

# LDA Documentation

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## Initial Setup

This is the essential step for setting up the LDA model. These functions include the sampling procedure from the *gutenbergr* library

```
# loading packages
library(gutenbergr)
library(dplyr)
library(tidyr)
library(stringr)
library(tidytext)
library(udpipe)
library(topicmodels)
library(ggplot2)

sampling_books <- function(seed=1234, n=20){
  # sample n books from the whole library
  set.seed(seed)
  gutenberg_works() %>%
    # select works with title
    dplyr::filter(!is.na(title)) %>%
    # set the sample size
    sample_n(n) %>%
    # set a special download link
    gutenberg_download(
      mirror = "http://mirrors.xmission.com/gutenberg/"
    )
}
```

- good separation for 4 topics:
  - seed=12345
  - seed=54321
- for 6 books:
  - seed=222
  - seed 101
- for 10 books:
  - seed=54321
  - seed=123456

```
sampling_books <- function(seed=1234, n=20){
  # sample n books from the whole library
  set.seed(seed)
  gutenberg_works() %>%
    # select works with title
    dplyr::filter(!is.na(title)) %>%
    # set the sample size
    sample_n(n) %>%
    # set a special download link
```

```

    gutenbergl_download(
      mirror = "http://mirrors.xmission.com/gutenberg/"
    )
  }

set_up_books <- function(n_books=4, seed=1992){
  # initial book sample
  books <- sampling_books(n=n_books, seed=seed)
  by_chapter <- books %>%
    group_by(gutenberg_id) %>%
    # split in chapters
    mutate(chapter = cumsum(str_detect(text, regex("^chapter ", ignore_case = TRUE)))) %>%
    ungroup() %>%
    # exclude books without chapters
    dplyr::filter(chapter > 0)
  return(by_chapter)
}

shorten_titles <- function(titles){
  # shorten very long book titles by setting
  # a subset of characters of the first line
  # of the title
  sub_inds <- titles %>%
    regex(pattern="\\n|\\r")-1
  sub_inds[sub_inds<0] <- nchar(titles)[sub_inds<0]
  titles %>%
    substr(1,sub_inds)
}

get_titles <- function(x, n_books){
  # get the sampled gutenbergl_ids
  unique_ids <- x %>%
    select(gutenberg_id) %>%
    unique() %>% unlist()
  # get the titles
  titles <- gutenbergl_works() %>%
    dplyr::filter(gutenberg_id %in% unique_ids) %>%
    select(gutenberg_id, title, author) %>%
    mutate(title=shorten_titles(title))
  # get the number of gutenbergl_ids
  len <- nrow(titles)
  if(n_books!=len) warning(paste("---- ",n_books-len,
                                " books have 0 chapters ---- "))

  # the output as a list
  ret <- list(
    titles=titles,
    len=len
  )
  return(ret)
}

append_by_chapter <- function(x=by_chapter, n_books, seed_index=1){
  # append the books matrix until
  # we get the desired number of books n_books

```

```

titles <- get_titles(x, n_books)
n <- titles$len
while (n<n_books) {
  book2add <- sampling_books(n=1, seed=seed_index)
  by_chapter_add <- book2add %>%
    group_by(gutenberg_id) %>%
    # split in chapters
    mutate(chapter = cumsum(str_detect(text, regex("^chapter ", ignore_case = TRUE)))) %>%
    ungroup() %>%
    # exclude books without chapters
    dplyr::filter(chapter > 2)
  titles2add <- get_titles(by_chapter_add, 1)
  # adding the book to by_chapter if there are chapters in the
  # book plus it is not in the data already
  if (titles2add$len==1) if(!titles2add$titles$gutenberg_id%in%titles$titles$gutenberg_id) {
    x <- bind_rows(x, by_chapter_add)
  }
  n<-get_titles(x, n)$len
  seed_index <- seed_index+1
}
return(x)
}

exclude_stop_words <- function(x){
  # unite chapter and document title
  by_chapter_word <- x %>%
    unite(document, gutenberg_id, chapter) %>%
    # split into words
    unnest_tokens(word, text)
  # import tibble stop words
  data(stop_words)
  # find document-word counts
  word_counts <- by_chapter_word %>%
    # exclude stop words
    anti_join(stop_words) %>%
    # count each word by chapter
    count(document, word, sort = TRUE) %>%
    ungroup()
  return(word_counts)
}

convert_to_dtm <- function(x, minfq = 2){
  # get into a format lda can handle
  chapters_dtm <- x %>%
    select(doc_id=document, term=word, freq=n) %>%
    document_term_matrix() %>%
    # reduce by low frequencies
    dtm_remove_lowfreq(minfreq = minfq)
  return(chapters_dtm)
}

convert_to_dtm_2 <- function(x, n=n, minfq = 2, top=10000){

```

```

# get into a format lda can handle
chapters_dtm <- x %>%
  select(doc_id=document, term=word, freq=n) %>%
  document_term_matrix() %>%
  # reduce by low frequencies
  dtm_remove_tfidf(top=top)
return(chapters_dtm)
}

```

Now we can use all these functions to get to the initial corpus sample.

```

n_books <- 6
by_chapter <- set_up_books(n_books=n_books, seed=222)
appended_by_chapter <- append_by_chapter(x=by_chapter, n_books = n_books)
word_counts <- exclude_stop_words(appended_by_chapter)

```

```
## Joining, by = "word"
```

These are the sampled titles for the book sample with the seed 222.

```

titles <- get_titles(appended_by_chapter, n_books)
titles$titles %>% stargazer(summary=FALSE, font.size = "footnotesize", header=FALSE, title="Book-titles")

```

Table 1: Book-titles

gutenberg_id	title	author
11	Alice's Adventures in Wonderland	Carroll, Lewis
3096	Beatrice	Haggard, H. Rider (Henry Rider)
7705	"My Novel" — Volume 04	Lytton, Edward Bulwer Lytton, Baron
25603	Detailed Minutiae of Soldier life in the Army of Northern Virginia, 1861-1865	McCarthy, Carlton
47402	Along Alaska's Great River	Schwatka, Frederick
49675	Hawkins Electrical Guide v. 5 (of 10)	Hawkins, N. (Nehemiah)

In the set up we have another parameter to adjust. The minimum frequency for the bag of words dictionary. Let us set it to 2 in this case, meaning that we include a word only if the frequency is 2 or more.

```

chapters_dtm <- convert_to_dtm(word_counts, minfq=2)
ncol(chapters_dtm)

```

```
## [1] 10685
```

Let us compare it to the case if we include all words.

```

chapters_dtm_all <- convert_to_dtm(word_counts, minfq=0)
ncol(chapters_dtm_all)

```

```
## [1] 17961
```

We also want to compare this to a reduction of the word dictionary by the tfidf. For the sake of comparison the reduction is made to the same value as used above via minfreq=2 (i.e. 10685 words).

```

chapters_dtm_tfidf <- convert_to_dtm_2(word_counts, top=10685)
ncol(chapters_dtm_tfidf)

```

```
## [1] 10685
```

## Applicate the LDA model on the full corpus

Set up the LDA model for the shrinked embedding corpus via frequency 2.

```
tim1 <- Sys.time()
chapters_lda <- LDA(chapters_dtm,
                    k = n_books, control = list(seed = 1234))
tim2 <- Sys.time()
u_1 <- tim2-tim1
```

In comparison set up the LDA model for the full word embedding corpus.

```
tim1 <- Sys.time()
chapters_lda_all <- LDA(chapters_dtm,
                        k = n_books, control = list(seed = 1234))
tim2 <- Sys.time()
u_all <- tim2-tim1
```

Third LDA setup is for the shrinkage of the dictionary by TFIDF.

```
tim1 <- Sys.time()
chapters_lda_tfidf <- LDA(chapters_dtm,
                           k = n_books, control = list(seed = 1234))
tim2 <- Sys.time()
u_tfidf <- tim2-tim1
chapters_lda
```

## A LDA\_VEM topic model with 6 topics.

Now we evaluate the model all in once:

```
ext_gamma_matrix <- function(model){
  # get gamma matrix for chapter probabilities
  chapters_gamma <- tidy(model, matrix = "gamma")
  # split joint name of book and chapter
  chapters_gamma <- chapters_gamma %>%
    separate(document, c("gutenberg_id", "chapter"), sep = "_", convert = TRUE)
  # get matrix with probabilities for each topic per chapter
  gamma_per_chapter <- chapters_gamma %>%
    spread(topic, gamma)
  return(chapters_gamma)
}

validate_LDAClassification <- function(x){
  #First we'd find the topic that was most associated with
  # each chapter using top_n(), which is effectively the
  # "classification" of that chapter
  chapter_classifications <- x %>%
    group_by(gutenberg_id, chapter) %>%
    top_n(1, gamma) %>%
    ungroup()

  # We can then compare each to the "consensus"
  # topic for each book (the most common topic among its chapters),
  # and see which were most often misidentified.
  book_topics <- chapter_classifications %>%
    count(gutenberg_id, topic) %>%
```

```

group_by(gutenberg_id) %>%
# just keep the most frequent one
top_n(1, n) %>%
ungroup() %>%
# keep title called census and topic
transmute(consensus = gutenberg_id, topic)

# check the fraction of missclassification
chapter_classifications %>%
  inner_join(book_topics, by = "topic") %>%
  # mismatches
  dplyr::filter(gutenberg_id != consensus)%>%
  nrow()/nrow(chapter_classifications)
}

```

Now we exclude 3 times the beta matrix and evaluate the most likely result with the real results. Depending on how good the LDA will separate the books, this influences the goodness of the fit.

```

misc.rate_1 <- ext_gamma_matrix(chapters_lda) %>%
  validate_LDAdclassification()

```

```

misc.rate_all <- ext_gamma_matrix(chapters_lda_all) %>%
  validate_LDAdclassification()

```

```

misc.rate_tfidf <- ext_gamma_matrix(chapters_lda_tfidf) %>%
  validate_LDAdclassification()

```

Following matrix gives an overview:

```

performance_matrix <- data.frame(freq2.embedding=c(misc.rate_1, u_1),
  all.embedding=c(misc.rate_all, u_all),
  tfidf=c(misc.rate_tfidf, u_tfidf))
rownames(performance_matrix) <- c("missc. rate", "time")
performance_matrix %>% stargazer(summary=FALSE, header=F)

```

Table 2:

	freq2.embedding	all.embedding	tfidf
missc. rate	0.636	0.636	0.636
time	15.187	15.038	15.031