Innovative tools for dietary assessment

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Image-Based Dietary Assessment

• Convenient & reduces burden
  – study participants
  – researchers
• Richer source of information
  – a repository of images
  – images for future research and analysis
• A tool that will connect with study participants
• Improve accuracy
Architecture of the Technology Assisted Dietary Assessment (TADA) image-based dietary assessment system

Main views of the mobile food record (mFR) user interface
Image acquisition process of the mFR application
Image quality checking in the mFR application
Image captured by adolescent during a 24-hour feeding study

Ground Truth

Automatic

Zhu et al. IEEE Journal of Selected Topics in Signal Processing, 2010
Feature Extraction

Input Image → Image Segmentation → Segments

- Segments
- Color features
- Texture features
- Local Region features

Classifier

Classifier's Confidence Improved?

Yes → Features → Yes

No → Ranked list of food classes

- Wheat Bread, Garlic Bread, ...
- Steak
- Butter, Mayonnaise, ...
- Ice Cream
- Fruit Cocktail, Pear, ...
- Pineapple
- Broccoli, Lettuce, ...
- Spinach
- Lasagna, Pizza, ...
- Mashed Potato
- Jelly, Chocolate, ...
- Jam

From the closest class to the furthest class

He Y et al ICIP 2014
Food identification

- Test images: 1453 images taken by 45 community dwelling participants over 7 days.
- Training images: 20-30 images per food class
- 42 food classes

He Y et al ICIP 2014
## Feature classification results

<table>
<thead>
<tr>
<th>Features</th>
<th>Classification Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Top 1</td>
</tr>
<tr>
<td>DCD+MDSIFT</td>
<td>60.9%</td>
</tr>
<tr>
<td>DCD+MDSIFT+SCD</td>
<td>62.9%</td>
</tr>
<tr>
<td>DCD+MDSIFT+SCD+SIFT</td>
<td>64.5%</td>
</tr>
<tr>
<td>DCD+MDSIFT+SCD+SIFT+EFD</td>
<td>63.5%</td>
</tr>
<tr>
<td>DCD+MDSIFT+SCD+SIFT+EFD+GFD</td>
<td>62.9%</td>
</tr>
<tr>
<td>Contextual Dietary Information</td>
<td>71.4%</td>
</tr>
</tbody>
</table>

He Y et al ICIP 2014
Volume Estimation
Comparison of Known Food Weights with Image-Based Portion-Size Automated Estimation and Adolescents' Self-Reported Portion Size

Figure 2. Weight error from images taken by 15 adolescents (11–18 years) at a breakfast meal. Ratio greater >1 is overestimated and ratio <1 is underestimated (mean and 95% CI). 2D, two dimensional portion estimation aid; MDes, multiple descriptors, e.g., cup, teaspoon. See text for further description.
## Generate or Pre-Define Food Shapes

<table>
<thead>
<tr>
<th>Shape</th>
<th>Example Food Type</th>
<th>Dimension Parameters</th>
<th>Locator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder</td>
<td>Orange juice, Milk</td>
<td>Radius, Height</td>
<td><img src="image" alt="Cylinder" /></td>
</tr>
<tr>
<td>Sphere</td>
<td>Apple, Orange</td>
<td>Radius</td>
<td><img src="image" alt="Sphere" /></td>
</tr>
<tr>
<td>Square Box</td>
<td>Chocaolate Cake, Brownie</td>
<td>Width, Length, Height, Rotation Angle</td>
<td><img src="image" alt="Square Box" /></td>
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<tr>
<td>Slice of Cone/ Slice of Sphere</td>
<td>Spaghetti, Ice Cream</td>
<td>Top Radius, Bottom Radius, Height</td>
<td><img src="image" alt="Slice" /></td>
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<tr>
<td>Prism</td>
<td>Bread, Scrambled Eggs</td>
<td>Area, Height</td>
<td><img src="image" alt="Prism" /></td>
</tr>
<tr>
<td>Irregular Shape</td>
<td>Banana, Pear</td>
<td>Scale X, Scale Y, Scale Z, (Rotation Angle)</td>
<td><img src="image" alt="Irregular Shape" /></td>
</tr>
</tbody>
</table>

Xu C et al ICIP 2013
TADA Fiducial Marker

• TADA color fiducial marker plays an important role for dealing with the challenges involved in food classification and volume estimation from a single image
  – Geometric reference
  – Color reference
  – Image quality reference

• Real time image quality check on the mobile phone
Examples of studies using TADA system

- **TADA Café**
  - Controlled conditions
  - Men & women, 21-65 y
  - 1 to 2 meals
  - n = 57

- **Food in Focus**
  - Community dwelling
  - Men & women, 21-63 y
  - 7 days
  - n = 45

- **Connecting Health and Technology (CHAT)**
  - Community dwelling
  - Men & women, 18-30 y
  - 4 days
  - n = 241

Daughtery BL et al. JMIIR 2012; Kerr DA et al. BMC Public Health 2012
Review Process

- Review
  - Trained Analyst
    - Without participant
    - With participant
  - Automated
    - Participant review
      - Trained Analyst
        - Trained Analyst PRN
      - Without participant
      - With participant
Review Process

- Review
  - Trained Analyst
    - Without participant
    - With participant
  - Automated
    - Participant review
      - Trained Analyst PRN
    - Without participant
    - With participant
<table>
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<tr>
<th></th>
<th>Day 0</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
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<th>Day 6</th>
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<tr>
<td>Thu</td>
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<td>n = 46</td>
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<td>n = 45</td>
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**Community Dwelling**

Men = 15 (33%)
Women = 30 (67%)
Mean age = 32 y (range: 21-63 y)
Conclusions

• Image-based dietary assessment appears to be a promising dietary assessment method
• Improvements in technology are likely easier to pursue than changes to humans
• Images will broaden research questions due to better information about the microenvironment and temporal aspects of eating.