Open Source Text Mining Tools and Libraries

Companion to the ESEC/FSE 2011 technical briefing on “Management of Unstructured Information during Software Evolution: Applications of Text Retrieval”
Lucene

http://lucene.apache.org

- High-performance, full-featured text search engine library
- Written entirely in Java
- Based on the Vector Space Model and the Boolean Model in IR
- Comes with a set of basic applications, which can be used as-is or modified by users
- Contains functionality for:
  - **Document processing**: stop-words removal, stemming, tokenization, etc.
  - **Indexing**
  - **Searching**
Supports the indexing and searching of several *fields* for each document (e.g., “title”, “contents”, etc.)

Accepts several types of queries:
- **Term query** (e.g., buffer edit)
- **Phrase query** (e.g., “buffer edit”)
- **Boolean query** (e.g., buffer AND edit OR modify)
- **Wildcard query** (e.g., te?t, test*, te*t)
- **Range query** (e.g., date: [20020101 TO 20030101)
- **Fuzzy query** - uses the Levenshtein Distance between strings (e.g., roam~ searches for terms similar to roam, like “roam”, “foam”)
- **Proximity query** – finds terms within a specific distance away (e.g., “jakarta apache”~10 searches for a “apache” and “jakarta” within 10 terms of each other in a document)
Other Lucene Implementations
http://lucene.apache.org

• There are also implementations of Lucene in many other programming languages:
  – **CLucene** - implementation in C++
  – **Lucene.Net** - implementation in .NET
  – **Lucene4c** - implementation in C
  – **Zend Search** - implementation in the Zend Framework for PHP 5
  – **Plucene** and **KinoSearch** - implementations in Perl
  – **PyLucene** - GCJ-compiled version of Java Lucene integrated with Python
  – **MUTIS** - implementation in Delphi
  – **Ferret** - implementation in Ruby
  – **Montezuma** - implementation in Common Lisp
jLSI
http://tcc.itc.it/research/textec/tools-resources/jlsi.html

• An open source Java tool for Latent Semantic Indexing

• Requires the following linguistic processing to be performed before its usage:
  – Tokenization
  – Sentence splitting
  – Part-of-speech tagging (optional)
  – Lemmatization (optional)
The Semantic Engine [http://knowledgesearch.org/]

- A C++ library that implements IR indexing and retrieval
- Uses mathematical algorithms based on graph theory to index the *latent semantic* content of documents
- A semantic graph of a text collection is created which can be used to find relevant documents that may not contain any keyword matches
- **Document processing** functionality: tokenization, POS tagging, stemming, stopwords removal
The Semantic Vectors Package
http://code.google.com/p/semanticvectors

• Support for indexing and retrieval of documents by applying a Random Projection algorithm to term-document matrices created using Apache Lucene

• The Random Projection algorithm is a form of automatic semantic analysis, similar to Latent Semantic Analysis (LSA) and Probabilistic Latent Semantic Analysis (PLSA)

• Very scalable, does not rely on the use of Singular Value Decomposition (SVD), even though it achieves a performance comparable with LSI
The Lemur Toolkit
http://www.lemurproject.org

- Supports the construction of basic text retrieval systems using language modeling, VSM, LSI, probabilistic model
- Interactive applications for Windows, Linux, and Web
- Cross-platform, fast and modular code written in C++
- APIs available for C++, Java, and C#
- Many sample applications, including information retrieval and document clustering applications
- In use for over 6 years by a large user community
Features of Lemur [http://www.lemurproject.org]

- **Document processing**
  - Tokenization
  - Porter and Krovetz word stemming
  - Stopwords removal
  - Acronym recognition
  - Token-level properties: part of speech, named entities

- **Indexing**
  - Incremental indexing
  - Out-of-the-box indexing support for plain text, HTML, XML, PDF, MBox, Microsoft Word, Microsoft PowerPoint, etc.
Features of Lemur (2) http://www.lemurproject.org

• Retrieval
  – Various retrieval models: language modeling approaches, VSM, LSI, tf-idf, Okapi and InQuery
  – Support for relevance feedback
  – Accepts term, phrase, and wildcard queries, as well as queries specified in a structured query language
  – Supports arbitrary document priors (e.g., Page Rank, URL depth)

• Summarization
  – Basic applications for the summarization of documents
Features of Lemur (3) [http://www.lemurproject.org]

• **Document Clustering**
  – Cosine similarity in the VSM as similarity measure for most clustering algorithms
  – Agglomerative and centroid clustering
  – Several clustering algorithms, including K-means and PLSA

• **Evaluation**
  – Applications for evaluating various IR techniques
  – The documents need to be in TREC format
Terrier IR Platform

- Open source search engine
- Deployable on large-scale collections of documents
- Implemented in Java
- Available as a desktop application, JSP web interface, and API
- Large user-base over 6 years of public release

http://terrier.org
Features of Terrier

• **Document processing**
  – Tokenizer
  – Various stemmers, including the Snowball and Porter stemmers
  – Stopwords remover
  – Acronym expander

• **Indexing**
  – Several indexing strategies
  – Indexing support for text, HTML, PDF, Microsoft Word, Excel, PowerPoint, and TREC collections
  – Indexing of field information (e.g., frequency of terms in the field TITLE)
  – Indexing of position information on a word, or a block
  – Support for fetching files to index by HTTP
Features of Terrier (2)  http://terrier.org

• Retrieval
  – Desktop, command-line and Web based querying interfaces
  – Many document weighting models, including 126 Divergence From Randomness (DFR) ranking models, Okapi BM25, language modeling, and TF-IDF
  – Query expansion facilities by pseudo-relevance feedback
  – Advanced query language that supports boolean operators, +/- operators, phrase and proximity search, and search on fields

• Evaluation
  – Application for evaluating results of TREC tasks
The Dragon Toolkit
http://dragon.ischool.drexel.edu

• Java development package for Text Mining
• Includes tools for text retrieval, classification, clustering, summarization, and topic modeling
• Integrates a set of NLP tools
• Various document representations including words, phrases, ontology-based concepts and relationships
• Very scalable, especially designed for large-scale application
Features of Dragon
http://dragon.ischool.drexel.edu

• **Document processing**
  - Tokenizers and phrase extractors
  - Part-of-speech tagger
  - Porter Stemmer
  - English lemmatizer
  - Named entity recognizer
  - Various taggers
  - Support for ontology extraction and building

• **Indexing**
  – Supports indexing at the sentence level and sequence level
Features of Dragon (2)
http://dragon.ischool.drexel.edu

• Retrieval
  – Supports retrieval based on language modeling methods as well as traditional probabilistic and vector space models
  – Various relevance feedback approaches: Minimum divergence feedback, Rocchio feedback, etc.

• Classification
  – Various classifiers: Naïve Bayes, Semantic Naïve Bayes, Nigam active learning, SVM

• Clustering
  – Various clustering algorithms: Hierarchical clustering, K-means, and Link-based K-Means
• **Summarization**
  – Supports generic multi-document summarization
  – Summarizer based on graph-based lexical centrality

• **Topic modeling**
  – Implements three state-of-the-art topic models: the aspect model, the LDA model, and the simple mixture model

• **Evaluation**
  – Provides an evaluation program for each text mining tasks including text retrieval, classification, clustering and summarization
Xapian  http://xapian.org/

- An open source search engine library
- Written in C++
- Bindings to allow use from PHP, Perl, Python, C#, Ruby.
- Supports the Probabilistic Information Retrieval model (Okapi BM25) and also a rich set of boolean query operators
- Besides the library, there are also a number of small example programs, and a larger application for indexing and search (Omega)
Features of Xapian

• **Document processing**
  – Tokenizer
  – Stemmers
  – Stopwords removal

• **Indexing**
  – Can index plain text, HTML, PHP, PDF, PostScript, OpenOffice, OpenDocument, Microsoft Word/Excel/Powerpoint/Works, etc.

• **Retrieval**
  – Support for relevance feedback and query expansion
  – Types of queries: boolean, term, wildcard, phrase, and proximity
  – Spelling corrector for queries
  – Support for the use of synonyms in queries (“∼term”)

http://xapian.org/
Unstructured Information Management Architecture (UIMA)

http://uima.apache.org

• An open, scalable and extensible platform for building analytic solutions that process and search unstructured information to find latent meaning, relationships and relevant facts
• Enables the creation and aggregation of single NLP tools (called Analysis Engines (AEs)) into pipelines (aggregate AEs)
• Developed by IBM, now part of Apache
• Available for Java and C++, but supports also components in Perl, Python, and TCL
UIMA Structure
http://uima.apache.org

• UIMA has three main parts:
  – *Frameworks*, which support configuring and running pipelines of *Annotator* components; frameworks available for Java and C++
  – *Components*, i.e, *Annotators*, which do the actual work of analyzing the unstructured information
  – *Infrastructure*, includes a server that can receive requests and return annotation results, for use by other web services
UIMA Components
http://uima.apache.org

• Current annotators available for UIMA include:
  – Tokenizers
  – Sentence Splitter
  – Stemmers
  – Acronym Annotator
  – Named Entity Tagger
  – Lucene Indexer
  – Concept Mapper
  – Feature Extractor, etc.

• Besides the ones already included in UIMA, annotators can be found at:
  – http://uima.lti.cs.cmu.edu
  – http://www.julielab.de/Resources/Software/NLP+Tools.html
GATE  http://gate.ac.uk/

- A comprehensive open source infrastructure for developing language processing applications
- Written in Java
- Mature and actively supported
- Leverages also other projects like:
  - **Information Retrieval**: Lucene, Google and Yahoo search APIs
  - **Machine Learning**: Weka, MaxEnt, SVMLight, etc.
  - **Ontology Support**: Sesame and OWLIM
  - **Parsing**: RASP, Minipar, and SUPPLE
  - **Other**: UIMA, Wordnet, Snowball, etc.
Tasks Covered by GATE

http://gate.ac.uk/

• Provides a baseline set of customizable Language Engineering components that can be extended and/or replaced by users, for the following NLP tasks:
  – Tokenization
  – POS tagging
  – Sentence splitting
  – Named entity recognition
  – Co-reference resolution
  – Information Extraction
  – Machine learning, etc.
The GATE Family

http://gate.ac.uk/

• GATE includes:
  – an IDE, GATE Developer for NLP components bundled with an information extraction system and a set of other plugins
  – a web app, GATE Teamware: a collaborative annotation environment for semantic annotation projects
  – a framework, GATE Embedded: an object library optimized for inclusion in diverse applications giving access to all the services used by GATE Developer and more
  – an architecture: a high-level organizational picture of language processing software composition
  – a process for the creation of robust and maintainable services
LanguageWare
http://www.alphaworks.ibm.com/tech/lrw

• An NLP technology developed by IBM, that allows the processing of natural language text
• It comprises a set of Java libraries which provide a range of NLP functions:
  – Dictionary lookup
  – Language identification
  – Text segmentation/tokenization
  – Parsing
  – Lexical and morphological analysis
  – Entity and relationship extraction
  – Semantic analysis and disambiguation
  – POS tagging
• Contains a set of configurable lexico-semantic resources which describe the characteristics and domain of the processed language

• LanguageWare Resource Workbench is a set of Eclipse-based customization tools and allows domain knowledge to be compiled into resources and incorporated into the analysis process

• LanguageWare can be deployed as a set of UIMA-compliant annotators, Eclipse plug-ins or Web Services
The Natural Language Toolkit
 http://www.nltk.org/

• A suite of Python modules for natural language processing
• Includes modules for:
  – Classification
  – Parsing
  – Tokenization
  – Stemming
  – Tagging
  – Discourse checking
  – Information Extraction
  – Theorem proving, etc.
LingPipe [http://alias-i.com/lingpipe/]

- A toolkit for processing text using computational linguistics, used for tasks like:
  - Named entity recognition
  - Topic classification
  - Clustering
  - POS tagging
  - Sentence detection
  - Spelling correction
  - Language Identification
  - Word Sense Disambiguation
  - Information Retrieval (LSI), etc.

- Java API with source code and unit tests available
Stanford NLP Software

http://nlp.stanford.edu/software/index.shtml

- The Stanford NLP Research group offers a series of open-source NLP tools for text manipulation, implemented in Java:
  - The **Stanford Parser**: probabilistic natural language parsers
  - The **Stanford POS Tagger**: a maximum-entropy POS tagger
  - The **Stanford Named Entity Recognizer**: features for Named Entity Recognition
  - The **Stanford Classifier**: conditional loglinear classifier
  - **Topic Modeling Toolbox**: a suite of topic modeling tools