Semantic Nutrition: Estimating Nutrition with Mobile Assistants

Joshua D'Arcy, M.D. [1,2,3] Sabrina Qi [3], Dori Steinberg, Ph.D., R.D. [4,5] , Jessilyn Dunn, Ph.D. [2,3]

[1] Duke University School of Medicine [2] Department of Bioinformatics and Biostatistics, Duke University Health System
[3] Duke University Pratt School of Engineering [4] Duke School of Nursing [5] Duke Global Digital Health Science Center

Background

Food logging is effective for improving dietary intake and clinical outcomes, but notoriously difficult in clinical and research settings. Determining the relationship between clinical outcomes and nutritional intake depends on accessing accurate nutrition data. Common food logging practices include handwritten food diaries or manual entry of foods into a smartphone application. Handwritten food diaries require significant effort to link the underlying nutritional information for each entry and transcribe it into a digital format. Smartphone applications introduce a need for technological literacy for food logging, but users still need to manually log their food diaries. Image-based food logging apps are inconsistent and often unreliable. Given the nearly infinite diversity of food, it is furthermore uncommon to find perfect matches of a logged food item in a nutrition database.

Objectives

Problem: Traditional food logging is difficult and introduces barriers for patient and provider compliance.
Solution: We built a platform for low-barrier nutrition data collection via mobile assistants, complete with an online database for provider and patient.

Problem: Food is diverse and resistant to simple matching methods.
Solution: We deployed a Word2Vec API for nutrition estimation between semantically neighboring foods.

Dataset

- Expertly annotated database consisting of 50,000+ food items and their nutrition profiles[1]
- Embedded word vector representations from the Google News Corpus[2]

food_name	carbohydrates	sugar	total_fats	sat_fats	protein	fiber	calories	cholesterol	potassium	sodium	calcium	magnesium	vector representation
avocado roll	50.70	0.29	10.98	1.60	6.54	4.72	321.41	0.0	422.22	34.26	13.0	37.0	[illegible]
fried tofu	2.51	0.77	5.72	0.83	5.34	1.51	76.55	0.0	41.39	4.54	105.0	17.0	[illegible]
orzo	63.51	2.27	1.28	0.24	11.09	2.72	315.54	0.0	189.66	7.50	15.0	45.0	[illegible]
green salad	7.00	5.07	8.68	3.69	3.82	1.37	119.25	18.5	203.96	400.00	118.0	14.0	[illegible]
coffee	0.00	0.00	0.05	0.00	0.28	0.00	2.37	0.0	116.53	4.74	4.0	7.0	[illegible]

Automated Pathway for Nutrition Logging

"hey {voice assistant}[3], I'm eating a kale salad with apple cobbler"

↓ Parse variable key phrase and send to online API[4]

"a kale salad with apple cobbler"

↓ Convert to vector embeddings using {food_name : vector representation} pairs from dataset. Non-food related words are dropped by default.

```
{
    kale : [-.0132, .643, …],
    salad : [.090, .312, …]
    apple : [.392, .421, …]
    cobbler : [.011, .253, …]
}
```

↓ Identify likely pairings and combinations of foods using generic rules, element-wise sums, exhaustive combinations, and cosine-similarity to dataset rows.

```
{
    kale salad : [.0768, .955, …]
    apple cobbler : [.403, .674, …]
}
```

↓ Find closest match (maximum cosine similarity) in database. Exact match will have cosine similarity of 1.0.

kale salad matches kale salad (1.0 cosine similarity)
apple cobbler closely matches peach cobbler (.86 cosine similarity) and is more distant from apples (.80 cosine similarity)

↓ Return and log the nutrition profile of the best match in an online database[4].

```
{
    kale salad : [ sugar : 2.11 g, calories : 83.69 cals, …]
    peach cobbler : [ sugar : 61.14 g, calories : 432.05 cals, …]
}
```

Recommended Implementation

1. Visit our GitHub repository at:
https://github.com/Big-Ideas-Lab/food2vec

2. Our repository details how to use the basic semantic nutrition API. We are making frequent updates as we migrate our process to secure servers and extend the mobile assistant connection for individual user sessions.

3. Give us feedback! @Big_Ideas_Lab on Twitter.

We are building this tool for clinicians and other nutrition researchers. Feel free to use and distribute the code as you see fit.

Future Directions

1. Train new embeddings on a more food-centric dataset. The current embeddings were trained on the Google News Corpus. More robust semantic relationships can be formed from a training dataset that is more food-centric. We are actively training new word embedding models using online food blogs and cookbooks.

2. Enable portion size correction. The current model assumes a single serving per entry.

3. Secure the process. This process uses open-source platforms and does not provide sufficient protection for user data. In order to become HIPAA-compliant and initiate a small pilot study, we will need to migrate our server and database to a more secure location.

Acknowledgements

[1]A special thank you to the staff at Duke Nutrition, whose tireless efforts produced our comprehensive food database

[2]Open-source word embeddings from this dataset:
https://code.google.com/archive/p/word2vec/

[3]Google Assistant and Apple's Siri were both tested on our platform

[4]Google's Firebase and App Engine cloud products were used to store user data and host our nutrition estimator API, respectively