  - Need for further transformation/preparation?
  - Is quality sufficient for goals?
  - Initial findings / hypotheses
Data Understanding: Verify Data Quality

- Completeness
- Correctness
  - Random errors
  - Systematic errors
  - Missing values
- Potential solutions

Phase 3: Data Preparation

- Data preparation:
  - Takes usually over 90% of the time
    - Collection
    - Assessment
    - Consolidation and Cleaning
      - table links, aggregation level, missing values, etc
    - Data selection
      - active role in ignoring non-contributory data?
      - outliers?
      - Use of samples
      - visualization tools
    - Transformations - create new variables
Data Preparation

- Select Data
- Clean Data
- Construct Data
- Integrate Data
- Format Data

Output: Dataset and Dataset Description
- Also reports on each stage

Data Preparation: Select Data

- Decide what to use for analysis
  - Data mining goals
  - Data quality
  - Technical constraints

- Report: Rationale for inclusion/exclusion
Data Preparation: Clean Data

• Where data quality insufficient, improve
  – Select only good subsets
  – Obtain better data
  – Modeling / imputation of values

• Report: Process
  – What has been done
  – How might this impact validity of results?

Data Preparation: Construct Data

• Feature construction
  – Document how this is done

• Generate records
  – E.g., will modeling technique require records for customers who have made no purchase during a year?
Data Preparation: Integrate Data

• Data may come from multiple sources
  – Often dissimilar
• Different types of data about same entities
  – Record linkage
• Similar information about different subsets of entities
  – Feature mapping
  – Duplicate elimination
• Data Aggregation

Data Preparation: Format Data

• (Primarily) syntactic modifications to satisfy tool requirements
  – Data format
  – Unique identifiers
• Normalization
Phase 4: Modeling

- Model building
  - Selection of the modeling techniques is based upon the data mining objective
  - Modeling is an iterative process - different for supervised and unsupervised learning
  - May model for either description or prediction

Modeling

- Select Modeling Technique
- Generate Test Design
- Build Model
  - Capture parameters
- Assess Model
Types of Models

• Prediction Models for Predicting and Classifying
  – Regression algorithms (predict numeric outcome): neural networks, rule induction, CART (OLS regression, GLM)
  – Classification algorithm predict symbolic outcome): CHAID, C5.0 (discriminant analysis, logistic regression)

• Descriptive Models for Grouping and Finding Associations
  – Clustering/Grouping algorithms: K-means, Kohonen
  – Association algorithms: apriori, GRI

Modeling: Select Modeling Technique

• General task
• Specific tool
• Rationale
How to Choose a Data Mining System?

- Commercial data mining systems have little in common
  - Different data mining functionality or methodology
  - May even work with completely different kinds of data sets
- Need multiple dimensional view in selection
- Data types: relational, transactional, text, time sequence, spatial?
- System issues
  - running on only one or on several operating systems?
  - a client/server architecture?
  - Provide Web-based interfaces and allow XML data as input and/or output?

How to Choose a Data Mining System? (2)

- Data sources
  - ASCII text files, multiple relational data sources
  - support ODBC connections (OLE DB, JDBC)?
- Data mining functions and methodologies
  - One vs. multiple data mining functions
  - One vs. variety of methods per function
    - More data mining functions and methods per function provide the user with greater flexibility and analysis power
- Coupling with DB and/or data warehouse systems
  - Four forms of coupling: no coupling, loose coupling, semitight coupling, and tight coupling
    - Ideally, a data mining system should be tightly coupled with a database system
How to Choose a Data Mining System? (3)

- **Scalability**
  - Row (or database size) scalability
  - Column (or dimension) scalability
  - Curse of dimensionality: it is much more challenging to make a system column scalable that row scalable

- **Visualization tools**
  - “A picture is worth a thousand words”
  - Visualization categories: data visualization, mining result visualization, mining process visualization, and visual data mining

- **Data mining query language and graphical user interface**
  - Easy-to-use and high-quality graphical user interface
  - Essential for user-guided, highly interactive data mining

Modeling: Generate Test Design

- **What are the metrics?**
  - Success metrics
  - Confidence in that metric

- **What data is needed to reliably evaluate?**
  - Type
  - Test/validation/?
  - Quantity to satisfy requirements
Modeling: Assess Model

- How does it fair on success metrics?
- Domain expert analysis
  - Does it make sense?
- Rank models
  - What will help business objective?
- *Iterate modeling process*
  - Does this invalidate your success metrics?

Phase 5: Evaluation

- Model Evaluation
  - Evaluation of model: how well it performed on test data
  - Methods and criteria depend on model type:
    - e.g., coincidence matrix with classification models, mean error rate with regression models
  - Interpretation of model: important or not, easy or hard depends on algorithm
Evaluation

- Evaluate Results
- Review Process
  - Anything missed?
  - Quality assurance
  - Compliance
- Determine Next Steps

Evaluation: Evaluate Results

- Does model meet business objectives?
- Test on real applications
- Findings of interest that may not relate to business objectives
Phase 6: Deployment

- **Deployment**
  - Determine how the results need to be utilized
  - Who needs to use them?
  - How often do they need to be used
- **Deploy Data Mining results by:**
  - Scoring a database
  - Utilizing results as business rules
  - Interactive scoring on-line

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**Deployment**

- **Plan Deployment**
- **Plan Monitoring and Maintenance**
- **Produce Final Report**
  - Written report
    - Include (and update) previous deliverables
  - Presentation
- **Review Project**
  - Document experience
Deployment: Plan Deployment

This is where projects typically fail!

• Do outcomes fit within existing business processes?
  – If not, what does it take to change processes?
• What might go wrong?
  – Are contingency plans needed?
• Cost of Deployment

Deployment: Plan Monitoring and Maintenance

• Model update
  – Process to ensure correctness over time
• Are business objectives being satisfied?
• Unanticipated impacts?
Why CRISP-DM?

- The data mining process must be reliable and repeatable by people with little data mining skills
- CRISP-DM provides a uniform framework for
  - guidelines
  - experience documentation
- CRISP-DM is flexible to account for differences
  - Different business/agency problems
  - Different data