Worldreader Query Data Project

A Capstone Project for the Data Science and Big Data course
at Universitat de Barcelona

Worldreader

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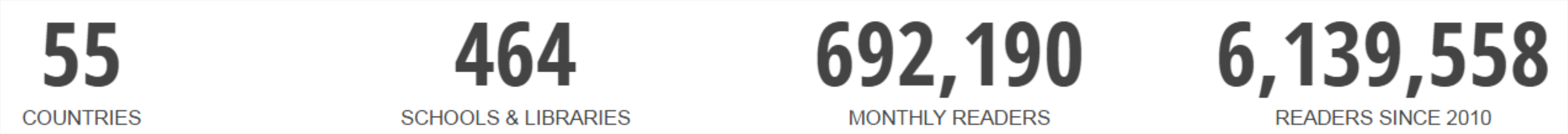
Introduction & Project Scope

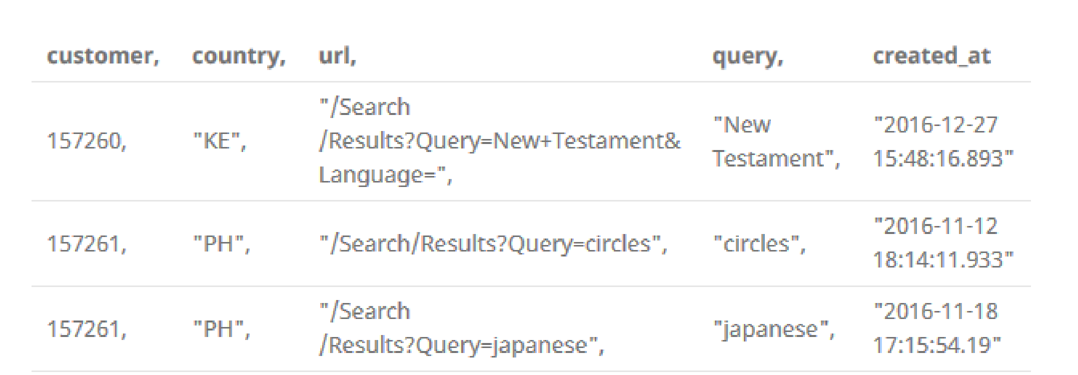
Worldreader is non-profit organization working to reduce illiteracy through its reading applications and sponsorship programs. The organization has a collection of over 40,000 books in more than 40 languages with the mission “to unlock the potential of millions of people through the use of digital books in places where access to reading material is very limited.”



55	464	692,190	6,139,558
COUNTRIES	SCHOOLS & LIBRARIES	MONTHLY READERS	READERS SINCE 2010

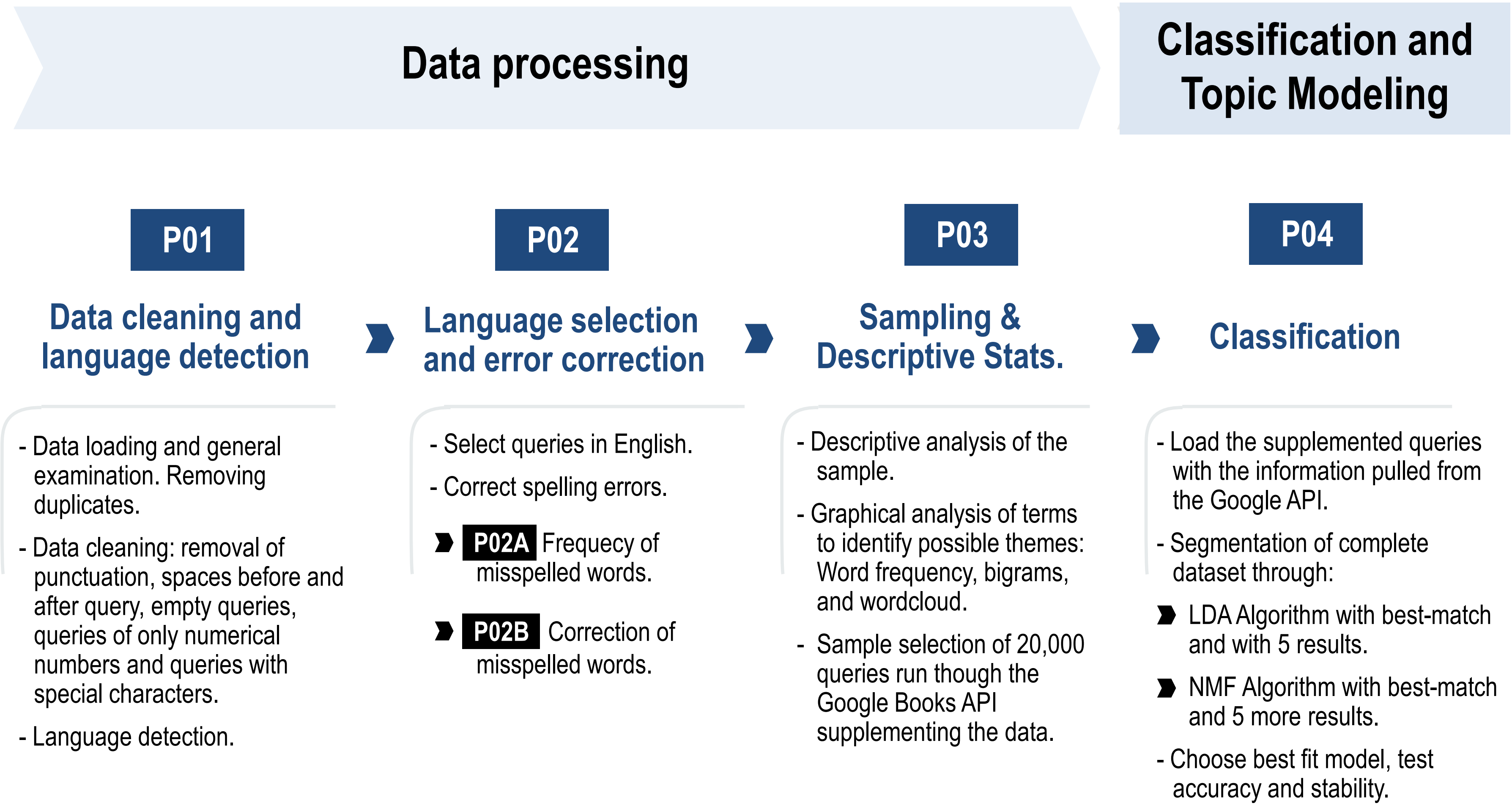
The Project Scope was to analyze queries made by users on the feature phone application by using clustering techniques to identify similar searches.

Worldreader provided our team with 6 CSV files consisting of over 3,000,000 queries and related information.



customer,	country,	url,	query,	created_at
157260,	"KE",	"/Search /Results?Query=New+Testament& Language=",	"New Testament",	"2016-12-27 15:48:16.893"
157261,	"PH",	"/Search/Results?Query=circles",	"circles",	"2016-11-12 18:14:11.933"
157261,	"PH",	"/Search /Results?Query=japanese",	"japanese",	"2016-11-18 17:15:54.19"

Project Work



Data processing

Classification and Topic Modeling

P01

Data cleaning and language detection

- Data loading and general examination. Removing duplicates.
- Data cleaning: removal of punctuation, spaces before and after query, empty queries, queries of only numerical numbers and queries with special characters.
- Language detection.

P02

Language selection and error correction

- Select queries in English.
- Correct spelling errors.

P02A Frequecy of misspelled words.

P02B Correction of misspelled words.

P03

Sampling & Descriptive Stats.

- Descriptive analysis of the sample.
- Graphical analysis of terms to identify possible themes: Word frequency, bigrams, and wordcloud.
- Sample selection of 20,000 queries run though the Google Books API supplementing the data.

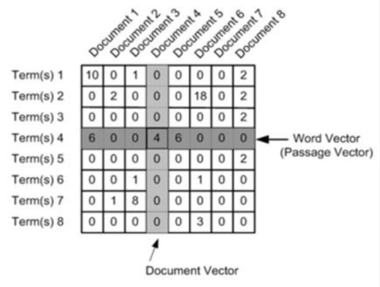
P04

Classification

- Load the supplemented queries with the information pulled from the Google API.
- Segmentation of complete dataset through:
  - LDA Algorithm with best-match and with 5 results.
  - NMF Algorithm with best-match and 5 more results.
- Choose best fit model, test accuracy and stability.

Classification Algorithms : LDA vs NMF

LDA (Latent Dirichlet Allocation) and NMF (Non-negative Matrix Factorization) are unsupervised techniques for topic discovery in large document collections. Discover different topics that a set of documents represent and how much of each topic is present in a document (or corpus).



	Document 1	Document 2	Document 3	Document 4	Document 5	Document 6	Document 7	Document 8
Term(s) 1	10	0	1	0	0	0	0	2
Term(s) 2	0	2	0	0	0	18	0	2
Term(s) 3	0	0	0	0	0	0	0	2
Term(s) 4	6	0	0	4	6	0	0	0
Term(s) 5	0	0	0	0	0	0	0	2
Term(s) 6	0	0	1	0	0	1	0	0
Term(s) 7	0	1	8	0	0	0	0	0
Term(s) 8	0	0	0	0	0	3	0	0

Each algorithm has a different mathematical underpinning:

- LDA is is based on a bayesian probabilistic graphical modeling
- NMF relies on linear algebra.

Both algorithms take as input a bag of words matrix (i.e., each document represented as a row, with each columns containing the count of words in the corpus) and produce 2 smaller matrices:

- a document to topic matrix (no documents * k topics)
- a word to topic matrix (k topics * no words) that when multiplied together reproduce the bag of words matrix with the lowest error.

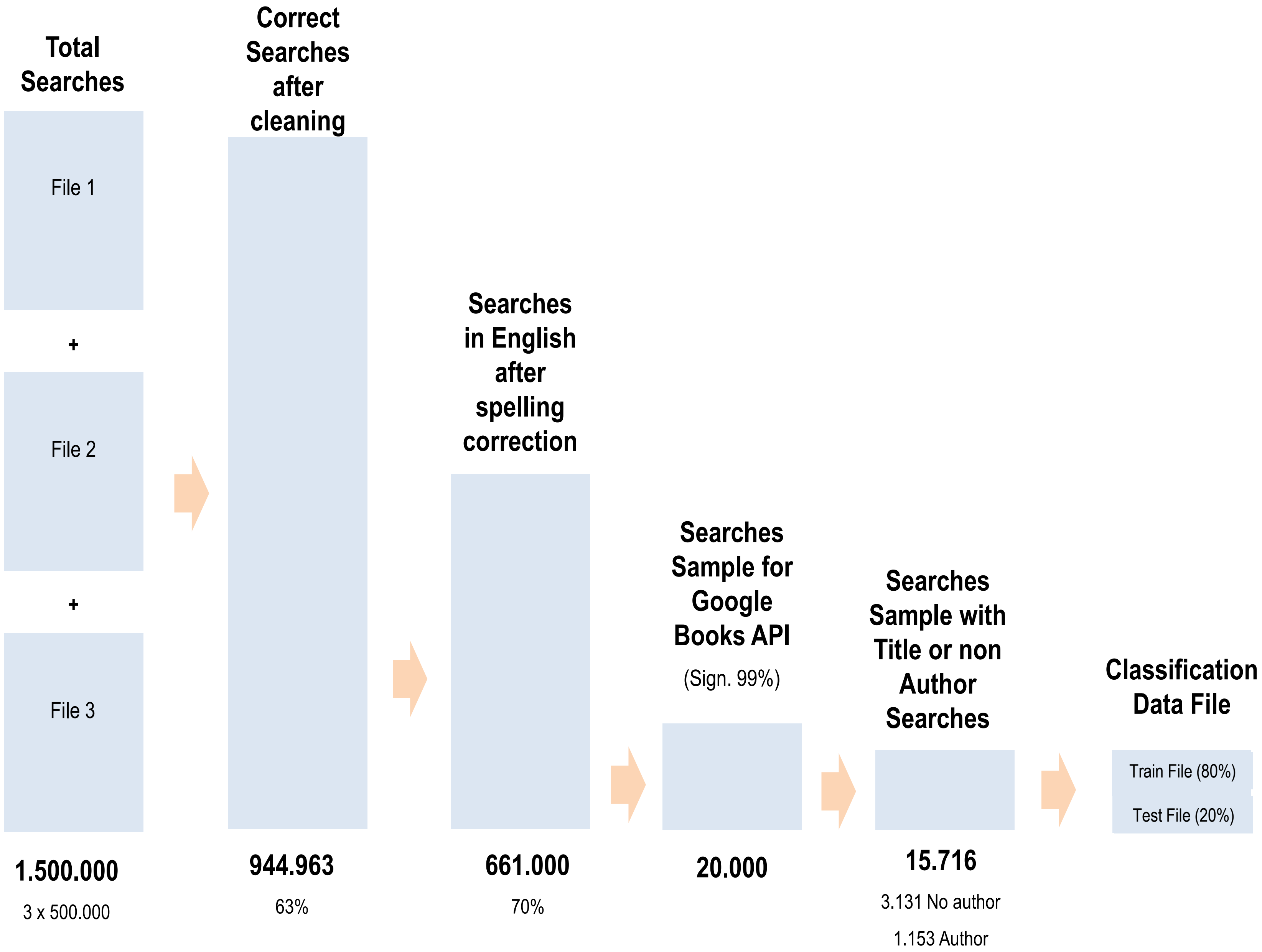
The output of the derived topics generated by both models involved assigning a numeric label to the topic and printing out the top words in a topic.

NMF and LDA are not able to automatically determine the number of topics and this must be specified.

NMF is usually cheaper in computation compared to LDA.

In cases where we believe that the topic probabilities should remain fixed per document (oftentimes unlikely)—or in small data settings — NMF performs better.

Searches file(s) process



Total Searches

File 1

+

File 2

+

File 3

1.500.000

3 x 500.000

Correct Searches after cleaning

944.963

63%

Searches in English after spelling correction

661.000

70%

Searches Sample for Google Books API

(Sign. 99%)

20.000

Searches Sample with Title or non Author Searches

15.716

3.131 No author

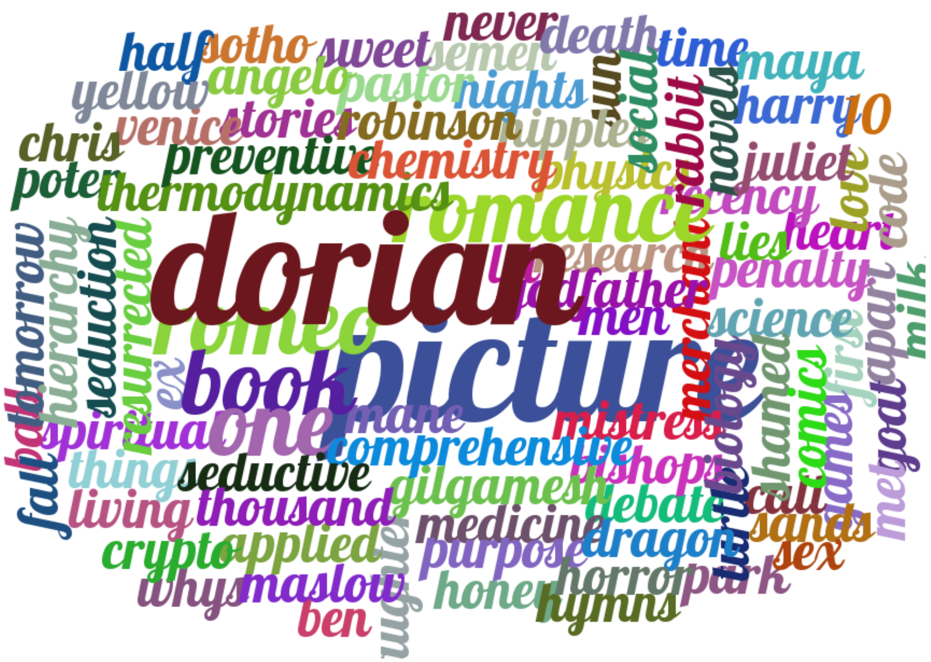
1.153 Author

Classification Data File

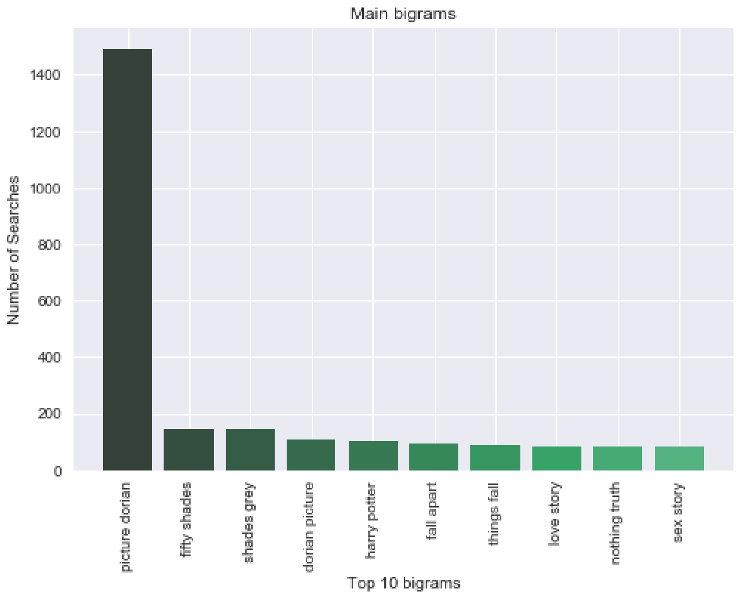
Train File (80%)

Test File (20%)

Word cloud Sample

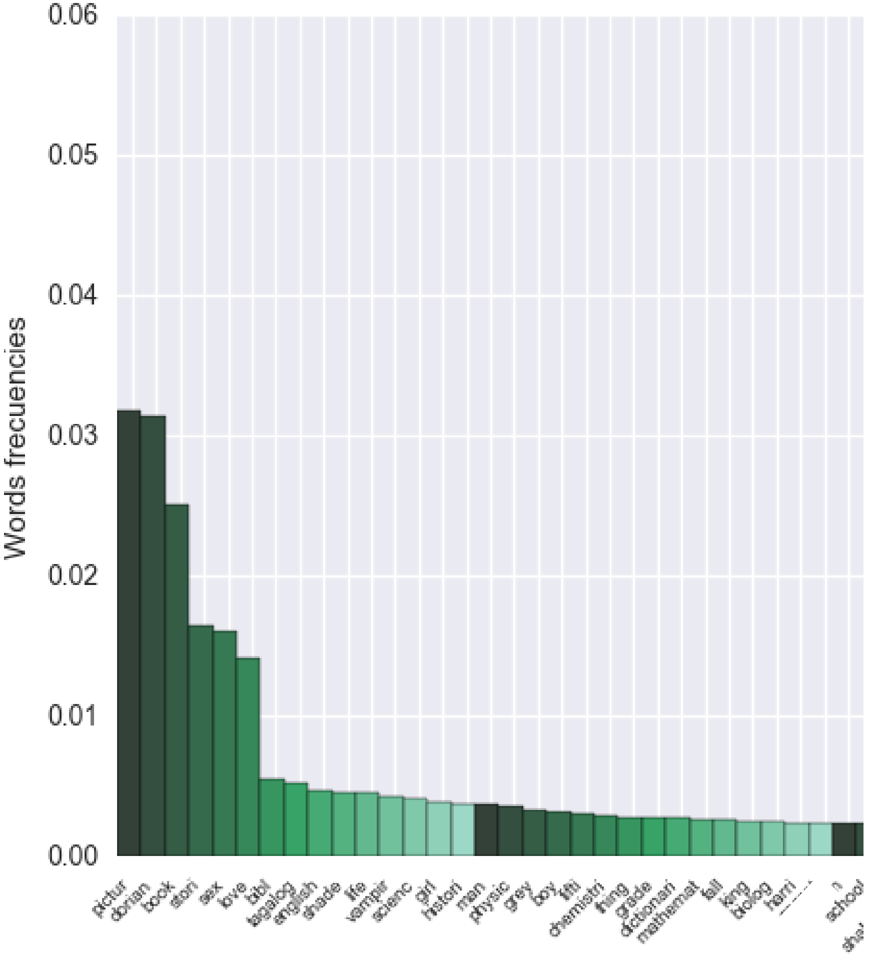


Bigrams Sample

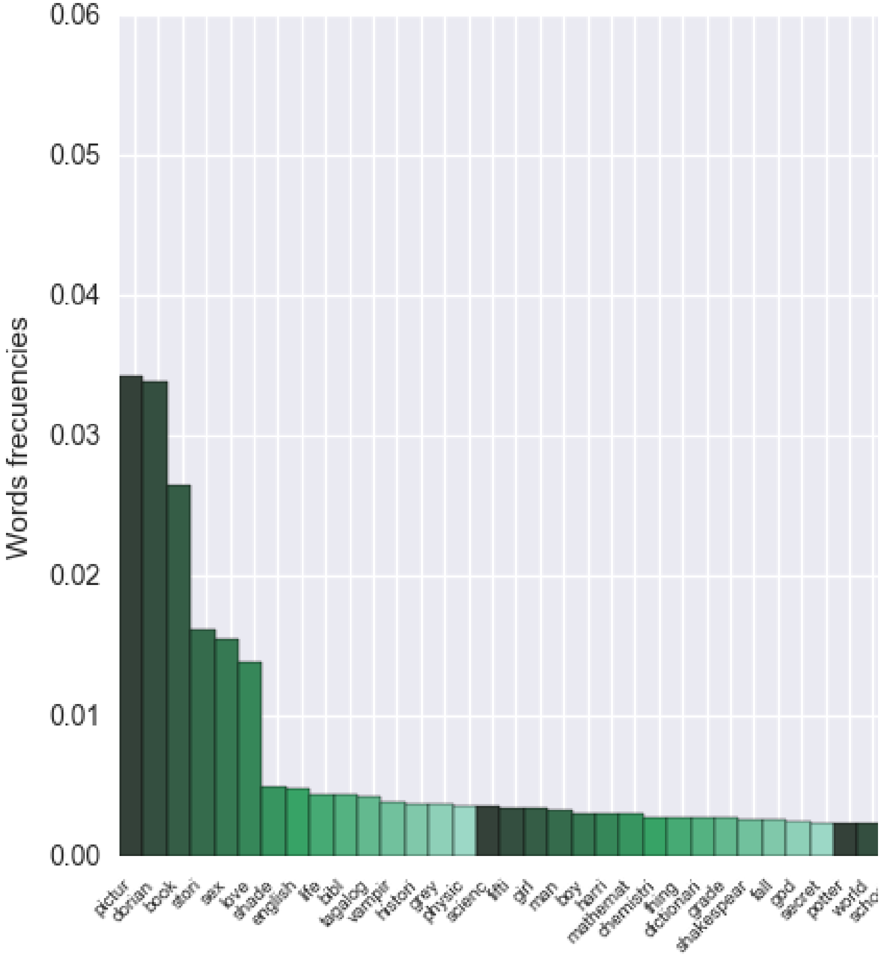


Sampling significance

Total Searches (N=661.000)



Sample (n=20.000)



Number of Topics

Iterative approach in both cases:

LDA

Perplexity is a commonly used measurement in information theory to evaluate how well a statistical model describes a dataset. Low perplexity indicates the probability distribution of the model is good at predicting the sample.

K	Perplexity
K = 5	249.759001877
K = 10	254.351936899
K = 15	250.765157719
K = 20	251.955603856
K = 25	254.939880397

NMF

Tested with same K numbers. K = 15 was the one that performed best too as we will see later on.

LDA Topic classification : Complete Train vs. Best Match

LDA Complete Train (Time 37’, words average 214)

Topic 0:	Topic 1:	Topic 2:	Topic 3:	Topic 4:	Topic 5:	Topic 6:	Topic 7:	Topic 8:	Topic 9:	Topic 10:	Topic 11:	Topic 12:	Topic 13:	Topic 14:
student	english	harri	histori	sex	book	book	horror	dorian	book	comic	anim	shade	play	love
book	book	potter	world	sexual	manag	will	stori	wild	game	book	novel	fifti	shakespear	stori
learn	languag	lord	studi	book	system	vampir	film	gray	think	novel	thing	grey	poem	life
use	bibl	give	cultur	stori	use	find	fiction	pictur	will	music	fall	christian	tale	will
practic	word	will	book	work	research	new	ghost	stori	kid	time	african	book	romeo	can
mathemat	dictionari	war	polit	women	develop	seri	fan	portrait	get	life	apart	recip	juliet	book
includ	use	shall	new	psycholog	inform	power	the	beauti	can	work	stori	ana	othello	time
studi	includ	must	social	men	new	love	tale	edit	success	stori	africa	world	includ	live

LDA Best Match (Time 37’, words average 92)

Topic 0:	Topic 1:	Topic 2:	Topic 3:	Topic 4:	Topic 5:	Topic 6:	Topic 7:	Topic 8:	Topic 9:	Topic 10:	Topic 11:	Topic 12:	Topic 13:	Topic 14:
book	book	will	histori	stori	love	shakespear	manag	law	dorian	book	sex	shade	book	dorian
student	languag	book	work	short	life	princ	busi	africa	gray	women	harri	fifti	histori	beauti
use	english	romanc	war	film	book	warrior	account	life	reader	sex	english	grey	scienc	portrait
includ	tagalog	seri	cultur	book	will	year	market	dictionari	pictur	food	sexual	christian	social	pictur
practic	stori	magic	new	horror	can	will	econom	legal	wild	vampir	dictionari	love	polit	begin
guid	play	ring	book	sex	live	play	develop	stori	young	men	potter	ana	human	depict
learn	student	king	art	adult	time	world	technolog	tale	first	journal	word	dark	studi	gray
provid	will	fantasi	poem	night	make	book	system	white	modern	recip	book	passion	new	physic

NMF Topic classification : Complete Train vs. Best Match

NMF Complete Train (Time 15”, words average 214)

Topic 0:	Topic 1:	Topic 2:	Topic 3:	Topic 4:	Topic 5:	Topic 6:	Topic 7:	Topic 8:	Topic 9:	Topic 10:	Topic 11:	Topic 12:	Topic 13:	Topic 14:
dorian	love	student	shade	sex	shakespear	apart	vampir	ring	harri	bibl	life	stori	dictionari	histori
wild	poem	mathemat	fifti	sexual	romeo	acheb	caitlin	king	potter	nameless	live	short	english	polit
gray	date	book	grey	disabl	juliet	fall	journal	fantasi	shall	holi	book	erotica	languag	cultur
pictur	relationship	chemistri	christian	gender	play	thing	legend	dragon	lord	god	god	tale	tagalog	war
portrait	romanc	engin	ana	patient	othello	chinua	rachel	sorcer	leav	translat	girl	children	word	social
ward	heart	practic	anastasia	mark	william	okonkwo	book	epic	harm	biblic	secret	erot	grammar	studi
oscar	alway	scienc	steel	men	languag	african	twilight	destini	breath	christian	make	horror	entri	american
mr	marriag	use	darker	studi	colour	novel	caleb	thor	climb	promis	want	collect	law	world

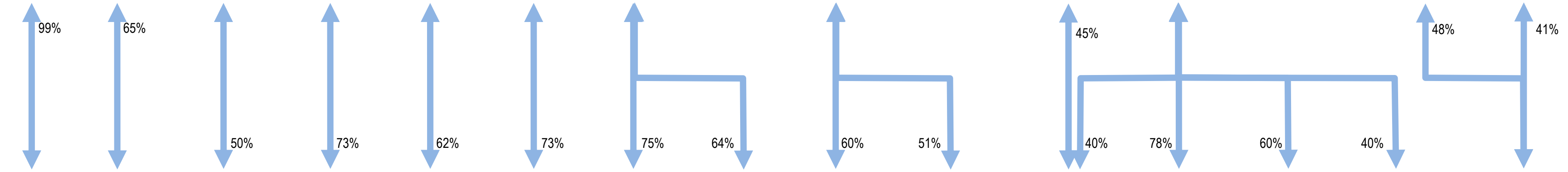
NMF Best Match (Time 15”, words average 92)

Topic 0:	Topic 1:	Topic 2:	Topic 3:	Topic 4:	Topic 5:	Topic 6:	Topic 7:	Topic 8:	Topic 9:	Topic 10:	Topic 11:	Topic 12:	Topic 13:	Topic 14:
dorian	life	dorian	sex	book	vampir	shade	bibl	english	harri	shakespear	histori	law	love	stori
gray	book	beauti	sexual	student	journal	fifti	nameless	languag	potter	romeo	cultur	legal	poem	short
wild	live	portrait	men	mathemat	book	grey	hero	dictionari	shall	play	polit	dictionari	marriag	erotica
pictur	time	pictur	male	scienc	twilight	christian	histori	word	lord	juliet	studi	entri	relationship	sexi
reader	world	depict	adult	engin	legend	ana	holi	oxford	leav	william	war	sourc	heal	night
remain	make	gray	enlighten	use	rachel	steel	heaven	tagalog	sky	othello	american social	crime	peter	erot
paint	god	begin	bodi	practic	diari	anastasia	way	grammar	drive	colour	centuri	term	richard	adult
portrait	famili	hedonist	character	studi	seri	darker	god	use	breath	classroom		inform	romant	romanc

LDA Topics classification : LDA Complete T. vs. NMF Complete T.

LDA Complete Train

Topic 8:	Topic 12:	Topic 13:	Topic 2:	Topic 11:	Topic 3:	Topic 6:	Topic 7:	Topic 1:	Topic 9:	Topic 4:	Topic 14:	Topic 10:	Topic 5:	Topic 0:
dorian	shade	play	harri	anim	histori	book	horror	english	book	sex	love	comic	book	student
wild	fifti	shakespear	potter	novel	world	will	stori	book	game	sexual	stori	book	manag	book
gray	grey	poem	lord	thing	studi	vampir	film	languag	think	book	life	novel	system	learn
pictur	christian	tale	give	fall	cultur	find	fiction	bibl	will	stori	will	music	use	use
stori	book	romeo	will	african	book	new	ghost	word	kid	work	can	time	research	practic
portrait	recip	juliet	war	apart	polit	seri	fan	dictionari	get	women	book	life	develop	mathemat
beauti	ana	othello	shall	stori	new	power	the	use	can	psycholog	time	work	inform	includ
edit	world	includ	must	africa	social	love	tale	includ	success	men	live	stori	new	studi



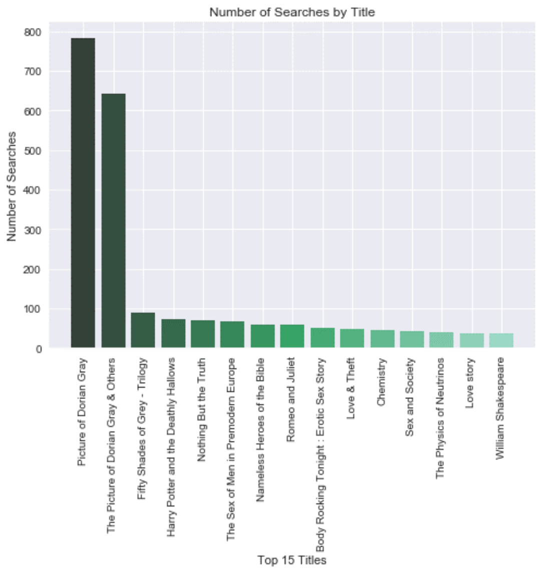
Topic #0	Topic#3	Topic#5	Topics#9	Topic#6	Topic#14	Topic#7	Topic#8	Topic#13	Topic#10	Topic#4	Topic#1	Topic#11	Topic#12	Topic#2
dorian	shade	shakespea	harri	apart	histori	vampir	ring	dictionari	bibl	sex	love	life	stori	student
wild	fifti	r romeo	potter	acheb	polit	caitlin	king	english	nameless	sexual	poem	live	short	mathemat
gray	grey	juliet	shall	fall	cultur	journal	fantasi	languag	holi	disabl	date	book	erotica	book
pictur	christian	play	lord	thing	war	legend	dragon	tagalog	god	gender	relationship	god	tale	chemistri
portrait	ana	othello	leav	chinua	social	rachel	sorcer	word	translat	patient	romanc	girl	children	engin
ward	anastasia	william	harm	okonkwo	studi	book	epic	grammar	biblic	mark	heart	secret	erot	practic
oscar	steel	languag	breath	african	american	twilight	destini	entri	christian	men	alway	make	horror	scienc
mr	darker	colour	climb	novel	world	caleb	thor	law	promis	studi	marriag	want	collect	use

NMF Complete Train

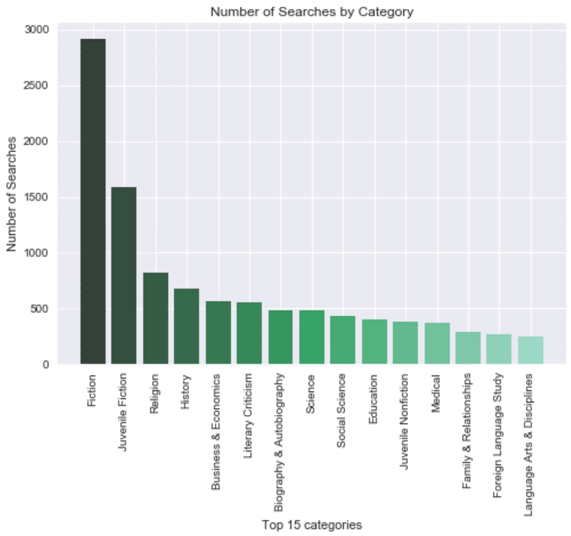
NMF Complete Train Google Categories

Novel										Book				
Topic #0	Topic #5	Topic #6	Topic #7	Topic #8	Topic #9	Topic #1	Topic #11	Topic #3	Topic#12	Topic #4	Topic #2	Topic #14	Topic #13	Topic #1
dorian	shakespear	apart	vampir	ring	harri	love	life	shade	stori	sex	student	histori	dictionari	bibl
wild	romeo	acheb	caitlin	king	potter	poem	live	fifti	short	sexual	mathemat	polit	english	nameless
gray	juliet	fall	journal	fantasi	shall	date	book	grey	erotica	disabl	book	cultur	languag	holi
pictur	play	thing	legend	dragon	lord	relationship	god	christian	tale	gender	chemistri	war	tagalog	god
portrait	othello	chinua	rachel	sorcer	leav	romanc	girl	ana	children	patient	engin	social	word	translat
ward	william	okonkwo	book	epic	harm	heart	secret	anastasia	erot	mark	practic	studi	grammar	biblic
oscar	languag	african	twilight	destini	breath	alway	make	steel	horror	men	scienc	american	entri	christian
mr	colour	novel	caleb	thor	climb	marriag	want	darker	collect	studi	use	world	law	promis
English Literature		African Liter.	Fiction/Juvenile Fiction			Family and relationships		Erotic Literature		Sex / Medical	Science	History	Language Study	Religion

Searches Top 15 Titles



Searches Top 15 Google Categories



Google Books example categories

Recurrent Titles	Google Category
Picture of Dorian Gray	Juvenile Fiction
Harry Potter	Juvenile Fiction
Fifty Shades	Fiction
Romeo and Julieta	Drama
Twilight	Literacy Criticism
Bible	Religion
Things Fall Apart	Social Science

Insights for Worldreader and Recommendations

- Users use the open search field looking for specific titles or looking for literature related to a topic. Low searches with author names.
- High frequency titles searched need to be included if not in catalog: The Picture of Dorian Grey, The Bible, Fifty Shades of Gray, Romeo and Julieta, Things fall Apart, Twilight and Harry Potter Series.
- Solve user ID instability in order to understand user profiles, searches and behavior.
- Create a country by country strategy in order to enhance libraries.

Conclusions in terms of analysis

- LDA and NMF use information about the word co-occurrences to extract the latent topics of the data. For this reason, they promote the predictive capacity of the titles of the books in the categories.
- Topics generated by LDA are close to human understanding, in terms of grouping co-occuring words together. However, these topics may not necessarily be the ones that distinguish different groups of documents-sometimes enforcing the documents to be sparse and specific in topics may help.
- The results of LDA seem unstable and are different depending on the sample of 80% chosen.
- When perplexity was calculated LDA seemed to be more stable for 5 or 15 topics. 15 topics seemed to reflect more precisely the diverse range of documents.
- NMF can be mostly seen as a LDA of which the parameters have been fixed to enforce a sparse solution. It may not be as flexible as LDA if you want to find multiple topics in single documents (e.g., from long articles), but it usually works better with short texts of different nature.
- NMF is faster than LDA for short text analysis, its computation time is lower.
- NMF seems to be a more stable model both with the best match and with all the suggestions.
- **For the purposes of this work, we think the results of NMF complete help us to understand better user's type of searches and recurrent topics.**

Possible next steps

- Classification of queries based off user information
  - Supplement data further with user profile information.
  - Supplement data further with information related to success or failure of the search results.

- Increase sample size to see if it improves the function of the models. Test different sample sets.

- Analysis of organization's catalog.

- Try to find other libraries with description. We could not access to any as good as Google Books.

- Compare the supplemented queries with the information extracted from the Google Books API against the organizational book catalog:
  - Identify the catalog books in high demand
  - A list of books in high demand and not part of the catalog
  - Create a recommenders system of the catalog based off the queries

- Query Classification Methodologies:
  - Test LDA removing words of low frequency.
  - Use PCA to try to find core topics within the data. Feature extraction method before NMF and LDA
  - Apply TextRank with the descriptions to extract keywords and run the models.
  - Apply technical analysis for graphs of the hyperonyms of the main search terms, using the NLTK library to retrieve WordNet hyperonyms.

Check out our project

GitHub and Jupyter Notebook: https://github.com/cnlewis/CAPE_stone

Blog: https://cnlewis.github.io/CAPE_stone

Thank you for your attention!