

DATA COLLECTION AND LANGUAGE UNDERSTANDING OF FOOD DESCRIPTIONS



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Introduction

- Existing approaches for the prevention and treatment of obesity are hampered by the lack of accurate, low-burden methods for self-assessment of food intake, especially for hard-to-reach, low-literate populations.
- Goal:** create a nutrition dialogue system that automatically extracts foods from a user's spoken meal log.
 - E.g., "This morning I ate **a bowl of Kellogg's cereal.**"
- We have explored two components:
 - Data collection
 - Language understanding (i.e., tagging and segmenting food concepts)

Data Collection

- We collected and labeled 1,302 breakfast diaries on Amazon Mechanical Turk (AMT).
- Three rounds:
 - Writing meal descriptions
 - Labeling foods
 - Labeling properties (i.e., brand, quantity, description)

Categories & Sample Phrases	
Brand	Trader Joe's, Kellogg's, homemade...
Quantity	a cup, a large bowl, two [eggs]...
Description	black [coffee], nonfat [milk]...

Instructions

You will be presented with several descriptions of meals. For each description, label the individual food AND drink items. Select a phrase to label as a food or drink item by dragging from the first word to the last word, then select the category "Food" from the popup menu.

For example:

I had two eggs and 2 and a half strips of bacon this morning with two pieces of toast with margarine and Smucker's strawberry jam on it. I had a cup of milk to drink with it.

Fig. 1. The AMT task for labeling foods in a meal description.

Instructions

You will be presented with several descriptions of meals. Within each description, one food item will be highlighted in red text. Categorize the words associated with that food item. Select a phrase to categorize by dragging from the first word to the last word, then select the relevant category from the popup menu.

Please review all categories and sample phrases on the left before you begin!

For example:

I had a large bowl of Kellogg's Frosted Flakes with about a cup of 2% milk.

Fig. 2. The AMT task for labeling properties of foods.

Methods

Tagging

- Goal:** label foods and properties in a spoken meal description.

I had **a bowl** of **Kellogg's** **frosted** **flakes**
Quantity Brand Description Food

- Semi-Markov conditional random field (semi-CRF): outputs labels for segments of input tokens.
- Chose features using 10-fold cross-validation: n-grams, food lexicon, and POS tags.

Features	Mean F1	Variance	St. Dev.
N-grams	84.6	0.6	0.8
+ Lexicon	84.6	1.3	1.1
+ POS tags	84.8	1.2	1.1

Table 1. Semi-CRF 10-fold results.

Segmenting

- Goal:** associate property labels with food labels.
- Framed as a BIO labeling classification task.

I had **a bowl** of **cereal** and **two cups** of **milk**
Quantity Food Quantity Food

O O B I I I O B I I I

- Simple rule baseline: assign properties to subsequent foods.
- Investigated three approaches:
 - CRF classifier (CRF++ toolkit)
 - Markov model (MM)
 - Each state represents a property or food.
 - Used a finite state transducer (FST).
 - Transformation-based learning (TBL)
 - Iteratively applies transformations to improve an initial solution.

Tagging Results

- Evaluated semi-CRF performance at the food concept level, rather than at the token level.

Label	Precision	Recall	F1
Food	92.5	87.5	89.9
Brand	87.3	71.0	78.3
Quantity	92.4	91.3	91.9
Description	85.6	77.6	81.4
Other	91.7	95.8	93.7
Overall	88.3	82.2	85.1

Table 2. Semi-CRF concept-level performance.

- Foods, quantities, and other were labeled more accurately than brands or descriptions.
- Semi-CRF performance was not significantly different from CRF (significance measured using McNemar's test).

Segmenting Results

- TBL improved upon the simple rule and Markov model baselines.
- CRF significantly better than other methods.

Approach	Acc	Prec	Recall	F1
Simple Rule	84.4	51.5	54.2	52.8
Simple + TBL	94.3	77.9	78.3	78.1
MM	84.9	54.6	57.2	55.9
MM + TBL	95.2	82.7	80.4	81.5
CRF	97.2	87.1	87.1	87.1
CRF + TBL	95.5	84.0	82.9	83.4

Table 3. Performance on food segmenting task (token-level accuracy and phrase-level F1).

- Simple rule incorrectly assigns properties if attribute comes after its corresponding food.
- Markov model makes mistakes by incorrectly segmenting foods.

Conclusions

- Performed data collection and annotation of food diaries via Amazon Mechanical Turk.
- Conducted semantic labeling experiments using a semi-CRF with an F1 test score of 85.1.
- Explored three methods for associating foods with their corresponding attributes: a Markov model (MM), transformation-based learning (TBL), and a CRF classifier.
- CRF is the best food segmenting model, achieving a phrase-level F1 score of 87.1.

Ongoing Work

- Asking follow-up questions to narrow down the database hits.
- Mapping user's spoken quantities to database quantities.
- Refining the user interface.