

NON-LITERAL TEXT REUSE IN HISTORICAL TEXTS: AN APPROACH TO IDENTIFY REUSE TRANSFORMATIONS AND ITS APPLICATION IN BIBLICAL REUSE

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INTRODUCTION

TEXT REUSE

Text Reuse:

- spoken and written repetition of text across time and space.

For example:

- citations, allusions, translations.

Detection methods are needed to support scholarly work.

- E.g. they help to ensure clean libraries or identify fragmentary authors.

Text is often modified during the reuse process.

Paraphrasing and **non-literal** reuse **challenges** many approaches:

- Alzahrani et al. (2012)
 - study n-gram-, syntax-, and semantic-based detection approaches;
 - they find: as soon as reuse is slightly modified (words changed) most approaches fail.
- Barrón-Cedeño et al. (2013)
 - experiment with paraphrasing to improve plagiarism detection;
 - they found that complex paraphrasing with a high density challenges plagiarism detection, and
 - that lexical substitution is the most frequent plagiarism technique.

TEXT REUSE DETECTION

The most of current NLP research **focuses on English**, but many **stronger inflecting languages** exist. Their computational processing is more challenging. Historical, especially **Ancient languages** are particularly problematic as they come with:

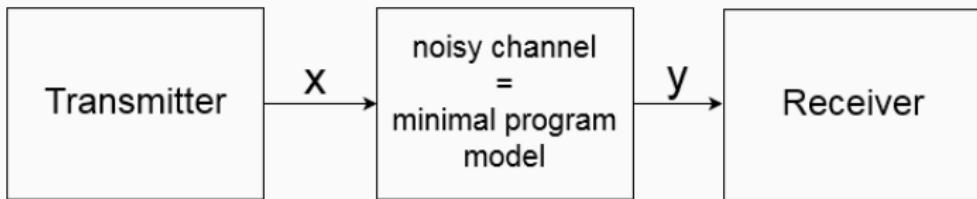
- **variants** due to long transmission time,
- **incomplete** witnesses,
- **diverse** reuse.

One solution: Reuse Style Investigation.

- I.e., how is reuse transferred, how literal is it, what kind of modification takes place?

APPROACH

- Inspired by
 - **Noisy channel model**: given a “scrambled” word or sentence, guess the intended version of that sentence (Brill, 2000),
 - **Kolmogorov Complexity**: describes the length of the shortest program that produces an output string (Li and Vitáni, 2008),
- we study Ancient text reuse to understand how text is transferred.
 - **Identify** operations to characterize morphological & semantic changes
 - **Design** an algorithm which applies these OPs to our datasets
 - **Transform** one text excerpt into another by a minimum OP set



METHODOLOGY

RESEARCH QUESTIONS

- RQ1. What is the extent of non-literal reuse in our datasets?
- RQ2. How is the non-literally reused text modified in our datasets?
 - RQ2.1. How can linguistic resources support the discovery of non-literal reuse?
 - RQ2.2. What are the limitations of an automated classification approach relying on linguistic resources?

We:

1. define operations reflecting literal reuse and semantic replacements,
2. develop an algorithm that looks for identical, similar words, morphological changes and semantic changes,
3. apply it to our two data-sets (next slide),
 - identifying the literal overlap in reuse (RQ1),
 - measuring occurrences of operations by covlem and covAGWN to assess the resources' coverage for our approach (RQ2.1),
4. manually analyze a smaller sample of our reuse using further operations. (RQ2.2).

DATA-SETS - ANCIENT GREEK AND LATIN DATA-SET

“Salvation for the Rich”

Clement of Alexandria

Christian theologian, 2nd cent.

- Known for his retelling of biblical excerpts
- Reuse annotated by Biblindex team (Mellerin, 2014; Mellerin, 2016)
- We obtain 199 verse-reuse-pairs
- Pointing to 15 Bible books

The data was tokenized and punctuation was kept but ignored in the analyses.

Extracts from 12 works & 2 collections

Bernard of Clairvaux

French abbot, 12th cent.

- Known for his influence on the Cistercian order and his work in biblical studies
- Reuse extracted by Biblindex team (Mellerin, 2014; Mellerin, 2016)
- We obtain 162 verse-reuse-pairs
- Pointing to 31 Bible books

BIBLICAL REUSE EXAMPLES

more literal	Bible verse	Bernard reuse
Proverbs 18:3	impius cum in profundum venerit peccatorum contemnit sed sequitur eum ignominia et obprobrium (<i>When the wicked man is come into the depth of sins, also contempt comes but ignominy and reproach follow him</i>)	Impius , cum venerit in profundum malorum , contemnit (<i>When the wicked man is come into the depth of evil</i>)
less literal	Bible verse	Clement reuse
1Cor 13:13	vouνὶ δὲ μένει πίστις , ἐλπίς , ἀγάπη , τὰ τρία ταῦτα μείζων δὲ τούτων ἡ ἀγάπη (And now remain faith, hope, love, these three; but the greatest of those is love.)	πίστει καὶ ἐλπίδι καὶ ἀγάπῃ (faith, and hope, and love - in dative case) ἀγάπην , πίστιν , ἐλπίδα (love, faith, hope - in accusative case) μένει δὲ τὰ τρία ταῦτα , πίστις , ἐλπίς , ἀγάπη . μείζων δὲ ἐν τούτοις ἡ ἀγάπη (and remain these three, faith, hope, love; but the greatest among them is love)
non-literal	Bible verse	Clement reuse
Mt 12:35	ό ἀγαθὸς ἄνθρωπος ἐκ τοῦ ἀγαθοῦ θησαυροῦ ἔκβαλλε ἀγαθά , καὶ ὁ πονηρὸς ἄνθρωπος ἐκ τοῦ πονηροῦ θησαυροῦ ἔκβαλλε πονηρά . (A good man out of good storage brings out good things , and an evil man out of the evil storage brings evil things .)	Ψυχῆς , τὰ δὲ ἑκτός , καν μὲν ἡ ψυχὴ χρῆται καλῶς , καλὰ καὶ ταῦτα δοκεῖ , ἐὰν δὲ πονηρῶς , πονηρά , ὁ κελεύων ἀπαλλοτριοῦν τὰ ὑπάρχοντα ([are whitin the] soul, and some are out, and if the soul uses them good, those things are also thought of as good, but if [they are used as] bad, [they are thought of as] bad; he who commands the renouncement of possessions)

LINGUISTIC SUPPORT - LEMMA RESOURCES

We aggregate:

- Biblindex' Lemma Lists
 - 65,537 Biblical Greek entries
 - 315,021 Latin entries
- Classical Language Tool Kit (CLTK) (Johnson et al., 2014)
 - 953,907 Ancient Greek words
 - 270,228 Latin words
- Greek New Testament of the Society of Biblical Literature¹ & Septuaginta (Rahlfs, 1935a; UPenn) 59,510 word-lemma-pairs

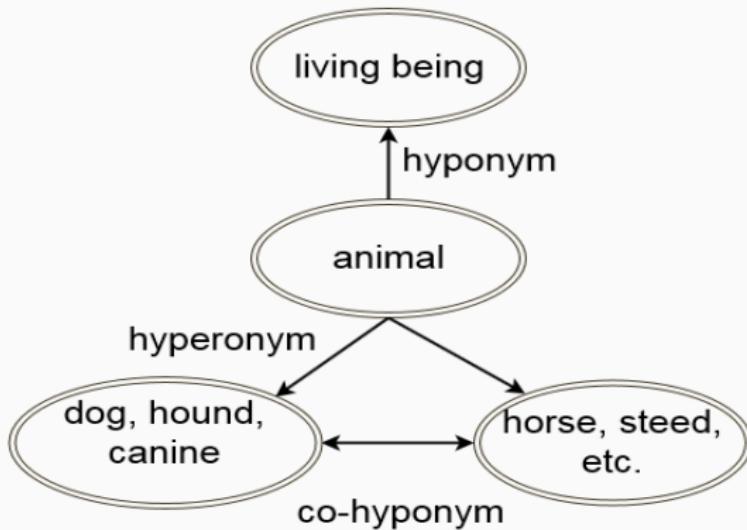
¹Logos Bible Software <http://sblgnt.com/about/>

LINGUISTIC SUPPORT - ANCIENT GREEK WORDNET (AGWN)

99K synsets

of which 33K contain Ancient Greek and 27K Latin words

(Bizzoni et al., 2014; Minozzi, 2009)



TRANSFORMATION OPERATIONS

Table 1: Operation list for the automated approach

operation	description	example
<i>NOP(reuse_word, orig_word)</i>	Original and reuse word are equal.	<i>NOP(maledictus, maledictus)</i>
<i>upper(reuse_word, orig_word)</i>	Word is lowercase in reuse and uppercase in original.	<i>upper(kai, Kai) - in Greek</i>
<i>lower(reuse_word, orig_word)</i>	Word is uppercase in reuse and lowercase in original.	<i>lower(Gloriam, gloriam)</i>
<i>lem(reuse_word, orig_word)</i>	Lemmatization leads to equality of reuse and original.	<i>lem(penetrat, penetrabit)</i>
<i>repl_syn(reuse_word, orig_word)</i>	Reuse word replaced with a synonym to match original word.	<i>repl_syn(magnificavit, glorificavit)</i>
<i>repl_hyper(reuse_word, orig_word)</i>	Word in Bible verse is a hyperonym of the reused word.	<i>hyper(cupit, habens)</i>
<i>repl_hypo(reuse_word, orig_word)</i>	Word in Bible verse is a hyponym of the reused word.	<i>hypo(dederit, tollet)</i>
<i>repl_co-hypo(reuse_word, orig_word)</i>	Reused word and original have the same hyperonym.	<i>repl_co-hypo(magnificavit, fecit)</i>
<i>NOPmorph(reuse_tags, orig_tags)</i>	Case or PoS did not change between reused and original word.	<i>NOPmorph(na.na)</i>
<i>repl_pos(reuse_tag, orig_tag)</i>	Reuse and original contain the same cognate, but PoS changed.	<i>repl_pos(n.a)</i>
<i>repl_case(reuse_tag, orig_tag)</i>	Reuse and original have the same cognate, but the case changed.	<i>repl_case(g.d) - cases genitive, dative</i>
<i>lemma_missing(reuse_word, orig_word)</i>	Lemma unknown for reuse or original word.	<i>lemma_missing(tentari, inlectus)</i>
<i>no_rel_found(reuse_wword, orig_word)</i>	Relation for reuse or original word not found in AGWN.	<i>no_rel_found(gloria, arguitur)</i>

QUALITATIVE COMPLEMENT

We manually analyze:

- 60 Ancient Greek & 100 Latin instances
- 192 & 224 replacements
- Using `ins(word)`, `del(word)` and replacements:
 - `NOP`, `lem`, `repl_syn`,
`repl_hyper`, `repl_hypo`,
`repl_co-hypo`
- We assign morphological categories from Perseus' tag-set (Bamman and Crane 2011)
 - E.g., `repl_case_a_g`
`repl_num_s_p`

Table 2: Excerpt from Perseus' tag-set

Category	Value	Tag
person	first person	1
	second person	2
	third person	3
number	singular	s
	plural	p
	dual	d
tense	present	p
	imperfect	i
	perfect	r
	pluperfect	l
	future perfect	t
	future	f
	aorist	a

RESULTS

LITERAL SHARE OF THE REUSE (RQ1)

What is the extent of non-literal reuse in our datasets?

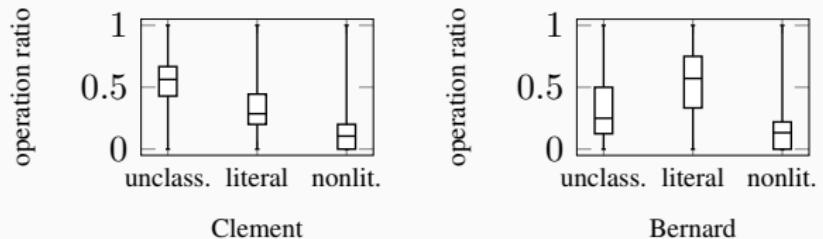


Figure 1: Ratios of operations in reuse instances. **literal:** NOP, lem, lower, etc.; **nonlit:** syn, hyper, etc.

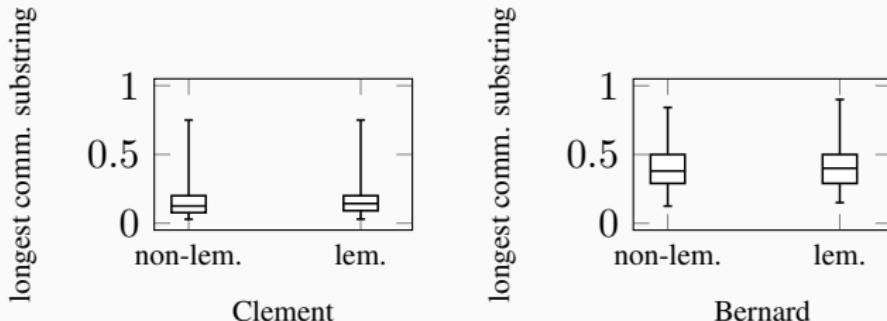


Figure 2: Ratios of literal overlap between reuse instances and originals.

AUTOMATED APPROACH (RQ2.1)

How is the non-literally reused text modified in our datasets? (RQ2)

How can linguistic resources support the discovery of non-literal reuse?
(RQ2.1)

Table 3: Absolute numbers of operations identified automatically.

	literal				non-literal					unclassified			total	
	NOP	upper	lower	lem	syn	hyper	hypo	co-hypo	no_rel_found	lem_missing				
Greek	337	6	0	356	153	20	14	101	563	639				2189
Latin	587	0	44	102	60	14	28	68	347	85				1335

AUTOMATED APPROACH (RQ2.1) - COVERAGE VALUES

Operations that successfully looked up a lemma:

`lem_success`=`{lem, syn, repl_hyper, repl_hypo, repl_co-hypo, no_rel_found}`, with `lem_missing` representing not found tokens in the lemmata.

$$\text{COV}_{\text{lem}} = \frac{\sum_{\text{Occ}(o)} o \in \text{lem_success}}{\sum_{\text{Occ}(o)} o \in \text{lem_success} \cup \{\text{lem_missing}\}}$$

$$\text{COV}_{\text{AGWN}} = \frac{\sum_{\text{Occ}(o)} o \in \text{agwn_success}}{\sum_{\text{Occ}(o)} o \in \text{agwn_success} \cup \{\text{no_rel_found}\}}$$

We obtain a cov_{lem} of **0.65** for our Greek and **0.88** for the Latin data-set.
And a cov_{AGWN} of **0.34** for our Greek and **0.33** for our Latin data-set.

Language resources help to get an idea of reuse components.

QUALITATIVE APPROACH (RQ2.2)

How is the non-literally reused text modified in our data-sets? (RQ2)

What are the limitations of an automated classification approach relying on linguistic resources? (RQ2.2)

Table 4: Exceptions that prevent applying the operations.

Exception	Quantity	
	Clement	Bernard
Word changed to antonym	1 ²	0
Synonym and morphology changed	1	16
More than one morphological category changed	1	7
Synonym is multi-word expression	3	5
Many-to-many	0	1 ³

²“the God, the good (**one**)” (Clement) vs. “**none** is good but the God” (Bible).

³“judged calmly” (Bernard) vs. “fake friend” (Sal 12 18).

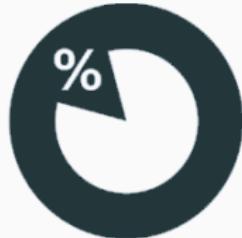
- RQ1. The reuse is significantly non-literal
 - Techniques beyond stemming & even semantic closeness are required;
suggestion: conceptualizing
- RQ2.1. Our results show
 - the possibility of supporting reuse detection with linguistic resources.
- RQ2.2. Qualitative complement
 - Especially the exceptions show that reuse detection needs looser relation (multi-to-multi-word) associations or implicit expert knowledge.

CONCLUSION AND FUTURE WORK

SUMMARY

We contributed:

- an automated approach to characterize how text is transformed between reuse and original,
- an application of the approach to two text data-sets where reuse was manually identified,
- empirical data based on the automated approach, complemented by a manual identification.



FUTURE WORK

A more comprehensive study could strengthen the findings.

- Using larger reuse data-sets, such as **Bible translations**⁴:
 - **27 English** Bible translations, e.g., the Tyndale Bible (16th cent.), King James V. (17th cent.), American Standard V. (19th cent.), Revised Standard V. (20th century),
 - **25 German** Bible translations, Luther Bibel (16th cent.), Elberfelder V. (19th cent.), Elberfelder V. (20th cent.).
- Using additional languages, such as
 - Historical German—**strongly inflecting**—and English—**less inflecting**.
- Improving the alignment priority of the algorithm and support nested operations in the form of trees.

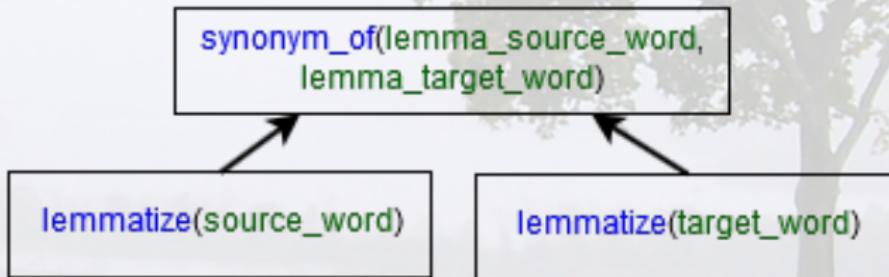
⁴www.paralleltext.info/ and www.biblestudytools.com/

Research Questions:

- RQ1 How is the reuse **changed?** Do word stems remain the same?
What remains stable?
 - Obtain a comprehensive analysis of modifications and stable elements
- RQ2 How high is the ratio of changes in a reused text? How often are **words substituted** and how often does **morphology change?**
 - Consider a high ratio of part-of-speech changes, not supported by a word net, then, better cluster together cognates as common concept

FUTURE WORK - EXPERIMENTS

- Identify nested operations in the form of trees by help of word nets
 - to gather reliable information on the share of semantic and morphological changes
- Visualizing morphological changes as part-of-speech matrix
 - to find possible dependencies between them and the context
- Back-up the word net coverage with word embedding approaches, e.g. distributional semantics
- Identify the support of a Semitic language as pivoting element
- Calculate a reuse model (probabilities by OP parameters)
- Publish a data set of historical writing variants (at best generate a BibleNet)



FUTURE WORK - DATA

Apply the essential approach to bigger data sets⁵

- 27 English Bible translations
 - e.g., Tyndale Bible (inspired by Luther) (ca. 1526–1536),
 - King James V. (1611–1769),
 - Webster's Revision (of the King James V.) (1833),
 - Darby Bible (1890),
 - American Standard V. (19th century).
- 25 German Bible translations
 - e.g., Luther Bibel (1545), Elberfelder V. (1871 and 1905).
- van Dyck's Arabic Bible from 1865 to use it as a pivot language
- The **verse-based structure** of the Bible enables a **reliable mapping of reuse by the unique** book, chapter, verse IDs. This also ensures a specific window in which the modification is measured.

⁵www.paralleltext.info/ and www.biblestudytools.com/

ONGOING WORK - ARABIC SEMANTICS AND MORPHOLOGY

Most Arabic words consist in a **root of three consonants**

- This **root** represents (carries) the meaning of a word, **the topic**
- **Affixes and infixes** between these consonants determine the part of speech or the **morphological categories** (case, number, count, etc.)
 - e.g., **K-T-B** carries **to write**
 - **KaTaBa** (*he wrote, he did write*)
 - **KāTiB** (*writing, writer*)
 - **KiTāB** (*book*)
 - **maKTūB** (*written, letter*)
 - **maKTaBa** (*library*)
- Simplified: the root consonants have semantic function and the vocals morphological function

ONGOING WORK - ARABIC SEMANTICS AND MORPHOLOGY

Another example *to fly*⁶

Main Word Text Desktop Mobile About

Enter a word:
fly

Autocomplete English to Arabic ▾

English-Arabic Dictionary is experimental and not complete.

Form	Gloss	POS	Root
فَلَجَةٌ	fly	Noun, female singular	ذَبٌ
فَلَجَةٌ	fly;tip	Noun, female singular	ذَبٌ
فَلَجَةٌ	fly;sight;bead	Noun, female singular	ذَبٌ
		Perfect tense verb, suffixed subject (3. person, male, singular)	طَلِيْرٌ
طَلِيْرٌ	he/it fly		طَلِيْرٌ

Main Word Text Desktop Mobile About

Enter a word:
bird

Autocomplete English to Arabic ▾

English-Arabic Dictionary is experimental and not complete.

Form	Gloss	POS	Root
طَلِيْرٌ	flying;bird;airborne	Noun	طَلِيْرٌ
طَلِيْرٌ	bird	Noun	طَلِيْرٌ
عُصَنْقُورٌ	bird;sparrow	Noun	عَصَنْقُورٌ
عُصَنْقُورَةٌ	bird;sparrow	Noun, female singular	عَصَنْقُورَةٌ

⁶<http://aratools.com/>

ONGOING WORK - ARABIC AS "PIVOT" LANGUAGE FOR SEMANTIC LOOKUP

Hypothesis: Using a root stemmed Arabic text possibly helps to find/evaluate semantically related words in an Indo-German language (given an aligned Bible Corpus).

- Due to the “root concept” semantic relationships can be **verified or identified**
- A 1st step is to prove the distribution of roots over the potential topic clusters in a DS task

مأْنِي	he/it fly	Perfect tense verb, suffixed subject (3. person, male, singular)	مأْنِي	طَائِرٌ	flying;bird;airborne	Noun	طَائِرٌ
			مأْنِي	طَائِرٌ	bird	Noun	طَائِرٌ
			مُصْنَفُورٌ	طَائِرٌ	bird;sparrow	Noun	عَصْنِفَرٌ
			مُصْنَفُورَةٌ	طَائِرَةٌ	bird;sparrow	Noun, female singular	عَصْنِفَرَةٌ



THANK YOU!



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APPENDIX

BIBLINDEX BIBLE EDITIONS AND CLEMENT EDITION

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New Testament:

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LICENCE

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