Harnessing Web Archives to Tackle Selected Societal Challenges

The Oral Exam of

Johannes Kiesel

To Obtain the Academic Degree of

Dr. rer. nat.

Web Technology & Information Systems Group
Bauhaus-Universität Weimar

www.uni-weimar.de www.webis.de

Harnessing Web Archives to Tackle Selected Societal Challenges

Societal challenges

Issues that concern most if not all members of a society, either now or in a likely future.

Well-known challenges:*

- ❑ Critical assessment of information
- ❑ Protection of the environment
- ❑ Preservation of culture
- ❑ Ensuring public health
- ❑ Security and privacy

*Taken from European Commission (Horizon 2020), World Economic Forum, Gesellschaft für Informatik

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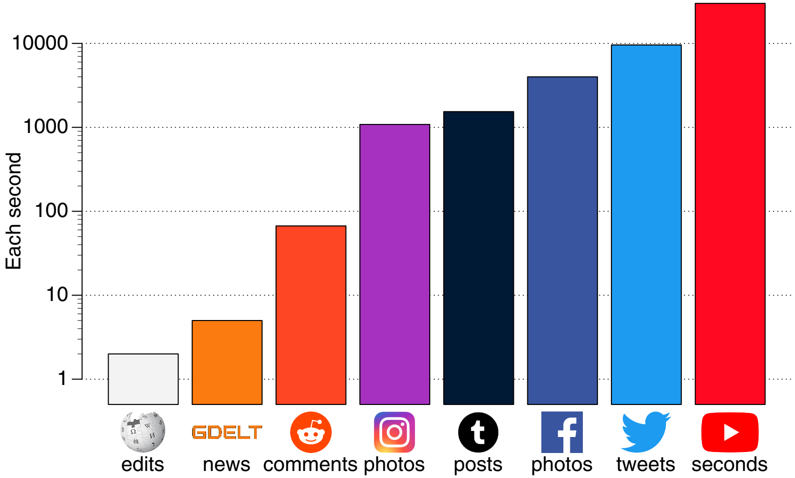
Society → Web



Source: DOMO, Reddit, GDELT, Wikipedia

Web archives

- ❑ Allow for large-scale analyses
- ❑ Allow to trace changes
- ❑ Allow to replicate analyses

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Harnessing Web Archives to Tackle Selected Societal Challenges

Main contributions

1. Preservation of digital culture

- ❑ 10K pages high-fidelity archive (FAIRest dataset award)
- ❑ Reproduction assessment task
- ❑ 9K pages segmentation dataset
- ❑ Segmentation evaluation measures

2. Critical assessment of information

- ❑ Revert-based vandalism detection
- ❑ 30K edits Wiki vandalism dataset
- ❑ 1M hyperpartisan news dataset
- ❑ Style-based polarity detection
- ❑ Hyperpartisan news challenge (SemEval, 42 teams)

3. Online security and privacy

- ❑ 3B web sentences dataset
- ❑ Position-dependent language model
- ❑ Security estimate: mnemonic passwords
- ❑ Personal archiving tool

Tailored web archiving technology (Webis Web Archiver)

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→ New tasks

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→ New tasks → New or improved algorithms

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Tailored web archiving technology (Webis Web Archiver)

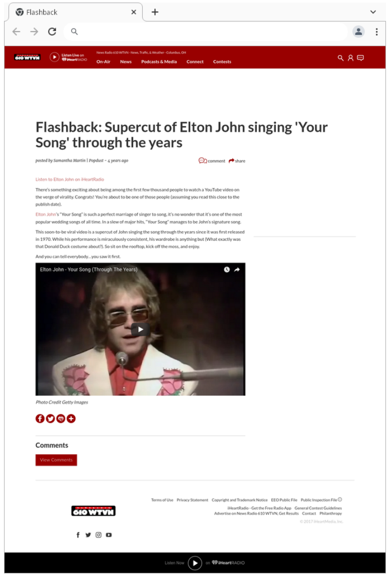
→ New tasks → New or improved algorithms → More adequate evaluation measures → Larger and more accurate datasets

Challenge 1
Preservation of Digital Culture

Web Page Segmentation

(highlighting reproducibility)

Web Page Segmentation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Flashback: Supercut of Elton John singing 'Your Song' through the years

posted by Samantha Martin | Popdust - 4 years ago

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Photo Credit Getty Images

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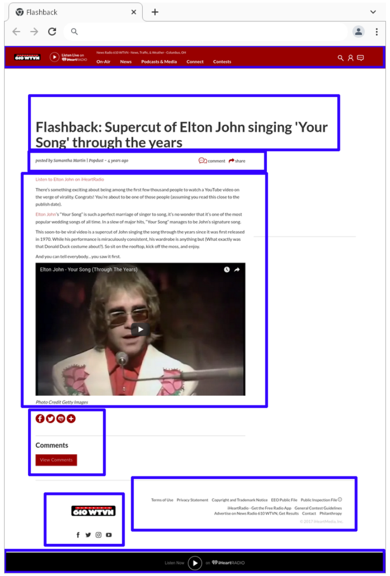
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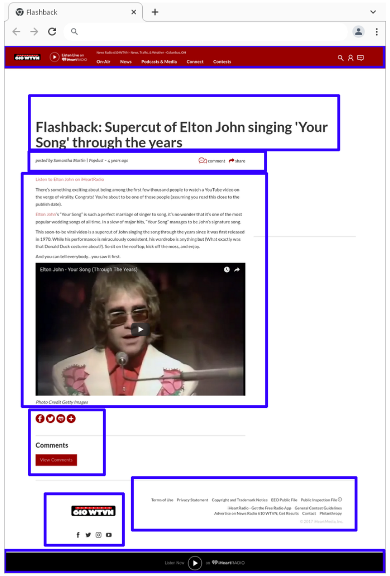
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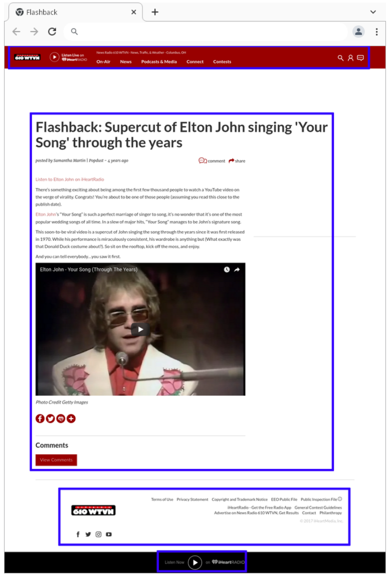
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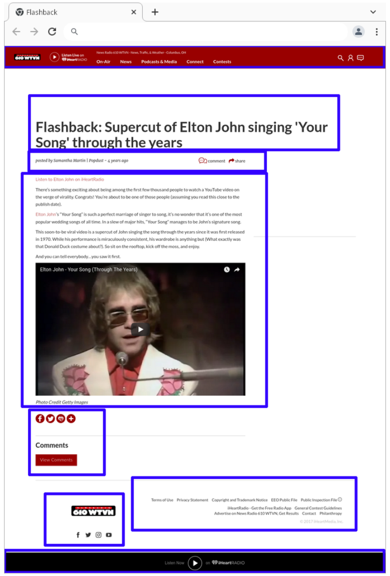
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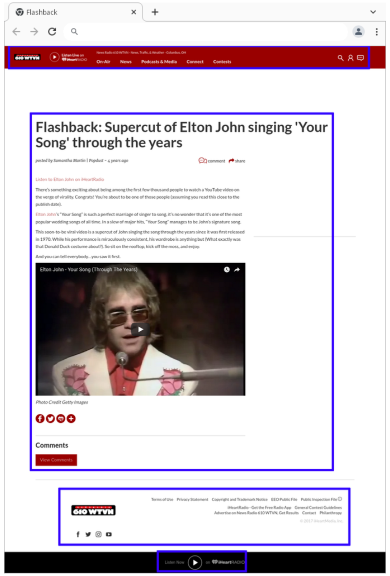
Visually distinct segments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Self-contained segments

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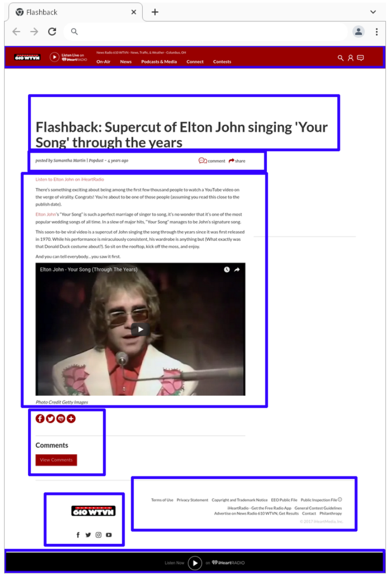

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On-Air News Podcasts & Media Connect Contests

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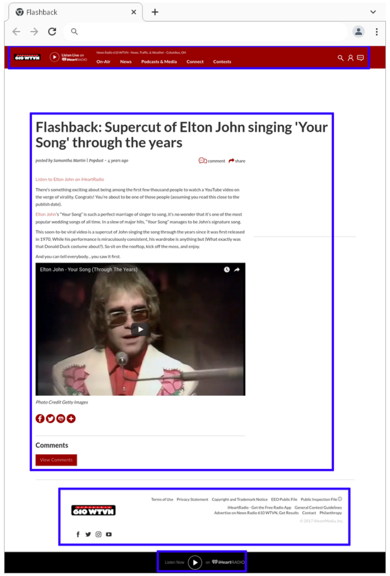

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Self-contained segments

Existing definitions (9): biased towards downstream tasks

- ❑ Segments are visual blocks (4), edge-delineated (2), visually distinct (1), self-contained (1), have a heading (1)
- → Problem: inconsistent evaluation methodology
- → No reliable benchmark of algorithms

Existing datasets (20): not re-usable

- ❑ The 12 with human annotations are small (max 1000 pages)
- ❑ Only 3 of these allow for algorithms based on computer vision
- ❑ None allow to reproduce page for browser-based algorithms

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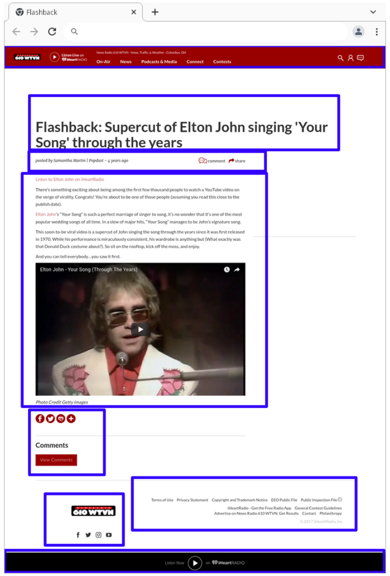

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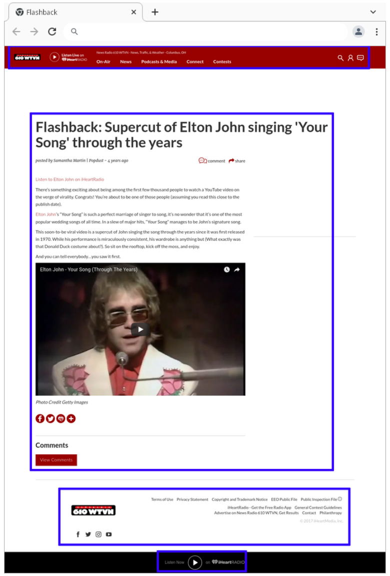

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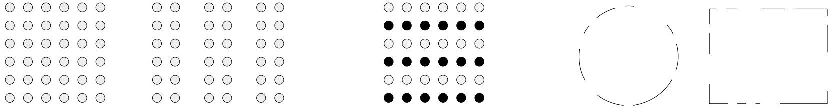
Solution

- ❑ Segment concept based on human viewer (Gestalt principles)
- ❑ Dataset of 8490 archived web pages
  (5 segmentations each; reproducible in browser)
- ❑ Segmentation fusion method
- ❑ Evaluation measure, tweakable towards downstream tasks

Gestalt principles (selection)



Proximity

Similarity

Closure

A web page segment is a part of a web page containing those elements that belong together as per agreement among a majority of viewers.

Elements $E = \{e_1, \ldots, e_n\}$

Segmentation $S = \{s_1, \ldots, s_m\}$ with segments $s_i \subseteq E$

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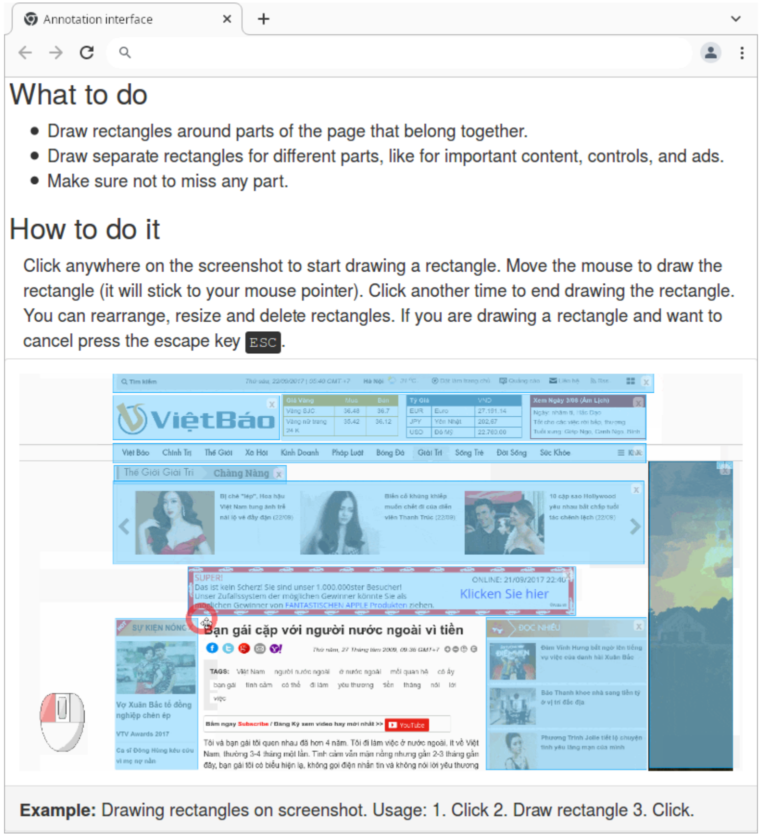
Large-scale human annotation (8490 pages × 5)



What to do

- Draw rectangles around parts of the page that belong together.
- Draw separate rectangles for different parts, like for important content, controls, and ads.
- Make sure not to miss any part.

How to do it

Click anywhere on the screenshot to start drawing a rectangle. Move the mouse to draw the rectangle (it will stick to your mouse pointer). Click another time to end drawing the rectangle. You can rearrange, resize and delete rectangles. If you are drawing a rectangle and want to cancel press the escape key `ESC`.

Example: Drawing rectangles on screenshot. Usage: 1. Click 2. Draw rectangle 3. Click.

→ Annotation of 600,000 segments in 4 months of full-time work

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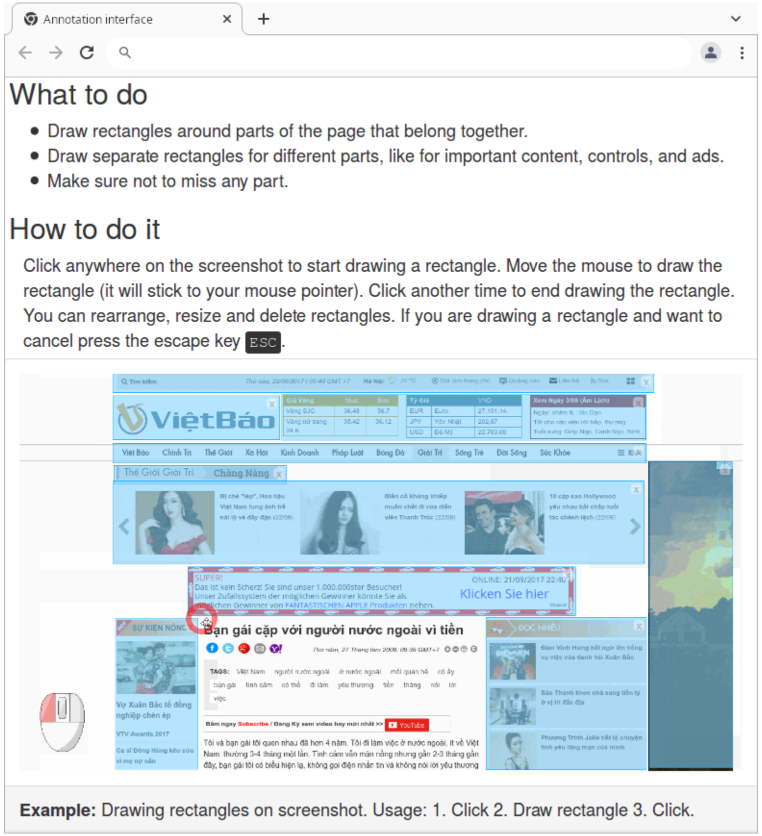

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Ground-truth fusion: hierarchical clustering (UPGMA)

Evaluation: $F_{B^3} \in [0, 1]$ (from clustering evaluation)

→ Decomposition into P_{B^3}, R_{B^3}
$\approx$ errors of oversegmentation, undersegmentation

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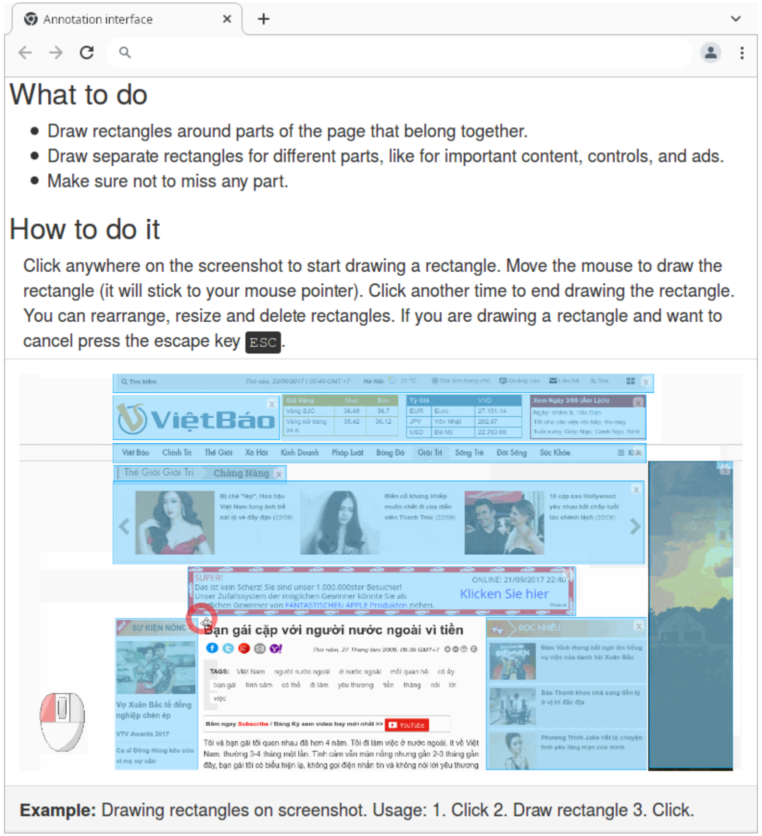

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Elements of downstream tasks

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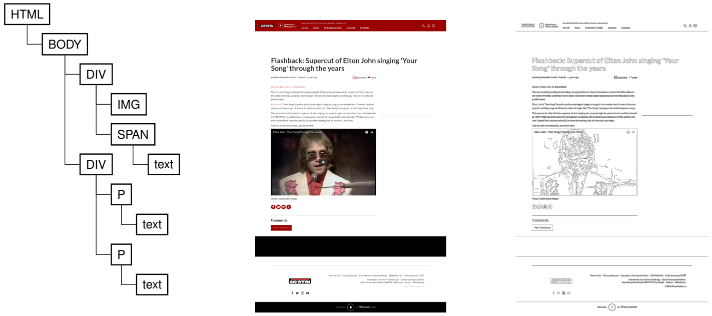
Characters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BODY
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IMG
SPAN
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DIV
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DOM nodes

Pixels

Edge pixels

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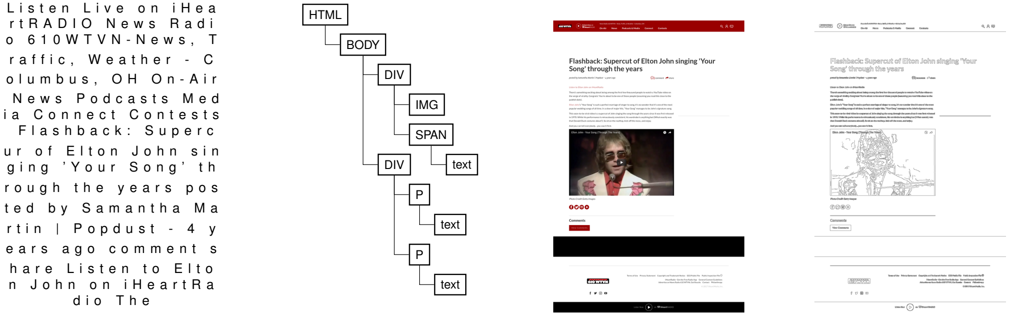
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Characters DOM nodes Pixels Edge pixels

High agreement for all tasks

Agreement measure	Characters	Nodes	Pixels	Edge pixels
F_{B^3}	0.78	0.74	0.65	0.73
max(P_{B^3}, R_{B^3})	0.97	0.95	0.94	0.96

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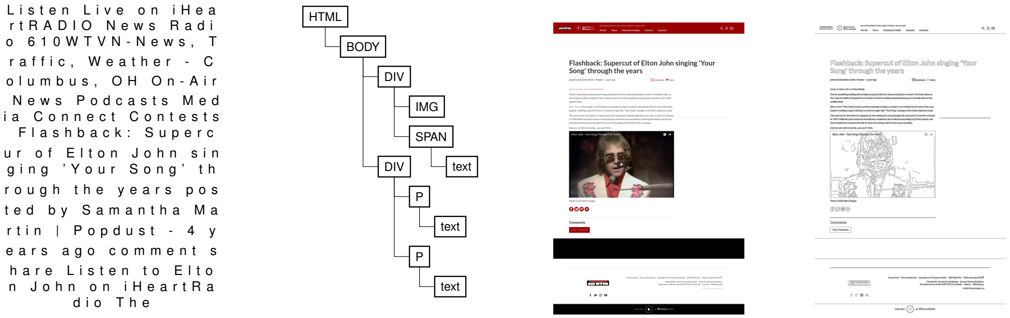
Evaluation: $F_{B^3} \in [0, 1]$ (from clustering evaluation)

→ Decomposition into P_{B^3}, R_{B^3}
$\approx$ errors of oversegmentation, undersegmentation

Elements of downstream tasks


Listen Live on iHeartRADIO News Radio 610WTVN-News, Traffic, Weather - Columbus, OH On-Air News Podcasts Media Connect Contests Flashback: Supercur of Elton John singing 'Your Song' through the years posted by Samantha Martin | Popdust - 4 years ago comment share Listen to Elton John on iHeartRadio The
HTML
BODY
DIV
IMG
SPAN
text
DIV
P
text
P
text
Flashback: Supercut of Elton John singing 'Your Song' through the years

Characters DOM nodes Pixels Edge pixels

High agreement for all tasks

Agreement measure	Characters	Nodes	Pixels	Edge pixels
F_{B^3}	0.78	0.74	0.65	0.73
$\max(P_{B^3}, R_{B^3})$	0.97	0.95	0.94	0.96

Insights into segmentation technology (F_{B^3})

Elements/task	1Seg	VIPS	HEPS	Cor.	MMD.	Meier	MV@2
Characters	0.52	**0.67**	0.50	0.61	0.61	0.50	0.62
Pixels	0.24	0.38	0.33	0.36	**0.42**	0.32	0.39

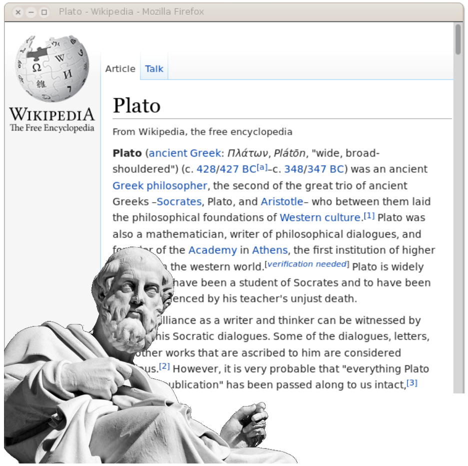
Challenge 2

Critical Assessment of Information

Spatio-Temporal Analysis of Vandalism in Wikipedia

(highlighting temporal dynamics)

Wikipedia Vandalism



Plato

From Wikipedia, the free encyclopedia

Plato (ancient Greek: *Πλάτων*, *Plátōn*, "wide, broad-shouldered") (c. 428/427 BC[a]–c. 348/347 BC) was an ancient Greek philosopher, the second of the great trio of ancient Greeks –Socrates, Plato, and Aristotle– who between them laid the philosophical foundations of Western culture.[1] Plato was also a mathematician, writer of philosophical dialogues, and fo der of the Academy in Athens, the first institution of higher
the western world.[verification needed] Plato is widely
have been a student of Socrates and to have been
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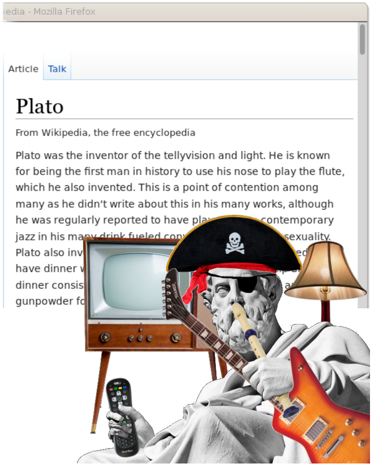

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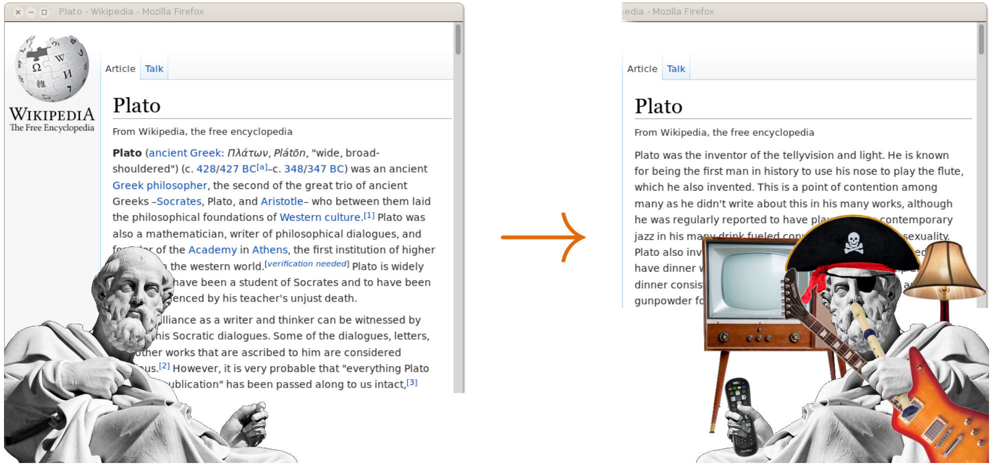

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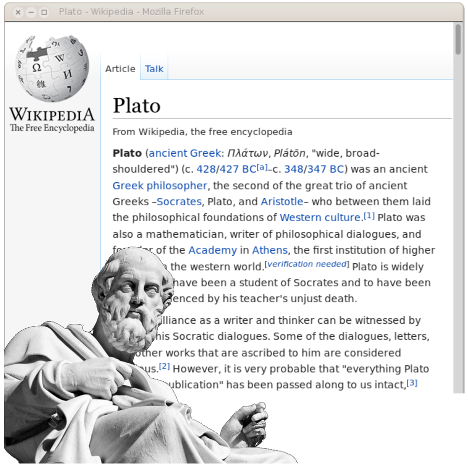
Vandalism is a problem for Wikipedia

- ❑ 470 million edits to the English Wikipedia (14 years)
- ❑ 40 million (9.5%) are vandalism
- → Rate of today: a vandalism case every 5 seconds

How to fight vandalism?

- ❑ Explain **why** people vandalize
- ❑ Analyze **when** people vandalize
- ❑ Analyze **where** these people are

Wikipedia Vandalism



Plato - Wikipedia - Mozilla Firefox

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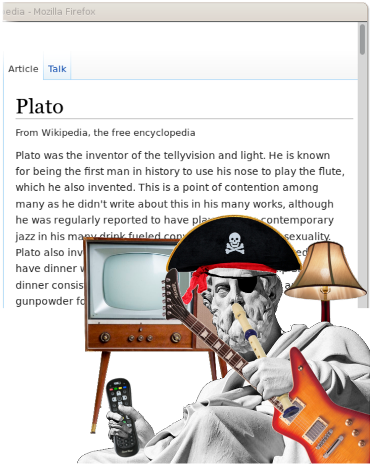

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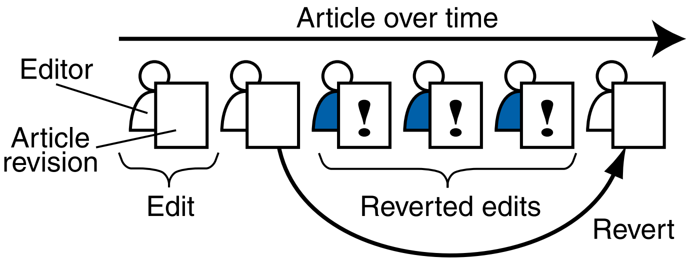
- ❑ Analyze **where** these people are

Language-independent detection approach

- ❑ Take all 1.2 billion edits to the 7 most-edited Wikipedias (english, german, french, spanish, russian, italian, japanese)
- ❑ Historical geolocation of anonymous editors (77% of edits by cross-checking RIR, IPligence, and IP2Location)
- ❑ Vandalism detector based on revert patterns (community behavior)
- → Spatio-temporal analysis per local time of anonymous editors

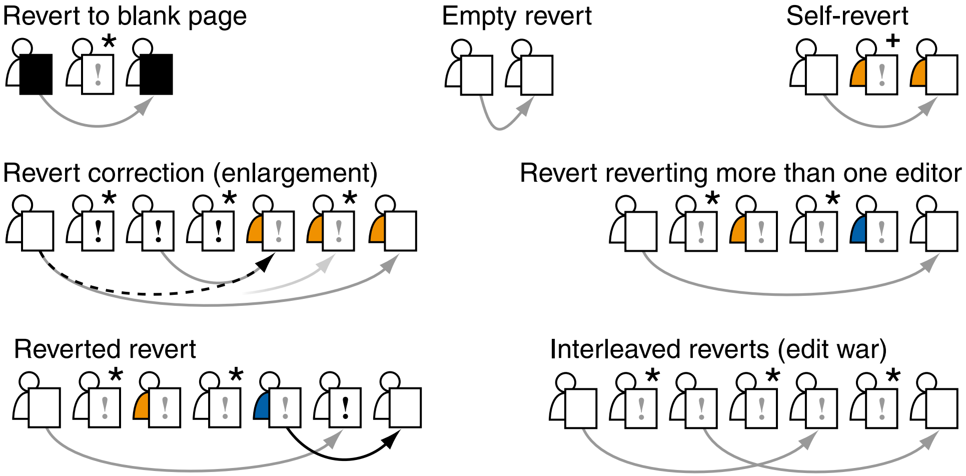
Reverts (supported by Wiki interface)



Not all reverts indicate vandalism

- ❑ Prior work: use only reverts whose comment indicates vandalism
- → Underestimates vandalism; language-dependent

- ❑ Our approach: identify revert patterns indicating non-vandalism



Revert to blank page

Empty revert

Self-revert

Revert correction (enlargement)

Revert reverting more than one editor

Reverted revert

Interleaved reverts (edit war)

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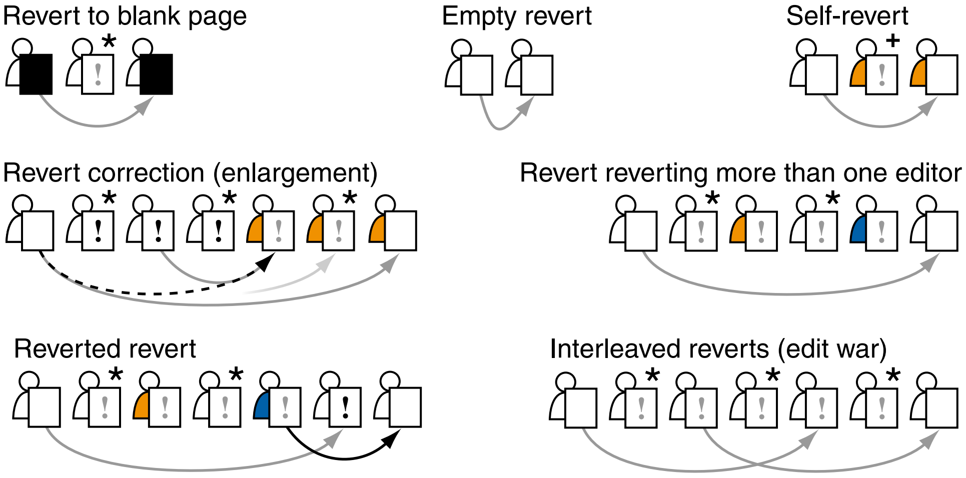

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Interleaved reverts (edit war)

❑ Only 46% of reverted edits are vandalism

❑ Human evaluation: precision 82.8%, recall 84.7%
(4 times the recall of prior work)

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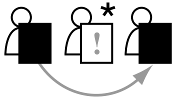
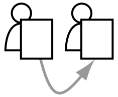
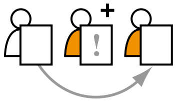


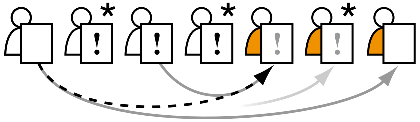
Empty revert



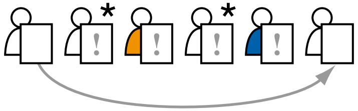
Self-revert



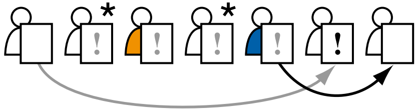
Revert correction (enlargement)



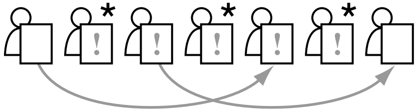
Revert reverting more than one editor



Reverted revert



Interleaved reverts (edit war)



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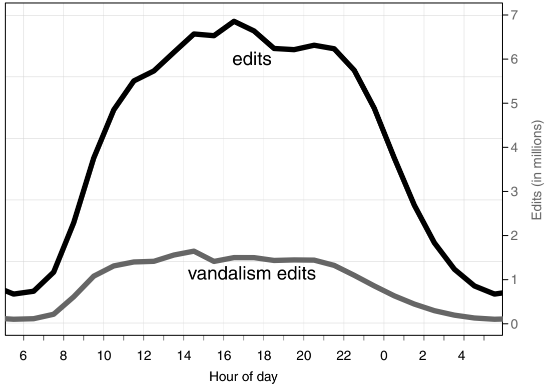
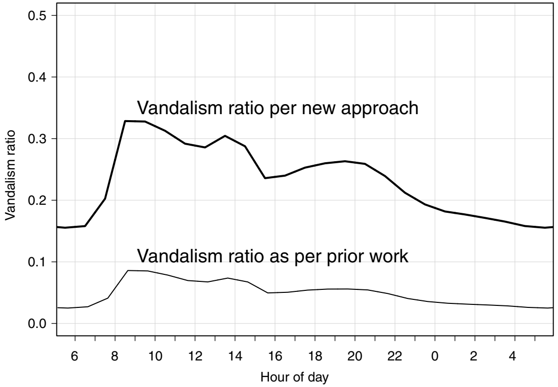
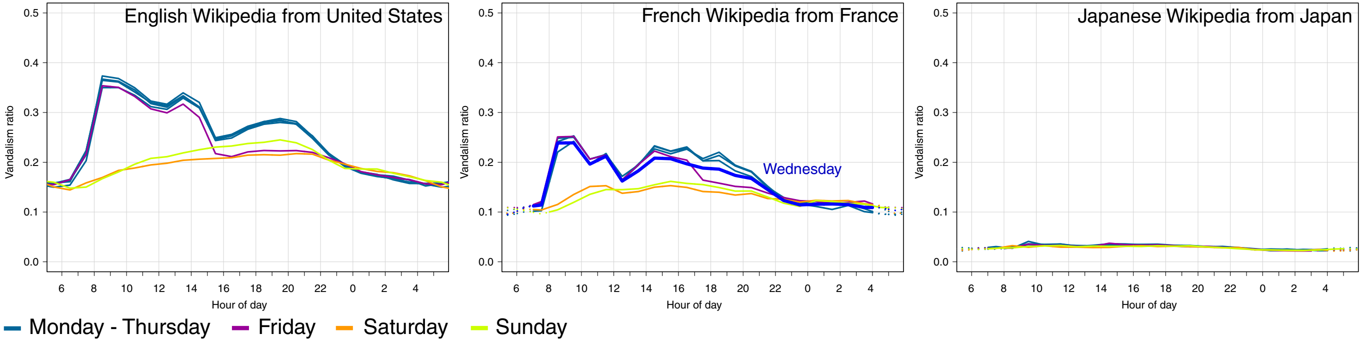
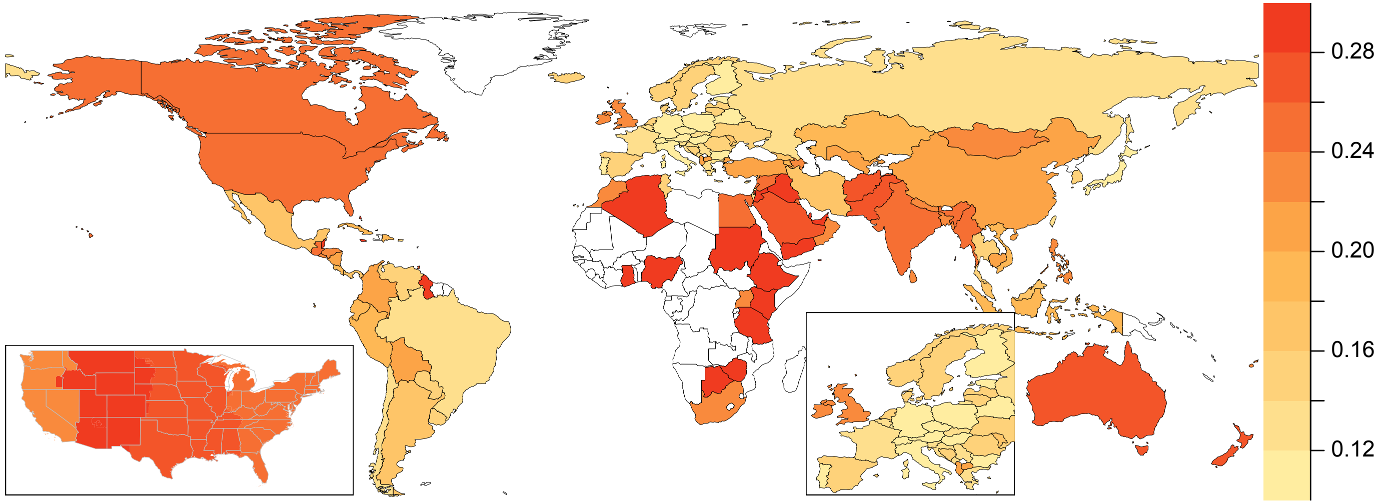
Vandalism over time of day

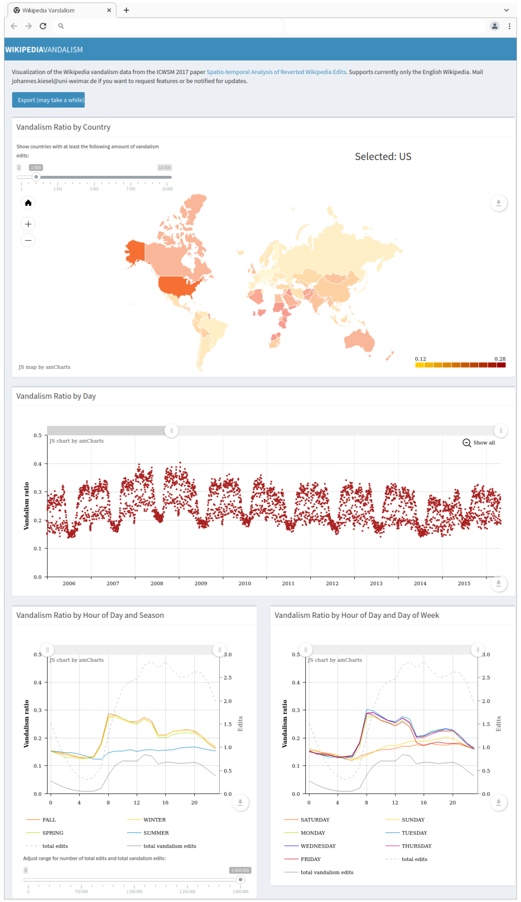




Spatio-temporal vandalism analysis







Wikipedia Vandalism

WIKIPEDIAVANDALISM

Visualization of the Wikipedia vandalism data from the ICWSM 2017 paper Spatio-temporal Analysis of Reverted Wikipedia Edits. Supports currently only the English Wikipedia. Mail johannes.kiesel@uni-weimar.de if you want to request features or be notified for updates.

Export (may take a while)

Vandalism Ratio by Country

Show countries with at least the following amount of vandalism edits: 1 000

Selected: US

Vandalism Ratio by Day

Vandalism Ratio by Hour of Day and Season

Adjust range for number of total edits and total vandalism edits: 0 – 3 000 000

Vandalism Ratio by Hour of Day and Day of Week

Challenge 3
Online Security and Privacy

Security Estimate for Mnemonic Passwords

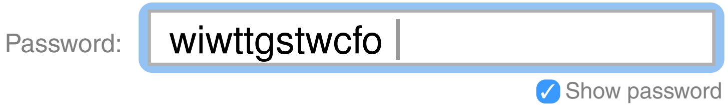
(highlighting volume)

The mnemonic password advice

(as per German BSI, Google, etc.)

1. Create a sentence
2. Memorize it
3. Concatenate the first characters of each word
4. Use the string as password

When I walked to the grocery store,
there were camels flying overhead!



Password: wiwttgstwcfo

☑ Show password

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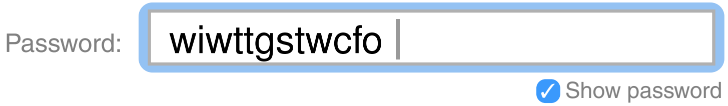


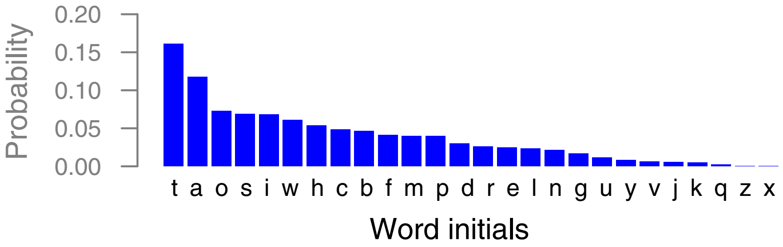
Password: wiwttgstwcfo

☑ Show password

Passwords that require a botnet $(H_1 \approx 65$ Bit$)$:

- □ 14 random lowercase letters (out of 26)
- □ 10 random ASCII characters (out of 96)
- □ 5 random words (out of 7776)

And for mnemonic passwords?



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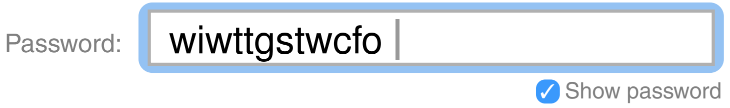

Password: wiwttgstwcfo

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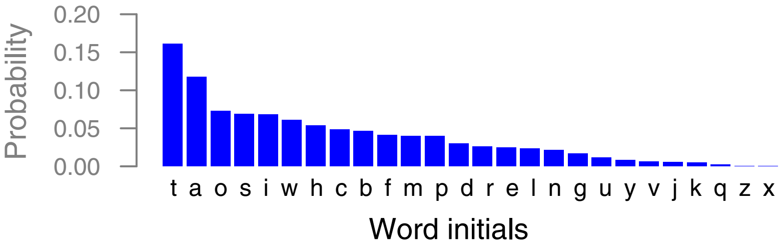

Depends on password distribution (Kerckhoffs' principle) → model distribution from a billion passwords

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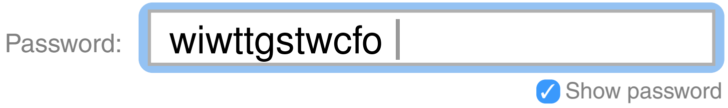

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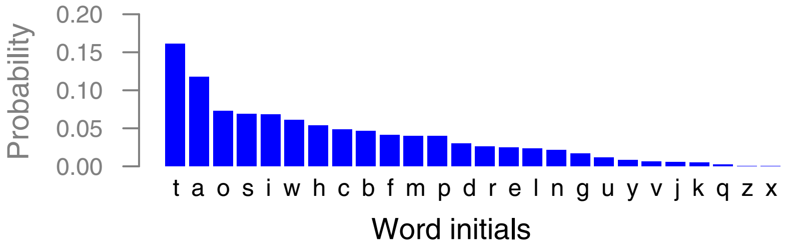


Depends on password distribution (Kerckhoffs' principle) → model distribution from a billion passwords

Approach: substitute mnemonics by web sentences

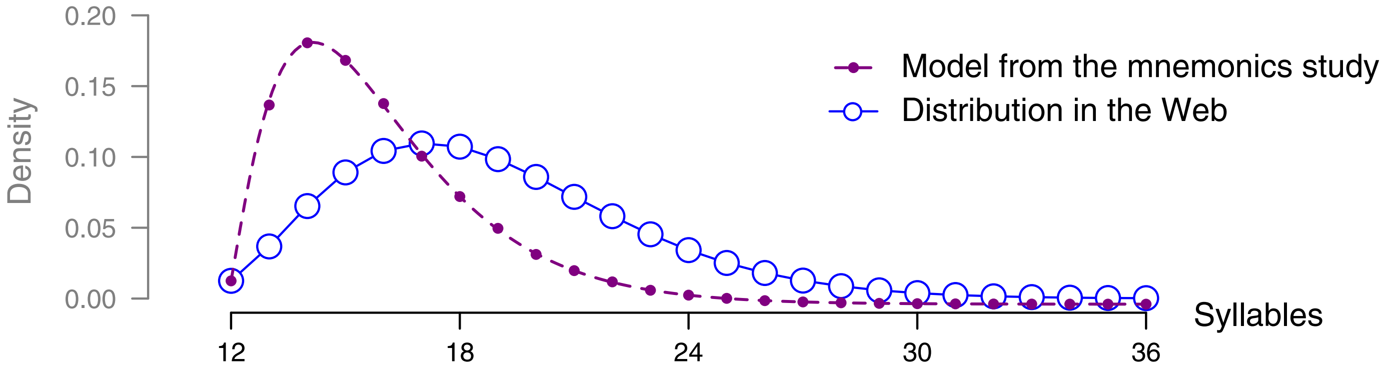
- 3 billion web sentences corpus from a standard web archive
- Statistically align the sentence corpus to mnemonics
- Estimate password distribution using position-dependent language models

→ Security estimates against offline (H_1) and online attacks (H_0, λ_n)

Sentence acquisition for password distribution estimate

5,000	Mnemonics	Study by Yang et al., 2016
80,000	Sentences	The Bible
5,000,000	Sentences	Encyclopedia Britannica
70,000,000	Passwords	Largest password corpus
730,000,000	Web pages	ClueWeb12, 27.3 TB
3,400,000,000	Sentences	Extracted and filtered
500,000,000	Sentences	And aligned to mnemonics

Alignment in sentence complexity (≈ readability)



Sentences of length 12

Security estimates (per character)

Language model	Lowercase letters		ASCII	
	H_1	Ppl.	H_1	Ppl.
Uniform	4.70	26.0	6.55	94.0
Order 0	4.15	17.8	5.09	34.1
Order 8	3.71	13.1	3.98	15.8
Order 8, position-dependent	3.65	12.6	3.70	13.0

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Reaching H_1 = 65 Bit with mnemonic passwords

❑ Lowercase letters from 13+ words sentence		54 Bit
❑ 7-bit visible ASCII (incl. %, !, @, #, etc.) (adds on average 2 characters ≈ 6.4 Bit)		8 Bit
❑ Word replacements (and → &, to → 2, etc.)		2 Bit
❑ Different characters (last of each word)		0 Bit
❑ Complex sentences (rich vocabulary)	+	2 Bit
		66 Bit

Harnessing Web Archives to Tackle Selected Societal Challenges

Summary

1. Preservation of digital culture

- 10K pages high-fidelity archive (FAIRest dataset award)
- Reproduction assessment task
- 9K pages segmentation dataset
- Segmentation evaluation measures

2. Critical assessment of information

- Revert-based vandalism detection
- 30K edits Wiki vandalism dataset
- 1M hyperpartisan news dataset
- Style-based polarity detection
- Hyperpartisan news challenge (SemEval, 42 teams)

3. Online security and privacy

- 3B web sentences dataset
- Position-dependent language model
- Security estimate: mnemonic passwords
- Personal archiving tool

Tailored web archiving technology (Webis Web Archiver)

Highlighted aspects:

- Reproducibility
- Temporal dynamics
- Volume