

Machine Learning for Social Sciences

Justin Grimmer

Associate Professor
Department of Political Science
University of Chicago

January 8th, 2018

Goal for Today: Document-Term Matrices

$$\mathbf{X} = \begin{pmatrix} 1 & 0 & 0 & \dots & 3 \\ 0 & 2 & 1 & \dots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & 5 \end{pmatrix}$$

$\mathbf{X} = N \times J$ matrix

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$\mathbf{X} = N \times J$ matrix

- N = Number of documents
- J = Number of features

Learning From Text

A plan for using texts

- 1) Acquiring text data
- 2) Regular expression search in text
- 3) Creating document-term matrices (term-document matrices)

Finding Text Data

Many places to find text

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Goal: plain text (.txt) file. (UTF-8, ASCII)

Finding Text Data

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Goal: plain text (.txt) file. (UTF-8, ASCII)

(May also want to create an XML or JSON file)

Plain Text

September 19, 2010 Sunday 10:46 AM EST

REP. FOXX VISITS LOCAL SCHOOLS, TALKS WITH STUDENTS ON
CONSTITUTION DAY

LENGTH: 320 words

CLEMMONS, N.C., Sept. 17 -- Rep. Virginia Foxx, R-N.C.
(5th CD), issued the following press release:

Congresswoman Virginia Foxx is celebrating Constitution Day today by visiting several schools in her district to talk with students about the Constitution and the individuals who helped create our charter document. She will visit Davie County High School, Forbush High School in Yadkin County and Piney Creek School in Alleghany County.

XML

```
<DOC>
```

```
<DOCNO>101-levin-mi-1-19901027< /DOCNO>
```

```
<TEXT>
```

Mr. LEVIN. Mr. President, today the House passed and sent to the President the Great Lakes Critical Programs Act.

... Mr. President, I commend and thank Ms. Bean for her exceptional efforts on the Great Lakes Critical Programs Act

```
< /TEXT>
```


```
< /DOC>
```

JSON

```
{"id":"tag:search.twitter.com,2005:287886850381713411",  
"objectType":"activity"...displayName:"Linda Bowersox",  
"postedTime":"2010-03-10T05:16:14.000Z"...  
"body":"@JeffFlake thank you for standing firm and voting  
NO on the #FiscalCliff (via #PJNET)","object"...
```

Prepackaged Data Sources

<http://dfr.jstor.org>



Search:

Selected: 9,290,921

Sort By:

...

Narrow results by:

+ Year of Publication

+ Content Type

+ Article Type

+ Key terms

+ Journal

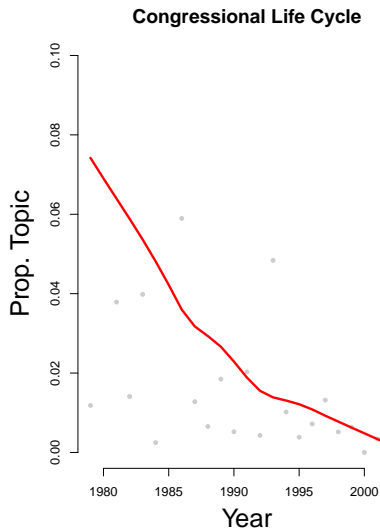
+ Publisher

+ Author

+ Language

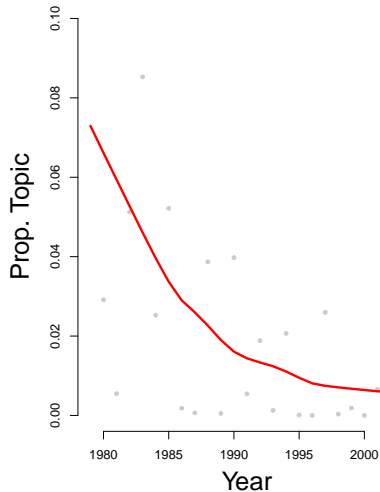
1. **Evaluating International Research Ethics Capacity Development: An En**
[Joseph Ali](#), [Nancy E. Kass](#), [Nelson K. Sewankambo](#), [Tara D. White](#), [Adnan A](#)
Journal of Empirical Research on Human Research Ethics: An International J
[More Info](#)
2. **Age of Fracture, by Daniel T. Rodgers**
[Michael J. Kramer](#)
American Political Thought, Vol. 3, No. 1 (Spring 2014), pp. 193-196
[More Info](#)
3. **The Failure of Popular Sovereignty: Slavery, Manifest Destiny, and the I**
[Martin H. Quitt](#)
American Political Thought, Vol. 3, No. 1 (Spring 2014), pp. 190-193
[More Info](#)

History of Home Style



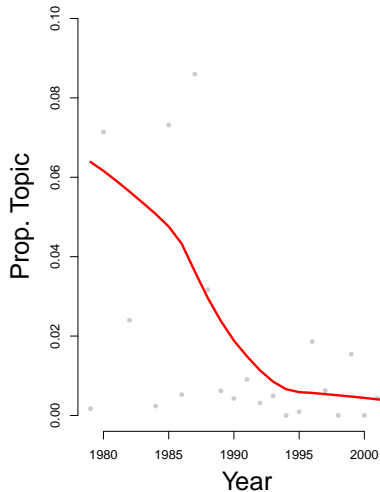
History of Home Style

Comparative Study of Home Style

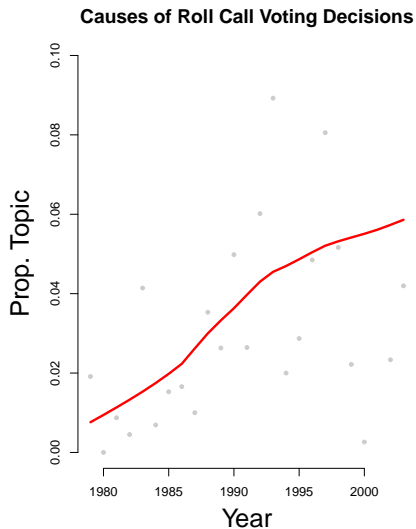


History of Home Style

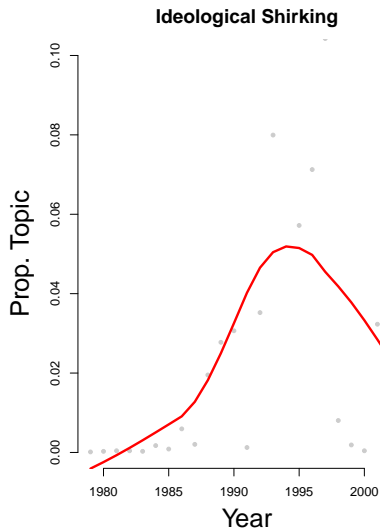
Casework and the Incumbency Advantage



History of Home Style

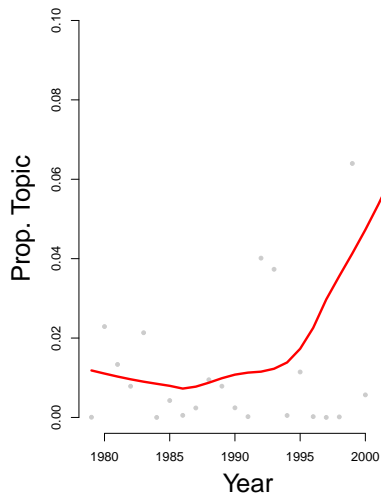


History of Home Style



History of Home Style

Biases in Congressional Communication



Prepackaged Data Sources

Lexis Nexis (and other data base sources)

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- 1) Batch search and download

Prepackaged Data Sources

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Application Programming Interface (APIs)

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Application Programming Interface (APIs)

- Facilitate interaction with applications (like Twitter)

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Application Programming Interface (APIs)

- Facilitate interaction with applications (like Twitter)
- Download data (often in JSON format)~→ Twitter, Data.gov, ...

Books, Archives, and Other Non-Digital Material

befit the servant towards the master; and he will not behave like many, who on meeting any great prince, with whom if only they have spoken but once, press forward with a certain smiling and friendly look, as if they" wished to caress an equal or show favour to an inferior.

"He will very rarely or almost never ask anything of his lord j for himself, lest his lord, being reluctant to deny it to him "directly, may sometimes grant it with an ill grace, which is much worse. Even in asking for others he will choose his time discreetly and ask proper and reasonable things; and he will so frame his request, by omitting what he knows may displease and by skilfully doing away with difficulties, that his lord shall always grant it, or shall not think him offended by refusal even if it be denied; for when lords have denied a favour to an importunate suitor, they often reflect that he who asked it with such eagerness, must have desired it greatly, and so having failed to obtain it, must feel ill will towards him who denied it; and believing this, they begin to hate the man and can never more look upon him with favour., 19.-" He will not seek to intrude unasked into his masters chamber or private retreats, even though he be of great consequence; for when great lords are in private, they often like a little liberty to say and do what they please, and do not wish to be seen or heard by any who may criticise them; and it is very proper. Hence I think those men do ill who blame great lords for consorting privately with persons who are of little worth save in matters of personal service, for I do not see why lords should not have the same freedom to relax their minds that we fain would have to relax ours. But if a Courtier accustomed to deal with important matters, chances to find himself in private with his lord, he must put on another face, postpone grave concerns to another place and time, and give the conversation a cast that shall amuse and please his lord, so as not to

Books, Archives, and Other Non-Digital Material

- 1) Create images of texts

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- 2) Optical Character Recognition

Books, Archives, and Other Non-Digital Material

- 1) Create images of texts
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 - Built in Adobe Pro

Books, Archives, and Other Non-Digital Material

- 1) Create images of texts
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 - Abbyy FineReader (Batch processing)

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 - Tesseract (Google, command line tool)

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 - Tesseract (Google, command line tool)
- 3) Also use, e-book formats...

Acquiring Data from Web: Automated Web Collection

HAGAMAN VOLUNTEER FIRE DEPARTMENT RECEIVES FEDERAL GRANT



08/22/12

HAGAMAN, N.Y. – Congressman Paul Tonko announced today that the federal government has awarded a grant of \$61,332 to the Hagaman Volunteer Fire Department, Inc. through the Department of Homeland Security's Assistance to Firefighters Grant Program in the eighth round of Fire Prevention & Safety (FP&S) announcements. The grant will help the company purchase a new safety trailer to provide fire prevention and life safety training to residents throughout Montgomery County.

"Our first responders not only help us in times of need, they educate our communities on safety and prevention," said Congressman Paul Tonko. "I want to congratulate Hagaman on receiving this award. These are the sort of investments that are worth making – bettering our communities and improving our quality of life."

"The Hagaman Volunteer Fire Department is humbled and honored to receive this Fire Prevention and Safety grant award to help improve our educational programs not only in the Village of Hagaman and the Town of Amsterdam but throughout our neighboring communities as well," said Hagaman Volunteer Fire Department, Inc. Chief Donald Reksc. "Our department is currently able to provide educational programs to about 1,800 children and adults annually. Through the use of this award, we'll be able to purchase a new safety trailer that will also allow us to accommodate students we currently haven't been able to include such as disabled and special needs students. We're very excited for the opportunity to extend our program further to our communities."

[Here are the details of the award:](#)

Acquiring Data from Web: Automated Web Collection

```
<table border="0" cellpadding="0" cellspacing="0" align="right"><tr><td valign="top">
<a href="#" onclick="return popup('/common/popup/popup.cfm?action=item.print&itemID=715',600,500);"></a>
</td></tr></table>
```

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Here are the details of the award:

· Hagaman Volunteer Fire Department, Inc: \$61,332 to purchase a new safety trailer for fire prevention and training purposes.

On April 11, 2012 Congressman Tonko wrote a letter of support on behalf of the Hagaman Volunteer Fire Department for the grant to the Assistant Administrator of Federal Emergency Management Agency (FEMA) Grant Programs.

The Fire Prevention and Safety Grants (FP&S) are part of the Assistance to Firefighters Grants (AFG), and are under the purview of the Grant Programs Directorate at FEMA. FP&S Grants support projects that enhance the safety of the public and firefighters from fire and related hazards. The primary goal is to target high-risk populations and reduce injury and prevent death. In 2005, Congress reauthorized funding for FP&S and expanded the eligible uses of funds to include Firefighter Safety Research and Development.

For more information on the FP&S grants program, click [here](http://www.fema.gov/fire-prevention-safety-grants).

Acquiring Data from Web: Automated Web Collection

```
base = 'http://tonko.house.gov'

for j in range(len(html)):#
    out = urlopen(html[j]).read()
    soup = BeautifulSoup(out)
    h3s = soup.findAll('h3')
    fr = []
    date = []
    for m in range(len(h3s)):
        dd = h3s[m].findNext('a')
        dd = dd['href']
        dd2 = base + dd.encode('UTF-8')
        fr.append(dd2)
        temp = h3s[m].findNext('span')
        temp2 = util.clean_html(str(temp)).split('/')
        mons = mon_key[temp2[0]]
        day = temp2[1]
        year = '20' + temp2[2]
        temp3 = day + mons + year
        date.append(temp3)
    for num in range(len(fr)):
        out2 = urlopen(fr[num]).read()
        soup2 = BeautifulSoup(out2)
        divs = soup2.findAll('div')
        content = ''
        for m in range(len(divs)):
            if divs[m].has_key('class'):
                if divs[m]['class']=='contentdata':
                    stuff = util.clean_html(str(divs[m]))
                    content += stuff
        names = date[num] + 'Tonko' + str(num) + '.txt'
        files = open(names, 'w')
        files.write(content)
    files.close()
```

Acquiring Data from Web: Automated Web Collection

WASHINGTON, D.C. -- Rep. Paul Tonko (NY-21) released the following statement on the passage of H.R. 3962, the Affordable Health Care for America Act:

"Today the House of Representatives took a giant step towards fixing our broken health care system by passing legislation that will provide coverage for millions of uninsured Americans, strengthen Medicare for our seniors, lower costs for businesses and individuals, and provide protections for those who already have health care coverage. In the 21st Congressional District alone, this bill will cover 22,000 of the uninsured and close the Medicare Part "donut hole" that currently has 7,300 of our seniors paying out of pocket for prescription drug costs.

"As I traveled throughout the district over the past 10 months, I heard heartbreaking stories of families thrust into bankruptcy because they had been denied coverage when they became ill, heard from people who've had to decide between buying food and prescription drugs, and from small business owners who cannot provide coverage to their employees because it's too expensive. The overwhelming number of voices have told me we need to fix the system, and that's what we are doing today."

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Homework: Scraping a Presidential Speech:

- <http://www.crummy.com/software/BeautifulSoup/>
- Parse paragraphs, label speakers

Scraping Demonstration

Acquiring Data from Web: Distributed Human Computing

Amazon.com's Mechanical Turk

- Marketplace for Human Intensive Tasks
- Requester (you): create HITs, offer \$ (about \$0.05 per task)
- Workers (bored + broke people): complete task
- Requester: evaluate and pay

You have text, now what?

Regular Expressions (from Jurafsky Slides)

REGULAR EXPRESSIONS

<

< PREV

RANDOM

NEXT >

>

WHENEVER I LEARN A NEW SKILL I CONCOCT ELABORATE FANTASY SCENARIOS WHERE IT LETS ME SAVE THE DAY.

OH NO! THE KILLER MUST HAVE FOLLOWED HER ON VACATION!



BUT TO FIND THEM WE'D HAVE TO SEARCH THROUGH 200 MB OF EMAILS LOOKING FOR SOMETHING FORMATTED LIKE AN ADDRESS!



IT'S HOPELESS!

EVERYBODY STAND BACK.



I KNOW REGULAR EXPRESSIONS.



Systematic Searches

A language for searching texts:

- Count mentions of a person
- Calculate amount of money discussed
- Prepare texts for analysis: Identify where to “split” a document
- ...

Provide a quick introduction here, with some examples

Regular Expressions, Some Basics (from Jurafsky Slides)

- Disjunctions

RE	Match	Example Patterns Matched
[mM]oney	Money or money	" <u>M</u> oney"
[abc]	'a', 'b', or 'c'	"Investing in <u>I</u> ran" "is <u>d</u> angerous <u>b</u> usiness"
[1234567890]	any digit	"sitting on \$ <u>7</u> . <u>5</u> billion dollars" " <u>2005</u> and <u>2006</u> , more than " "\$ <u>150</u> million dollars"
[\.]	A period	" 'Run!', he screamed <u>.</u> "

Regular Expressions, Some Basics (from Jurafsky Slides)

- Ranges

RE	Match	Example Patterns Matched
[A-Z]	an upper case letter	" <u>R</u> ep. <u>A</u> nthony <u>W</u> einer (<u>D</u> - <u>B</u> rooklyn & <u>Q</u> ueens)"
[a-z]	a lower case letter	"ACORN' <u>s</u> "
[0-9]	a single digit	"(<u>9</u> th CD) "

Regular Expressions, Some Basics (from Jurafsky Slides)

- Negations

RE	Match	Example Patterns Matched
[^A-Z]	not an upper case letter	“ACORN' <u>s</u> ”
[^Ss]	neither 'S' nor 's'	“ <u>ACORN</u> 's”
[^\.]	not a period	“ ‘Run!’, he <u>screamed.</u> ”

Regular Expressions, Some Basics (from Jurafsky Slides)

- Optional Characters: ?, *, +

RE	Match	Example Patterns Matched
colou?r	Words with u 0 or 1 times	<u>“color”</u> or <u>“colour ”</u>
oo*h!	Words with o 0 or more times	<u>“oh!”</u> or <u>“ooh!”</u> or <u>“oooh!”</u>
o+h!	Words with o 1 or more times	<u>“oh!”</u> or <u>“ooh!”</u> or <u>“oooooh!”</u> or

Regular Expressions, Some Basics (from Jurafsky Slides)

- Wild Cards .

RE	Match	Example Patterns Matched
beg.n	Any word with “beg” then “n”	“begin” or “began” or “begun” or “begn” (Poor grammar!)

Regular Expressions, Some Basics (from Jurafsky Slides)

- Start of the line anchor \wedge , end of the line anchor $\$$

RE	Match	Example Patterns Match
$\wedge[A-Z]$	Upper case start of line	" <u>P</u> alo Alto" "the town of Palo Alto"
$\wedge[^\wedge A-Z]$	Not upper case start of line	" <u>t</u> he town of Palo Alto" "Palo Alto"
$\wedge.$	Start of line	" <u>P</u> alo Alto" " <u>t</u> he town of Palo Alto"
$.\$$	Identify character that ends a line	"Wait <u>!</u> " "This is the end <u>.</u> "

Regular Expressions, Some Basics (from Jurafsky Slides)

- “Or” | statements, Useful short hand

RE	Match	Example Patterns Matched
yours mine	Matches “yours” or “mine”	“it’s either <u>yours</u> or <u>mine</u> ”
\ d	Any digit	“ <u>1</u> -Mississippi”
\ D	Any non-digit	“1- <u>Mississippi</u> ”
\ s	Any whitespace character	“1, <u>2</u> ”
\ S	Any non-whitespace character	“ <u>1</u> , <u>2</u> ”
\ w	Any alpha-numeric	“ <u>1</u> - <u>Mississippi</u> ”
\ W	Any non-alpha numeric	“1- <u>Mississippi</u> ”

Regular Expressions, Some Basics (from Jurafsky Slides)

Quick Example to Illuminate Differences:

A “simple” example: identify all instances of **the**.

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Misses capitalized examples

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Returns words that are too long (theocrat, theme)

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- **[^a-zA-Z][tT]he[^a-zA-Z]**

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Misses the first “the” in a sentence

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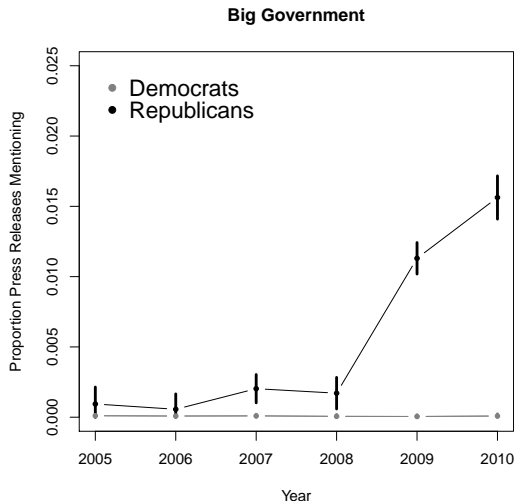
- **(^ | [^ a-zA-Z])[tT]he[^ a-zA-Z]**

An Example: Searching for Tea Party Language

Grimmer, Westwood, and Messing (2014): Criticism and credit

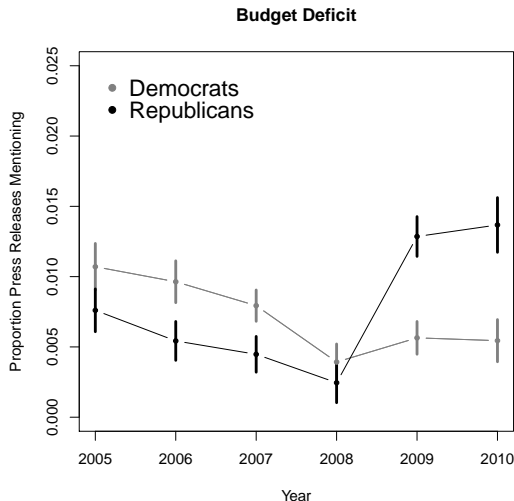
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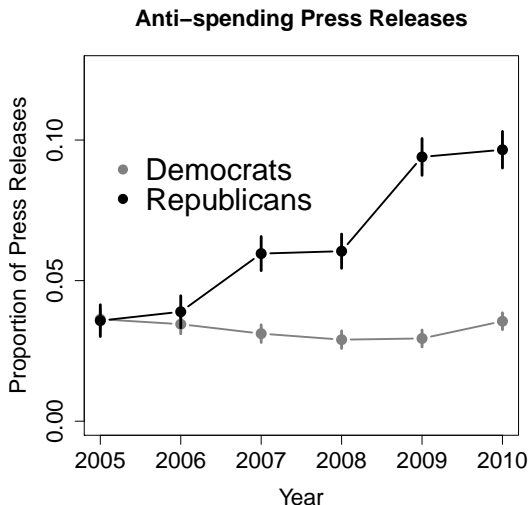
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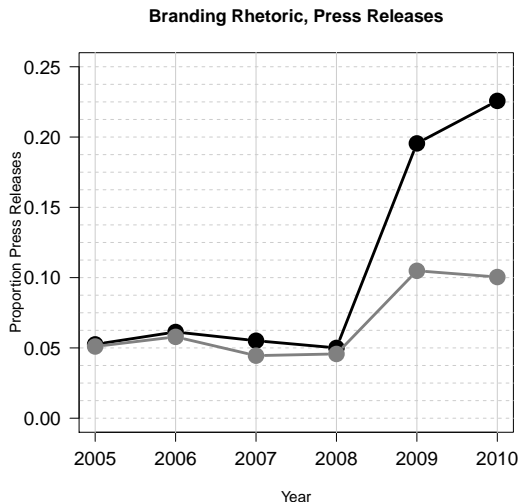
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An Example: Searching for Tea Party Language

Goodman, Grimmer, Parker, Zlotnik (2015): Criticism



Regular Expressions on Steroids: Cheating Detection Software

- WCopyFind:

<http://plagiarism.bloomfieldmedia.com/z-wordpress/software/wcopyfind/>

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- What constitutes **plagiarism**?

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 - Heuristically: how many letters to change from a to b

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- Sets many parameters:

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 - Number of differences between pair of “strings”

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 - Length of character strings to consider

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 - Number of matching strings to constitute match

Regular Expressions on Steroids: Cheating Detection Software

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 - Heuristically: how many letters to change from a to b
- Sets many parameters:
 - Number of differences between pair of “strings”
 - Length of character strings to consider
 - Number of matching strings to constitute match
- Useful:

Regular Expressions on Steroids: Cheating Detection Software

- WCopyFind:

<http://plagiarism.bloomfieldmedia.com/z-wordpress/software/wcopyfind/>

- What constitutes **plagiarism**?
- **Edit distance**:
 - Heuristically: how many letters to change from a to b
- Sets many parameters:
 - Number of differences between pair of “strings”
 - Length of character strings to consider
 - Number of matching strings to constitute match
- Useful:
 - Media uptake

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Document Term Matrices

Regular expressions and search are useful

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We want to use statistics/algorithms to characterize text

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We'll put it in a document-term matrix

Document Term Matrices

Preprocessing \rightsquigarrow **Simplify** text, make it useful

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- If you want to analyze a straw of hay, these methods **are unlikely to work**

Document Term Matrices

Preprocessing \rightsquigarrow **Simplify** text, make it useful
Lower dimensionality

- **For our purposes**

Remember: characterize the **Hay stack**

- If you want to analyze a straw of hay, these methods **are unlikely to work**
- But even if you want to closely read texts, characterizing hay stack can be useful

Preprocessing for Quantitative Text Analysis

One (of many) recipe for preprocessing: retain **useful** information

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Output: Count vector, each element counts occurrence of stems
Provide tools to preprocess via this recipe

Preprocessing Texts

We're going to use the Natural Language Toolkit (nltk) to work with texts

- Built in functionality
- Ensures we can customize our feature spaces

Text Loaded into Python

mac_2.py

Gettysburg Address

```
from BeautifulSoup import BeautifulSoup
from urllib import urlopen
import re, os
url =
urlopen('http://avalon.law.yale.edu/19th_century/gettyb.asp').read()
soup = BeautifulSoup(url)
text = soup.p.contents[0]
```

Preprocessing Texts

Removing capitalization:

- Python : `string.lower()`
- R : `tolower('string')`

Removing punctuation

- Python: `re.sub('\W', ' ', string)`
- R : `gsub('\W', ' ', string)`

Preprocessing Texts

```
text_1 = text.lower()  
text_2 = re.sub('\W', ' ', text_1)
```

The Bag of Words Assumption

Assumption: Discard Word Order

Now we are engaged in a great civil war, testing whether that nation, or any nation

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	Unigram	Count
	a	1
	any	1
	are	1
	civil	1
	engaged	1
	great	1
	in	1
Unigrams	nation	2
	now	1
	or	1
	testing	1
	that	1
	war	1
	we	1
	whether	1

The Bag of Words Assumption

Assumption: Discard Word Order

	Bigram	Count
	now we	1
	we are	1
	are engaged	1
	engaged in	1
	in a	1
	a great	1
Bigrams	great civil	1
	civil war	1
	war testing	1
	testing whether	1
	whether that	1
	that nation	1
	nation or	1
	or any	1
	any nation	1

The Bag of Words Assumption

Assumption: Discard Word Order

Trigrams	Trigram	Count
	now we are	1
	we are engaged	1
	are engaged in	1
	engaged in a	1
	in a great	1
	a great civil	1
	great civil war	1
	civil war testing	1
	war testing whether	1
	whether that nation	1
	that nation or	1
	nation or any	1
	or any nation	1

How Could This Possibly Work?

Speech is:

- Ironic

I'm sure that Ryan Pace is going to make a great decision about who to hire as head coach

- Subtle Negation (Source: Janyce Wiebe) :

They have not succeeded, and will never succeed, in breaking the will of this valiant people

- Order Dependent (Source: Arthur Spirling):

Peace, no more war

War, no more peace

How Could This Possibly Work?

Three answers

- 1) **It might not**: Validation is critical (task specific)
- 2) **Central Tendency in Text**: Words often imply what a text is about
war, civil, union or tone consecrate, dead, died, lives.
Likely to be used repeatedly: create a theme for an article
- 3) **Human supervision**: Inject human judgement (coders): helps methods identify subtle relationships between words and outcomes of interest

Dictionaries

Training Sets

Discarding Word Order in Python

```
from nltk import word_tokenize
from nltk import bigrams
from nltk import trigrams
from nltk import ngrams
```

```
text_3 = word_tokenize(text_2)
text_3_bi = bigrams(text_3)
text_3_tri = trigrams(text_3)
text_3_n = ngrams(text_3, 4)
```

Stop Words

- **Stop Words:** English Language place holding words

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To the Python code!

Creating an Equivalence Class of Words

Reduce dimensionality further

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- Stemming/Lemmatizing algorithms: Many-to-one mapping from words to stem/lemma

Comparing Stemming and Lemmatizing

Stemming algorithm:

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Key comparison: **equivalence classes**

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Key comparison: **equivalence classes**

Python Code!

All together now...

Four score and seven years ago our fathers brought forth on this continent a new nation, conceived in liberty, and dedicated to the proposition that all men are created equal.

All together now...

Four score and seven years ago our fathers brought forth on this continent a new nation, conceived in liberty, and dedicated to the proposition that all men are created equal.

Step 1: Remove capitalization and punctuation:

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Step 2: Discard word order:

:

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Step 2: Discard word order:

four, score, and, seven, years, ago, our, fathers, brought,
forth, on, this, continent, a, new, nation, conceived, in,
liberty, and, dedicated, to, the, proposition, that, all,
men, are, created, equal

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Step 3: Remove stop words :

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Step 4: Applying Stemming Algorithm

All together now...

Step 1: Remove capitalization and punctuation:

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four, score, seven, year, ago, father, brought, forth,
contin, new, nation, conceiv, liberti, dedic, proposit,
men, creat, equal

Step 5: Create Count Vector (Python Code!)

Stem	Count
------	-------

ago	1
-----	---

brought	1
---------	---

seven	1
-------	---

creat	1
-------	---

conceiv	1
---------	---

men	1
-----	---

father	1
--------	---

⋮	⋮
---	---

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Step 1: Remove capitalization and punctuation:

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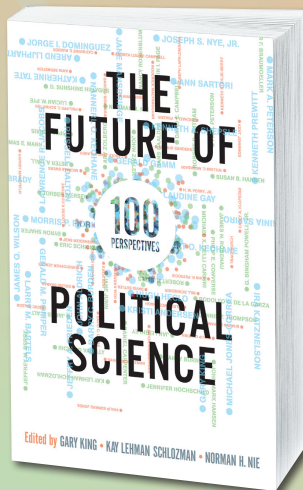
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Evaluators' Rate Machine Choices Better Than Their Own (Grimmer and King)

Generate pairs of **similar** documents: Humans vs Machines

- Scale: (1) unrelated, (2) loosely related, or (3) closely related
- Table reports: mean(scale)

Pairs from	Overall Mean	Evaluator 1	Evaluator 2
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p.s. The hand-coders did the evaluation!