



TOPIC MODELING IN R

Why learn topic modeling

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What are topic models

- Topics give us a quick idea what a document is about.
- A topic is a label for a collection of words that often occur together. E.g., ***weather*** includes words: rain, storm, snow, winds, ice
- Topic modeling is the process of finding a collection of topics fitted to a set of documents



Rise of popularity

- Topic models are a way to get an idea what the documents are about, quickly.
- Because topics are quantified, it is possible to track topic prevalence, compute similarity (or distance) between topics, and use tools like linear regression.
- More technical applications involve use of topic models as classifiers, or as input to other tools like text segmentation.



Topic models - descriptive side

- Our course will focus on one specific implementation of topic modeling algorithms, called Latent Dirichlet Allocation (LDA)
- LDA takes a document-term matrix as its input
- LDA returns two matrices: one contains prevalence of topics in documents, the other - probability of words belonging to topics.

Illustration 1

- We have a tiny collection of documents.
- They refer to two topics: ***restaurants*** and ***loans***.
- A collection of documents is also called a **corpus**.

```
the_corpus =  
c("Due to bad loans, the bank agreed to pay the fines",  
  "If you are late to pay off your loans to the bank, you will face fines",  
  "A new restaurant opened in downtown",  
  "There is a new restaurant that just opened on Warwick street",  
  "How will you pay off the loans you will need for the  
  restaurant you want opened?")
```

Illustration 2

This corpus is converted into a document-term matrix (dtm).

A dtm is a bag-of-words representation of text: the word order is lost.

	Terms						
Docs	bank	finer	loans	pay	new	opened	restaurant
d_1	1	1	1	1	0	0	0
d_2	1	1	1	1	0	0	0
d_3	0	0	0	0	1	1	1
d_4	0	0	0	0	1	1	1
d_5	0	0	1	1	0	1	1

Note: document 5 has both topics



Illustration 3

The model is fitted by calling function `LDA`

```
lda_mod <- LDA(x=d, k=2, method="Gibbs",  
              control=list(alpha=1, delta=0.1, seed=10005, keep=1))
```

	bank	finer	loans	pay	new	opened	restaurant
1	0.1963	0.1963	0.2897	0.2897	0.00935	0.00935	0.00935
2	0.0115	0.0115	0.0115	0.0115	0.24138	0.35632	0.35632

	1	2
d_1	0.833	0.167
d_2	0.833	0.167
d_3	0.200	0.800
d_4	0.200	0.800
d_5	0.667	0.333



Topic modeling - the other parts

- Matrices are not a good way to present the results. We need to use charts.
- There are choices which words to keep and which ones to exclude from a document-term matrix.
- Documents can be constructed in multiple way: they can be based on chapters in a novel, on paragraphs, or even on a sequence of several words.
- The LDA algorithm relies on control parameters which can impact the output.



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**Now lets start doing it
ourselves**



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Counting words

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Splitting text

- The task of splitting text into words is also called 'tokenization'
- Package `tidytext` has function `unnest_tokens()` that does the splitting.

```
unnest_tokens(data, input=text, output=word,  
              format="text", tokens="word", drop=TRUE, to_lower=TRUE)
```

- It returns a tidy table, with one word per row.

Example of using unnest_tokens

We have a data frame named `book`

```
book
  chapter      text
1      1  It is what it is
2      2 What goes around comes around
```

And obtain a table

	chapter	word
1	1	it
1.1	1	is
1.2	1	what
1.3	1	it
1.4	1	is
2	2	what
2.1	2	goes
2.2	2	around
2.3	2	comes
2.4	2	around

We call `unnest_tokens`:

```
book %>%
  unnest_tokens(input=text, output=word,
                token="words", format="keyval",
                drop=T, to_lower = T)
```

Counting words

- We will use package `dplyr` to count word frequencies.
- Function `count()` groups rows by chapter and word and returns the word frequency.
- Each chapter-word pair now has its own row.

```
book %>%  
  unnest_tokens(input=text, output=word)  
  count(chapter, word)
```

	chapter <dbl>	word <chr>	n <int>
1	1	is	2
2	1	it	2
3	1	what	1
4	2	around	2
5	2	comes	1
6	2	goes	1
7	2	what	1



Getting the top words 1

- We often are interested in the most frequent words.
- They can be extracted using `dplyr` functions
- To get the top- n words: group words by chapter, sort/arrange by count in descending order, keep rows whose number is less than n



Getting the top words 2

```
book %>%  
  unnest_tokens(input=text,  
    output=word) %>%  
  count(chapter, word) %>%  
  group_by(chapter) %>%  
  arrange(desc(n)) %>%  
  filter(row_number() < 3) %>%  
  ungroup()
```

	chapter	word	n
	<dbl>	<chr>	<int>
1	1	is	2
2	1	it	2
3	2	around	2
4	2	comes	1

Casting counts into a document-term matrix

- Casting a table means transforming it into a different format
- A document-term matrix (dtm) contains counts of words.
- Each row corresponds to a document, each column - to a word.
- In our case, each chapter is its own document.
- Package `tidytext` has function `cast_dtm` to do this transformation.
- Just add `cast_dtm` **after** `count`

```
cast_dtm(data, document=chapter, term=word, value=n)
```


Example of using `cast_dtm()`

```
dtm <- book %>%  
  unnest_tokens(input=text,  
output=word) %>%  
count(chapter, word) %>%  
  cast_dtm(document=chapter,  
term=word, value=n)  
  
as.matrix(dtm)
```

	Terms					
Docs	is	it	what	around	comes	goes
1	2	2	1	0	0	0
2	0	0	1	2	1	1



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It's time to practice



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Displaying results with ggplot

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Frequencies and probabilities

- We will be interested in displaying two kinds of data:
 - Word counts, and
 - Probabilities of topics and words.
- `ggplot` can do it all!
- Counts come as a tidy table. Results of LDA can be converted into a tidy format using function `tidy()`



From LDA model to tidy table

- When we fit a topic model, the result is an LDA model object.
- It contains two matrices: **beta** and **gamma**
 - **beta** contains probabilities of words in topics
 - **gamma** contains probabilities of topics in documents

```
lda_mod <- LDA(x=d2, k=2, method="Gibbs",  
              control=list(alpha=1, delta=0.1, seed=10005))
```

```
str(lda_mod)  
...  
..@ beta          : num [1:2, 1:34] -5.68 -3.58 -3.29 -5.98 -5.68 ...  
..@ gamma         : num [1:5, 1:2] 0.231 0.167 0.875 0.846 0.333 ...
```

Using function tidy

- Function `tidy` takes an LDA model object and returns a tidy table with a specified matrix.

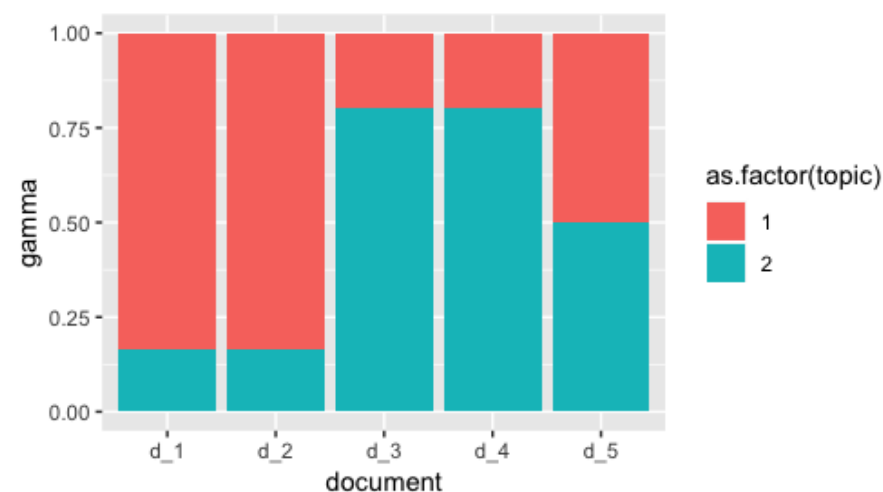
```
tidy(lda_mod, matrix="gamma")
```

	document <chr>	topic <int>	gamma <dbl>
1	d_1	1	0.231
2	d_2	1	0.167
3	d_3	1	0.875
4	d_4	1	0.846
5	d_5	1	0.333
6	d_1	2	0.769
7	d_2	2	0.833
8	d_3	2	0.125
9	d_4	2	0.154
10	d_5	2	0.667

Stacked columns chart

- `geom_col()` in `ggplot2` will produce a column chart
- by default, the columns will be stacked
- Calling `ggplot2`: the aesthetics specifies that values for axis `x` will come from column `document`, for axis `y` - from column `gamma`

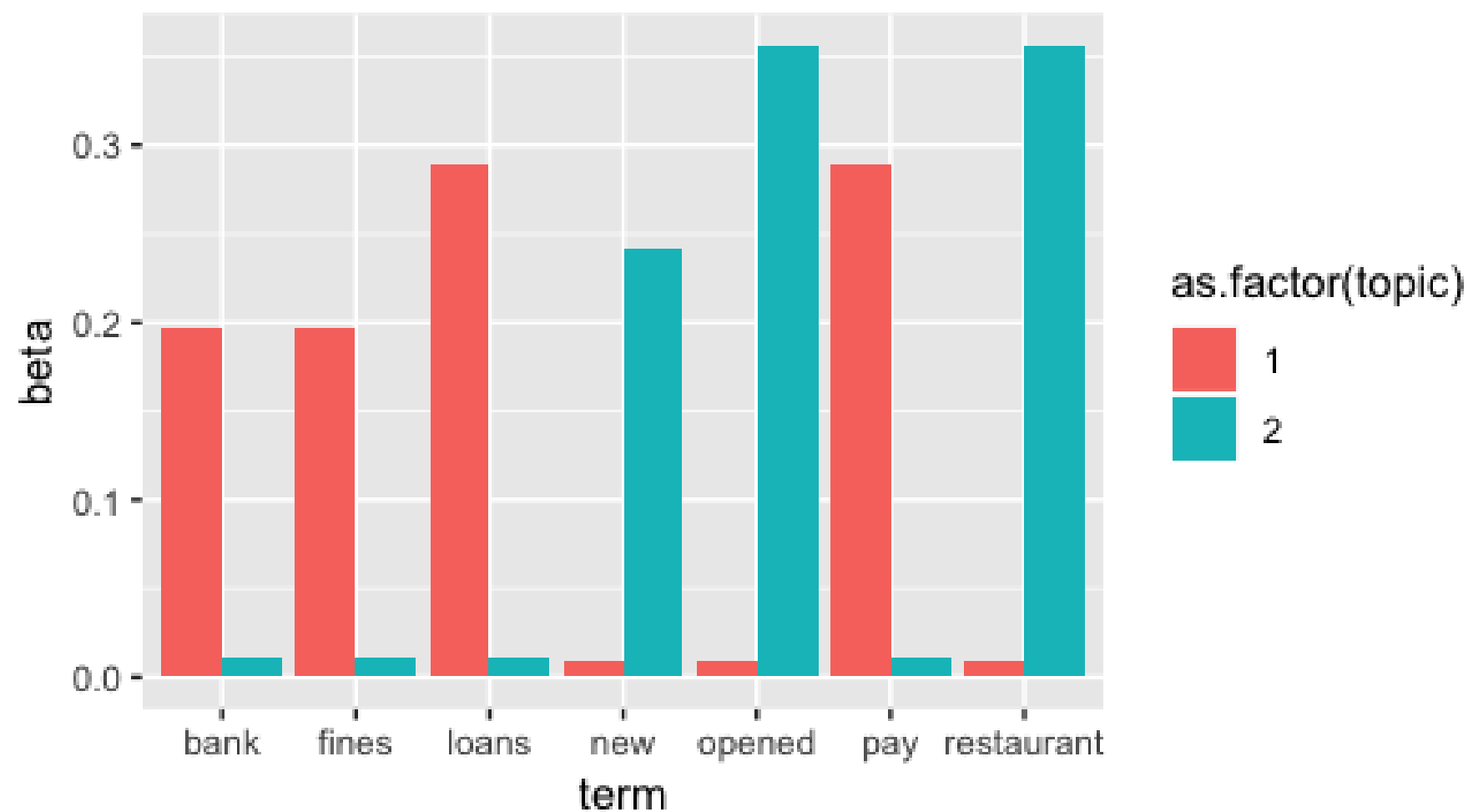
```
tidy(lda_mod, matrix="gamma") %>%  
  ggplot(aes(x=document, y=gamma)) +  
  geom_col(aes(fill=as.factor(topic)))
```



Dodged columns

- Matrix `beta` contains probabilities of words.

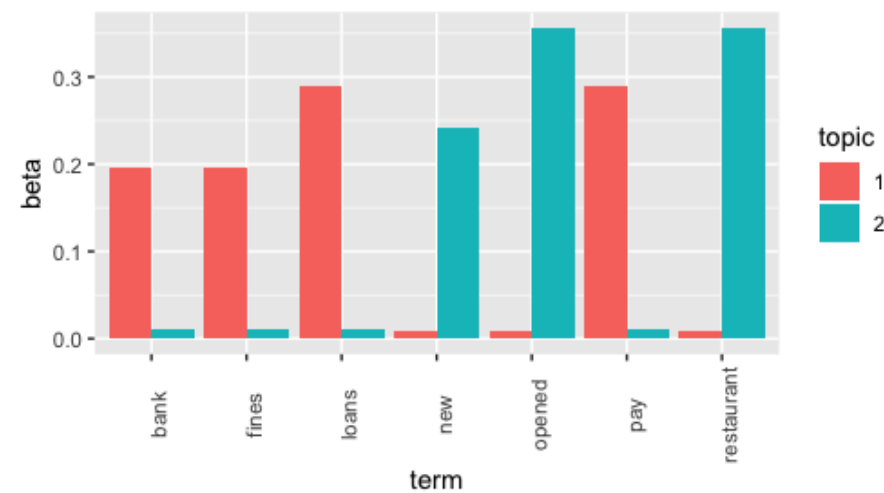
```
tidy(lda_mod, matrix="beta") %>%  
ggplot(aes(x=term, y=beta)) +  
geom_col(aes(fill=as.factor(topic)), position=position_dodge())
```



Rotated labels

- Text of labels on x axis is controlled through `axis.text.x` element in a theme

```
tidy(lda_mod, matrix="beta") %>%  
mutate(topic = as.factor(topic)) %>%  
ggplot(aes(x=term, y=beta)) +  
geom_col(aes(fill=topic),  
         position=position_dodge()) +  
theme(axis.text.x = element_text(angle=90))
```





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Let's do a few examples