Introducing Relate

A Software for Establishing Quantitative Relationships between Manuscripts

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What is Relate?

A software that efficiently relates manuscripts in a quantitative manner

- **Uses transcriptions only**
  - Does not require collations, variation units or encodings
- **Once texts are transcribed, it can relate hundreds of manuscripts in matter of hours**
  - No need to rely on samples anymore
  - All textual data can be considered in each manuscript tradition
- **Now exists as source code**
  - Does not have GUI (graphical user interface)
- **Written in Python**
- **GitHub**

Background

Colwell and Tune

- **”Quantitative method of textual analysis”**
- **Based on collations and units of variation**
- **Records instances of agreements in places of variation**
  - Agreements are converted into percentages by dividing the number of agreements and the number of all variation places between pairs of MSS
- **Definition of a variation place**
  - A segment of a text containing at least two variants supported by at least two MSS
- **Genetically significant variants**

Gordon Fee

- **Calculating agreements in two stages**
- **Continued the usage of genetically significant variants**

Background

CBGM

- **Pre-genealogical coherence**
- **Singular readings are also considered**
- **Almost all types variations are considered**

The concept of a genetically significant variant lives on

- **Hurtado (1981), Geer (1994), Osburn (2004), Donker (2011)**

Problems

- **Different definitions of the variatio unit leads to differing agreements rates**
- **Critics divides texts into variation units very differently**
  - This also affects the agreement rates
  - Colwell and Tune acknowledged this problem already in 1964
- **Coventional quantitative methods of textual analysis takes lots of time**

A	the fox jumped over the hedge
B	-
C	the cat jumped over the fence
D	a man saw that the fox jumped over the hedge
E	a man saw that the fox jumped over the fence

Solution 1			Solution 2		
A	–	the fox jumped over the hedge	–	the fox jumped	over the hedge
B	–	–	–	–	–
C	–	the cat jumped over the fence	–	the cat jumped	over the fence
D	a man saw that	the fox jumped over the hedge	a man saw that	the fox jumped	over the hedge
E	a man saw that	the fox jumped over the fence	a man saw that	the fox jumped	over the fence

Agreement rates	
A, D	50 %
C, E	0 %

Agreement rates	
A, D	66,6 %
C, E	33,3 %

A	the fox jumped over the hedge
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Solution 1			Solution 2		
A	–	the fox jumped over the hedge	–	the fox jumped	over the hedge
B	–			-	–
C	–			jumped	over the fence
D	a man saw tha			jumped	over the hedge
E	a man saw tha			jumped	over the fence

Countless of decisions needs to be made and every one of them have a direct impact on the similarity values

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Toward a New Way of Thinking

Testing different stemmatological approaches

- **CBGM**
  - *”Evolving Gamaliel Tradition in Codex Bezae Cantabrigiensis, Acts 5:38–39: A Novel Application of Coherence-Based Genealogical Method (CBGM)”*
- **Phylomemetics**
  - *”The Changing Text of Acts: A Phylogenetic Approach”*

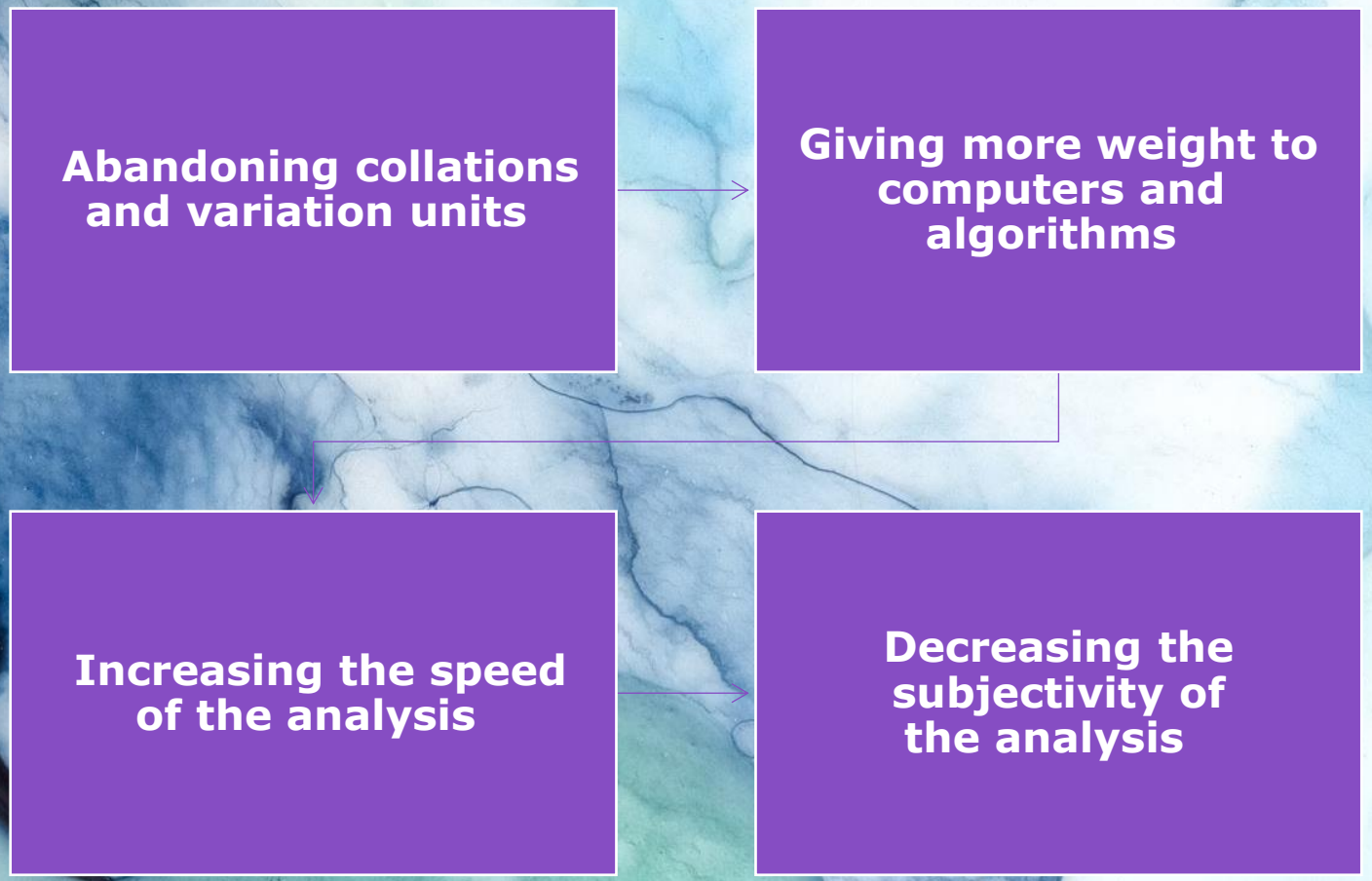
Interdisciplinary state of mind

- **String metrics**
- **Set theory**
- **Data mining**

Considering all textual data

- **Relying on samples is not an ideal situation**
  - *Teststellen*
  - Michelle Barbi on Dante
    - From 396 lines, only 121 proved to be useful

Toward a New Way of Thinking



Used Methodology

Theoretical foundation of the methodology:

- *”A new method in establishing quantitative relationships between manuscripts of the New Testament”* in *Digital scholarship in the Humanities, 2022* (open-access)

String metrics

- **Measures the similarity between two strings**
  - String is a sequence of chracters = a text
- **Allows one to operate using transcriptions only**
  - No need for collations or variation units
- **This can be calculated in several ways**
  - Character-based string metrics
    - *Levehnstein, Hamming, Jaro etc.*
  - Token-based string metrics
    - *Bag-of-Words (BOW)*
    - *Shingling*
    - *Jaccard, Overlap, and Sørensen-Dice*

Used Methodology

Problems with the character-based approaches

- **Cannot be used in Greek NT manuscripts**
  - Records similarities between words that are entirely different
    - περιβάλλω / περιπλέπω
  - Results to overly high similarity values
- **Requires too many operations**
  - Calculations takes too much time

Token-based approaches

- **Are much simpler**
  - Demand fewer operations
  - Faster
- **Record all types of variations between manuscripts**
  - Word changes, additions, deletions, word order changes
- **Results to similar agreement rates compared to conventional calculations**
- **Standardization of the spelling is recommended**

Step 1: K-Shingling

a man saw that the fox jumped over the fence

a man	man saw	saw that	that the	the fox	fox jumped	jumped over	over the	the fence

that the	fox jumped	the fence	a man	jumped over	over the	the fox	saw that	man saw

Step 1: K-Shingling

a man saw that the fox jumped over the fence

a man saw that the fox jumped over the hedge

fox jumped	man saw	jumped over	that the	saw that	the fox	a man	over the	the fence	
that the	fox jumped	the hedge	a man	jumped over	over the	the fox	saw that	man saw	

Step 2: Calculating similarities

Set1	fox jumped	man saw	jumped over	that the	saw that	the fox	a man	over the	the fence

Set2	that the	fox jumped	the hedge	a man	jumped over	over the	the fox	saw that	man saw

Word bigram	*Set 1*	*Set 2*
fox jumped	1	1
man saw	1	1
jumped over	1	1
that the	1	1
saw that	1	1
the fox	1	1
a man	1	1
over the	1	1
the hedge	0	1
the fence	1	0

Intersection = 8

Union = 10

Jaccard coefficient = $\frac{intersection}{union}$

= 8 / 10 = 0.8 = 80 %

Step 2: Calculating similarities

Set1	fox jumped	man saw	jumped over	that the	saw that	the fox	a man	over the	the fence

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the fence	1	0

Intersection = 8

Union = 10

Sørensen-Dice Coefficient (SDC)

$$\frac{2\ x\ intersection}{sum\ of\ the\ number\ of\ elements\ in\ each\ set}$$

= 16 / 18 = 0.888 = 88 %

Letter bigram	*Set1*	*Set2*
'a	1	1
' m'	1	1
'ma'	1	1
'an'	1	1
'an'	1	1
'n '	1	1
' s'	1	1
'sa'	1	1
'aw'	1	1
'w '	1	1
' t'	1	1
'th'	1	1
'ha'	1	1
'at'	1	1
't '	1	1
' t'	1	1
'th'	1	1
'he'	1	1
'e '	1	1
' f'	1	1
'fo'	1	1
'ox'	1	1

Sørensen-Dice Coefficient
64 / 71 = 0.90 = 90 %

Speed

Token-based approach is fast

- **The combination of k-shingling and the Sørensen-Dice coefficient**
  - 54 manuscripts of Acts can be analyzed, using the letter-grams, in their entirety (28 chapters) in ten minutes
    - (2916 comparisons x 0.21 sec = 612 sec = 10.2 min)

Character-based approach is slower

- **Fastest Levenshtein algorithm (Myers)**
  - 54 manuscripts of Acts can be analyzed in their entirety in 100 minutes
    - (2916 comparisons x 2,05 sec = 6000 sec = 100 min)

Accuracy: Acts 5

MSS	CBGM	K-shingling + SDC
03, 05	73.93	74.12
03, 1175	94.26	94.26
614, 876	89.54	90.84
1409, 1739	91.24	91.71

Relate includes

Tokenization:

- K-shingling (character and word)

Character-based metrics:

- Levenshtein and Hamming

Token-based metrics:

- Jaccard, Overlap, Sørensen-Dice

Matrixes:

- Similarity, distance (with or without a standardizing function)

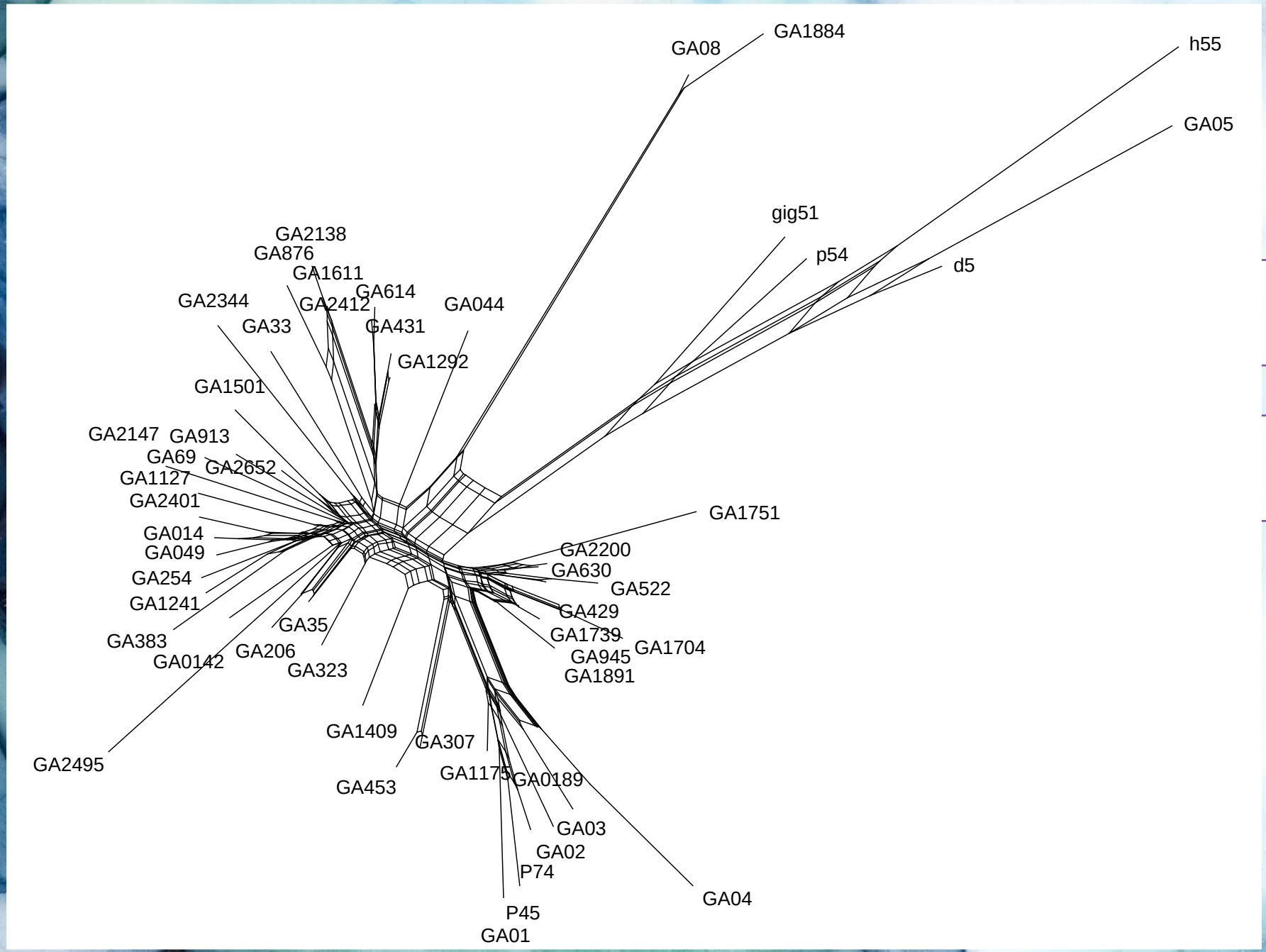
Prospects

Developing GUI for Relate…?

- It needs some studying to use Relate at this stage of development

Integrating tree inference and network methods

- Network analysis is promising


GA08
GA1884
h55
GA05
gig51
p54
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GA2138
GA876
GA1611
GA614
GA2344
GA2412
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GA431
GA1292
GA1501
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GA206
GA323
GA1891
GA1409
GA307
GA2495
GA1175
GA0189
GA453
GA03
GA02
P74
GA04
P45
GA01

Prospects

Developing GUI for Relate…?

- **It needs some studying to use Relate at this stage of development**

Integrating tree inference and network methods

- **Network analysis is promising**

Transcribing process must be automated

- **Using machine learning and neural networks**
  - Handwritten text recognition (HTR) techniques


Thank you!
Enjoy your time in Denver!