

Introduction to the **tm** Package

Text Mining in R

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Abstract

This vignette gives a short overview over available features in the **tm** package for text mining purposes in R.

Loading the Package

Before actually working we need to load the package:

```
> library("tm")
```

Data Import

The main structure for managing documents is a so-called text document collection (`TextDocCol`). Its constructor takes following arguments:

- **object**: a `Source` object which abstracts the input location.
- **readerControl**: a list with the named components **reader**, **language**, and **load**. A reader constructs a text document from a single element delivered by a source. A reader must have the argument signature (**elem**, **load**, **language**, **id**). The first argument is the element provided from the source, the second gives the text's language, the third indicates whether the user wants to load the documents immediately into memory, and the fourth is a unique identification string. If the passed over **reader** function has the attribute **FunctionGenerator**, it is assumed to be a function generating a reader. This way custom readers taking various parameters (specified in ...) can be built, which in fact must produce a valid reader signature but can access additional parameters via lexical scoping (i.e., by the including environment).
- **dbControl**: a list with the named components **useDb** indicating that database support should be activated, **dbName** giving the filename holding the sourced out objects (i.e., the database), and **dbType** holding a valid database type as supported by **filehash**. Under activated database support the **tm** packages tries to keep as few as possible resources in memory under usage of the database.
- ...: Further arguments to the reader.

Available sources are `DirSource`, `CSVSource`, `GmaneSource` and `ReutersSource` which handle a directory, a mixed CSV, a Gmane mailing list archive RSS feed or a mixed Reuters file (mixed means several documents are in a single file). Except `DirSource`, which is designated solely for directories on a file system, all other implemented sources can take connections as input (a character string is interpreted as file path).

This package ships with several readers (`readPlain()` (default), `readRCV1()`, `readReut21578XML()`, `readGmane()`, `readNewsgroup()`, `readPDF()`, and `readHTML()`). Each source has a default reader which can be overridden. E.g., for `DirSource` the default just reads in the whole input files and interprets their content as text.

Plain text files in a directory:

```
> txt <- system.file("texts", "txt", package = "tm")
> (ovid <- TextDocCol(DirSource(txt),
+                     readerControl = list(reader = readPlain,
+                                         language = "en_US",
+                                         load = TRUE)))
```

A text document collection with 5 text documents

A single comma separated values file:

```
> cars <- system.file("texts", "cars.csv", package = "tm")
> TextDocCol(CSVSource(cars))
```

A text document collection with 5 text documents

Reuters21578 files either in directory (one document per file) or a single file (several documents per file). Note that connections can be used as input:

```
> # Reuters21578 XML
> reut21578 <- system.file("texts", "reut21578", package = "tm")
> reut21578XML <- system.file("texts", "reut21578.xml", package = "tm")
> reut21578XMLgz <- system.file("texts", "reut21578.xml.gz", package = "tm")
> (reut21578TDC <- TextDocCol(DirSource(reut21578),
+                             readerControl = list(reader = readReut21578XML,
+                                                 language = "en_US",
+                                                 load = FALSE)))
```

A text document collection with 10 text documents

```
> TextDocCol(ReutersSource(reut21578XML),
+             readerControl = list(reader = readReut21578XML,
+                                   language = "en_US", load = FALSE))
```

A text document collection with 10 text documents

```
> TextDocCol(ReutersSource(gzfile(reut21578XMLgz)),
+             readerControl = list(reader = readReut21578XML,
+                                   language = "en_US", load = FALSE))
```

A text document collection with 10 text documents

Depending on your exact input format you might find `preprocessReut21578XML()` useful. For the original downloadable archive this function can correct invalid UTF8 encodings and can copy each text document into a separate file to enable load on demand.

Analogously we can construct collections for files in the Reuters Corpus Volume 1 format:

```
> rcv1 <- system.file("texts", "rcv1", package = "tm")
> rcv1XML <- system.file("texts", "rcv1.xml", package = "tm")
> TextDocCol(DirSource(rcv1), readerControl = list(reader = readRCV1,
+   language = "en_US", load = TRUE))
```

A text document collection with 2 text documents

```
> TextDocCol(ReutersSource(rcv1XML), readerControl = list(reader = readRCV1,
+   language = "en_US", load = FALSE))
```

A text document collection with 2 text documents

Or mails from newsgroups (as found in the UCI KDD newsgroup data set):

```
> newsgroup <- system.file("texts", "newsgroup", package = "tm")
> TextDocCol(DirSource(newsgroup), readerControl = list(reader = readNewsgroup,
+   language = "en_US", load = TRUE))
```

A text document collection with 6 text documents

RSS feed as delivered by Gmane for the R mailing list archive:

```
> rss <- system.file("texts", "gmane.comp.lang.r.gr.rdf", package = "tm")
> TextDocCol(GmaneSource(rss), readerControl = list(reader = readGmane,
+   language = "en_US", load = FALSE))
```

A text document collection with 21 text documents

For very simple HTML documents:

```
> html <- system.file("texts", "html", package = "tm")
> TextDocCol(DirSource(html), readerControl = list(reader = readHTML,
+   load = TRUE))
```

A text document collection with 1 text document

And for PDF documents:

```
> pdf <- system.file("texts", "pdf", package = "tm")
> TextDocCol(DirSource(pdf), readerControl = list(reader = readPDF,
+   language = "en_US", load = TRUE))
```

A text document collection with 1 text document

Note that `readPDF()` needs `pdftotext` and `pdftinfo` installed on your system to be able to extract the text and meta information from your PDFs.

Inspecting the Text Document Collection

Custom `show` and `summary` methods are available, which hide the raw amount of information (consider a collection could consists of several thousand documents, like a database). `summary` gives more details on metadata than `show`, whereas in order to actually see the content of text documents use the command `inspect` on a collection.

```
> show(ovid)
```

```
A text document collection with 5 text documents
```

```
> summary(ovid)
```

```
A text document collection with 5 text documents
```

```
The metadata consists of 2 tag-value pairs and a data frame
```

```
Available tags are:
```

```
  create_date creator
```

```
Available variables in the data frame are:
```

```
  MetaID
```

```
> inspect(ovid[1:2])
```

```
A text document collection with 2 text documents
```

```
The metadata consists of 2 tag-value pairs and a data frame
```

```
Available tags are:
```

```
  create_date creator
```

```
Available variables in the data frame are:
```

```
  MetaID
```

```
[[1]]
[1] "  Si quis in hoc artem populo non novit amandi,"
[2] "      hoc legat et lecto carmine doctus amet."
[3] "  arte citae veloque rates remoque moventur,"
[4] "      arte leves currus: arte regendus amor."
[5] ""
[6] "  curribus Automedon lentisque erat aptus habenis,"
[7] "      Tiphys in Haemonia puppe magister erat:"
[8] "  me Venus artificem tenero praefecit Amori;"
[9] "      Tiphys et Automedon dicar Amoris ego."
[10] "  ille quidem ferus est et qui mihi saepe repugnet:"
[11] ""
[12] "      sed puer est, aetas mollis et apta regi."
[13] "  Phillyrides puerum cithara perfecit Achillem,"
[14] "      atque animos placida contudit arte feros."
[15] "  qui totiens socios, totiens exterruit hostes,"
[16] "      creditur annosum pertimuisse senem."
```

```
[[2]]
```

```

[1] "    quas Hector sensurus erat, poscente magistro"
[2] "        verberibus iussas praebuit ille manus."
[3] "    Aeacidae Chiron, ego sum praeceptor Amoris:"
[4] "        saevus uterque puer, natus uterque dea."
[5] "    sed tamen et tauri cervix oneratur aratro,"
[6] ""
[7] "        frenaque magnanimi dente teruntur equi;"
[8] "    et mihi cedet Amor, quamvis mea vulneret arcu"
[9] "        pectora, iactatas excutiatque faces."
[10] "    quo me fixit Amor, quo me violentius ussit,"
[11] "        hoc melior facti vulneris ultor ero:"
[12] ""
[13] "    non ego, Phoebe, datas a te mihi mentiar artes,"
[14] "        nec nos aëriae voce monemur avis,"
[15] "    nec mihi sunt visae Clio Cliusque sorores"
[16] "        servanti pecudes vallibus, Ascra, tuis:"
[17] "    usus opus movet hoc: vati parete perito;"

```

Transformations

Once we have a text document collection one typically wants to modify the documents in it, e.g., stemming, stopword removal, et cetera. In **tm**, all this functionality is subsumed into the concept of *transformations*. Transformations are done via the **tmMap** function which applies a function to all elements of the collection. Basically, all transformations work on single text documents and **tmMap** just applies them to all documents in a document collection.

Loading Documents into Memory

If the source objects supports load on demand, but the user has not enforced the package to load the input content directly into memory, this can be done manually via **loadDoc**. Normally it is not necessary to call this explicitly, as other functions working on text corpora trigger this function for not-loaded documents (the corpus is automatically loaded if accessed via **[[**).

```
> reut21578TDC <- tmMap(reut21578TDC, loadDoc)
```

Converting to Plaintext Documents

The text document collection **reut21578TDC** contains documents in XML format. We have no further use for the XML interna and just want to work with the text content. This can be done by converting the documents to plaintext documents. It is done by the generic **asPlain**.

```
> reut21578TDC <- tmMap(reut21578TDC, asPlain)
```

Eliminating Extra Whitespace

Extra whitespace is eliminated by:

```
> reut21578TDC <- tmMap(reut21578TDC, stripWhitespace)
```

Convert to Lower Case

Conversion to lower case by:

```
> reut21578TDC <- tmMap(reut21578TDC, tmTolower)
```

Remove Stopwords

Removal of stopwords by:

```
> reut21578TDC <- tmMap(reut21578TDC, removeWords, stopwords("english"))
```

Stemming

Stemming is done by:

```
> tmMap(reut21578TDC, stemDoc)
```

A text document collection with 10 text documents

Filters

Often it is of special interest to filter out documents satisfying given properties. For this purpose the function `tmFilter` is designated. It is possible to write custom filter functions, but for most cases the default filter does its job: it integrates a minimal query language to filter metadata. Statements in this query language are statements as used for subsetting data frames.

E.g., the following statement filters out those documents having `COMPUTER TERMINAL SYSTEMS <CPML> COMPLETES SALE` as their heading and an ID equal to 10 (both are metadata slot variables of the text document).

```
> query <- "identifier == '10' &  
+         heading == 'COMPUTER TERMINAL SYSTEMS <CPML> COMPLETES SALE'"  
> tmFilter(reut21578TDC, query)
```

A text document collection with 1 text document

There is also a full text search filter available which accepts regular expressions:

```
> tmFilter(reut21578TDC, FUN = searchFullText, "partnership",  
+         doclevel = TRUE)
```

A text document collection with 1 text document

Adding Data or Metadata

Text documents or metadata can be added to text document collections with `appendElem` and `appendMeta`, respectively. The text document collection has two types of metadata: one is the metadata on the document collection level (`cmeta`), the other is the metadata related to the individual documents (e.g., clusterings) (`dmeta`) in form of a dataframe. For the method `appendElem` it is possible to give a row of values in the dataframe for the added data element.

```

> data(crude)
> reut21578TDC <- appendElem(reut21578TDC, crude[[1]], 0)
> reut21578TDC <- appendMeta(reut21578TDC, cmeta = list(test = c(1,
+   2, 3)), dmeta = list(cl1 = 1:11))
> summary(reut21578TDC)

```

A text document collection with 11 text documents

The metadata consists of 3 tag-value pairs and a data frame

Available tags are:

create_date creator test

Available variables in the data frame are:

MetaID cl1

```

> CMetaData(reut21578TDC)

```

An object of class "MetaDataNode"

Slot "NodeID":

[1] 0

Slot "MetaData":

\$create_date

[1] "2007-07-19 13:40:21 CEST"

\$creator

LOGNAME

"hornik"

\$test

[1] 1 2 3

Slot "children":

list()

```

> DMetaData(reut21578TDC)

```

	MetaID	cl1
1	0	1
2	0	2
3	0	3
4	0	4
5	0	5
6	0	6
7	0	7
8	0	8
9	0	9
10	0	10
11	0	11

Removing Metadata

The metadata of text document collections can be easily modified or removed:

```
> data(crude)
> reut21578TDC <- removeMeta(reut21578TDC, cname = "test",
+   dname = "c11")
> CMetaData(reut21578TDC)
```

An object of class "MetaDataNode"

Slot "NodeID":

```
[1] 0
```

Slot "MetaData":

\$create_date

```
[1] "2007-07-19 13:40:21 CEST"
```

\$creator

LOGNAME

```
"hornik"
```

Slot "children":

```
list()
```

```
> DMetaData(reut21578TDC)
```

	MetaID
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0

Operators

Many standard operators and functions (`[`, `[<-`, `[[`, `[[<-`, `c`, `length`, `lapply`, `sapply`) are available for text document collections with semantics similar to standard R routines. E.g., `c` concatenates two (or more) text document collections. Applied to several text documents it returns a text document collection. The metadata is automatically updated, if text document collections are concatenated (i.e., merged).

Note also the custom element-of operator—it checks whether a text document is already in a text document collection (metadata is not checked, only the corpus):


```
> crude[[1]] %IN% reut21578TDC
```

```
[1] TRUE
```

```
> crude[[2]] %IN% reut21578TDC
```

```
[1] FALSE
```

Keeping Track of Text Document Collections

There is a mechanism available for managing text document collections. It is called `TextRepository`. A typical use would be to save different states of a text document collection. A repository has metadata in list format which can be either set with `appendElem` as additional argument (e.g., a date when a new element is added), or directly with `appendMeta`.

```
> data(acq)
> repo <- TextRepository(reut21578TDC)
> repo <- appendElem(repo, acq, list(modified = date()))
> repo <- appendMeta(repo, list(moremeta = 5:10))
> summary(repo)
```

A text repository with 2 text document collections

The repository metadata consists of 3 tag-value pairs
Available tags are:
created modified moremeta

```
> RepoMetaData(repo)
```

```
$created
[1] "2007-07-19 13:40:28 CEST"
```

```
$modified
[1] "Thu Jul 19 13:40:28 2007"
```

```
$moremeta
[1] 5 6 7 8 9 10
```

```
> summary(repo[[1]])
```

A text document collection with 11 text documents

The metadata consists of 2 tag-value pairs and a data frame
Available tags are:
create_date creator
Available variables in the data frame are:
MetaID

```
> summary(repo[[2]])
```

A text document collection with 50 text documents

The metadata consists of 2 tag-value pairs and a data frame

Available tags are:

create_date creator

Available variables in the data frame are:

MetaID

Creating Term-Document Matrices

A common approach in text mining is to create a term-document matrix for given texts. In this package the class `TermDocMatrix` handles sparse matrices for text document collections.

```
> tdm <- TermDocMatrix(reut21578TDC)
> Data(tdm)[1:8, 150:155]
```

```
8 x 6 sparse Matrix of class "dgCMatrix"
  weeks year york zone activities america
1      1      2      8      1          .          .
2      .      .      .      .          1          2
3      .      .      .      .          .          .
4      1      1      .      .          .          .
5      .      .      .      .          .          .
6      .      .      .      .          .          .
7      .      .      .      .          .          .
8      .      .      .      .          .          .
```

Operations on Term-Document Matrices

Besides the fact that on the `Data` part of this matrix a huge amount of R functions (like clustering, classifications, etc.) is possible, this package brings some shortcuts. Consider we want to find those terms that occur at least 5 times:

```
> findFreqTerms(tdm, 5, Inf)
```

```
[1] "bags"      "cocoa"      "comissaria" "crop"      "dec"
[6] "dlrs"      "july"       "mln"        "sales"     "sept"
[11] "smith"     "times"     "total"      "york"      "oil"
[16] "analysts"  "bankamerica" "debt"       "price"     "stock"
[21] "the"       "level"     "apr"        "feb"       "mar"
[26] "nil"       "prev"      "computer"   "terminal"
```

Or we want to find associations (i.e., terms which correlate) with at least 0.97 correlation for the term `crop`:

```
> findAssocs(tdm, "crop", 0.97)
```

crop	155	221	325	340
1.00	0.98	0.98	0.98	0.98
345	350	351	375	380
0.98	0.98	0.98	0.98	0.98
400	415	450	480	750
0.98	0.98	0.98	0.98	0.98
753	780	785	850	870
0.98	0.98	0.98	0.98	0.98
875	880	995	alleviating	areas
0.98	0.98	0.98	0.98	0.98
argentina	arrivals	arroba	aug	bags
0.98	0.98	0.98	0.98	0.98
bahia	bean	booked	butter	buyers
0.98	0.98	0.98	0.98	0.98
cake	carnival	certificates	cocoa	comissaria
0.98	0.98	0.98	0.98	0.98
consignment	continued	convertible	cruzados	cumulative
0.98	0.98	0.98	0.98	0.98
currently	dec	delivered	destinations	dificulties
0.98	0.98	0.98	0.98	0.98
doubt	doubts	drought	dry	end
0.98	0.98	0.98	0.98	0.98
estimated	estimates	experiencing	exporters	farmers
0.98	0.98	0.98	0.98	0.98
final	fit	fob	hands	harvesting
0.98	0.98	0.98	0.98	0.98
held	humidity	hundred	improving	included
0.98	0.98	0.98	0.98	0.98
june	kilos	levels	liquor	may
0.98	0.98	0.98	0.98	0.98
means	midday	middlemen	named	nearby
0.98	0.98	0.98	0.98	0.98
normal	obtaining	period	ports	practically
0.98	0.98	0.98	0.98	0.98
processors	prospects	published	quality	registered
0.98	0.98	0.98	0.98	0.98
reluctant	restored	review	rose	routine
0.98	0.98	0.98	0.98	0.98
sales	season	selling	sept	shipment
0.98	0.98	0.98	0.98	0.98
shippers	showers	spot	stage	superior
0.98	0.98	0.98	0.98	0.98
temporao	thousand	throughout	times	tonne
0.98	0.98	0.98	0.98	0.98
trade	uruguay	view	weekly	york
0.98	0.98	0.98	0.98	0.98
zone				
0.98				

The function also accepts a matrix as first argument (which does not inherit from a term-document matrix). This matrix is then interpreted as a correlation matrix and directly used. With this approach different correlation measures can be employed.

Term-document matrices tend to get very big already for normal sized datasets. Therefore we provide a method to remove *sparse* terms, i.e., terms occurring only in very few documents. Normally, this reduces the matrix dramatically without losing significant relations inherent to the matrix:

```
> removeSparseTerms(tdm, 0.4)
```

```
An object of class "TermDocMatrix"
```

```
Slot "Data":
```

```
11 x 2 sparse Matrix of class "dgTMatrix"
```

	Docs	
	dlrs	reuter
1	14	1
2	.	1
3	2	1
4	3	1
5	2	1
6	.	1
7	1	1
8	2	1
9	.	1
10	4	1
127	2	1

```
Slot "Weighting":
```

```
[1] "tf"
```

This function call removes those terms which have at least a 40 percentage of sparse (i.e., terms occurring 0 times in a document) elements.

Dictionary

A dictionary is a (multi-)set of strings. It is often used to represent relevant terms in text mining. We provide a class `Dictionary` implementing such a dictionary concept. It can be created via the `Dictionary` constructor, e.g.,

```
> (d <- Dictionary(c("dlrs", "crude", "oil")))
```

```
An object of class "Dictionary"
```

```
[1] "dlrs" "crude" "oil"
```

and may be passed over to the `TermDocMatrix` constructor. Then the created matrix is tabulated against the dictionary, i.e., only terms from the dictionary appear in the matrix. This allows to restrict the dimension of the matrix a priori and to focus on specific terms for distinct text mining contexts, e.g.,

```
> tdmD <- TermDocMatrix(reut21578TDC, dictionary = d)
```

```
> Data(tdmD)
```

```
11 x 4 sparse Matrix of class "dgCMatrix"
```

```
Docs
  dlrs oil  crude
1    14   . .    .
2     .   3 .    .
3     2   . .    .
4     3   . .    .
5     2   . .    .
6     .   2 .    .
7     1   . .    .
8     2   1 .    .
9     .   . 0     .
10    4   . .    .
127   2   5 .    2
```

You can also create a dictionary from a term-document matrix via `createDictionary` holding all terms from the matrix e.g.,

```
> createDictionary(tdm)[100:110]
```

```
[1] "midday"      "middlemen" "mln"        "named"      "nearby"
[6] "normal"      "obtaining" "oct"        "offer"      "period"
[11] "ports"
```