

# Flow graph construction from unsupervised cooking recipes

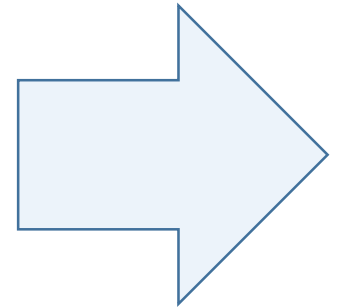
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## Cooking recipe for human

- + 2 cups chopped onion
- + 4 cubes chicken bouillon
- + 2 1/2 pounds peeled and cubed potatoes
- + salt and pepper to taste
- + 2 tablespoons margarine
- + 3 cups fresh broccoli, cooked and drained
- + 5 cups boiling water
- + 3 cups shredded Cheddar cheese

- 1 In a large stock pot saute onion in butter. Add potatoes, water and bouillon cubes. Cover, bring to boil and then reduce heat to medium and cook until potatoes are tender, about 15 minutes.
- 2 Remove tough outer skin of broccoli stems and cook broccoli. Once cooked add to soup.
- 3 In a blender or food processor puree half of the soup and return to stock pot. Season with salt and pepper.
- 4 Add cheese and heat soup through until cheese is melted. Serve warm.

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## Cooking recipe for robot

ACTION Object → Target

PUT butter → pot

SAUTE onion (2 cups) → \\_/\_/

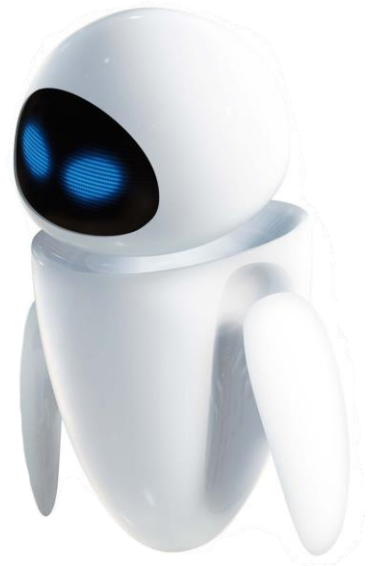
ADD potato (2.5 pounds) → \\_/\_/

COVER \\_/\_/

BOIL \\_/\_/

COOK (15 mins) \\_/\_/

...



# Challenges

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Hypernyms

Verbs-like-nouns

Approximate measures  
and timings

No labeled data

Slang words

## Co-reference resolution



Pretrained models  
only from completely  
different field

Imperative  
sentences

# Data preprocessing

## 1. Collect data

70 000 raw recipes  
In json format  
from allrecipes.com

Title  
Popularity  
List of ingredients  
List of directions  
Cooking time

## 2. Build dictionaries

Actions  
Ingredients  
Utensils  
Measures

## 3. Label data

60 hand labeled flow graphs

line_id	action	object	target	no	nt	description
0	season	garlic salt	chicken breasts	6	1 teaspoon	0
0	season	pepper	body	6	0	0
2	cook	chicken breasts	0	0	0	until browned
3	add	onion	body	1	0	0
4	cook	body	0	0	0	until onion is browned 3 to 4 minutes
5	pour	diced tomatoes	chicken	1 (14.5 ounce)	0	0
5	pour	balsamic vinegar	body	1/2 cup	0	0

0 stir butter and 1 teaspoon sugar into  
hot milk until butter is melted

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1 when mixture is lukewarm , stir in yeast  
and set aside for 5 minutes

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2 when mixture is creamy , transfer to  
a large mixing bowl

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3 mix in 2 cups of bread flour

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4 add 1/2 cup sugar , eggs , orange juice ,  
orange zest , and salt and beat

# Approach

## 1. Raw recipe directions

*"Heat olive oil in a skillet over medium heat"*

Semantic  
role labeling

Cleaning,  
checking dictionaries  
etc.

## 2. Annotated directions

**V:** heat  
**A1:** olive oil  
**AM-LOC:** in a skillet  
**AM-MNR:** over medium heat

## 3. States

### Action

Heat (medium)

### Object

olive oil, 1 tbsp

### Target

skillet



# Evaluation

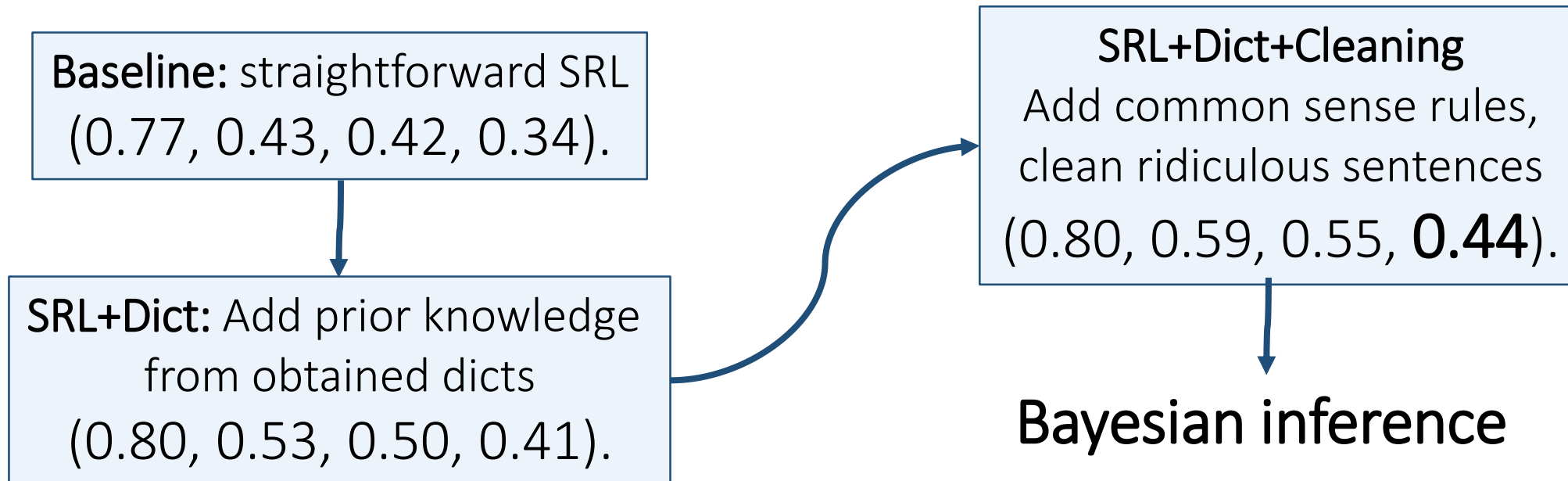
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- $E_a, E_o, E_t$  - accuracy of correctly predicted actions only  
/actions+objects/actions+targets
- $E$  – accuracy of correctly predicted states  
(Action+Object+Target)

## Results

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Score ( $E_a, E_o, E_t, E$ ) was calculated over all labeled recipes

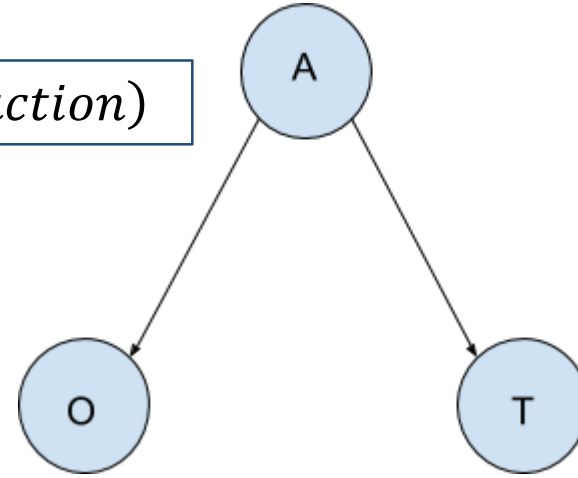


# Bayesian inference

$$P(\text{sent}) = P(\text{object}|\text{action}) P(\text{target}|\text{action}) P(\text{action})$$

$$P(\text{recipe}) = \prod P(\text{sent})$$

$$P(\text{action}|\text{object}) = \frac{\text{Count}(\text{action}, \text{object})}{\text{Count}(\text{action})}$$



## Produced flow graph

COMBINE cheese → bowl  
COMBINE pepper → bowl  
COMBINE powder → bowl  
UNFOLD pastry  
BRUSH egg  
SPRINKLE cheese → bowl

PRESS pastry  
CUT sheet  
TWIST  
PLACE sheet → bowl  
BAKE 0 → oven

## Some frequent patterns

combine sugar 0.093  
mix well 0.10  
stir mixture 0.043  
fry brown 0.084  
cool wire 0.05  
boil minutes 0.46  
place minutes 0.04

# Working Example

## HAND LABELED

line_id	action	object	target	no	nt
0	combine	cheese	body	1/2 cup	0
0	combine	pepper	body	3/4 teaspoon	0
0	combine	garlic powder	body	1/2 teaspoon	0
1	unfold	pastry sheets	cutting board	1 (17.5 ounce)	0
2	brush	pastry sheets	egg	1 (17.5 ounce)	0
3	sprinkle	body	sheet	0	0
3	turn over	body	0	0	0
4	press	body	pastry	0	0
4	turn over	body	0	0	0
5	repeat	body	0	0	0
6	cut	body	strips	0	0
7	twist	body	0	0	0
8	place	body	sheet	0	0
8	bake	body	oven	0	350 f

## OUR MODEL

line_id	action	object	target	no	nt
0	combine	cheese	body	1/2 cup	0
0	combine	pepper	body	3/4 teaspoon	0
0	combine	garlic powder	body	1/2 teaspoon	0
1	unfold	pastry sheets	cutting board	0	0
1	cutting	board	body	0	0
2	brush	body	egg white	0	1
3	sprinkle	cheese	body	1/4	0
4	press	body	pastry	0	0
4	turn over	body	0	0	0
6	cut	sheet	body	0	0
8	place	body	sheet	0	350 175 degrees

## Evaluation

(0.79, 0.57, 0.57, 0.57)