Business Intelligence
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Text Mining

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Content

- Introduction and Terminology
- Data Preparation and Modelling
- Descriptive Analysis of the DTM
- Analysis of a Text Corpus
- Topic Models
- Further Aspects of Text Mining

Introduction and Terminology, Data

- Text documents may be of different origin
  - Reports, abstracts, journal articles, blogs, tweets, email,…
- There are many different formats
  - .txt, .pdf, .doc, html, xml,…

Introduction and Terminology, Approaches

- Two different views:
  - Metadata view: a description of the document
    - There exist a number of standards for describing resources
    - One popular standard is the Dublin Core Metadata Initiative (DCMI): http://dublincore.org/

Introduction and Terminology, Approaches

- Example for Metadata using R:

  author : Rinderle-Ma, Grossmann

  datetimestamp: 2014-09-28 08:09:19

  description : Brief Task description

  heading : 1.3.5 Evaluation and Reporting Task

  id : 11

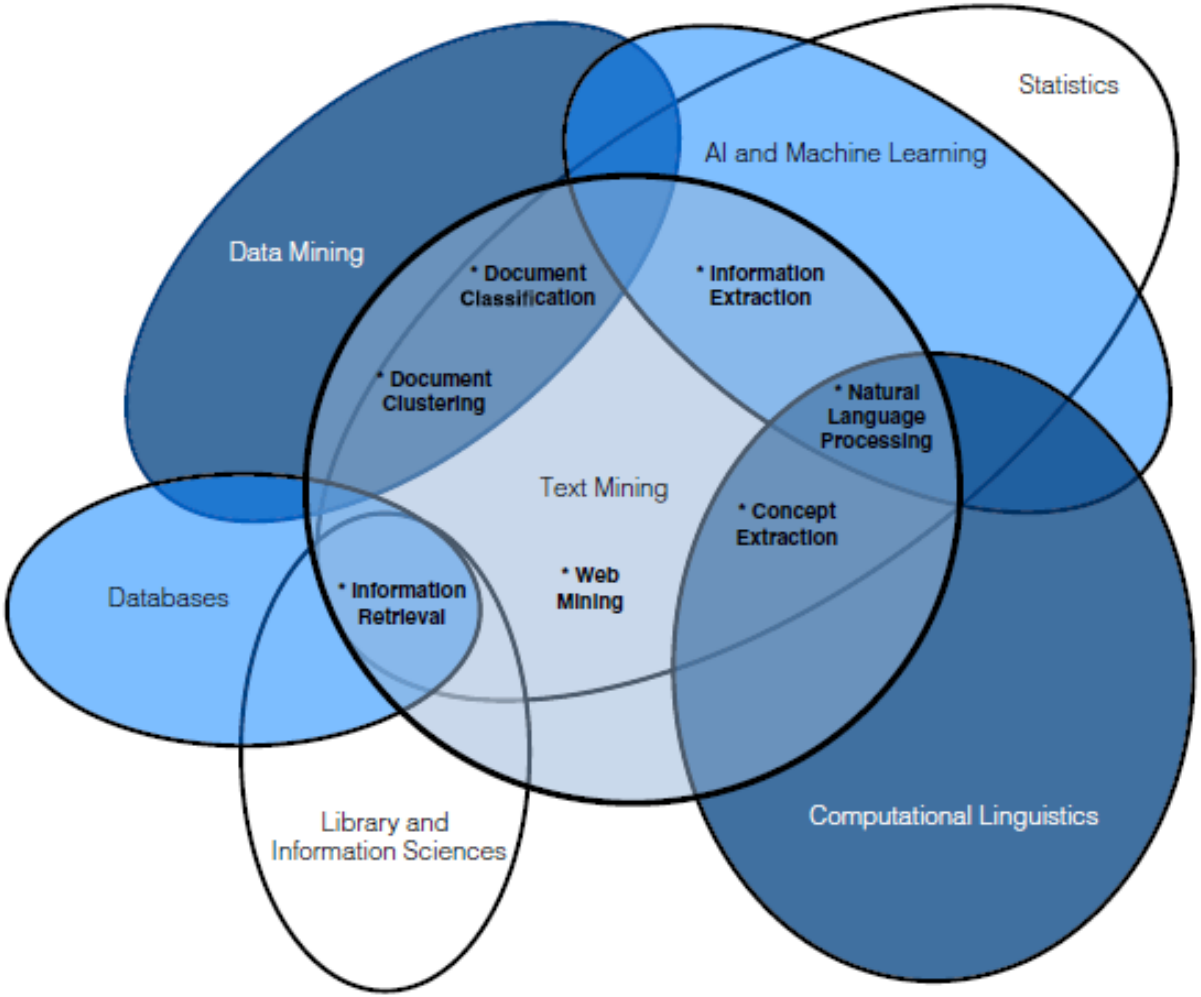
  language : en

  origin : Fundamentals of Business Intelligence V1.0Text Mining (Text Analytics view)

Introduction and Terminology, Approaches

- Text analytics combines knowledge and techniques from different areas as shown in the graphic (Miner et al. Practical Text Mining, Elsevier (2012))

Introduction and Terminology, Approaches



Introduction and Terminology, Levels of Text Mining

- Text Mining can be done at different levels
  - Word level
  - Sentence level
  - Document level
  - Corpus level = Collection of documents
- A Document can be defined in different ways:
  - Sections of a document, paragraphs in text, …
  - A tweet, an email,…

Introduction and Terminology, Analytical Goals

We will focus on the analysis of a corpus

Analytical Goals in Text Mining

- Descriptive Goals: Description of the contents of the documents in a corpus based on properties of word frequencies in the documents.
- Understanding goals: Find clusters of documents which are similar with respect to content identify the topics in these groups.

Introduction and Terminology, Methodology

Template: Text Mining for a Corpus

- **Relevant Business and Data:** A text corpus defined by a collection of text documents
- **Analytical Goals:**
  - Description of the documents in the corpus
  - Clustering the documents in the corpus
  - Finding topics of the corpus
- **Modeling Task:** Definition of the document term matrix by appropriate data preparation steps
- **Analysis task:**
  - *Description of Corpus:* Determination of type-token relation and association measures; visualization of the content in the corpus using word clouds and correlation plots.
  - *Clustering documents:* Use cluster analysis methods of chapter 5 for cluster the documents based on the document term matrix.
  - *Topic Models:* Define a number of topics and find the probability of assignment of the documents to the topics.
- **Evaluation and Reporting Task:** Represent the results of the analysis by word clouds, by correlation plots and by characterization of the topics with terms.

Data Preparation and Modeling, Transformations

- Usually not the original text is used for text mining but a transformed (purged) text
- Basic standard transformations
  - Removal operations (punctuation, numbers, special characters (@, /,…), email address,
  - White space operations
  - Lower case letters
  - Stop words (articles, prepositions,…)
  - Stemming (words without endings)

Data Preparation and Modeling, Transformations

- Example sentence
  - Its main goals are the interpretation of the results in reference to domain knowledge and coming to a decision of how to proceed further.
- Transformed sentence
  - main goals interpretation results reference domain knowledg coming decision proceed

Data Preparation and Modeling, Document Term Matrix

- After the transformations the corpus consists of a number of documents with preprocessed terms
- These terms are organized in a list of tokens and the frequency of the tokens obtained by tokenization
  - A token is defined by a n-gram = n contiguous words in the document, usually 1-grams (one term) or bigrams (2 words)

Data Preparation and Modeling, Document Term Matrix

- The basic unit for analysis is the

  document term matrix (DTM)

$$DTM = (t_{ij}), \quad i = 1,...,d, \; j = 1,....,n$$

$$t_{ij} = \textit{frequency of term } j \textit{ in document } i$$

- Sometimes also the transposed matrix is used and called TDM (term document matrix)
- Other name for the DTM: Bag of words

Data Preparation and Modeling, Document Term Matrix

- An alternative to the DTM is often to replace the frequency simply by an indicator

$$DTMI = (d_{ij}), \quad i = 1,...,d, \; j = 1,....,n$$

$$d_{ij} = \begin{cases} 1 & if \; term \; j \; occurs \; in \; document \; i \\ 0 & otherwise \end{cases}$$

Data Preparation and Modeling, Document Term Matrix

- Usually the DTM has many columns and contains many terms with low frequency
- General assumption:
  - Frequency of a term informs about the importance of the term for the contents
  - There are terms occurring frequently due to linguistic reasons, for example verbs like “have”, “is”, etc.

Data Preparation and Modeling, Document Term Matrix

- Solution of the problem:
  - Define upper and lower thresholds for the terms
  - Use instead of the DTM the TF-IDF = Term frequency – inverse document frequency matrix
- Inverse document frequency (IDF) = Number of documents divided by the frequency of the documents which contain the term
  - Reduces the importance of terms which occur in many documents

Data Preparation and Modeling, Document Term Matrix

- Formulas:

$$D = \{d_1, d_2, \ldots\}\ Documents$$

$$W = \{w_1, w_2, \ldots\}\ Words$$

$$IDF_{ij} = \frac{|D|}{1 + DF_{ij}}, \quad DF_{ij} = card\{d_i : w_j \in d_i\}$$

$$TF - IDF_{ij} = t_{ij} * \log(IDF_{ij})$$

- TF-IDF is of special interest for key-words differentiating between documents

Descriptive Analysis of the DTM, Word Clouds

- A useful representation of a DTM is using a word cloud
  - Representation of the terms in the DTM with size according to the frequency of the terms
  - Usually the most frequent terms are in the center
  - Terms can be also rotated and colored

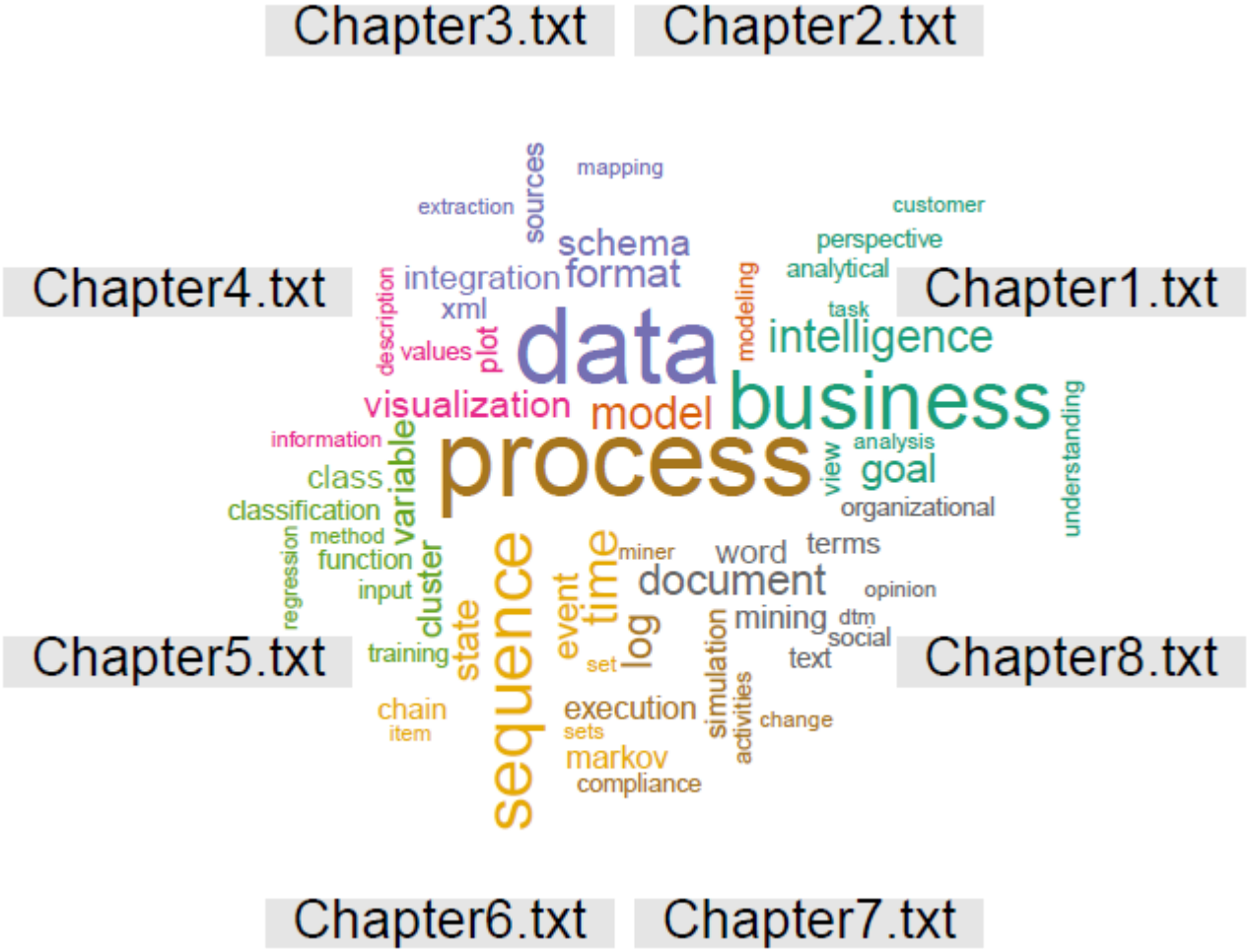
Descriptive Analysis of the DTM, Word Clouds

- Example of a word cloud

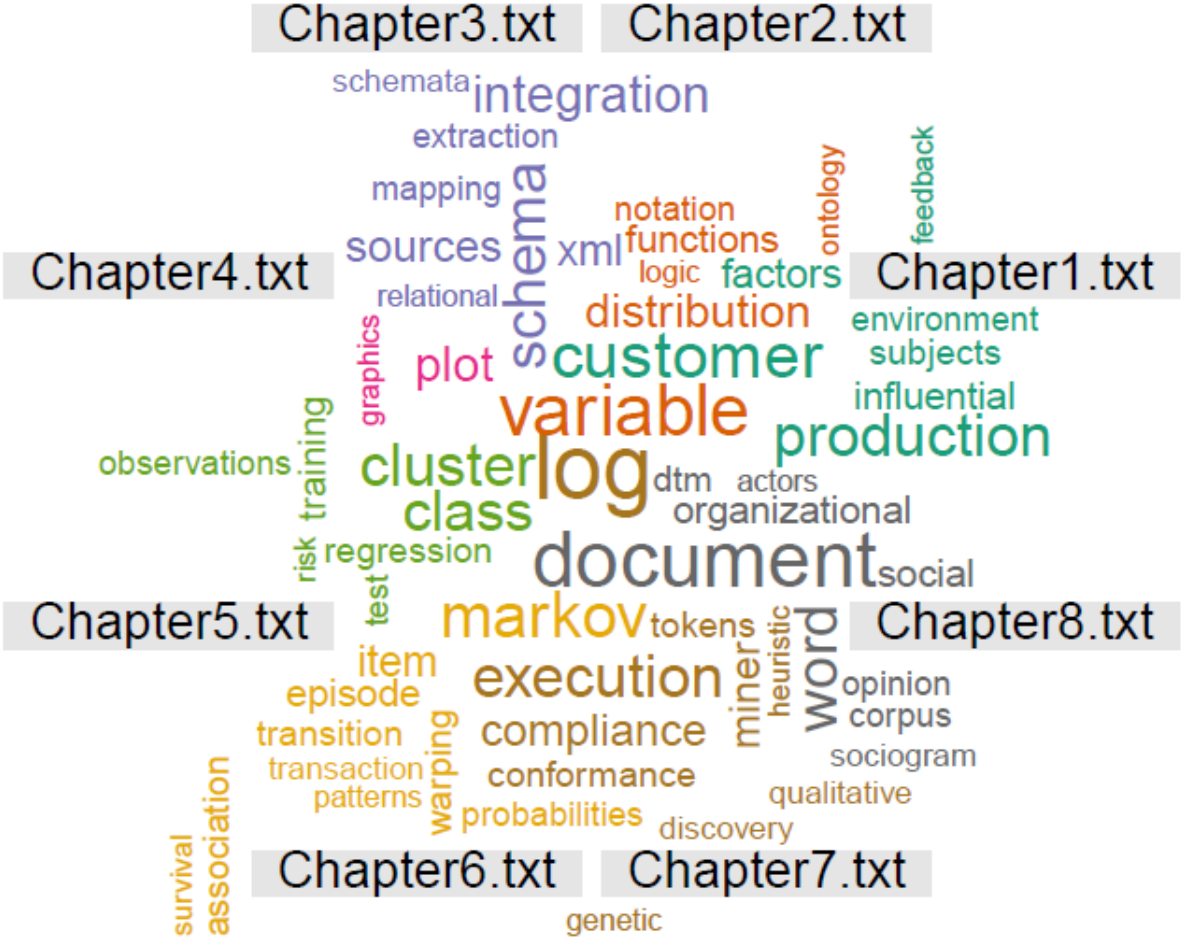
Descriptive Analysis of the DTM, Word Clouds

- For comparison of documents a comparison cloud is a useful tool
  - The documents are organized in an outer circle in the graphic
  - Terms are shown with size according to their frequency and are positioned according to their occurrence in the documents

Descriptive Analysis of the DTM, Comparison Cloud for terms



Descriptive Analysis of the DTM, Comparison Cloud for TF-IDF



Descriptive Analysis of the DTM, Associations between terms

- Another way to describe the contents of a the document is to use correlation between the term frequencies in the different documents
- One can use also the indicator matrix for such associations

Descriptive Analysis of the DTM, Associations between terms

- Example of association above 0.7 for the term “busi”:

Intellig	new	understand	aspect
0.76	0.76	0.72	0.71

Analysis of a Text Corpus, Clustering

- Cluster analysis of text data is based on the definition of similarities between documents
- For definition of the similarity the most popular measure is the cosine measure of the term frequencies in the documents

$$sim(d_i, d_j) = \frac{t_{i\bullet} \cdot t_{j\bullet}}{\|t_{i\bullet}\| \cdot \|t_{j\bullet}\|}$$

$$t_{i\bullet} = \textit{frequency vector of terms in document } i$$

Analysis of a Text Corpus, Clustering

- Based on this distance one can apply any cluster analysis algorithm (hierarchical or k-means)
- Many other methods have been proposed
  - Co-Clustering:
    - Interpret the DTM as a bipartite graph: Terms and documents
    - Partition the two sets in such a way that the edges between different clusters are minimized

Analysis of a Text Corpus, Classification

- Classification of documents can be done by interpretation of the terms as variables (features) describing the documents
  - Hence the DTM is a classical feature matrix for the documents and we can apply any classification algorithm
  - Frequently the indicator version DTMI is used instead of the DTM
  - Classical application: Spam detection in emails