Bachelor‘s Thesis Colloquium

Identification of Processing Steps and their Arguments in German Recipes

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Date:
20 February 2020

6,000 Year Old Sumerian Beer Recipe

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In pot one:
500 g (dry weight) pulverized sprouted barley gruel
1 biscuit (~200 g dry weight) sprouted wheat or spelt bread
2 ltrs of the last barley rinse water
200 g cracked winter wheat
In pot two:
2 biscuits (~250 g dry weight) sprouted barley bread
100 g unsprouted barley, crushed
200 g unsprouted spelt, crushed
2.5 ltrs cold water

Method
Thoroughly break up the biscuits and allow them to soak.
While the first pot soaks at room temperature, slowly heat the second pot to boiling. Once it has reached boiling, mix the contents of the two pots, and slowly bring the temperature back to boiling.
With a wooden spoon, push the mash to one side of the pot and collect the liquid (plus any grain that happens to be floating around) with a cup and transfer it to another pot.
Add 1 litre of boiling water to the mash, stir and repeat the pressing procedure.
Repeat this until you have collected several litres of brown, gravy-like liquid, along with some grains
Bring the liquid to a boil to sterilise it, cool and pitch with your favorite wild yeast.

Modern Recipe

Backen | Ei | Hauptspeise | Kuchen

Drucken/PDF | Teilen | Rezept speichern

Käsekuchen ohne Boden

für eine Springform (26cm)

☆☆☆☆☆ 0 bei 0 Bewertungen | 3 Kommentare

30 Min. | simpel | 10.09.2010

Zutaten für 1 Portionen

4	Ei(er), getrennt
750 g	Magerquark
1 Prise(n)	Salz
1 TL, gehäuft	Aroma, (Finesse-Orange)
220 g	Zucker
1 TL, gehäuft	Vanillezucker, echte Bourbon
125 g	Grieß, Hartweizen-
2 TL	Backpulver
1 Pck.	Puddingpulver, Vanille-
80 ml	Öl
120 ml	Öl, (Zitronenöl)
evtl.	Mandarine(n) -Orangen, Pfirsiche oder Aprikosen zum Belegen
	Puderzucker, zum Bestäuben

Zubereitung

Arbeitszeit: ca. 30 Minuten | Gesamtzeit: ca. 30 Minuten

Die Eier trennen, das Eiweiß mit Salz steif schlagen und kühl stellen. Das Eigelb mit den restlichen Zutaten verrühren, den Eischnee locker unterheben.
Den Teig in eine gefettete Springform füllen und evtl. mit Früchten belegen.
Bei 170° C ca. 1 Std. backen. Die Oberfläche sollte goldgelb sein. Abgekühlt mit Puderzucker bestäuben und in Stücke schneiden.

Applications

- Dialogue Systems
  „What should I do next?“,
  „What does sauté mean?“,
  „How much will I have to clean?“
- (semi-)Robotic cooking, e.g. Thermomix, microwave ovens

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Content

- Motivation
- Characteristics of (German) Recipes
- Recipe Graphs
- Parsing Task
- Future Work
- Conclusion

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c. Kühl stellen.
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d. Das Eigelb mit den restlichen Zutaten verrühren,
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e. den Eischnee locker unterheben.
   'gently fold in the beaten egg whites.'
f. Den Teig in eine gefettete Springform füllen [...]
   'Pour the batter into a greased (springform) baking pan [...]'

Anonymous Objects

- Intermediate products are not always mentioned explicitly as the result of the action in which they are generated.
- May be named in a different part of the recipe.

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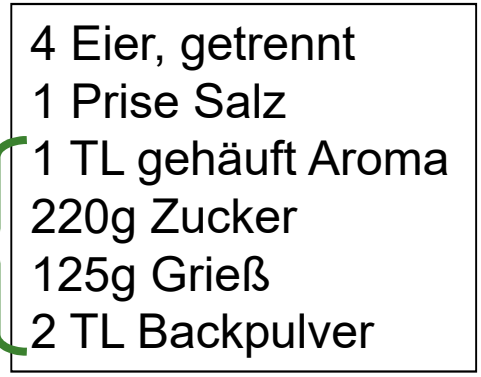

Zero Anaphora

- Elliptic device: direct object of a verb is omitted.

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a. Alle Zutaten mit dem Schneebesen zu einem Teig vermengen.
   'Combine all ingredients into a batter with a whisk.'
b. Eine Stunde ruhen lassen
   'Let rest for one hour.'

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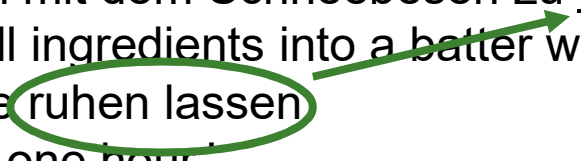

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- **Recipe Graphs**
  - Sequence Types
  - Graph Construction
- Parsing Task
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Goals

- Make recipes machine-readable
- Preserve all information necessary for successful execution of the recipe
- Lay groundwork for further research

Sequence Types

Zutat	**Ingredient**
Zwischenprodukt	Product
Gerät	Tool
Kochschritt	Action
Bedingung	Specification
Präposition	Preposition
Disjunktion	Disjunction

a. Die **Eier** trennen,
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Mix in **100 g** flour and **immediately** bake at **170°C** for **20 min**.

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Put Cheese **on top of** the tomatoes.

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Use lemon **or** lime slices as garnish.

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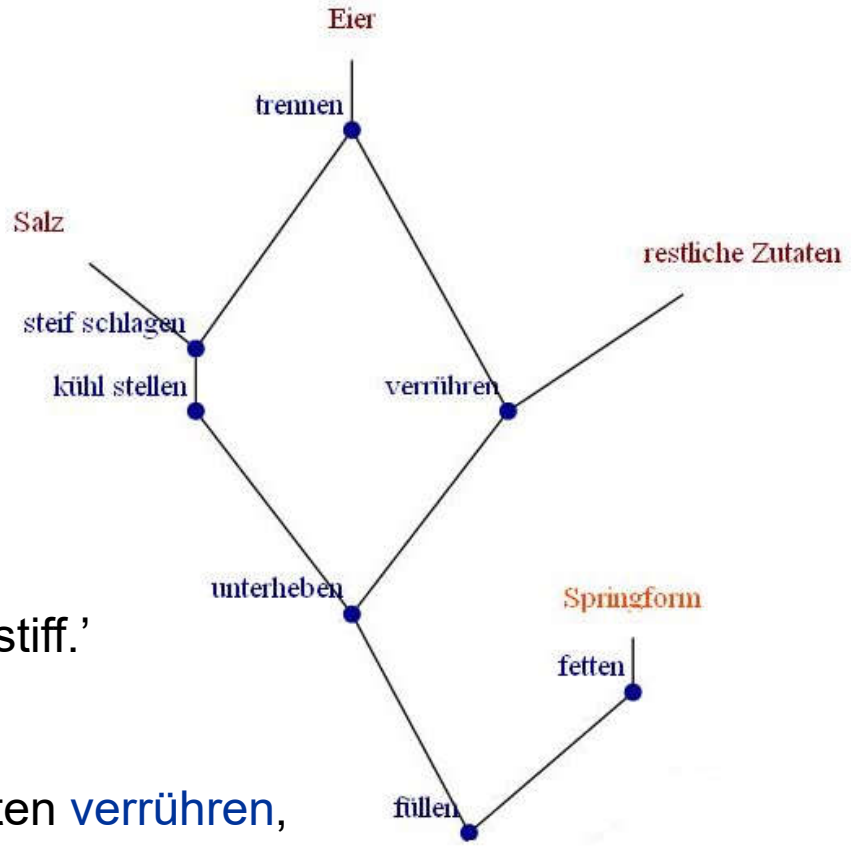
Actions

- Actions depend on ingredients, tools and previous actions.



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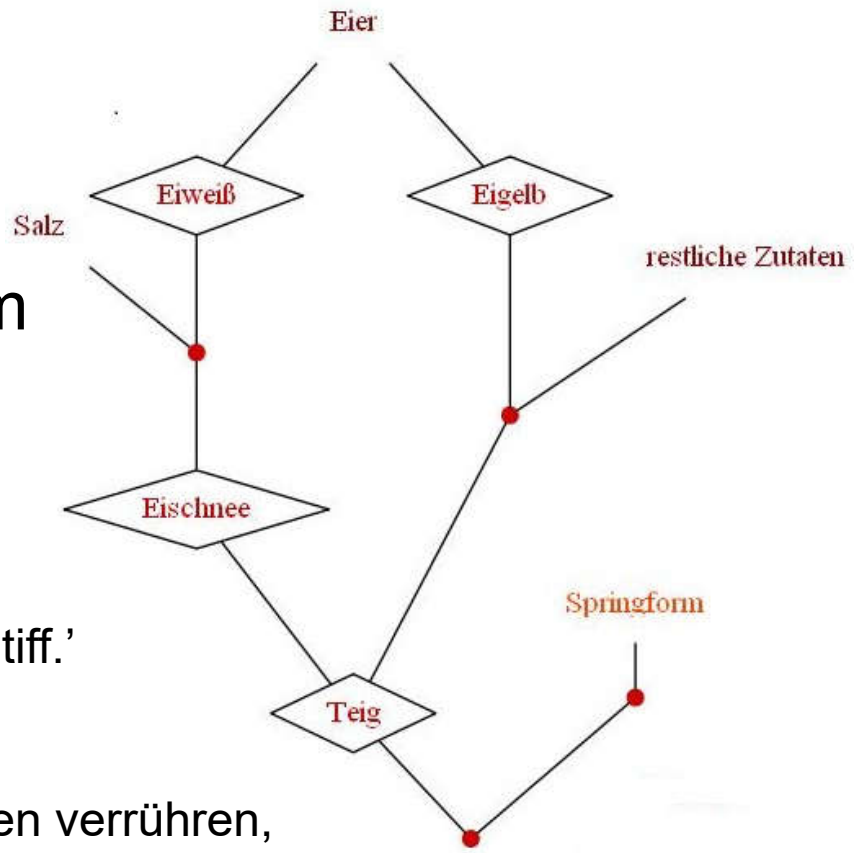
Products

- Cooking process can be defined by a system of product states derived from input combinations.



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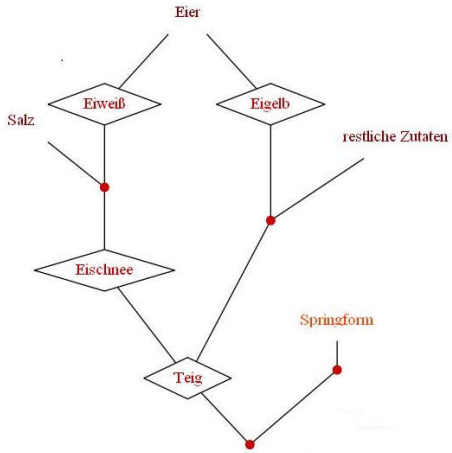
Merge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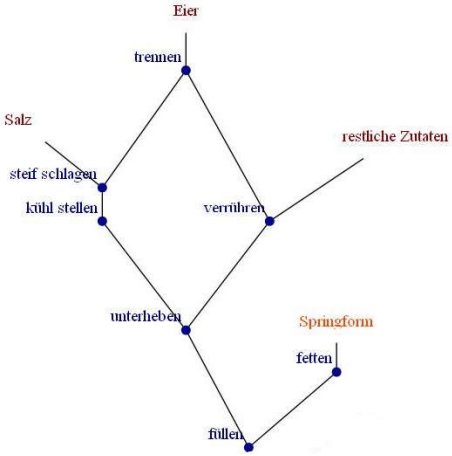
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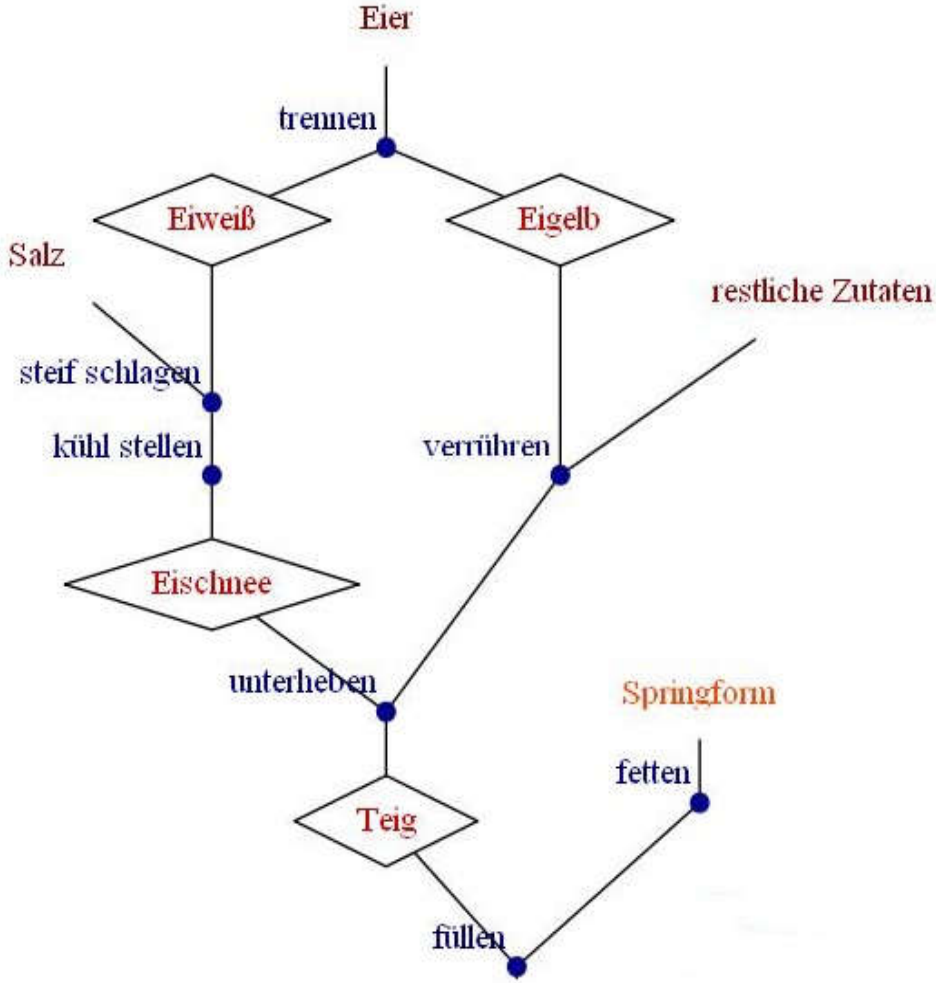
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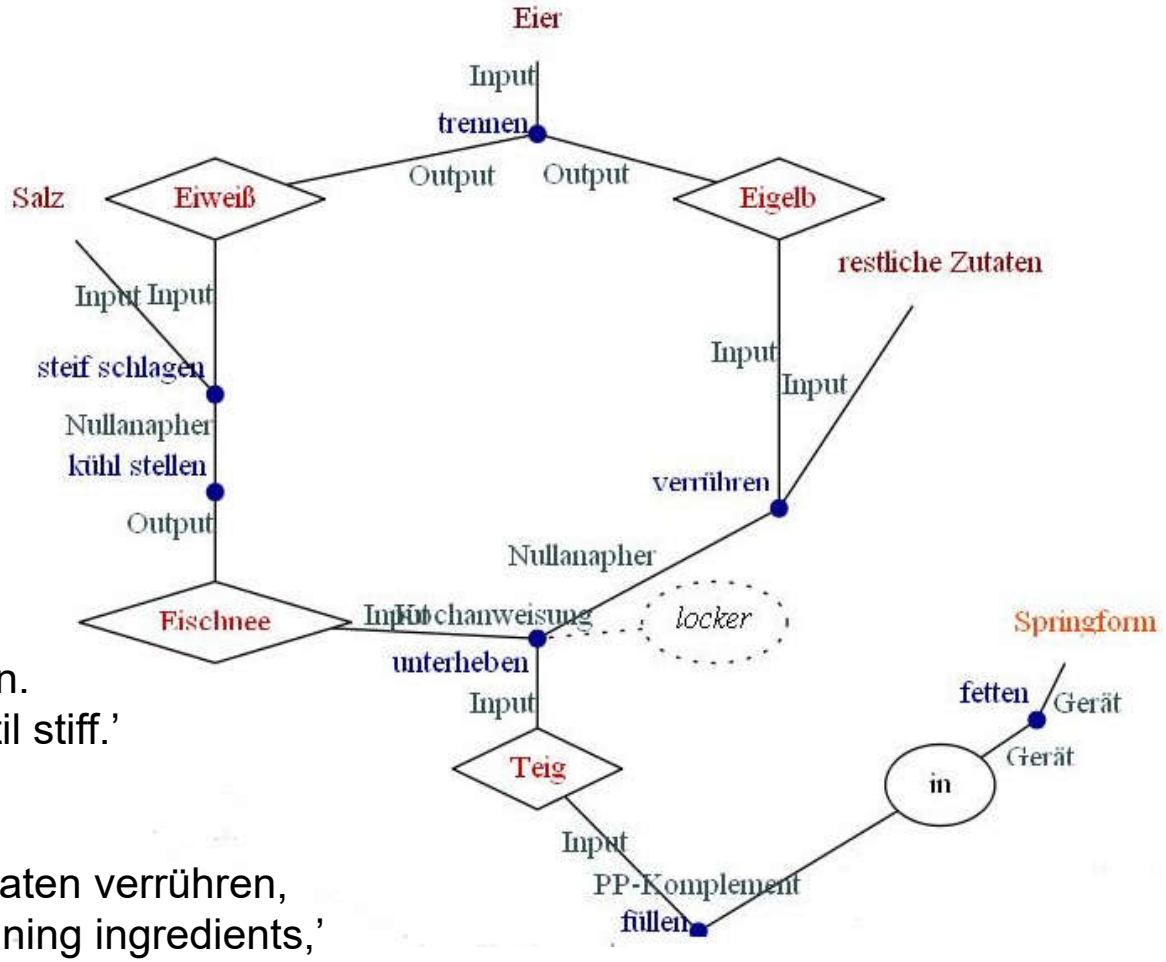
Recipe Graphs



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Recipe Graphs

- Merge of action and product graphs, plus additional (necessary) information (e.g. modals, time spans)
- Named dependency relations
- Very detailed representation, s.t. it can be simplified according to individual requirements of a certain use case

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Pilot Corpus

- Size: 100 recipes (descriptions only)
- Source: chefkoch.de
- Annotator: myself
- Format: CoNLL with BIOUL tags

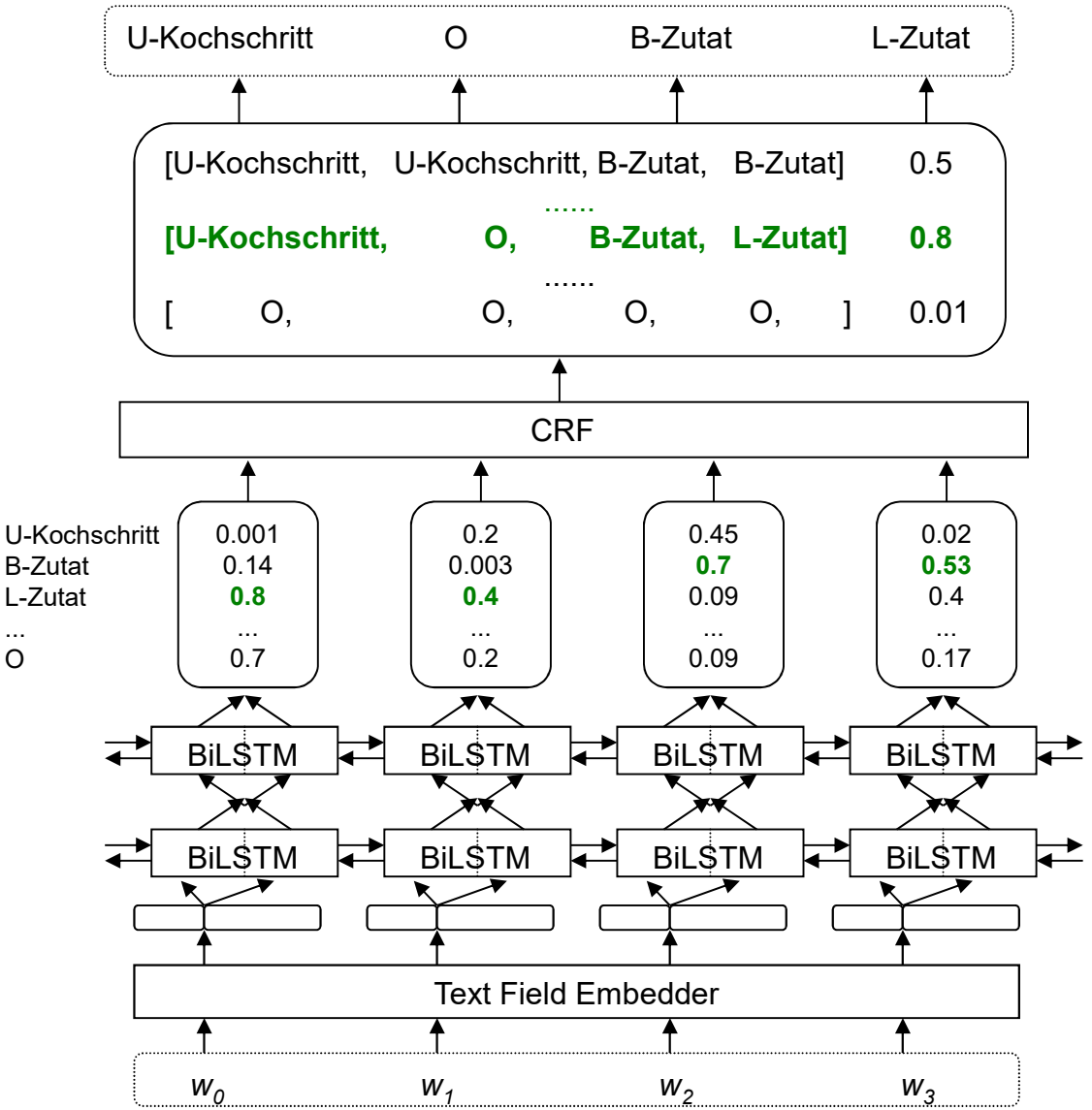
Pilot Corpus

1	Die	ART	B-Zutat	3	Input	_
2	Eier	NN	L-Zutat	3	Input	_
3	trennen	VVFIN	U-Kochschritt	5	Output	[('15', 'Output')]
4	,	$,O	O	0	root	_
5	das	ART	B-Zwischenprodukt	9	Input	_
6	Eiweiß	NN	L-Zwischenprodukt	9	Input	_
7	mit	APPRO	O	0	root	_
8	Salz	NN	U-Zutat	9	Input	_
9	steif	ADJD	B-Kochschritt	12	Nullanapher	_
10	schlagen	VVINF	L-Kochschritt	12	Nullanapher	_
11	.	$.O	O	0	root	_

Parsing Task

- Corpus split: 80 / 10 / 10
- Sequence Labelling
  - Identification and classification of relevant sequences
  - Token embeddings: ELMo vs BERT
- Dependency Relations
  - Structure of the recipe
  - Input: recipe text with labelled sequences
- Models constructed as neural networks

Sequence Labelling: Architecture



Sequence Labelling: Performance

Model	F1 Measure	Precision	Recall	Accuracy
ElMo (development data)	82.3	81.6	83.0	83.9
ELMo (evaluation data)	80.2	78.9	81.6	78.7
BERT (development data)	79.3	79.3	79.2	80.1
BERT (evaluation data)	76.9	77.0	76.8	77.5

Performance of fine-tuned models for ELMo and BERT embeddings. Best of four runs.

- State-of-the-art for German NER, F1 Measure: 88.3
  (Akbik et al. (2018), CoNLL-2003 data)

Sequence Labelling: Performance

Label	Precision	Recall	F1 Measure
Zutat	70.6	81.4	75.6
Zwischenprodukt	69.5	60.0	64.4
Gerät	60.8	77.5	68.1
Kochschritt	96.3	98.6	97.4
Bedingung	71.9	70.3	71.1
Präposition	76.4	85.7	80.8
Disjunktion	83.3	58.3	68.6

Detailed performance metrics on the evaluation data for the model with ELMo embeddings

Dependency Parsing

- Off-the-shelf parser (Biaffine Dependency Parser from AllenNLP)
- Input: full-length recipes
  Output: labelled trees

Dependency Parsing

- Performance on evaluation set:
  Unlabeled Attachment Score (UAS): 80.0
  Labeled Attachment Score (LAS): 78.3
- Previous approach of parsing recipes into dependency structures, UAS: 93.5

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Future Work

- Further development of the presented outline
- Applications, e.g. interactive cookbook, translation, …
- Learning entailments
- Generalization to other domains

Conclusion

- Key information in (German) recipes: ingredients, tools, actions, products
- Underlying structure: graphs
- Parsing can be achieved with neural network models in two steps:
  - Sequence labelling
  - Dependency parsing
- Many possibilities for further development

Thank you for your attention!

Questions?

Corpus Statistics

	Recipes	Sentences	Tokens	Sequences	Labelled Tokens
Training	80	808	9494	3750	6381
Development	10	114	1234	473	811
Evaluation	10	122	1310	541	1016

Corpus Statistics

Label	Training	Development	Evaluation
Zutat	774 | 1.5	119 | 1.4	118 | 1.7
Zwischenprodukt	469 | 1.8	74 | 1.9	92 | 1.9
Gerät	255 | 1.9	29 | 1.7	40 | 2.0
Kochschritt	1225 | 1.1	157 | 1.1	195 | 1.1
Bedingung	493 | 4.4	85 | 2.7	91 | 3.2
Präposition	305 | 1.0	43 | 1.0	49 | 1.0
Disjunktion	29 | 1.0	2 | 1.0	8 | 1.2

Corpus Statistics

Relation Type	Training	Development	Evaluation
Input	1313	203	221
Output	475	75	99
Nullanapher	729	88	112
Gerät	318	34	48
Zeitangabe	184	22	21
Mengenangabe	138	19	13
Kochanweisung	402	48	58
PP-Komplement	304	43	49
Disjunkt	32	4	12

Future Work

- Improving parsing results (bigger corpus, POS tags as input features, fine-tuning on unannotated data, exhaustive fine-tuning on hyperparameters)
- Rule-based approach for comparison
- Improving sequence labelling (refine loss function, dealing with infrequent tags, assess BIOUL annotation scheme)
- Approaches to dependency parsing (shorten input to sentences, include all edges, pre-training on syntactic dependencies, rule-based constraints)

Further Research Based on Recipe Graphs

- Re-linearisation / text generation (heuristic for temporal ordering)
- Include title and ingredient list
- Resolve collective noun phrases (world knowledge, ontology)
- Recipe adaptation to user experience (learning entailments)
- **Generalization to other domains**
- **Applications, e.g. interactive cookbook, translations, …**
- Eventually: recipe generation

Issues with Temporal Order

- Hierarchical structure is presented linearly.
- Actions do not necessarily appear in the order they are executed.

a. Die Eier trennen,
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Participles: (usually but not always) actions with respective ingredient or tool as argument

Hierarchical structure (parallel threads)
-> but: re-linearlisation for output (e.g. interactive cook book

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b. das Eiweiß mit Salz steif schlagen.
   'beat the egg whites with salt until stiff.'
c. Kühl stellen.
   'Put in a cool place.'
d. Das Eigelb mit den restlichen Zutaten verrühren,
   'Mix the egg yolks with the remaining ingredients,'
e. den Eischnee locker unterheben.
   'gently fold in the beaten egg whites.'
f. Den Teig in eine gefettete Springform füllen [...]
   'Pour the batter into a greased (springform) baking pan [...]'

Participles: (usually but not always) actions with respective ingredient or tool as argument

Hierarchical structure (parallel threads)
-> but: re-linearlisation for output (e.g. interactive cook book

Issues with Temporal Order

- Hierarchical structure is presented linearly.
- Actions do not necessarily appear in the order they are executed.

a. Die Eier trennen,
   'Separate the eggs,'
b. das Eiweiß mit Salz steif schlagen.
   'beat the egg whites with salt until stiff.'
c. Kühl stellen.
   'Put in a cool place.'
d. Das Eigelb mit den restlichen Zutaten verrühren,
   'Mix the egg yolks with the remaining ingredients,'
e. den Eischnee locker unterheben.
   'gently fold in the beaten egg whites.'
f. Den Teig in eine gefettete Springform füllen [...]
   'Pour the batter into a greased (springform) baking pan [...]'

Participles: (usually but not always) actions with respective ingredient or tool as argument

Hierarchical structure (parallel threads)
-> but: re-linearlisation for output (e.g. interactive cook book

Dependency Parsing

- Training on text and POS tags rather than on text and sequence labels yields a UAS of 45.4 and an LAS of 42.2.
  → Sequence tagging and dependency parsing are not independent tasks.

- Training only on text yields a AUS of 39.4 and an LAS of 35.2.
  → Weak correlation to syntactic dependencies.

(e.g. the inputs and outputs of a Kochschritt very often are the objects of the corresponding verb

suggest that the cooking dependency model could profit from pre-training on syntactic dependencies of a bigger corpus before fine-tuning it to the domain specific sequence labels and relations

Zwischenprodukt

- A *Zwischenprodukt* sequence describes food items, tools or a combination of both.

- ’Take the soup off the stove.’
  ’Take the pot off the stove. ’

Equivalent instructions

Metonymic (pars pro toto)
And
Logistic reality that both will be moved either way

Reasons to include tools

e.g. muffin tin
e.g. water bath to melt chocolate

- Ignorance of the user (special tools, performing actions in a certain way)
- Relevance for applications (e.g. „How many dishes will I have to clean?“, „I have only one pot; will that be enough to cook this dish?“)

→ most relevant in planning phase (= deciding on a dish)

Applications

- Script learning / knowledge assembly
- Comparing recipes with respect to various aspects (length, similarity, tools & ingredients)
- Adapting recipe representations to user knowledge
- Translation
- Parsing makes details in recipe text more accessible for dialogue systems

Characteristics: Temporal Ordering

- Temporal Order: Hints and suggestions in the end, noun phrases, examples of where participles are not to be treated as actions

Sequence Labelling: Performance

Label	Precision	Recall	F1 Measure
Zutat	66.2	78.0	71.6
Zwischenprodukt	69.8	67.3	68.5
Gerät	78.1	62.5	69.4
Kochschritt	94.4	96.2	95.3
Bedingung	59.8	57.1	58.4
Präposition	78.0	65.3	71.1
Disjunktion	30.0	50.0	37.5

Detailed performance metrics on the evaluation data for the model with BERT embeddings.

References

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