Determining the Similarity of Research Data by Using an Interoperable Metadata Extraction Method

CoRDI Conference 2023
2023-09-14

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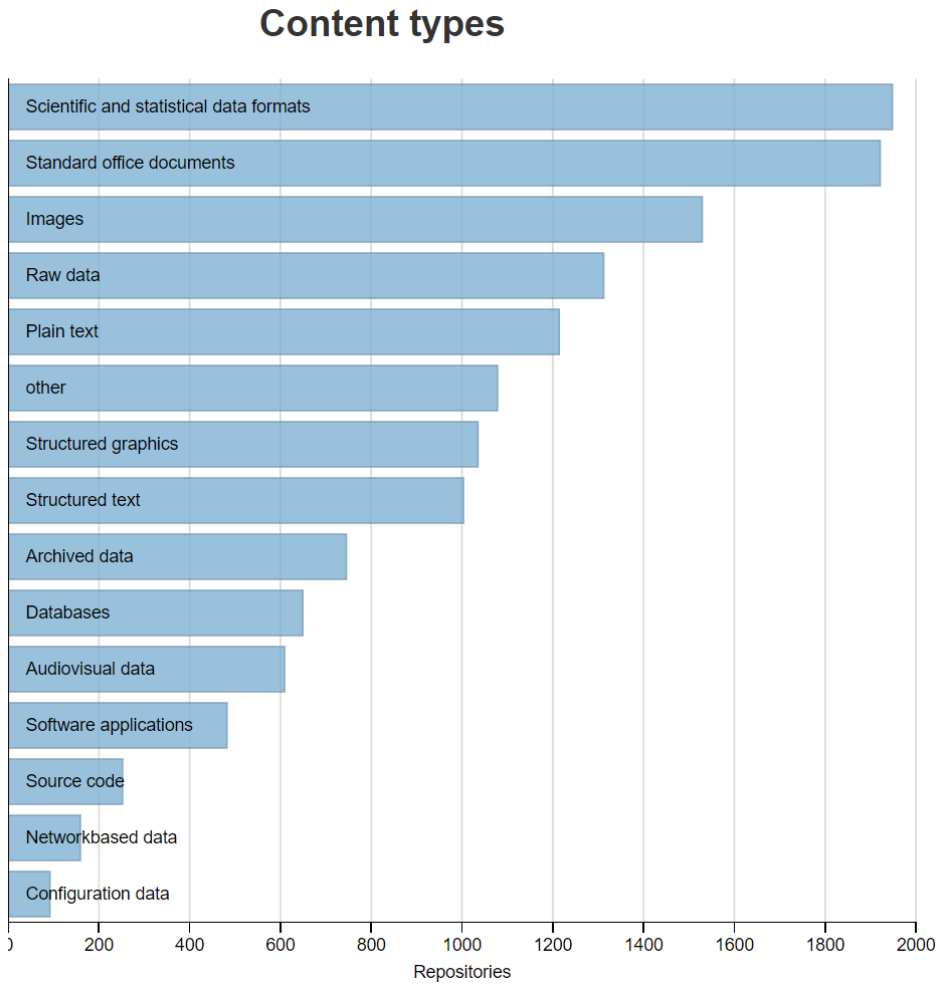
Comparing Research Data is Hard

- Research Data can be in many different formats
- This results in difficulties comparing research data
- With textual formats this might be easier since text comparison is easily doable
- With binaries, this becomes more difficult
- Especially comparing across formats is a difficult task



Content types from https://www.re3data.org/

Comparing Binary Research Data is Hard

```
0A27AF0 2CFC 2DC7 479C F23F B90D 5995 999D F23F  ,ü-ÇG ò?¹.Y   ò?
0A27B00 2CFC 2DC7 479C F23F E1E2 D72A A499 F23F  ,ü-ÇG ò?áâ×*¤ ò?
0A27B10 E1E2 D72A A499 F23F E1E2 D72A A499 F23F  áâ×*¤ ò?áâ×*¤ ò?
0A27B20 8D22 8463 EB9E F23F 2CFC 2DC7 479C F23F   " cë ò?,ü-ÇG ò?
0A27B30 E1E2 D72A A499 F23F A53A AF31 3DA0 F23F  áâ×*¤ ò?¥:¯1= ò?
0A27B40 24DB AC5C 5298 F23F E1E2 D72A A499 F23F  $Û¬\R ò?áâ×*¤ ò?
```

```
234EF0 2D30 342D 3031 2031 353A 3435 3A30 302E  -04-01 15:45:00.
234F00 3000 0000 0000 0000 0000 3C00 0000 88E6  0.........<... æ
234F10 9BA1 A353 0440 08C2 1C16 3FB6 0240 54E2   ¡£S.@.Â..?¶.@Tâ
234F20 A401 96AC 0640 50C7 6AD9 76CB 973F 2FE4  ¤. ¬.@PÇjÙvË ?/ä
234F30 C48C E026 943F 6F25 F5B6 26B7 A43F 3230  Ä à& ?o%õ¶&·¤?20
234F40 3134 2D30 342D 3031 2031 353A 3436 3A30  14-04-01 15:46:0
```

- How do you get a good idea on what is different when comparing two binaries (in this case HDF5 files)?

Possible ways to compare research data

- Use domain knowledge and use a similarity method for a specific type
- Compare the raw research data
- Use a representation of the research data

Representations of Research Data

- We talk a lot about creating metadata and extracting metadata
  - Why don’t we make use of this metadata?
- A method has been proposed that can turn research data into (interoperable & content-based) metadata
  - This can act as a representation of research data
  - Making use of such a method could lead to format independent similarity computation
- The goal here is: Make use of the content-based representation and compare research data with it

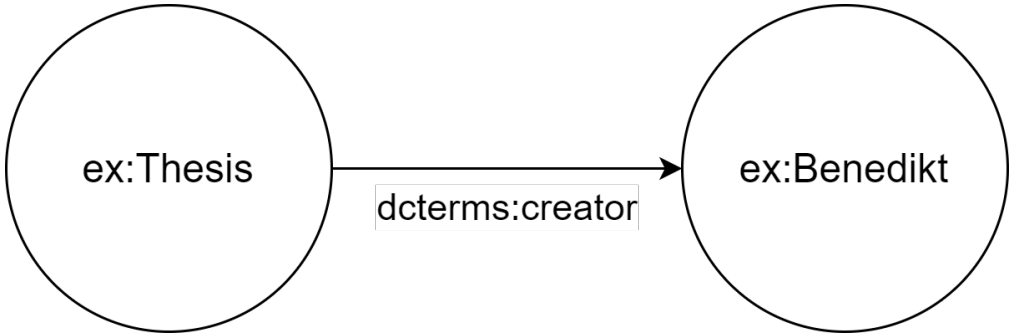
Metadata Extraction Pipeline

Metadata Extraction

Heinrichs, B. ; Politze, M.
Moving Towards a General Metadata Extraction Solution for Research Data with State-of-the-Art Methods
12th International Conference on Knowledge Discovery and Information Retrieval, KDIR 2020, online, 2 Nov 2020 - 4 Nov 2020

Comparing Research Data with their Metadata

- The provided metadata is formulated in triples of subject, predicate and object pairs (RDF)
  - Follows ontologies and is interoperable
- This metadata can be represented as graphs where:
  - Subjects and Objects are the nodes
  - Predicates are the directed arcs that point from a subject to an object



Comparing Research Data with their Metadata

- A multitude of graph similarity algorithms can be used to determine the similarity between metadata
- In this context, domain knowledge can be used as the properties of the interoperable metadata are known
- Known properties:
  - The subjects are usually unique and do not provide a lot of value in a similarity comparison, so they are *filtered* out
  - The *structure* of the interoperable metadata is similar
  - A couple of triples are only there to describe the internal structure and not the content, so the metadata can be *simplified*

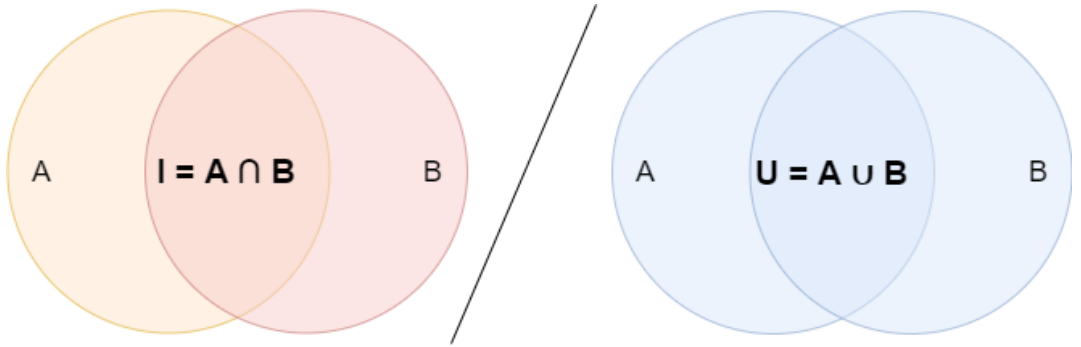
Developed Method - FSS Jaccard

- The known properties lead to a method that follows:
  - a *filter* step
  - makes use of the *structure*
  - *simplifies* the metadata

  ➢ FSS

- We want to know the similarity between research data based on their metadata
  - This problem can be described when viewing research data as sets
  - Similar parts are in the intersections between sets
- Similarity algorithm to compute this: Jaccard

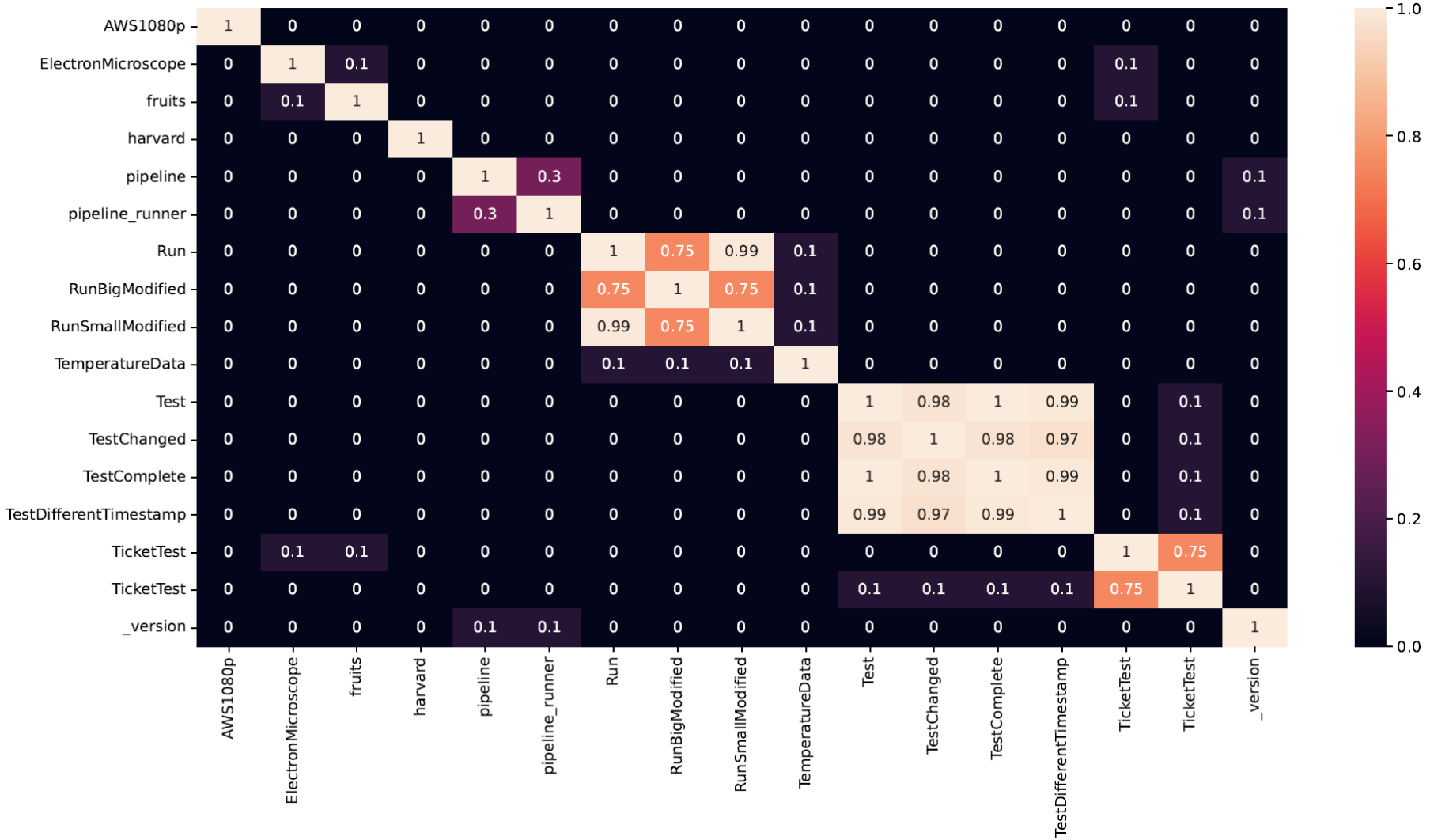
➢ FSS Jaccard was created



Developed Comparison Methods

- Based on interoperable metadata:
  - FSS Cosine – FSS with cosine similarity
  - FSS Similarity – FSS with a custom similarity
  - Jaccard Similarity – Jaccard similarity directly applied on the metadata
  - Filter Similarity – Similarity only on predicate & object pairs
- Based on research data:
  - Jaccard Binary – Jaccard similarity applied on research data
  - Cosine Binary – Cosine similarity applied on research data

Evaluation Dataset



Evaluation

Table 1

Diagnostical Analysis

	Error Values		Reliability	Test Characteristics			Inter-rater reliability
	Mean	SD	true score	Sensitivity	Specificity	Accuracy	Cohen's Kappa
FSS Similarity	0,021	0,0442	0,9633	0,6491	0,9655	0,9031	0,6677
FSS Cosine	0,0218	0,0445	0,9628	0,6491	0,9655	0,9031	0,6677
FSS Jaccard	0,0195	0,0436	0,9628	0,6721	0,9912	0,9239	0,7437
Filter Similarity	0,0495	0,0494	0,9404	0,8182	0,7607	0,7716	0,4386
Cosine Binary	0,1304	0,2061	0,6772	0,9459	0,5952	0,6401	0,2514
Jaccard Binary	0,0504	0,1253	0,8433	0,6596	0,8182	0,7924	0,3853
Jaccard Similarity	0,0264	0,0704	0,9451	0,5738	0,9912	0,9031	0,6601

Note. Error values are determined by the absolute distance of the values from the validation values. Reliability is defined as the proportion of true variance, measured as covariance between the validation values and the test values, of the overall variance of the test values. Values are considered true positive if the data and validation value is larger than 0, but the data value is not bigger than 1.3 times the validation value (false positive) or less than 77% of the validation value. The data is still considered true negative if the validation value is 0 and the data value is less than 0.083 (average standard deviation of all algorithms).

Evaluation – Ranking

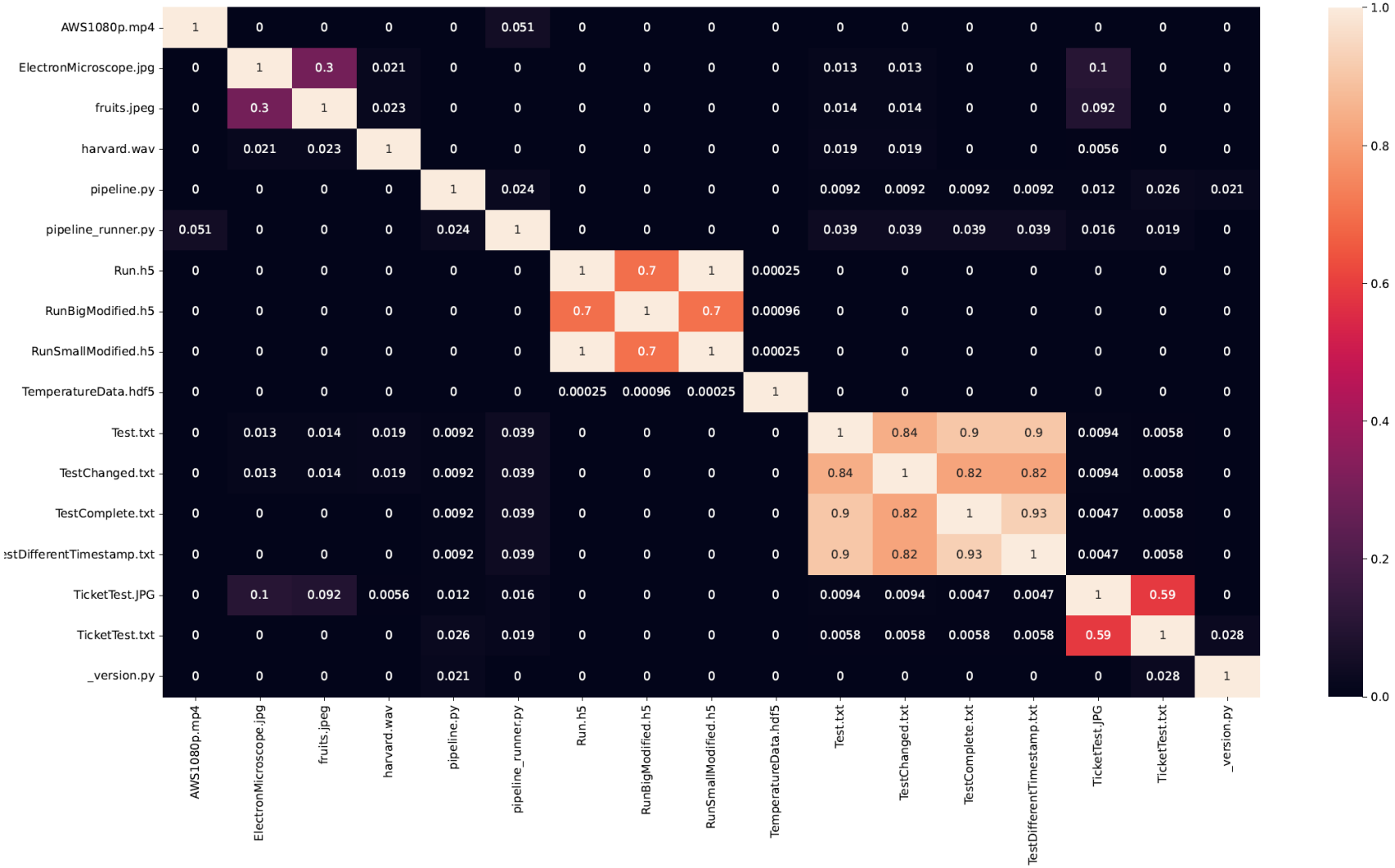
1. FSS Jaccard
2. FSS Cosine & FSS Similarity
3. Jaccard Similarity
4. Filter Similarity
5. Jaccard Binary
6. Cosine Binary

Table 1

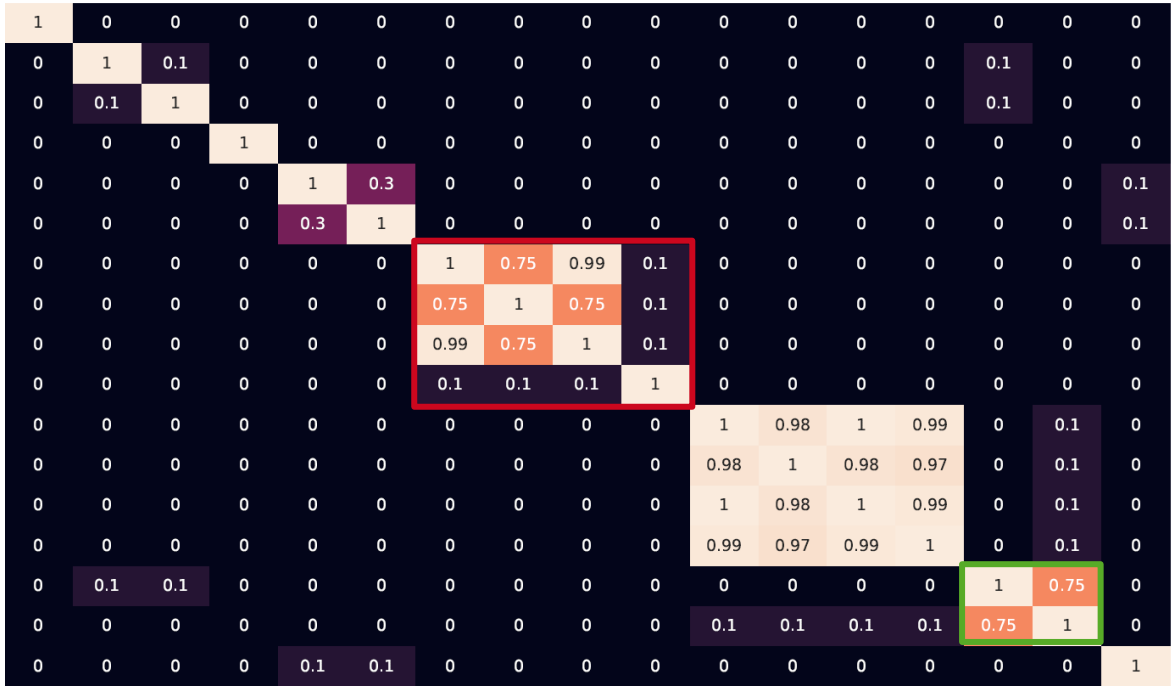
Diagnostical Analysis

	Inter-rater reliability
	Cohen's Kappa
FSS Similarity	0,6677
FSS Cosine	0,6677
FSS Jaccard	0,7437
Filter Similarity	0,4386
Cosine Binary	0,2514
Jaccard Binary	0,3853
Jaccard Similarity	0,6601

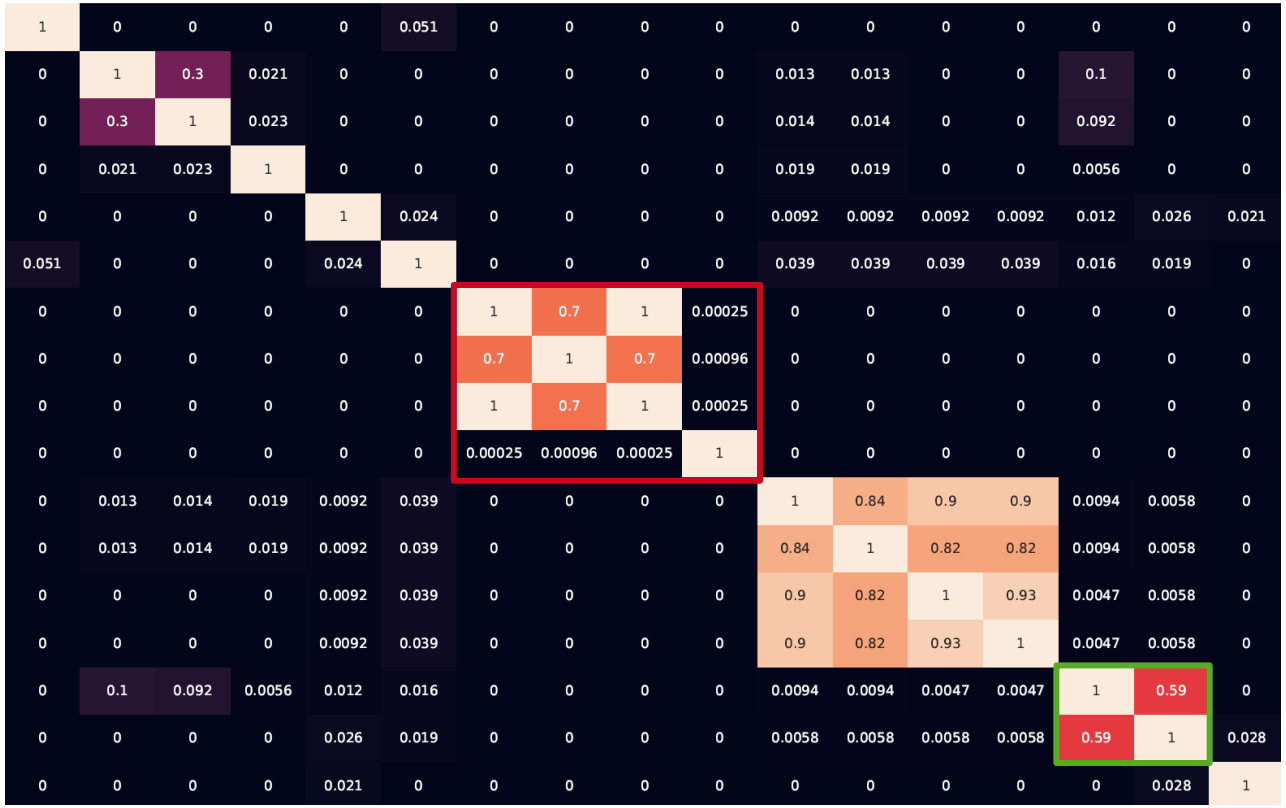
Results – FSS Jaccard



Results – FSS Jaccard

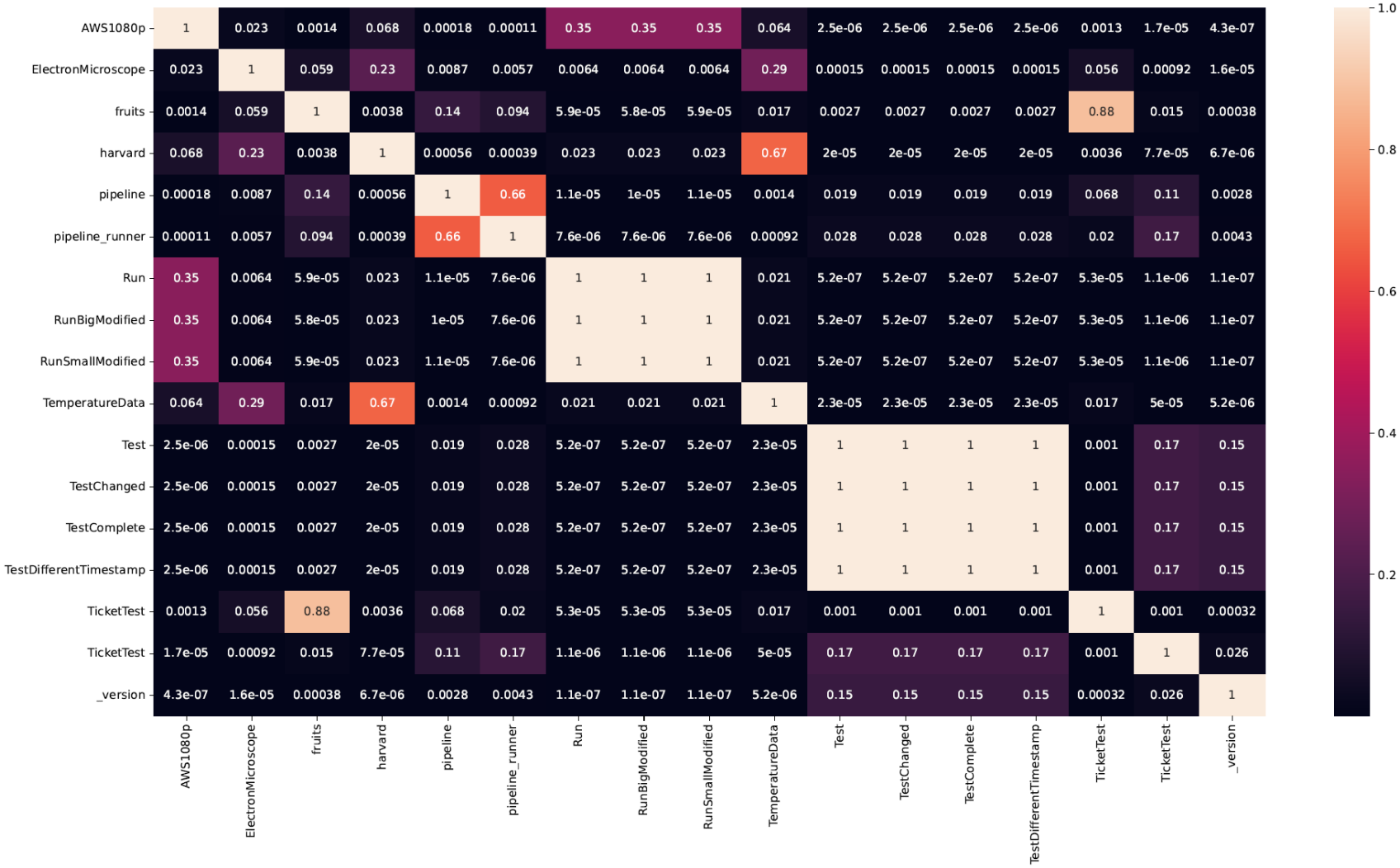


Evaluation Dataset

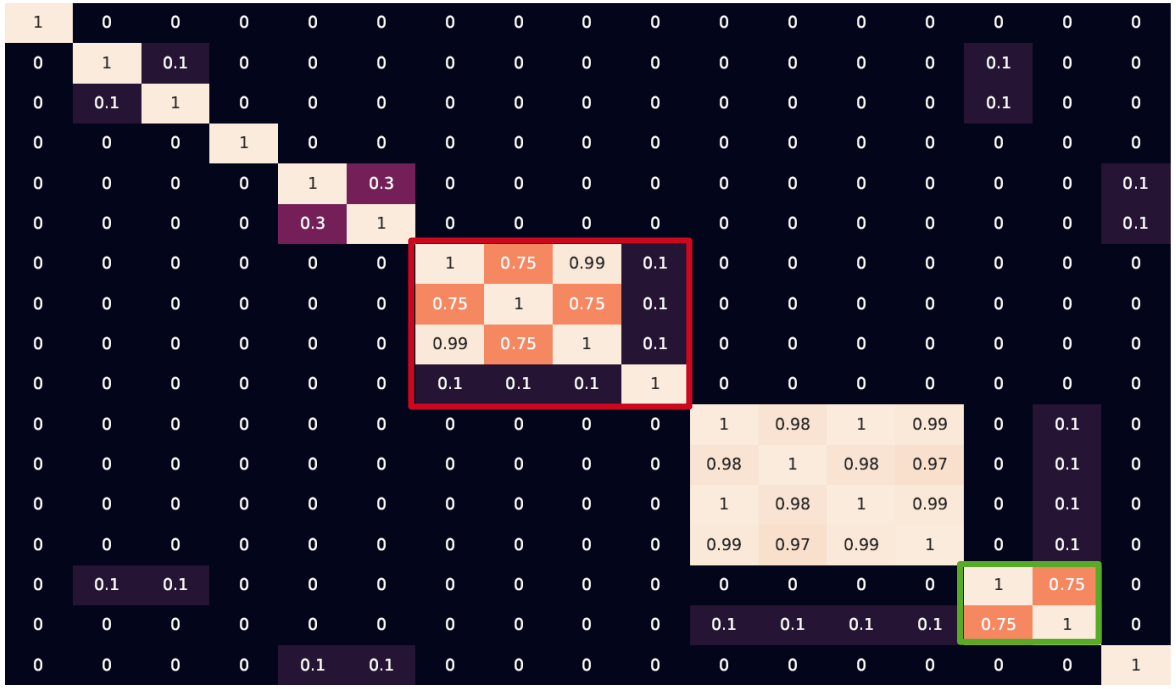


FSS Jaccard

Results – Jaccard Binary



Results – Jaccard Binary



Evaluation Dataset

Jaccard Binary

Conclusion

- Making use of extracted interoperable metadata to compare research data shows promising results!
  - Methods based on interoperable metadata outperformed methods based on the research data itself in this experiment
  - The proposed method FSS Jaccard performed best out of the presented methods
- The results can be used when wanting to determine the similarity between research data when interoperable metadata is available (or extractable)
  - Applications could be provenance tracking
    (e.g., interoperable metadata of an older version is present and has suddenly changed)
  - Insights can be gained when applying it to use cases
- Code available to test it out yourself:
  - https://git.rwth-aachen.de/coscine/research/semanticsimilarity

Thank you
for your attention!

Results – Use Case – Clusters inD