PLATEMATE
CROWDSOURCING NUTRITION ANALYSIS FROM FOOD PHOTOGRAPHS

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OVERVIEW

- Combines many crowdsourcing techniques
- Accuracy comparable to trained dietitians
MOTIVATION

- Calorie counting apps?
- Remote food photos?
- Computer vision?
- Use the crowd!

Vision *isn’t* there yet

Experts are scarce

Amateurs are *biased*

Logging food is hard

CHALLENGE: SOLVE A COMPLEX REAL-WORLD PROBLEM WITH AN UNTRAINED CROWD
APPROACH

• Observed professional nutritionist
• Noticed three steps
  * Partition plate into distinct items
  1. Identify foods
  2. Estimate portions
  3. Calculate calories
WORKFLOW
OVERVIEW

Stages
- Tag
- Identify
- Measure

HITs
- Draw Boxes (2)
- Vote (3)
- Describe (3)
- Match (2)
- Vote (5)
- Measure (5)

Results
- Baked or Fried Chicken Drumstick
- Barbeque Sauce (Low Sodium, Canned)
- Cooked Spinach (from Fresh)
- Italian Flatbread Focaccia
- 2.53 drumstick
- .40 cup
- .83 cup, fresh
- 1.33 slice

PlateMate

kCal: 869.6
Fat: 41.9g
Protein: 53.1g
Carbs: 69.4g
TAG DISTINCT FOODS ON THE PLATE

Stages
- Tag

HITs
- Draw Boxes (2)
- Vote (3)

Results
- Baked or Fried Chicken Drumstick: 2.53 drumstick
- Barbeque Sauce (Low Sodium, Canned): .40 cup
- Cooked Spinach (from Fresh): .83 cup, fresh
- Italian Flatbread Focaccia: 1.33 slice

PlateMate

kCal: 869.6
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TAG DISTINCT FOODS ON THE PLATE
IDENTIFY EACH ITEM

PlateMate

Stages
Tag

Draw Boxes (2) → Vote (3)

Identification
Identify

Describe (3) → Match (2) → Vote (5)

Results

Baked or Fried Chicken Drumstick
Barbeque Sauce (Low Sodium, Canned)
Cooked Spinach (from Fresh)
Italian Flatbread Focaccia

Results

kCal: 869.6
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2.53 drumstick
.40 cup
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1.33 slice
DESCRIBE FOOD AND COMPONENTS ITERATIVELY

Step 1: Look at the picture. Decide what food is in the solid red box. Ignore foods that belong to other boxes, which are marked with dashed lines.

Step 2: What is this food? What do people call it? Name the food as a whole, even if it contains many parts. Example: "turkey sandwich", "lettuce and tomato"

salad with chicken

Step 3: What is it made of? Is it as a combination of other foods?

arugula
shredded chicken
olives
tomato
onion
feta cheese
Step 1: Look at the picture. Decide what food is in the solid red box. Ignore foods that belong to other boxes, which are marked with dashed lines.

Step 2: Read the food description below. This was written by earlier Turkers looking at the same picture. It could be wrong or incomplete, but it might help you identify the food.

What this is
salad with chicken

What it’s made of
arugula
shredded chicken
olives
tomato
onion
feta cheese

Step 3: Find matching foods in the database.

Click on an item to remove it.

<table>
<thead>
<tr>
<th>Arugula Lettuce</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken (Skin Not Eaten)</td>
</tr>
<tr>
<td>Olives</td>
</tr>
<tr>
<td>Feta Cheese</td>
</tr>
</tbody>
</table>
MEASURE PORTIONS IN TERMS OF DATABASE UNITS

Stages
- Tag
- Identify

HI Ts
- Draw Boxes (2)
- Vote (3)
- Describe (3)
- Match (2)
- Vote (5)
- Measure (5)

Results
- Baked or Fried Chicken Drumstick
- Barbeque Sauce (Low Sodium, Canned)
- Cooked Spinach (from Fresh)
- Italian Flatbread Focaccia

Measurements
- kCal: 869.6
- Fat: 41.9g
- Protein: 53.1g
- Carbs: 69.4g

Measure (5)
- 2.53 drumstick
- .40 cup
- .83 cup, fresh
- 1.33 slice
MEASURE PORTIONS IN TERMS OF DATABASE UNITS

Step 1
Look at the **White Rice** in the red box

Step 2
Choose the best measurement option

1 cup cooked

Step 3
Estimate the portion

0.75 x 1 cup cooked = 153 calories.

Step 4
Double check your answer
EXAMPLE

PlateMate

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FRAMEWORK

• Simulating expertise in crowd of amateurs
• Prior work on “programming crowds”
  • Our paradigm: organizational structure
• “Managing crowds”
  • Division of labor
  • Managers assign, evaluate, and route work
  • Employees are Turkers or other managers
EVALUATION
GROUND TRUTH STUDY

• 36 distinct foods
  • Plates, bowls, packages
  • Restaurant, cafeteria, grocery
  • Weighed as needed
• 3 trained experts
USER STUDY

• 10 participants (6 female)
• 2 days receiving PlateMate estimates
• 2 days manually logging with photo
• Before/after interviews on habits, preferences
USER STUDY

- 7/10 users preferred PlateMate overall
  - Emphasized convenience, accuracy, ease of correction
- 3/10 preferred manual logging
  - Easier to do it themselves, couldn’t trust results

Ease of Use

Accuracy
“It was really helpful to have someone else do that for me rather than guess myself.”

Prior attempts to record eating were “annoying,” “tedious,” and “inconvenient.”

The evaluation “confirmed my suspicions that you guys were more accurate than I was. The tendency is always to say, ‘oh, I didn’t have that much.’”
FUTURE WORK

• Improve accuracy, lower costs
  • Geolocation
  • Personalization
  • Vision / learning
• Text/voice annotation
• Applying framework elsewhere
CONTRIBUTIONS

1. **PlateMate**, an end-to-end system for crowdsourced nutrition analysis from food photographs

2. **An evaluation** demonstrating PlateMate’s accuracy, usability, and robustness

3. **The Management Framework** for solving complex problems with untrained crowds
QUESTIONS?
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BACKUP SLIDES
FRAMEWORK

• Hierarchy of virtual “managers”
  • Assign work to employees
  • Combine and verify results
USER STUDY

• Experts saw no significant accuracy difference
• 49% of estimates within 100 calories of each other
• PlateMate larger 63% of time
  • PM overestimates slightly
  • Amateurs heavily underestimate
• Daily intake +229 calories higher according to PlateMate
MATCH DESCRIBED ITEMS TO NUTRITION DATABASE

Step 1: Look at the picture. Decide what food is in the solid red box. Ignore foods that belong to other boxes, which are marked with dashed lines.

Step 2: Pick the best option below. Other Turkers selected these foods to match the solid red box in the photo. Think about how well each food or list of foods matches the photo. Choose the most accurate option. If many choices are accurate, pick the simplest one that still fully describes the food(s) in the box. **Never select a choice with duplicates, or multiple descriptions of the same food, like "brown rice, white rice"**

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<td>Feta Cheese</td>
</tr>
<tr>
<td>Oriental Chicken or Turkey Garden Salad (Chicken and/or Turkey, Lettuce, Fruit, Nuts)</td>
</tr>
</tbody>
</table>
def work(self):
    for input in self.assigned:
        self.employee('draw').assign(photo=input.photo)

    for output in self.employee('draw').finished:
        bg1, bg2 = output.box_groups.all()
        similarity = BoxGroup.similarity(bg1, bg2)

        # If responses are similar enough, don't bother voting
        if similarity > MIN_SIMILARITY:
            self.finish(photo=output.photo, box_group=bg1)

        # Otherwise, we need to vote
        else:
            self.employee('vote').assign(photo=output.photo, bx