Efficient and Accurate Annotation of Large Text Corpora Using Representative Class Archetypes

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04.03.2023, Kick-Off

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Outline

Introduction to CreateData4AI

Extrapolation

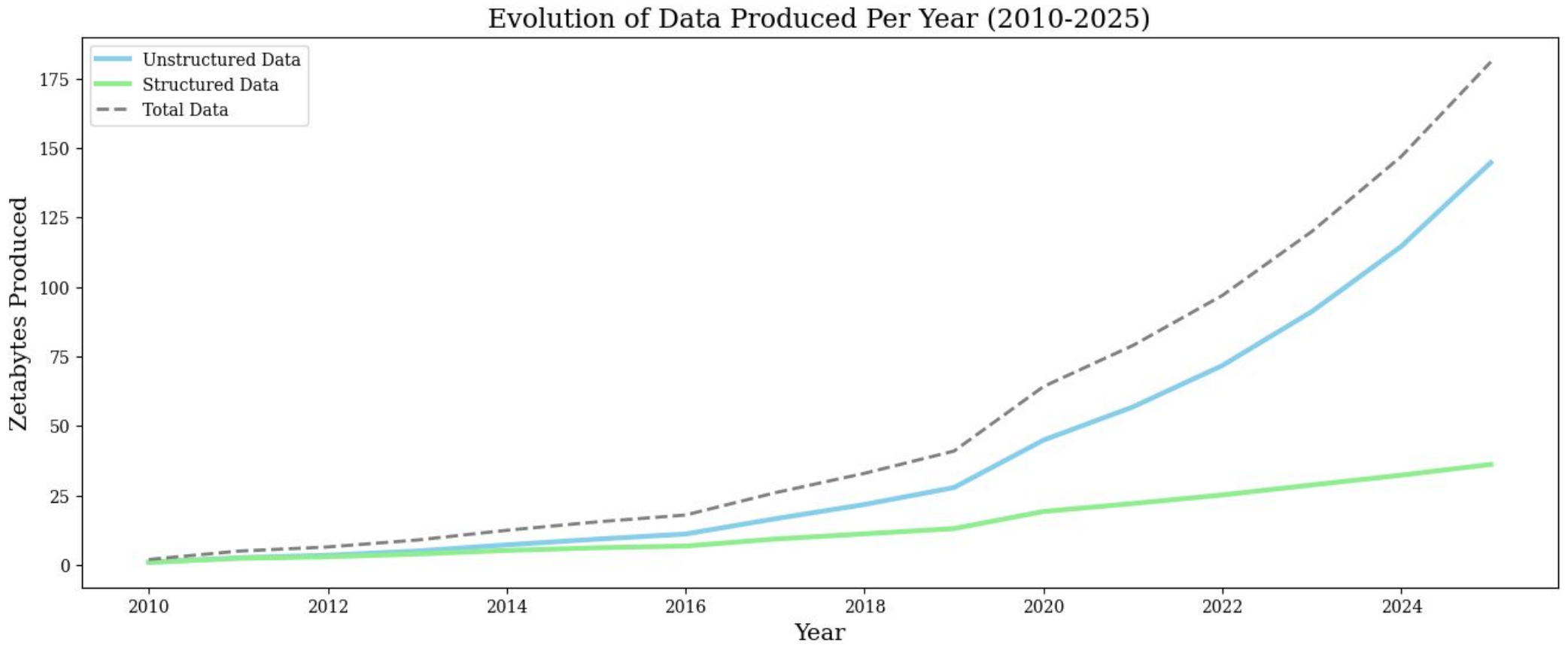
Initial Findings

Proposed Research Questions

Tasks & Timeline

Evolution of Data Creation

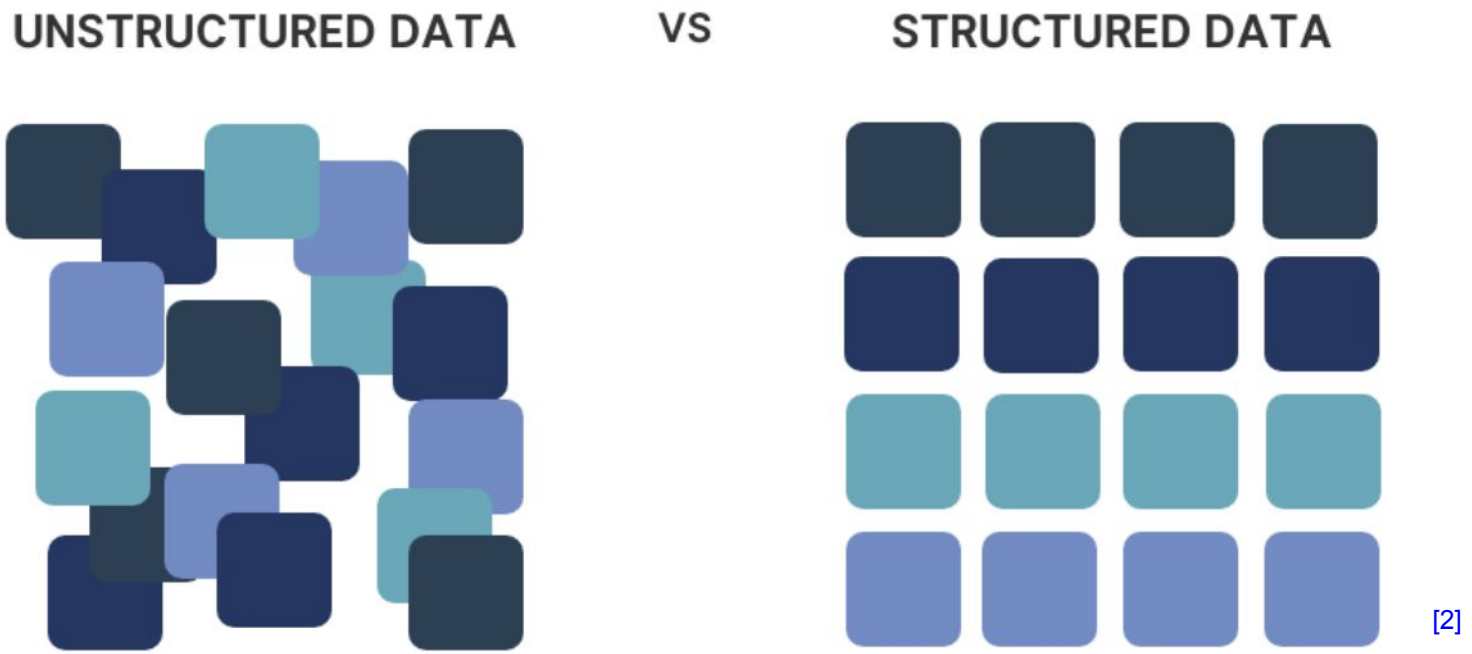
- With data creation increasing exponentially, we expect to produce 150 zetabytes globally in 2024.
- However ~80% of that data will be unstructured!



[1]

The Value of Structured Data

- Structuring unstructured data is still human-dependent and resource-intense
- Automating that process will allow especially smaller organizations to...
  - extract valuable insights from their data
  - train new models
  - enhance current model performance



[2]

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Rental Bau GmbH	Durchführung der Sanierung, Verkauf, Verwaltung von Immobilien oder grundstücksgleichen Rechten.
...	...

class	class_description
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B	Bergbau und Gewinnung von Steinen und Erden
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CD4AI Pipeline

Keyword Extraction → Context Windows → Extrapo-lation

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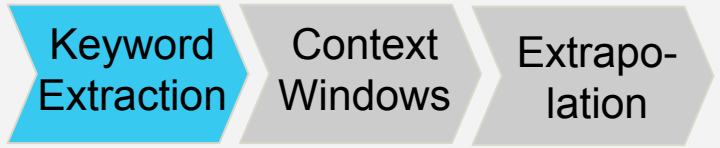

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"Bauernhof"

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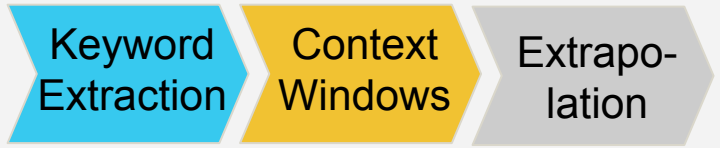

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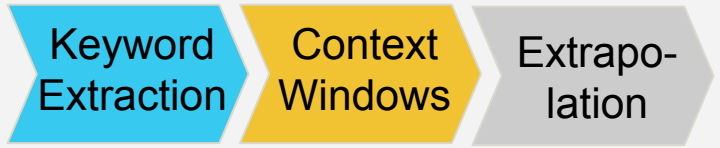

"Betreiben eines Bauernhofs"

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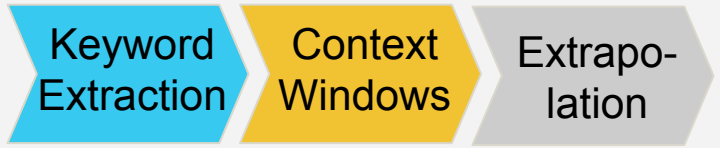

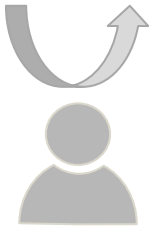

Domain Expert

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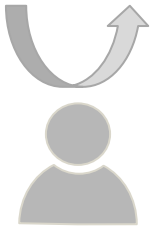

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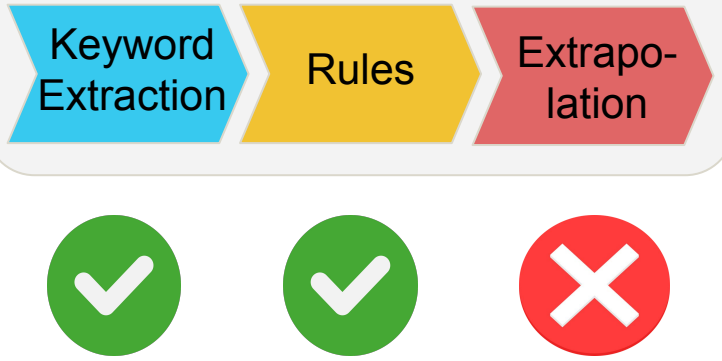

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Proposed Research Questions

Main Research Question:

How can current state-of-the-art NLP techniques be used to annotate large, domain-specific text corpora?

Supporting Research Questions:

1. What is the most efficient and accurate approach for partitioning a set of text documents into categories defined by specific context rules?
2. What NLP strategies are best suited for identifying the most representative sentences in a text document?
3. What is the best method to evaluate a system that annotates large, domain-specific text corpora?

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Extrapolation - A two stage process

- The rules will capture both the semantic and the syntactic core of their class
- Since we are dealing with big data (~3 million rows) we have to find an accurate yet efficient solution
- The idea is to first leverage the syntactic similarities of the rules to narrow down the search space
- Then in a second step, we want to use more advanced semantic based techniques to assign the final label
- We will use the following as a running example:

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I	Gastgewerbe	['Hotellerie und Touristik', 'Gastronomische Einrichtungen'

Extrapolation - Stage 1

- The goal of the first stage is to narrow down the search space by utilizing the syntactic similarity between rules and documents
- So we want to find the top k classes (k << 21), according to the number of matches found through exact or fuzzy string matching

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Extrapolation - Stage 2

- With a smaller search space we can use more resource-intensive methods which leverage the semantic similarity between rules and documents
- In a first step, we will use to boil down the document to the most meaningful parts using e.g textRank [3]
- In a second step, we will use state-of-the-art transformer models, e.g. S-BERT[4] or setfit [5], to find the set of rules that best match our document's meaning and assign the corresponding class.

Extrapolation - Stage 2

Stage 1

Sentence Ranking via e.g. **textRank**

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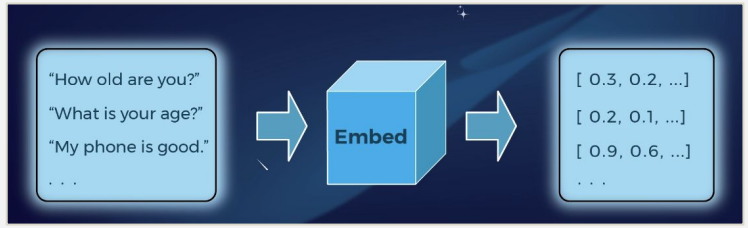
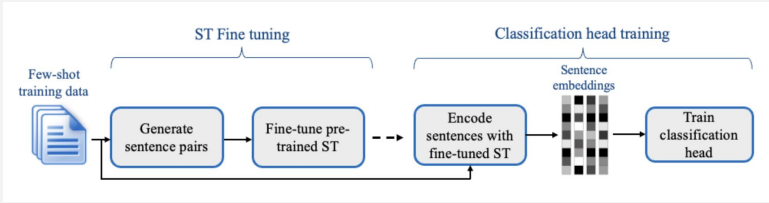
To be decided

Embeddings and Similarity Comparison



Fine-Tuned Sentences Transformer



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Initial Findings

- Disclaimer: We are currently still improving the process of creating the rules, so these results are very much preliminary.

Stage	Strategy	Computation Time per Document [2]	Accuracy [1]
1	Exact String Matching	~0.1 seconds	~67%
1	Fuzzy String Matching[3]	~0.5 seconds	~52%
2	S-BERT Embeddings	~0.2 seconds	~50%[4]

1. For Stage 1 we measure if the correct class is in the top 3 classes.
   For Stage 2 we measure if the final class is correct.
   Furthermore we used 33 documents with a balanced class distribution.
2. Measured on shared T4 GPU in Google Colab.
3. We used `partial_token_sort_ratio` from “thefuzz” [6]
4. Here we are limited by the accuracy of stage 1, so 0.5/0.67 = 74%

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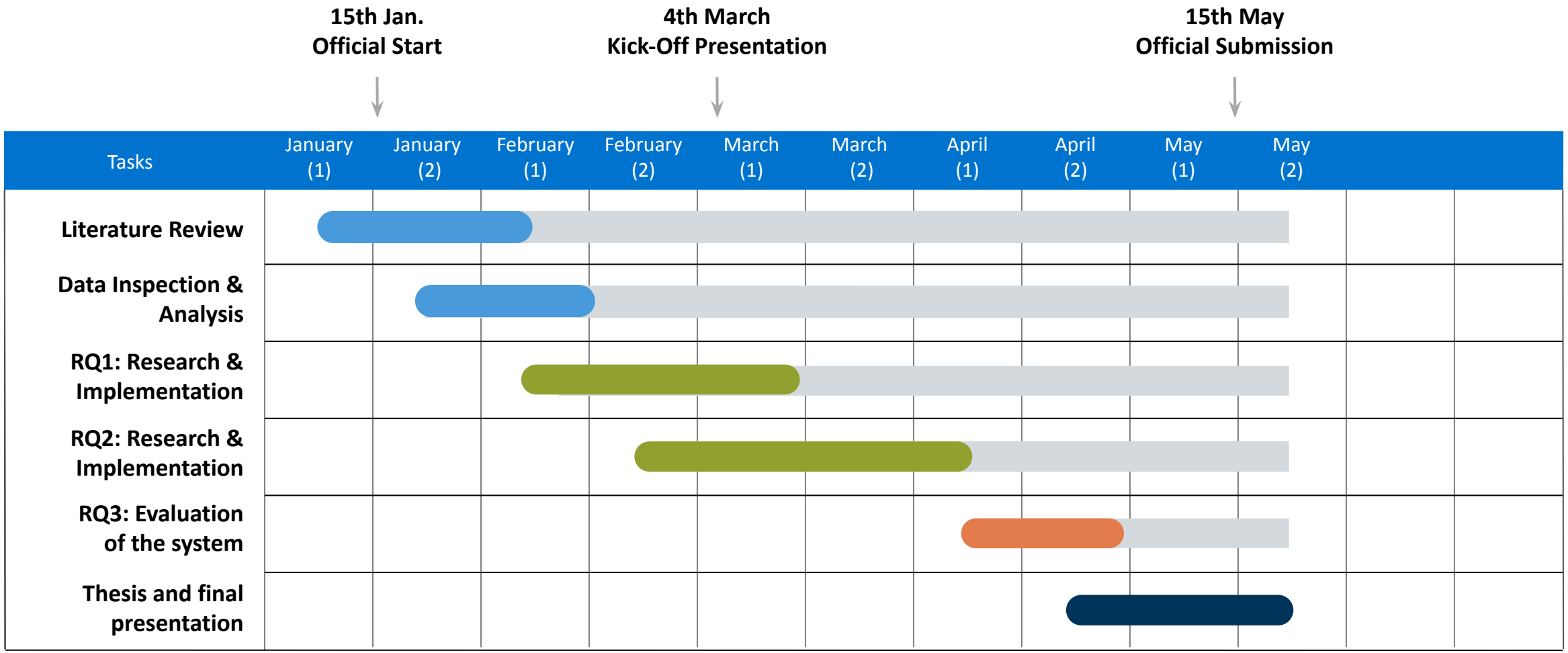

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References

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[3] Mihalcea, R., & Tarau, P. (n.d.). TextRank: Bringing Order into Texts. Department of Computer Science, University of North Texas. Retrieved from cs.unt.edu

[4] Reimers, N., & Gurevych, I. (2020). Making Monolingual Sentence Embeddings Multilingual using Knowledge Distillation. In *Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing (EMNLP)*. arXiv:2004.09813v2 [cs.CL]. https://doi.org/10.48550/arXiv.2004.09813

[5] Tunstall, L., Reimers, N., Jo, U. E. S., Bates, L., Korat, D., Wasserblat, M., & Pereg, O. (2022). Efficient Few-Shot Learning Without Prompts. arXiv. https://doi.org/10.48550/arXiv.2209.11055

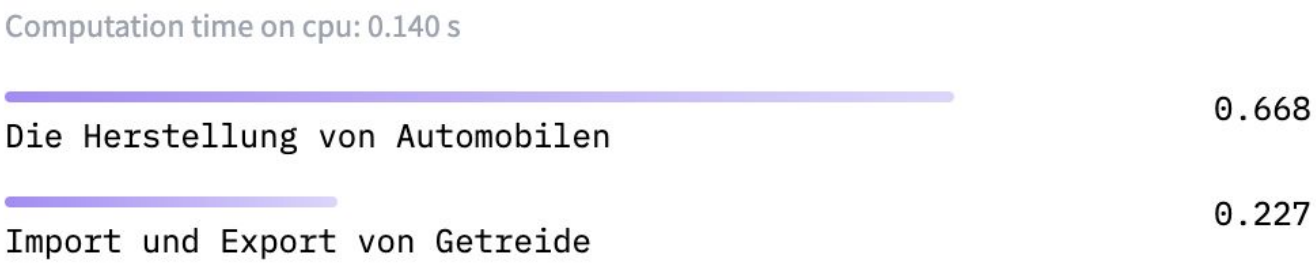
[6] https://github.com/seatgeek/thefuzz?tab=readme-ov-file

SetFit

- SetFit could be very useful for us because for our classification tasks sentences that are semantically similar in general, do not always belong to the same class.
- For example consider:

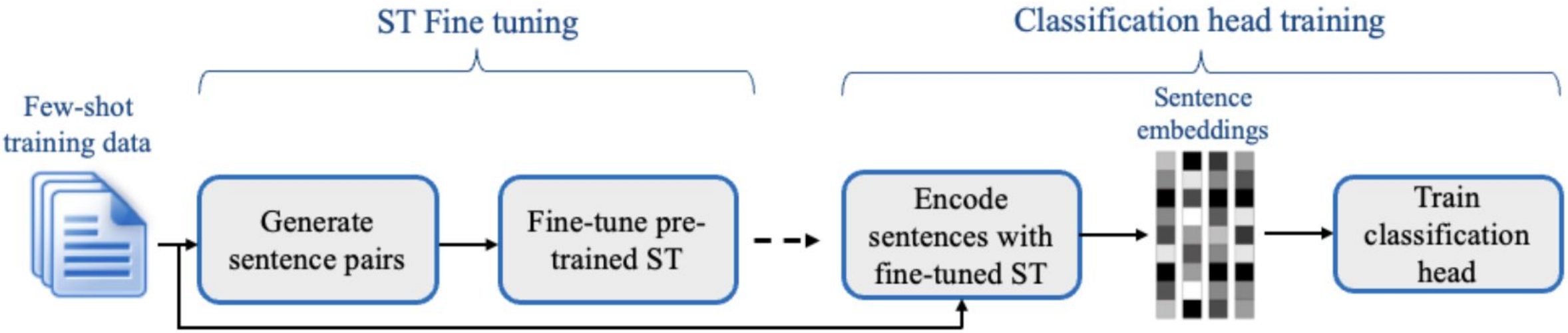
1. “Der Handel mit gebrauchten Automobilen.” → G: Handel
2. “Die Herstellung von Automobilen.” → C: Verarbeitendes Gewerbe
3. “Import und Export von Getreide” → G: Handel

- When comparing 1&2 and 1&3 this is the output of a sentence transformer not fine-tuned on our data:



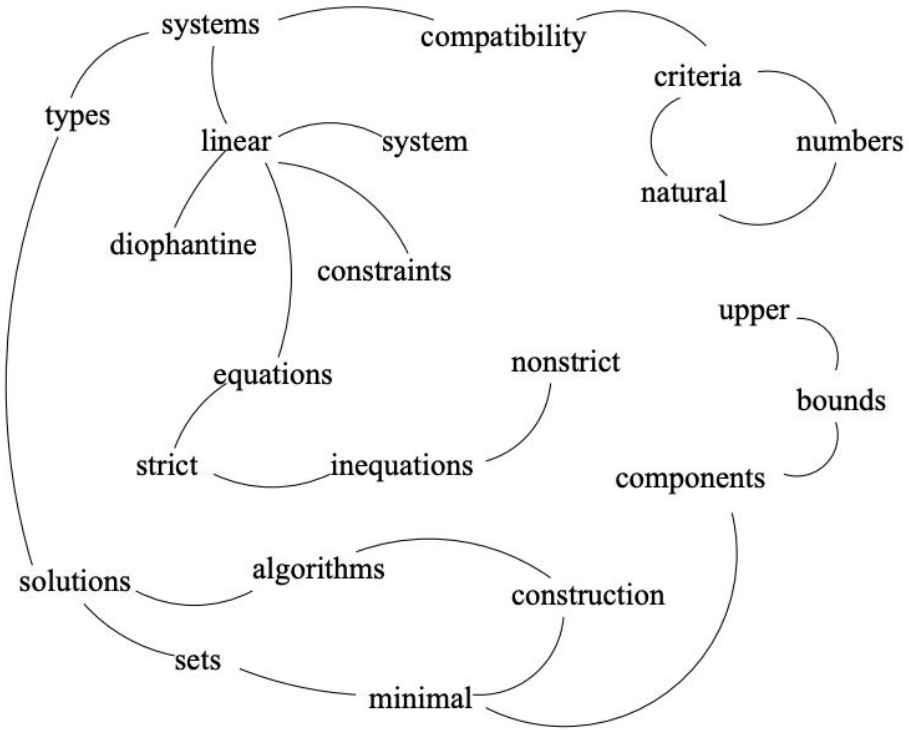
- SetFit allows us to efficiently fine-tune our sentence transformer, so that the produced embeddings are customized to our specific classification task.

SetFit

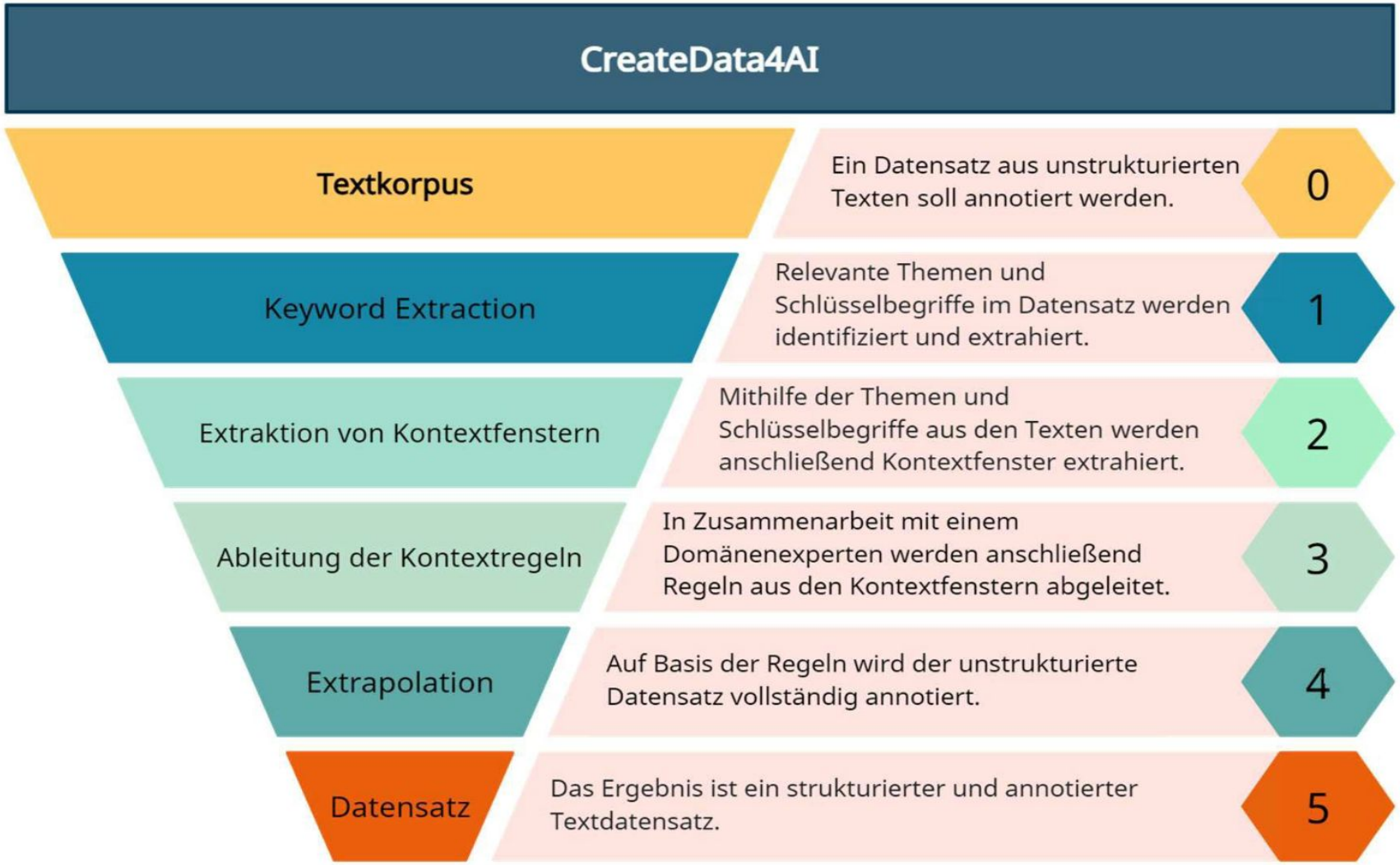

ST Fine tuning
Classification head training
Few-shot training data
Generate sentence pairs
Fine-tune pre-trained ST
Encode sentences with fine-tuned ST
Sentence embeddings
Train classification head

TextRank

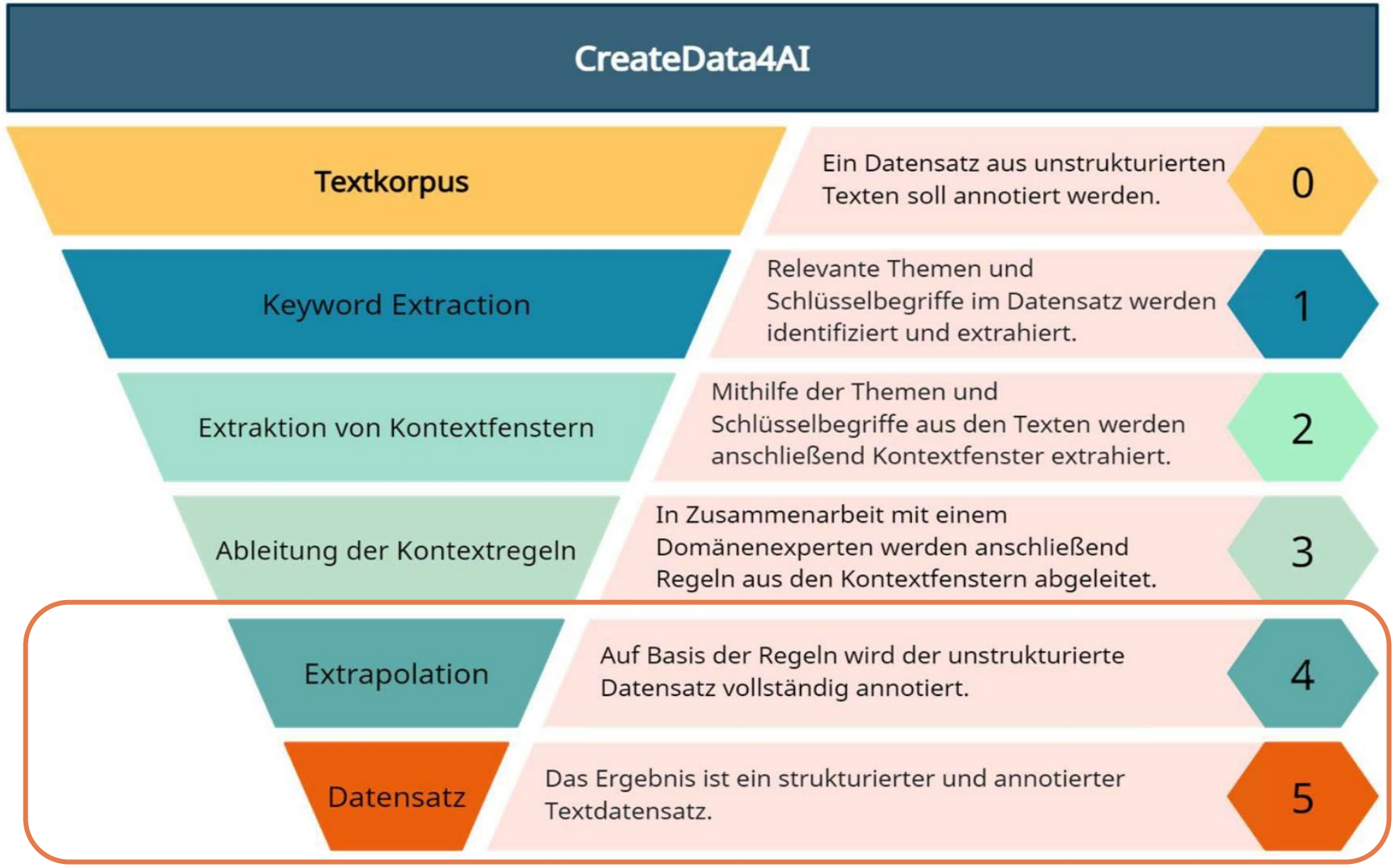
- textRank is a graph-based ranking model for sentences and keywords
- The graph is constructed according to either the content overlap of two sentences or the frequency of two words following each other in the document
- Once constructed, the pageRank algorithm is run to find the most important sentences/words



Overview of CreateData4AI



Overview of CreateData4AI



Process Flow

Input

Category rules and the unlabeled dataset

1 **Efficiently partitioning the dataset into categories using the rules**

2 **Finding the most relevant sentences in each document**

3 **Confidently labelling each document based on the rules**

Output

The original dataset with accurate labels

Efficiency ⟷ **Accuracy**

Technical details

- Efficient semantic embeddings
- Efficient, seeded clustering algorithms

Technical details

- Text Ranking Algorithms
- And some other stuff thats not so relevant

Technical details

- Highly accurate semantic embeddings
- Ensemble approach & Active Learning

Motivation for CreateData4AI (CD4AI)

328.77 million terabytes

The amount of data that is produced globally every day!

80% unlabeled

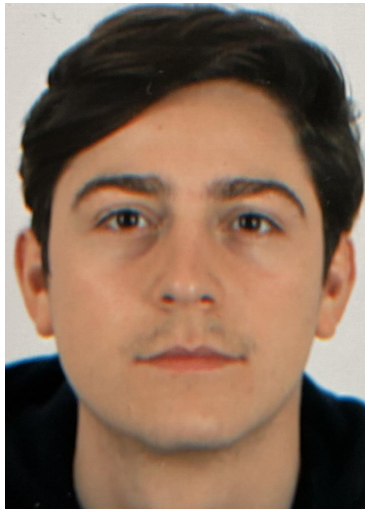
This leaves ~263 million terabytes of data unlabeled!

80/20 Rule

Highlights the fact that data scientists spend about 80% of their time preparing datasets.

Process Black Box

Personal Introduction



Curriculum Vitae

- Born in Hamburg, Germany
- Abitur in Hamburg at Gelehrtenschule des Johanneums (Grade: 1,4)
- B.Sc. in Computer Science at TUM
- Sport enthusiast, currently playing hockey at a professional level
- Interested in economics, productivity and AI

Relevant Experience

- **Preisenergie (Working Student) - 1.5 years:** Fundamentals of software engineering and architecture
- **Celonis (Internship) - 3 months:** Project management and efficient communication
- **Jamie (Working Student) - Current:** Hands-on experience with advanced AI systems

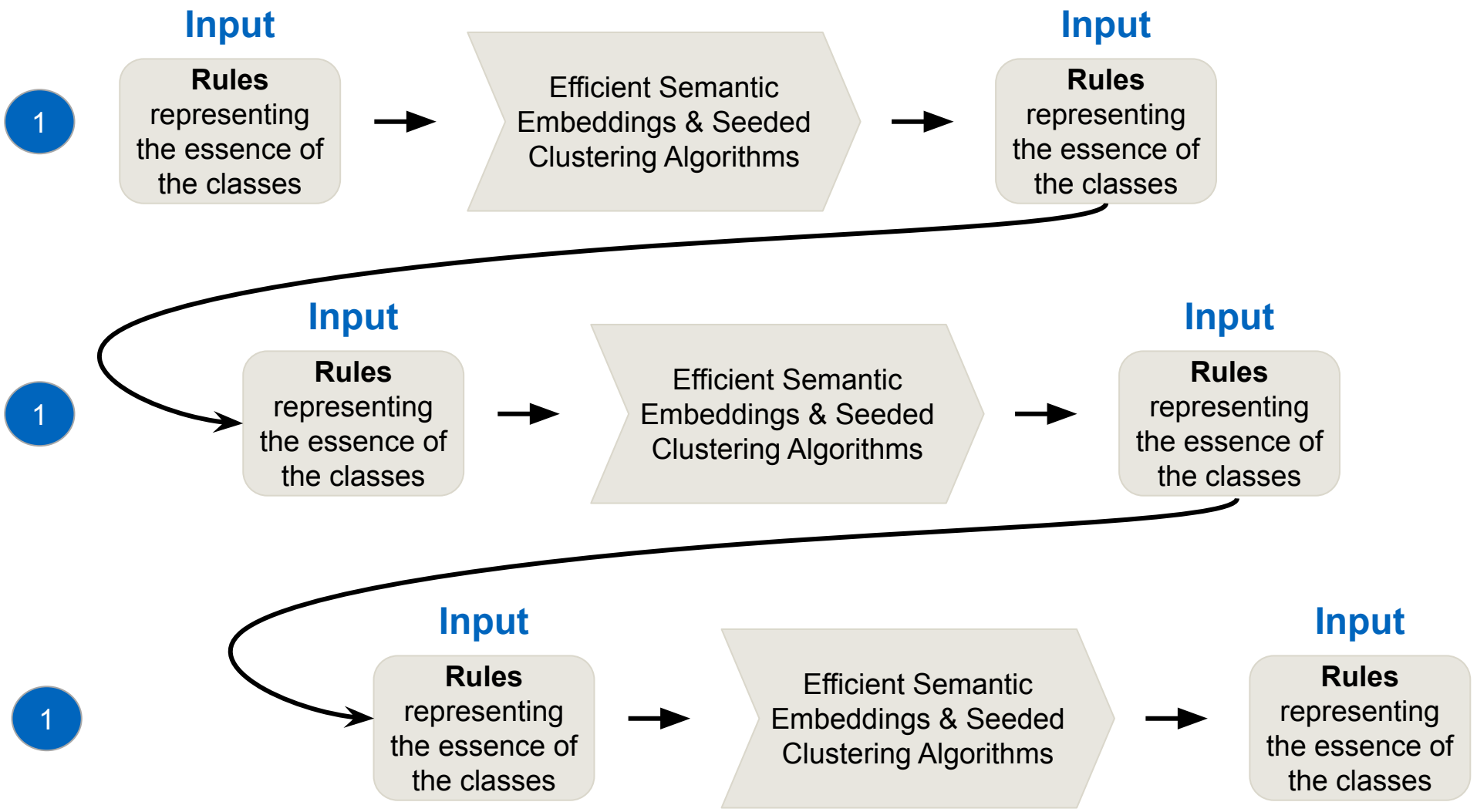
Tasks & Timeline

Official Start Date: 15th of January 2024

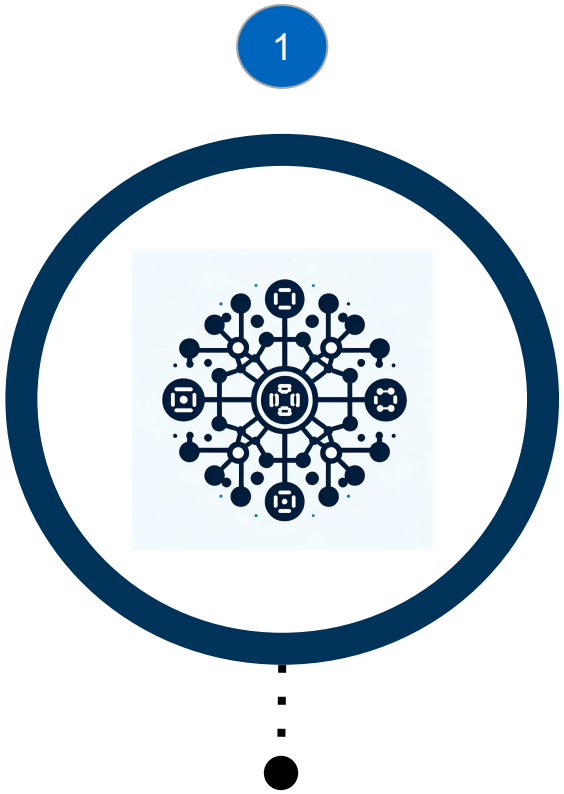
Official Submission Date: 15th of May 2024

Tasks	Timeline
Data inspection & analysis	Week 1
Research into efficient semantic embeddings & seeded clustering + Implementation	Week 2 - 4
Research into text ranking + Implementation	Week 5 - 7
Research into active learning & ensemble models + Implementation	Week 8 - 10
Writing of thesis & creation of final presentation	Week 11 - 16

Proposed Process Flow



Proposed Process Flow



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  - The unusual date format simplifies the search for the latest version of a slide in an alphabetical directory listing (Dropbox, Explorer, Tricia, Sky-Drive)

[Ha13g] Hauder, M., Roth, S., Matthes, F.: Current Tool support for Metrics in Enterprise Architecture Management

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