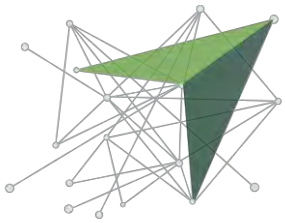
CLAIM ANALYTICS | Smarter decisions

Text Mining: Approaches and Applications
Claim Severity Case Study
2011 SOA Health Meeting
Session 61



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Agenda

- Text Mining for Health Insurers
- Case Study
  - Overview
  - Text Mining
  - Results
- Questions

Text Mining For Health Insurers

Text Mining for Health Insurance

- **Risk Measurement**
  - Underwriting
  - Pricing
- **Claims Management**
  - Fraud detection
  - Claim approval
  - Case management

Sources of Text

- **Application Process**
  - Application for insurance
  - Attending physician statements
  - Call center logs
- **Post Claim**
  - Claim application
  - Attending physician statements
  - Adjuster notes
  - Call center logs
  - Other correspondence

Why Use Text Mining?

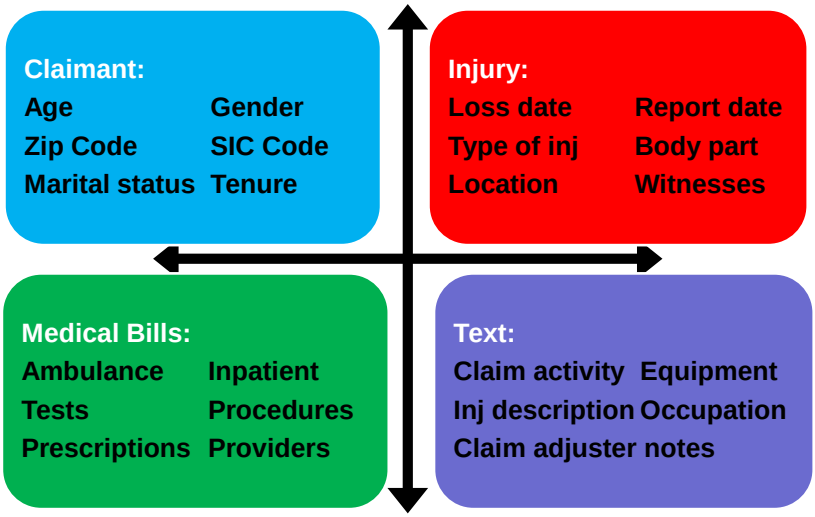
- **May contain information not available in structured data fields**
- **May contain subjective data (eg, expert opinions)**
- **May be an early indicator of severity**
  - Lags in receiving treatment
  - Lags in receiving and processing bills

Case Study Overview

Project Overview

- **Workers compensation business**
- **Medical only claims**
- **15 days from First Notice on Loss (FNOL)**
- **For each claim predict likelihood that Total Claim Cost will exceed a specified threshold**

Data Sources



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Case Study
Text Mining

Modeling Approach

1. **Exploratory stage:**
   a. Train models without any text mining
   b. Train models exclusively with text mining
2. **Intermediate stage:**
   a. Apply text mining to predict residuals of non-text model
3. **Final model:**
   a. Combine text and non-text predictors using the findings from Steps 1a and 2a

Text Mining Considerations

1. **Word frequencies**
2. **Stemming**
3. **Exclusion list**
4. **Phrases**
5. **Synonyms**
6. **Negatives**
7. **Singular value decomposition**

1. Word Frequencies

- **Text mining for predictive modeling:**
  - Identify words or phrases that occur frequently within the text
  - Test to see if any of these words or phrases are predictive of the event being modeled
  - Typically limit analysis to words whose frequency in the text exceeds a minimum amount (eg, is contained in at least 3% of all records)

Word Frequency Example

Word	% of Records
Employee	62.3%
Doctor	47.8%
Back	23.0%
Hand	17.2%
Contact	14.1%
Pay	11.8%
Lift	8.7%
Pain	7.6%
Strain	5.5%
Visit	4.2%
Clinic	3.4%

2. Stemming

- **Reduce words to their roots so that related words are treated as the same**
- **For example:**
  - ***Investigate***, ***investigated***, ***investigation***, ***investigator***
  - Can all be stemmed to ***investigat*** and treated as the same word

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3. Exclusion List

- **Common words that carry little meaning can be defined and excluded from the text mining analysis**
- **For example: *the*, *of*, *and* are unlikely to provide predictive value**

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4. Phrases

- **Common phrases may be pre-specified by the user to consider as one string**
  - Eg, ***lower back***, ***lost time***
- ***N-grams*: count frequency of every combination of *N* consecutive words**
  - May be more effective to identify groups of words that appear together frequently even if not consecutively

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5. Synonyms

- **Words with the same meaning can be considered as the same**
  - Eg, ***doctor***, ***dr***, ***physician***, ***gp***
  - Eg, ***acetaminophen***, ***Tylenol***, ***APAP***
  - Eg, ***return to work***, ***rtw***

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6. Negatives

- **Should negatives be isolated?**
  - Eg, ***no pain*** vs ***pain***
- **Negatives may be difficult to identify:**
  - ***MRI not required, no MRI required, does not need an MRI, no need for an MRI***
- **The mention of a negative may imply concern**
- **In this case study, negatives provided small amount of lift but not isolated for final model due to practical considerations**

7. Singular Value Decomposition

- **Similar to Principal Components Analysis**
- **Convert a vector of word counts into lower dimension while maximizing retention of info**
- **In essence, a numeric summary of the observed word frequencies for a record**
- **Drawback is lack of interpretability of results**
  - End users may wish to understand which word is driving the risk assessment

Word Frequencies by Record

Record	$Word_1$	$Word_2$	$Word_{50}$	$Word_{100}$	$Word_{200}$	$Word_k$
100001	1	0	0	0	1	0
100002	0	1	1	0	0	0
100003	0	0	0	1	0	1
100004	0	0	0	1	1	0
100005	1	0	0	0	0	0
100006	0	1	0	0	0	0
100007	1	0	1	0	0	0
100008	0	0	1	0	0	0
100009	0	0	0	0	1	1

Singular Value Decomposition

Record	Val_1	Val_2
100001	0.87	0.82
100002	0.62	-0.55
100003	-0.15	0.15
100004	0.01	0.91
100005	-0.67	-0.42
100006	0.34	0.44
100007	-0.77	-0.15
100008	0.22	0.33
100009	0.44	-0.74

SVD compresses k-dimensions (one per each word) to lower dimensionality (eg, 1, 2 or 3)

The compression algorithm maximizes the information retained

Each new dimension is a linear combination of the original k-dimensions

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Predicting Outcomes with Text

- **Predictor variables are the word frequencies**
  - Or binary variables indicating presence of word
- **May be several hundreds or thousands of these**
- **Select a subset to include in final model**
  - Univariate analysis
  - CART
  - Stepwise regression

Stepwise Regression

- **Backward stepwise regression:**
  - Build regression model with all variables
  - Remove the one var that results in least loss of fit
  - Continue until marginal decrease in fit > threshold
- **Forward stepwise regression:**
  - Build regression model with one var with best fit
  - Add the one variable that results in most lift
  - Continue until marginal increase in lift < threshold

Case Study Results

Text Mining: Phrases Selected

	Combined	Text Only
# Total Phrases	9	15
# Phrases: Claims Mgmt Action	5	6
# Phrases: Medical Procedures	2	2
# Phrases: Injury Type	1	4
# Phrases: Type of Medical Provider	1	2
# Phrases: Time reference	0	1

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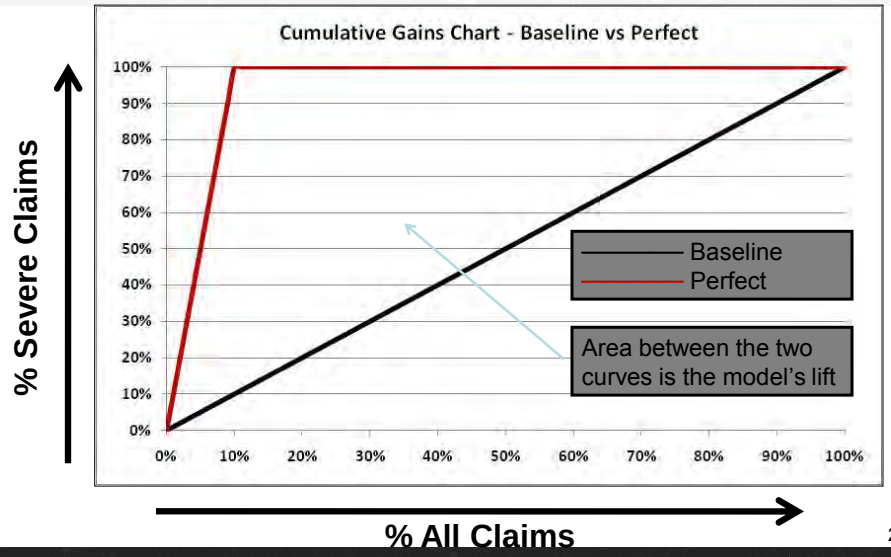
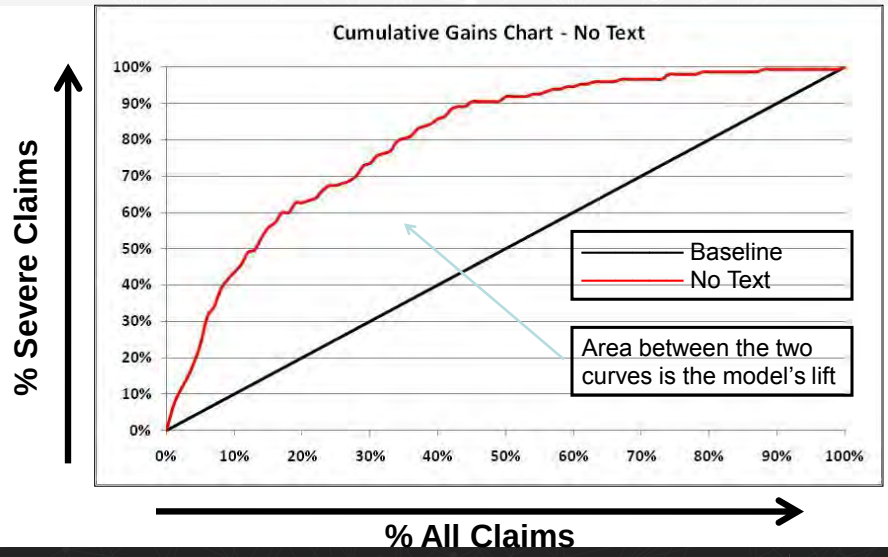
Model Evaluation

- **Measuring goodness of fit should be performed on out-of-sample data**
  - Protects against overfit and ensures model is robust
  - For this project, 10% of data was held back
- **Measures for comparing goodness of fit include:**
  - Gains or lift charts
  - Squared error

Cumulative Gains Chart - Baseline



Cumulative Gains Chart – No Text



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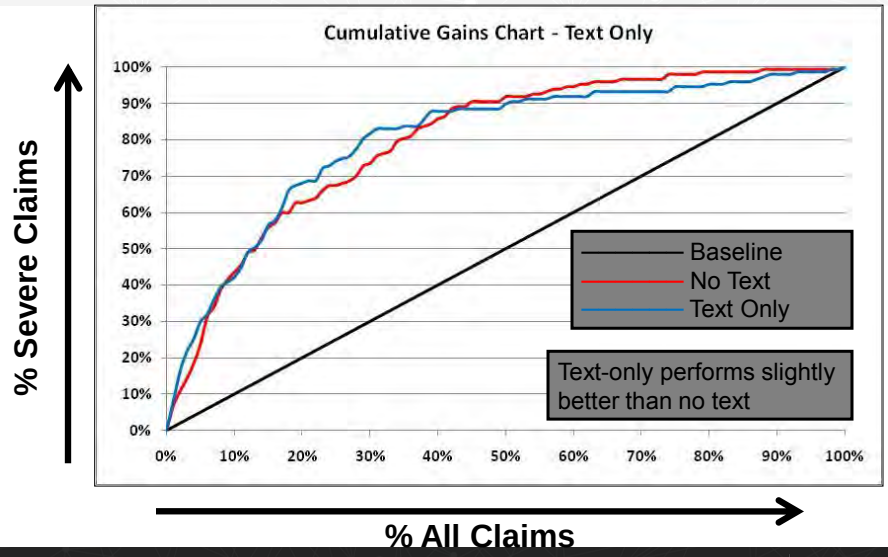
Cumulative Gains Chart – Text Only



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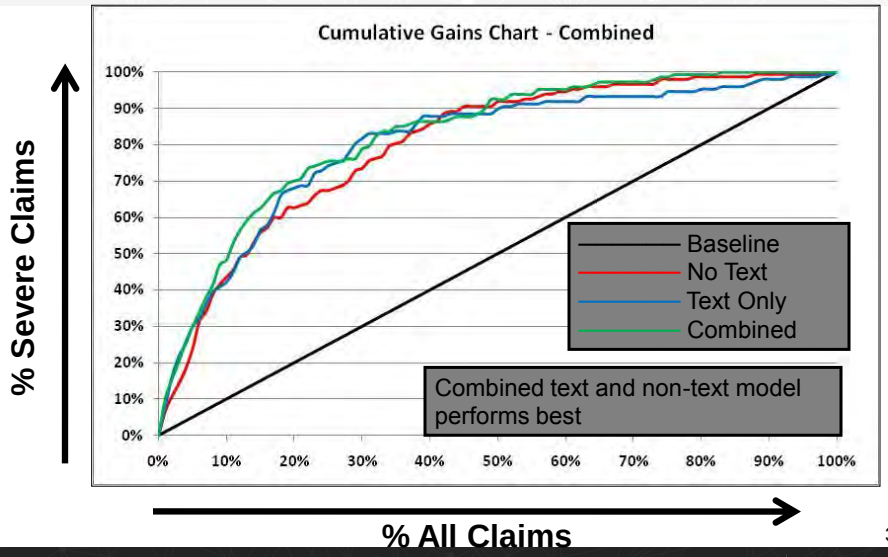
Cumulative Gains Chart – Combined



Case Study Findings

- **Text-only model slightly better than model without text**
- **Combined (text and non-text) model performs best**
- **Analyzing text can be simpler than summarizing medical bill transaction data**
- **Text mining is easy to interpret: certain words or phrases are correlated with higher or lower risk**
- **Text mining may provide extra lift for less experienced modelers**
  - Adding additional strong predictors may compensate for other modeling deficiencies

Questions