SAS® Modeling Best Practices

Using SAS® Enterprise Miner™

**Presenter:** Melodie Rush, Principal Data Scientist

**Q&A:** Twanda Baker, Data Scientist

**Host:** Dean Shaw, Global Webinar Strategist
Agenda

- Problem definition
- Supervised vs. unsupervised learning

- Best model for available data?
  - Modeling assumptions
  - Objective
  - Target data available?
- Choosing & transforming features

- Holdout & test samples
- Statistics
Scenario: The loan officers of the bank are trying to decide what rate to offer loan applicants.

Available Data:
- 1000 observations (past applicants)
- Information on attributes & behavior of past applicants
  - Ex: property, age, savings
- Label indicating “good” or “bad” candidates
  - Based on loan result (i.e. whether the applicant was able to pay the loan while adhering to the terms of service)
  - 70% good, 30% bad

Considerations:
- Offering a “good” applicant a more favorable rate will result in a 35% profit, while offering a “bad” applicant the same rate will result in a total unit loss
## Predicting Credit Risk

### Data Columns

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age_in_years</td>
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<td>Interval</td>
</tr>
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<td>Input</td>
<td>Interval</td>
</tr>
<tr>
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<td>Input</td>
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<tr>
<td>Creditability</td>
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<tr>
<td>Further_running_credits</td>
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<td>Installment_in___of_available_in</td>
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</table>
## Predicting Credit Risk

### Data

<table>
<thead>
<tr>
<th>Creditability</th>
<th>Occupation</th>
<th>Telephone</th>
<th>NewCar</th>
<th>Balance of current account</th>
<th>Duration in month</th>
<th>Payment of previous credits</th>
<th>Purpose of credit</th>
<th>Amount of credit in DM</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>bad</td>
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<td>2.960518</td>
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<td>no running account</td>
<td>36.0</td>
<td>no problems with current credits at this bank</td>
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<td>other</td>
<td>2070.0</td>
<td>less than 10</td>
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</tbody>
</table>
Business Purpose

Understanding your Objective
THE PREDICTIVE ANALYTICS LIFECYCLE

IDENTIFY / FORMULATE PROBLEM

BUSINESS MANAGER
Domain Expert
Makes Decisions
Evaluates Processes and ROI

DATA MINER / STATISTICIAN
Exploratory Analysis
Descriptive Segmentation
Predictive Modeling

IT SYSTEMS / MANAGEMENT
Model Validation
Model Deployment
Model Monitoring
Data Preparation

DATA EXPLORATION
BUILD MODEL
TRANSFORM & SELECT
VALIDATE MODEL
DEPLOY MODEL
DATA PREPARATION
MONITOR RESULTS
EVALUATE

BUSINESS ANALYST
Data Exploration
Data Visualization
Report Creation
Business Purpose

Common Questions to Ask

What is your objective about?

What are you trying to learn?

Are we trying to predict, classify, or describe something?
Business Purpose

Clients

Objectives

Criteria

Decision Makers

Problem Definition

- People or groups who benefit from the outcomes of the models
- Goals to be achieved that serve the interests of the clients
- Measures of success or failure
- People who influence the achievement of objectives
Business Purpose

Problem Definition

- Available time, labor, capital for development & deployment of model

Constraints

- Limitations

Critical Assumptions

- Implicit & explicit assumptions about the world or industry in which the model/project is being developed
# Modeling Best Practices Case Study

## Predicting Credit Risk

<table>
<thead>
<tr>
<th>Clients</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Loan officers</td>
<td></td>
</tr>
<tr>
<td>- Bank institution/organization</td>
<td></td>
</tr>
<tr>
<td>- IT available to deploy model?</td>
<td></td>
</tr>
<tr>
<td>- Type of system used</td>
<td></td>
</tr>
<tr>
<td>- Analysts &amp; programmers available to create and maintain model?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objective(s)</th>
<th>Criteria</th>
<th>Constraints</th>
<th>Critical Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Accurate classification of applicant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Maximum average profit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Initial: model evaluation statistics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Long term: profit derived from results</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Data limitations (availability, amount of observations)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- System limitations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Higher interest rate for riskier applicants prevents large loss of $</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Reward less risky applicants with more lower interest rates in effort to attract more favorable business</td>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Decision Makers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Chief Financial Officer (CFO)</td>
<td></td>
</tr>
<tr>
<td>- Chief Information Officer (CIO)</td>
<td></td>
</tr>
</tbody>
</table>

Clients

- Loan officers
- Bank institution/organization

Objective(s)

- Accurate classification of applicant
- Maximum average profit

Criteria

- Initial: model evaluation statistics
- Long term: profit derived from results

Constraints

- Data limitations (availability, amount of observations)
- System limitations

Critical Assumptions

- Higher interest rate for riskier applicants prevents large loss of $
- Reward less risky applicants with more lower interest rates in effort to attract more favorable business
Model Objective → Supervised vs. Unsupervised Learning?
Types of Learning

Supervised Learning

Trained on labeled examples
Types of Learning
Unsupervised Learning
Trained on unlabeled examples
## Common Questions Answered

- How much will prospect x spend?
- Will customer x default on her loan?

## Techniques

### Supervised Learning
- Involves classification or regression
- Random forests
- Decision trees
- Neural networks*
- Linear regression
- Logistic regression
- Support vector machines
- k-NN (k-nearest neighbors)
- Gradient boosting
- Ensembles

### Unsupervised Learning
- What items are commonly purchased together?
- What other companies are like our best small business customers?
- What does normal behavior look like?
- Do my customers form natural groups?

*Can be used as an unsupervised learning technique as well*
Data Understanding
Choosing the Best Technique
THE PREDICTIVE Analytics LIFECYCLE

DATA PREPARATION
- Identify/ Formulate Problem
- Evaluate/ Monitor Results
- Deploy Model

DATA EXPLORATION
- Build Model
- Transform & Select
- Validate Model

BUSINESS MANAGER
- Domain Expert
- Makes Decisions
- Evaluates Processes and ROI

BUSINESS ANALYST
- Data Exploration
- Data Visualization
- Report Creation

IT SYSTEMS / MANAGEMENT
- Model Validation
- Model Deployment
- Model Monitoring
- Data Preparation

DATA MINER / STATISTICIAN
- Exploratory Analysis
- Descriptive Segmentation
- Predictive Modeling
Does my objective require supervised techniques?

Yes

No

Not sure

Is there a specific, quantifiable target I am interested in or trying to predict?

No

Yes

No

Supervised Learning

Unsupervised Learning

Do I have data on this target?

Yes

No

Note: Quantifiable targets do not seek to answer things like whether my customers fall into natural groups, that is an unsupervised task.

Note: Try to obtain data for same or related phenomenon to perform supervised tasks.
Modeling Best Practices Case Study
Predicting Credit Risk

- Is there a specific, quantifiable target I am interested in or trying to predict?
  - Yes → we are interested in the credit risk of loan applicants (either “bad” or “good”)

- What question am I seeking to answer?
  - Does applicant X have “good” or “bad” credit?

- Do I have data on the target?
  - Yes → 1000 observations of previous applicants & resulting behavior (labels that indicate as “good” or “bad”)

Supervised Learning
Supervised Learning Techniques
Data Understanding
Supervised Learning ➔ Classification or Regression?

• Classification ➔ categorical target
  • Target has discrete, NON-ordinal values
  • Most common case = binary classification
  • Probability estimation or ranking
    - Exception wherein classification model predicts continuous values such as probabilities or ranks/scores
    - Probability estimation ➔ model predicts a score b/w 0 & 1 for each available class
      - Use: cost or benefit is known relatively precisely & may not be constant across instances
    - Ranking ➔ model predicts a score wherein a higher score indicates higher likelihood of being in given class (in case of binary classification)
      - Use: cost or benefit is constant across instances & is unknown or difficult to calculate

• Regression ➔ numeric target
Data Understanding
Decision Tree vs. Linear Models

• Questions to Consider:
  • What is more comprehensible to stakeholders? Rules or a numeric function?
  • How “smooth” is the underlying phenomenon being modeled?
  • How “non-linear” is the underlying phenomenon being modeled?
  • How much data do you have?
  • What are the characteristics of the data?
Data Understanding

When to apply Machine Learning?

Questions to Consider:

• How large is your data set?
  - Speaks to scalability → may be easy to classify a few hundred emails as spam or not but this problem becomes more tedious & difficult as the size of the emails increases to the millions

• How easily can you outline the underlying phenomenon?
  - Large # of factors could influence answer to specific classification or prediction problem
  - Rules overlap or need to be finely tuned
  - Ex: classify email as spam or not
    - What constitutes spam?
    - What affects whether an email is spam?
    - Is this specific to the person or organization?
Unsupervised Learning Techniques
Unsupervised learning techniques can be used in conjunction with supervised techniques in an effort to improve model performance. Additionally, it can be used on its own when there is a lack of target data.

- Observation or Variable Clustering
  - Obs. clustering provides description of data (ex: do your consumers fall naturally in to specific groups? \(\rightarrow\) regionally, financially, etc.)
  - Variable clustering reduces # of variables for use in supervised modeling technique \(\rightarrow\) improves performance by minimizing modeling complexity

- Additional dimension reduction techniques
Unsupervised learning techniques can be used in conjunction with supervised techniques in an effort to improve model performance. Additionally, it can be used on its own when there is a lack of target data.

• Identifies items, events or observations which do not conform to an expected pattern or other items in dataset → descriptive

• Analyzing data from more than one variable
• ANOVA or MANOVA
  • ANOVA tests for difference in means b/w 2 or more groups
  • MANOVA tests for difference in 2 or more vectors of means
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TRANSFORM & SELECT
Transforming & Selecting Variables

• Reasons to transform
  • Force variable distribution to be normal
  • Standardize all inputs to make sure all are on same scale
  • Remove bias

• Methods
  • Nominal → dummy indicators, group rare levels
  • Interval → bucket, center, equalize, exponential, inverse, log, optimal binning, quantile, square, square root, standardize (normalize)
Transforming & Selecting Variables

• Transform variables
  • Modeling assumptions → for models such as linear regression, there are certain assumptions that need to be met to ensure the accuracy of the model
    - Linearity, normality, heteroscedasticity
    - Adherence to assumptions looser for logistic regression
  • Normality assumes all inputs have normal distribution (skewed distribution can be normalized by applying log transformation, exponential)
Transforming & Selecting Variables

• Selecting variables
  • Many modeling methods choose inputs as a part of the building process
  • Linear or logistic regression employs stepwise, backward or forward selection (can also choose to just include all available inputs)

• Tree models
  - Decision → builds tree based on variable importance
  - Random forests → builds multiple trees, each with different sampling of observations & inputs

• Prior to applying model
  - Chi square or R square
  - LASSO or LAR
  - Unsupervised → correlation, covariance, sum of squares or cross product
Predicting Credit Risk Case Study
Applying Techniques in Enterprise Miner™
Modeling & Evaluation

Meeting your Objective
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VALIDATE MODEL

BUILD MODEL

DEPLOY MODEL

IDENTIFY / FORMULATE PROBLEM

EVALUATE / MONITOR RESULTS

DATA PREPARATION

DATA EXPLORATION

TRANSFORM & SELECT

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Modeling & Evaluation
Measuring Accuracy

• Partition data
  • Train, validate & test (holdout) samples
  • Validate normally used to choose model (technique, features, complexity parameters) while test confirms accuracy
  • 40-30-30 split is default
• Additional technique → cross validation
  - Randomly partition data into k folds, run training/test evaluation k times
• Be aware of overfitting or underfitting
  - Validation set helps to prevent overfitting
  - Overfitting → model fits data well but is not generalizable
Modeling & Evaluation
Measuring Accuracy

- **Fit statistics**
  - Depends on many factors including objective & available information
  - Regression → Average square error
  - Classification
    - Misclassification/error rate = percentage of incorrect classifications
    - Confusion matrix
      - True positive rate (sensitivity or recall) = \( \frac{a}{a+c} \)
      - True negative rate (specificity) = \( \frac{d}{b+d} \)
      - Positive predictive value (precision) = \( \frac{a}{a+b} \)
Classifier Evaluation

**Business Costs & Benefits**

- Taking into account business objective
- Example:
  - Objective $\rightarrow$ maximize profit
  - Target $\rightarrow$ binary, yes or no
  - Need to combine accurate classification with profit & losses
Modeling & Evaluation
Measuring Accuracy

• Visual evaluation
  • Works for both classification & regression models
    - ROC chart, AUC (area under ROC curve)
      - For classifier, gives probability that model will rank a positive case higher than negative case
      - Fair measure of quality of probability estimates
    - Lift chart
      - Measures effectiveness of predictive model calculated as ratio b/w results obtained w/ & w/o predictive model
Predicting Credit Risk Case Study
Applying Techniques in Enterprise Miner™
Summary

• Business objective & available data is key to choosing the best model
• Modeling is cyclical
  • Questions to consider along the way are helpful in determining what methodologies to apply but you may have to make changes or tweak things along the way as you learn more about your data & the underlying phenomenon
• Try multiple methodologies to obtain the best possible model
  • Enterprise Miner™ is especially good for this (can easily evaluate multiple models at once)
  • EM™ is also good at making quick changes that will affect the rest of the process
Resources

Where to learn more
Ready to Get on the Fast Track with Enterprise Miner?

Visit sas.com/learn-em and sign up to receive EM technical resources, tips & tricks delivered directly from Brett Wujek, Sr. Data Scientist from SAS R&D
Further Reading

Papers

• **Identifying and Overcoming Common Data Mining Mistakes** by Doug Wielenga, SAS Institute Inc., Cary, NC

• **Best Practices for Managing Predictive Models in a Production Environment** by Robert Chu, David Duling, Wayne Thompson, SAS Institute Cary, NC

• **From Soup to Nuts: Practices in Data Management for Analytical Performance** by David Duling, Howard Plemmons, Nancy Rausch, SAS Institute Cary, NC

• (All available on [support.sas.com](http://support.sas.com))
Resources
Suggested Reading

Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners
By Jared Dean

Available on Amazon

Data Mining Techniques: For Marketing, Sales, and Customer Relationship Management
by Gordon S. Linoff and Michael J. A. Berry

Available on Amazon
Resources
Suggested Reading

By Kattamuri S. Sarma, PhD
Available on Amazon

Applied Analytics Using SAS Enterprise Miner
By: SAS
Available on Amazon
Questions?

Thank you for your time and attention!

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