



HARVARD

School of Engineering
and Applied Sciences

PLATEMATE

CROWDSOURCING NUTRITION ANALYSIS FROM FOOD PHOTOGRAPHS

JON NORONHA

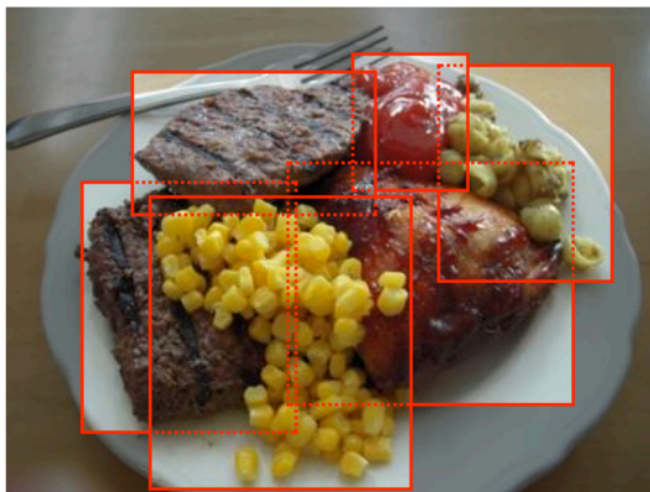
ERIC HYSEN

HAOQI ZHANG

KRZYSZTOF Z. GAJOS

OVERVIEW

DINNER



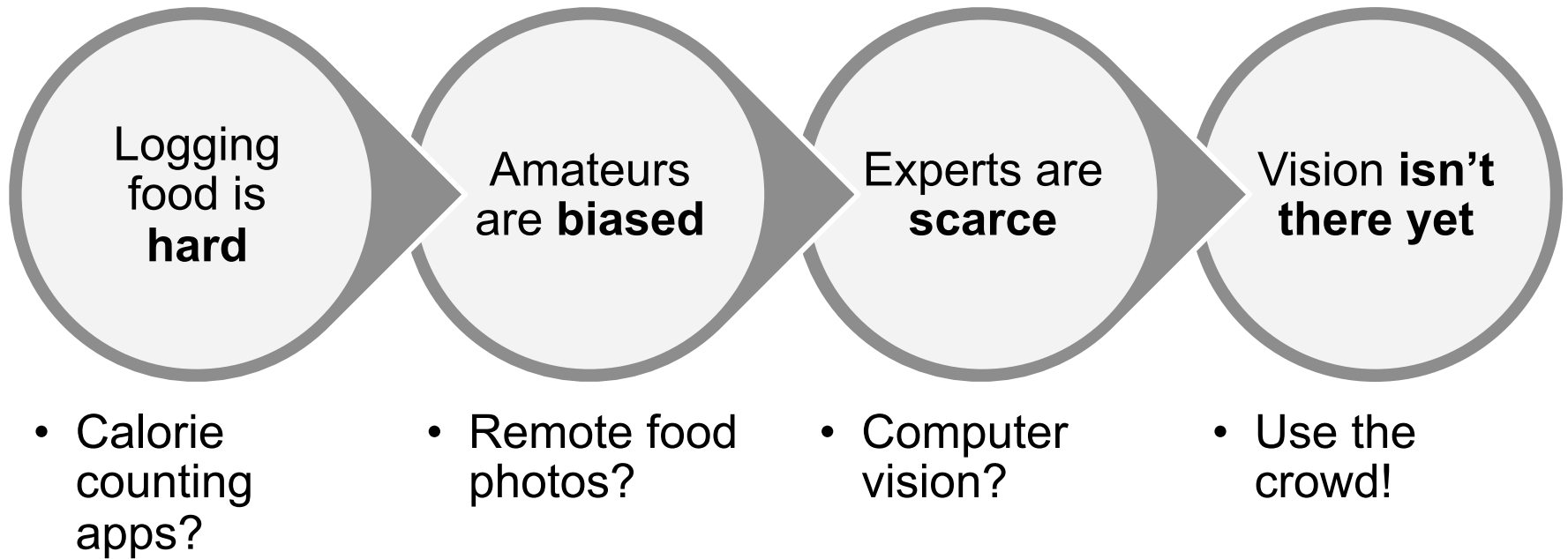
| | kcal | fat (g) | carbs (g) | protein (g) |
|--|--------|---------|-----------|-------------|
| | 1573.2 | 72.9 | 84 | 138.9 |
| Yellow Corn (0.50 cup) | 303 | 3.9 | 61.6 | 7.8 |
| barbeque chicken breast | | | | |
| Chicken Breast Meat and Skin (Broilers or Fryers) (1.00 breast, bone removed) | 249 | 13.4 | 0 | 30.2 |
| Barbeque Sauce (Low Sodium, Canned) (0.14 cup) | 26.6 | 0.6 | 4.5 | 0.6 |
| Beef Steak (0.92 medium steak (yield after cooking, bone removed)) | 471.3 | 28.1 | 0 | 51.0 |
| Hominy (White, Canned) (0.44 cup) | 52.8 | 0.6 | 10.4 | 1.1 |
| Ketchup (2.00 tbsp) | 30 | 0.1 | 7.5 | 0.5 |
| Beef Steak (0.86 medium steak (yield after cooking, bone removed)) | 440.5 | 26.2 | 0 | 47.7 |

+ Add Food

🗑 Delete this photo

- Combines many crowdsourcing techniques
- Accuracy comparable to trained dietitians

MOTIVATION



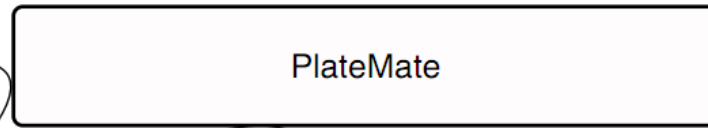
CHALLENGE: SOLVE A COMPLEX REAL-WORLD PROBLEM WITH AN UNTRAINED CROWD

APPROACH

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

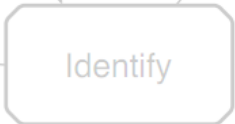
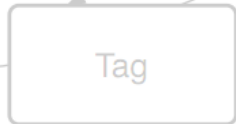
WORKFLOW

OVERVIEW

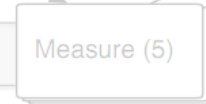


kCal: 869.6
Fat: 41.9g
Protein: 53.1g
Carbs: 69.4g

Stages



HITs



Results

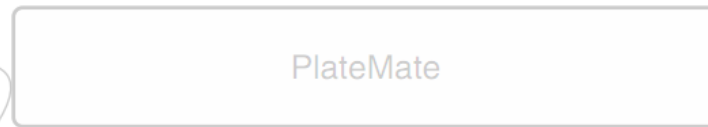


- Baked or Fried Chicken Drumstick
- Barbeque Sauce (Low Sodium, Canned)
- Cooked Spinach (from Fresh)
- Italian Flatbread Focaccia

- 2.53 drumstick
- .40 cup
- .83 cup, fresh
- 1.33 slice

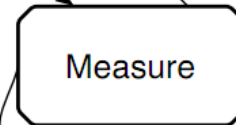
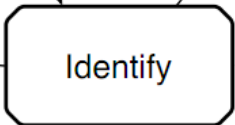
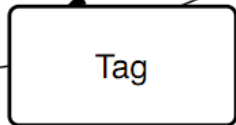


OVERVIEW

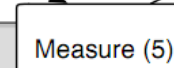
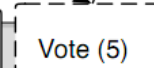
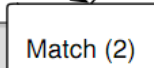
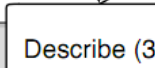
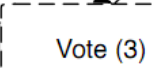
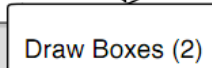


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HITs



Results



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TAG DISTINCT FOODS ON THE PLATE



PlateMate

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

Stages

Tag

Identify

Measure

HITs

Draw Boxes (2)

Vote (3)

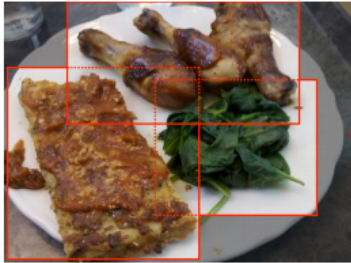
Describe (3)

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

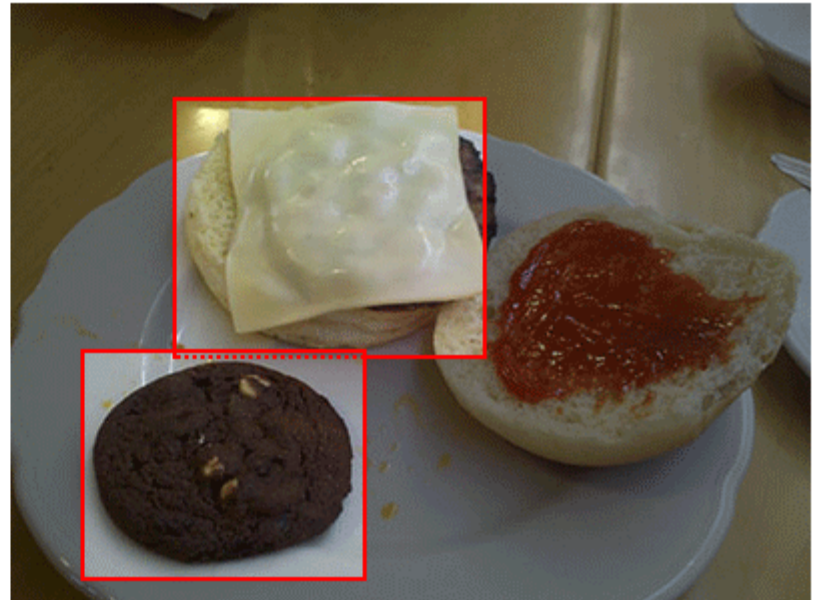
.40 cup

.83 cup, fresh

1.33 slice



TAG DISTINCT FOODS ON THE PLATE



IDENTIFY EACH ITEM



PlateMate

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Stages

Tag

Identify

Measure

HITs

Draw Boxes (2)

Vote (3)

Describe (3)

Match (2)

Vote (5)

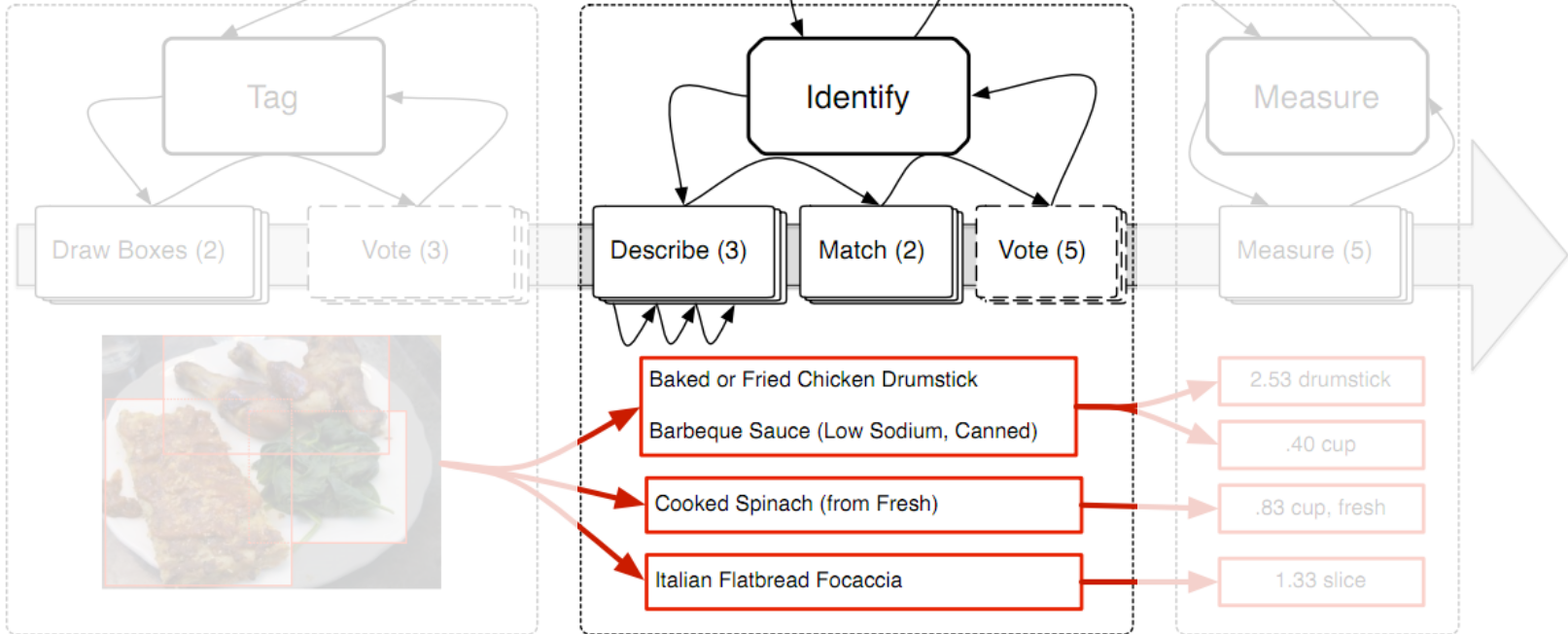
Measure (5)

Results



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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

MATCH DESCRIPTIONS 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: 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.

feta 🔍

- Feta Cheese
- Feta Cheese
- Feta Cheese Dressing
- Cheese-Filled Pastry
- Spanakopitta
- Stella Feta Cheese
- Athenos Feta Cheese
- President Feta Cheese

Click on an item to remove it.

- Arugula Lettuce
- Chicken (Skin Not Eaten)
- Olives
- Feta Cheese

MEASURE PORTIONS IN TERMS OF DATABASE UNITS



PlateMate

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Carbs: 69.4g

Stages

Tag

Identify

Measure

HITs

Draw Boxes (2)

Vote (3)

Describe (3)

Match (2)

Vote (5)

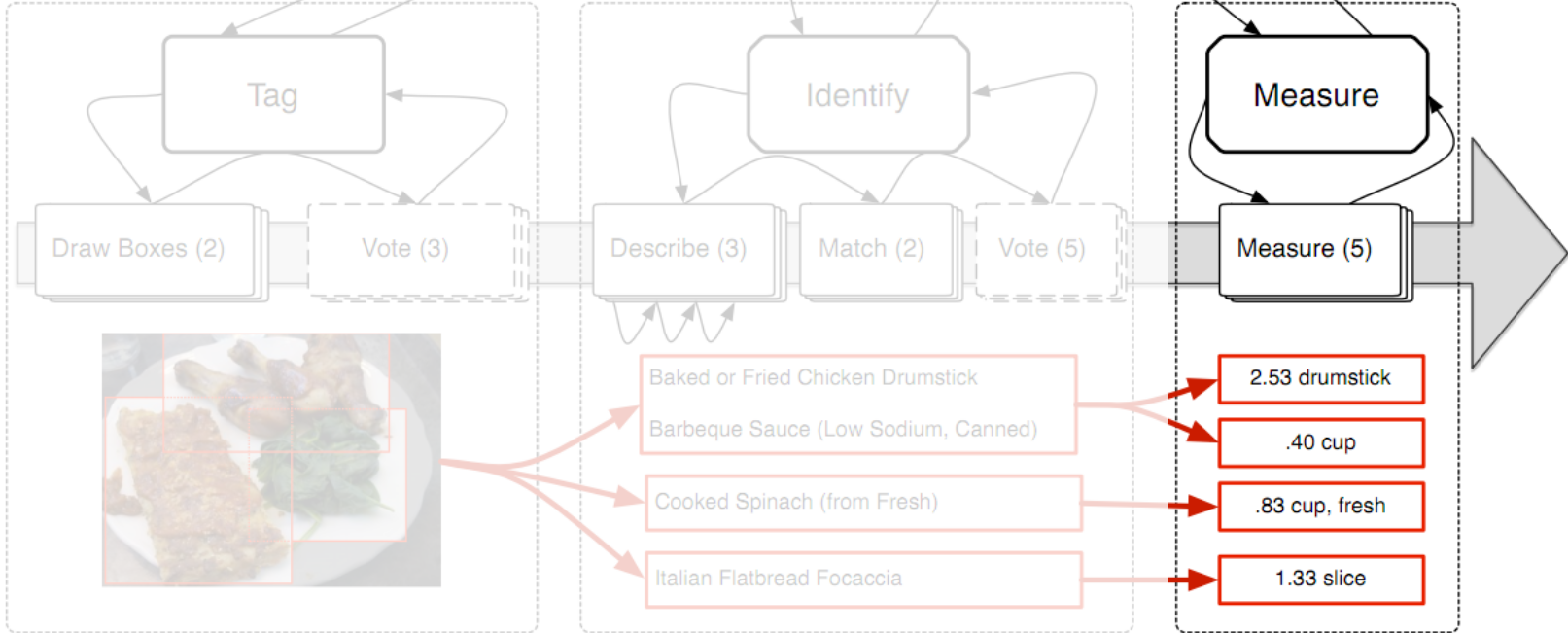
Measure (5)

Results

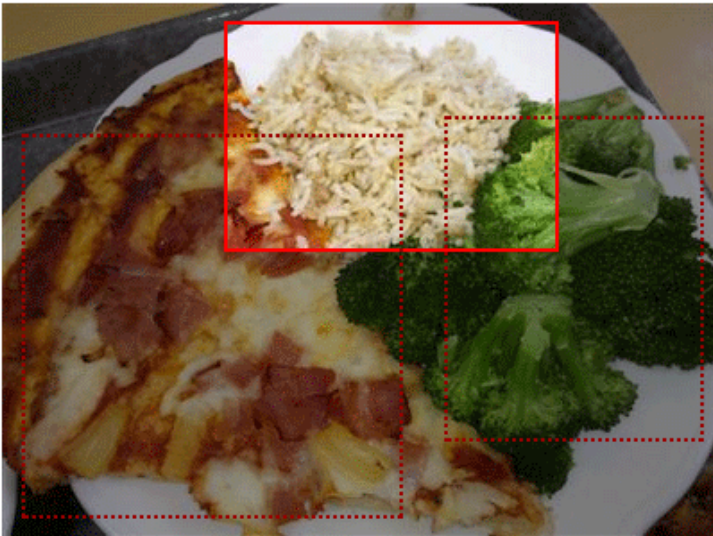


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MEASURE PORTIONS IN TERMS OF DATABASE UNITS



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

.75 x 1 cup cooked = 153 calories.

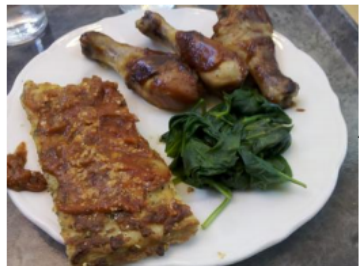
Step 4

Double check your answer

PORTION GUIDE

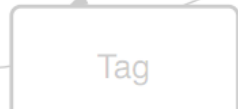
| | |
|----------------------|------------------------------|
| 1 teaspoon (tsp) | single dice, finger tip |
| 1 tablespoon (Tbsp) | thumb tip |
| 2 tablespoons (Tbsp) | ping pong ball or shot glass |
| 1/4 cup | large egg or golf ball |
| 1/2 cup | tennis ball, computer mouse |
| 1 cup | baseball or apple |

EXAMPLE

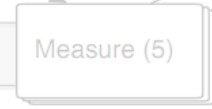
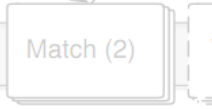
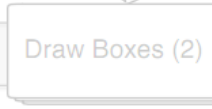


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HITs



Results



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.40 cup

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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

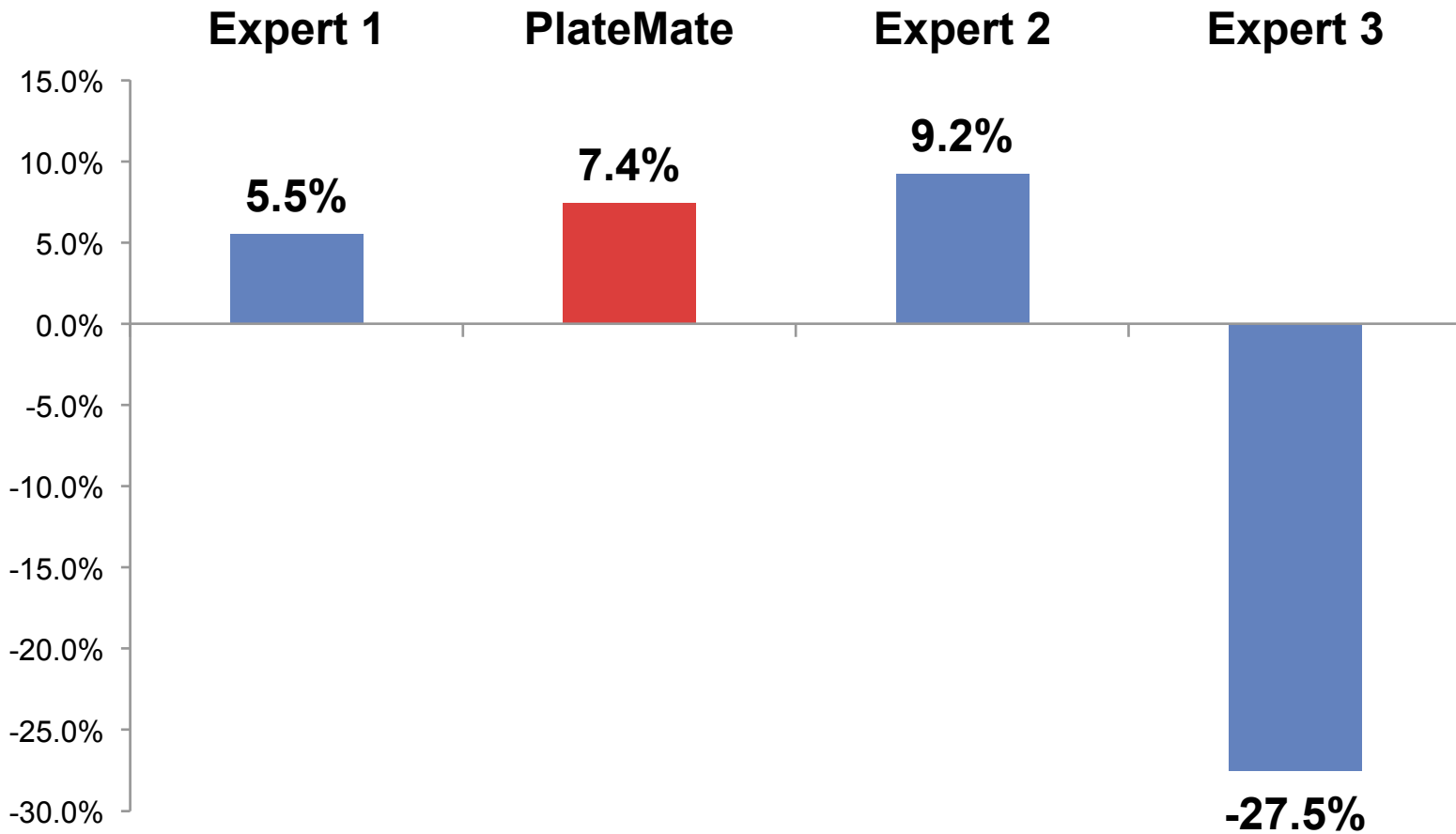
EVALUATION

GROUND TRUTH STUDY

- **36 distinct foods**
 - Plates, bowls, packages
 - Restaurant, cafeteria, grocery
 - Weighed as needed
- **3 trained experts**




GROUND TRUTH STUDY



USER STUDY

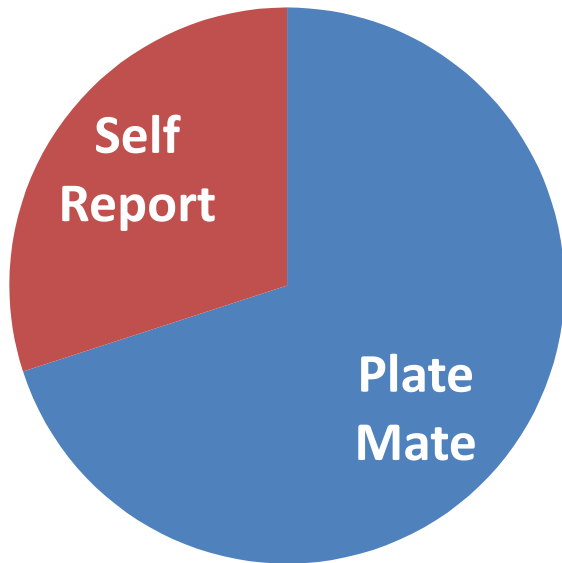
- 10 participants (6 female)
- 2 days receiving PlateMate estimates
- 2 days manually logging with photo
- Before/after interviews on habits, preferences

DINNER

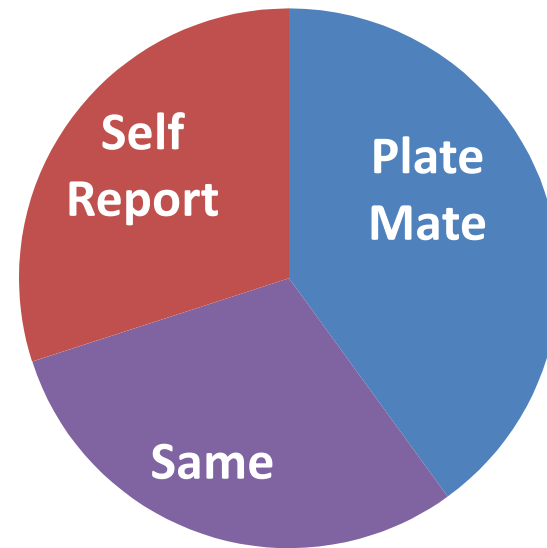
| | | | | | | |
|---|--|------|-----|------|---|------|
| | | | 304 | 19 | 0 | 30.8 |
|  | Chicken Thigh | 2.00 | 304 | 19.0 | 0 | 30.8 |
| | 1 medium (yield after cooking, bone removed) | | | | | |
| | + Add Food <input type="text" value="bru"/> | | | | | |
| | - Delete this pl | | | | | |
| | Brussels Sprouts | | | | | |
| | Brussels Sprouts (Frozen) | | | | | |
| | Acme Brussells Sprouts | | | | | |
| | Veuve Clicquot NV Brut Champagne | | | | | |

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

USER STUDY

“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.’”

EASY AND HARD PHOTOS



(a)



(b)



(c)



(d)



(e)



(f)

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?

noronha

hysen

hqz

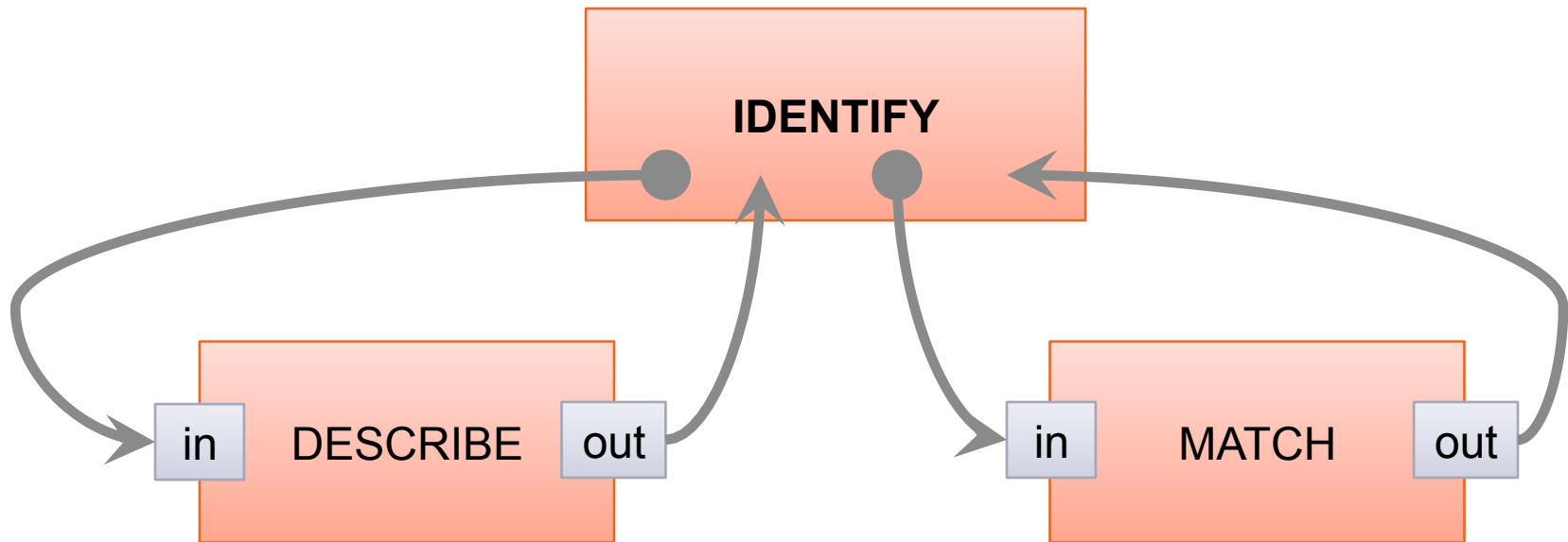
kgajos

@seas.harvard.edu

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"**

- | | |
|----------------------------------|--------------------------|
| <input checked="" type="radio"/> | Arugula Lettuce |
| <input type="radio"/> | Olives |
| <input type="radio"/> | Chicken (Skin Not Eaten) |
| <input type="radio"/> | Feta Cheese |
-
- | | |
|-----------------------|---|
| <input type="radio"/> | Oriental Chicken or Turkey Garden Salad (Chicken and/or Turkey, Lettuce, Fruit, Nuts) |
|-----------------------|---|

MANAGEMENT FRAMEWORK

```
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, bc
```