



Innovative Technologies for Improving Dietary Assessment

Rick Weiss

President, Founder & Chief Wellness Engineer, Viocare, Inc.

weiss@viocare.com

Innovative Technologies for
Longitudinal Birth Cohort Study Visit Assessments
Web Seminar

July 19, 2011

Nutritional Assessment Techniques

- Food records
 - Estimated and weighed
- 24 hour diet recalls
- Questionnaires/Surveys – Food Frequency Questionnaires (FFQ)
- Metabolic feeding study

Challenges in Diet Assessment

- All self-report (24h recall, record, FFQ)
- Prone to measurement error (e.g., recall bias, observer bias)
- High respondent burden
- Costly processing (all but FFQ)

Nutritional Assessment Technology

- Paper
- Interviews
- Tape recorders
- Scales
- Observation
- Native computer software for data entry
- Photos
- Web-based
- Mobile
- Combination

Genes, Environment, and Health Initiative (GEI)

- NIH-wide, 4 year program
- Aims to better understand the genetic and environmental contributions to health and disease
- \$40M/y in FY07- FY10
- Components
 - Genetics – NHGRI led
 - Exposure Biology – NIEHS led

Exposure Biology Program Areas

- Chemical Exposures (NIEHS)
- Diet and Physical Activity (NCI/NHLBI)
- Psychosocial Stress and Addictive Substances (NIDA)
- Biological Response Indicators of Environmental Stress (NIEHS)

Goals of the Improved Measures of Diet and Physical Activity Program

- Develop new or refine existing technologies to measure dietary intake or physical activity or both
 - Reliable and valid
 - Low respondent burden
 - Economically feasible for use in large studies of free-living, diverse populations
- Small-scale validation
- Prototype developed by FY10



24 Hour Dietary Recall Technologies

Rationale for ASA24

Amy F. Subar, PhD, MPH, RD
National Cancer Institute

- Traditional 24-hour recalls
 - Less measurement error than FFQ
 - Highest quality, least biased method
 - Validated
 - Recommended by expert groups
- Previously not feasible in large-scale research
 - Expensive: trained interviewers, multiple days
- NCI's response: Develop ASA24
 - Low cost means to obtain high-quality dietary data

What is ASA24?

- Fully automated, web-based, self-administered 24-hour recall, freely available to researchers as Beta
 - Format based on recalls collected in NHANES
 - Uses state-of-the art computer technology
 - Includes optional dietary supplement module
 - Culturally neutral
 - Will be available in Spanish

Actions

Select an action below to edit your foods and drinks.

- Add a meal or snack
- Delete a meal or snack
- Edit a meal or snack

- Delete a food or drink
- Move a food or drink
- Copy a food or drink
- Edit a food or drink

- Done entering all meals and snacks
- Undo
- Finish later



Find a Food or Drink

Browse the categories or search using the box below.



- Beans, peas, nuts, soy products
- Beverages
- Breads, other baked goods
- Cereals and energy bars
- Chicken, turkey, poultry
- Dairy, dairy substitutes
- Desserts and sweets
- Eggs
- Fats, Oils, Dressings, Spreads
- Fish, shellfish
- Fruit
- Meat
- Miscellaneous
- Mixtures, Chinese, Mexican, Chili, Other
- Pancakes, waffles, crepes
- Pasta, noodles, and spaghetti
- Pizza, calzones, hot pockets



No Match Found

My Foods and Drinks

What I ate and drank yesterday, Monday, May 09.

- Breakfast - 8:00 AM
 - Cheerios (Honey Nut)
 - Orange juice
 - Coffee (brewed)
- Lunch - 12:00 PM
 - Tuna sandwich
 - Apple (fresh or raw)
 - Skim milk
 - Chocolate chip cookie (regular)**

Status of respondent site

- Version 1 – end of summer 2011
 - New interface for respondent site
 - Updates to food list terms and related probes
 - Database updates (FNDDS 4.1, MPED 2.0, NHANES 07-08 supplement database)
 - New optional modules: supplements, who ate with, TV/computer use
 - Spanish version

Impact of Using ASA24

- High-quality dietary data
 - Validation work underway and planned: will assess new administration mode
 - Enhanced ability to detect relationships between dietary intakes and health outcomes
 - Significant cost savings to researchers and funding agencies
- 

Food Intake Recording Software System – version 4 (FIRSt4)

**Baylor College of Medicine
Department of Pediatrics
Children's Nutrition Research Center**

PI: Tom Baranowski, PhD

Staff:

Noemi Islam, MPH

Deirdre Douglas, MPH, RD

Alicia Beltran, MS

Janice Baranowski, MPH, RD

FIRSt4: Significance

- FIRSt4 will be web-based self administered 24hr for children
 - Comparable to dietitian conducted 24hr
 - Lower in cost (essentially free?)
 - If minimal burden, may be used for multiple recalls
 - Enhance quality of dietary assessment among children (especially interventions)
 - Available on NCI website

FIRSt4: Formative Studies

- Pre-study – 5 Card sorts: identifying child food categories
- FS1: Do child generated food categories enable children to more accurately and quickly code foods than professional categories? (+ overflow vs. tree structure)
 - Result: Encourage children to search, not browse
- FS2: Does small pictures on screen all at once enable more accurate food size estimation than each picture one at a time? (+ size cues vs. none)
 - Result: Use pictures on screen at once
- FS3: How well can children directly use ASA24? How well can younger children (8-9 yo) perform these tasks compared to older children (10-13 yo)?

FIRSt4: Development Work

- Conducted extensive review of ASA24
 - Reduced 45% of food list terms
 - Reduced 46% of food probes
- Taken 15,000 food images to enhance portion size assessment
 - Foods in 8 progressively larger portions
- Looks like 8-9 yo have substantial error
 - FIRSt4 should be used with 10 yo +

FIRSt4: Tasks Remaining

- Complete ASA24
 - Beta test
- Complete adaptation of ASA24 to FIRSt4
 - Beta test – staff/children
- Validate FIRSt4
 - School observations
 - FIRSt4
 - Dietitian 24hr

Image-based Food Record Technologies



An Electronic Chest Button for Objective and Integrated Assessment of Food Intake and Physical Activity

Mingui Sun, John Fernstrom, Wenyan Jia,
Robert Sclabassi, Zhi-Hong Mao, Madelyn
Fernstrom,
and James Delany

**University of
Pittsburgh**



Wearable device for objective and combined studies of food intake, physical activity, and human behavior:

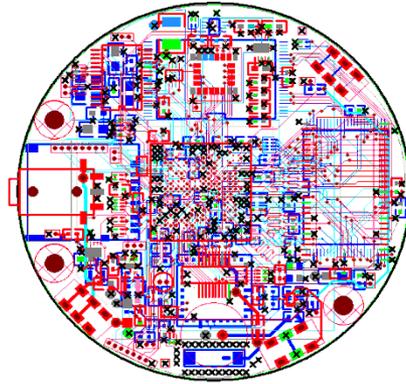


- A video camera, a GPS sensor, an accelerometer, a UV sensor, and a digital compass are included in a compact, button like device (see the figure);
 - Subject does nothing other than wearing the device and recharging it at night;
 - Custom sensors can be connected to the data ports available in the device.
-
- Compressed data are stored in a SD card and then uploaded;
 - Multimedia data processing is used to evaluate food intake, physical activity, and behavior/lifestyle.

The device is unobstructive



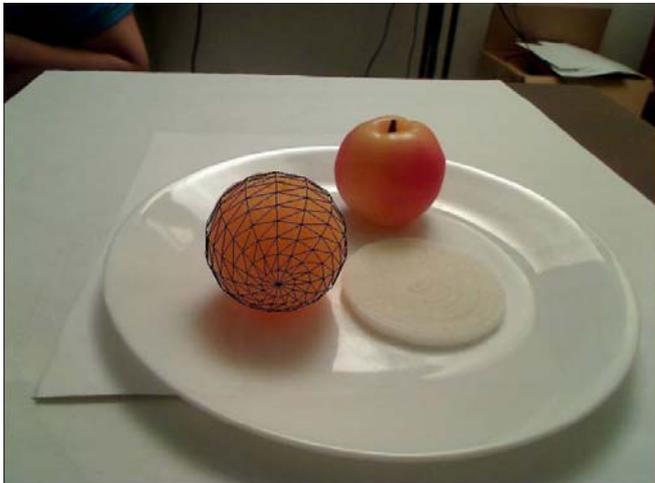
Advanced electronic design



Summary of major activity during a day



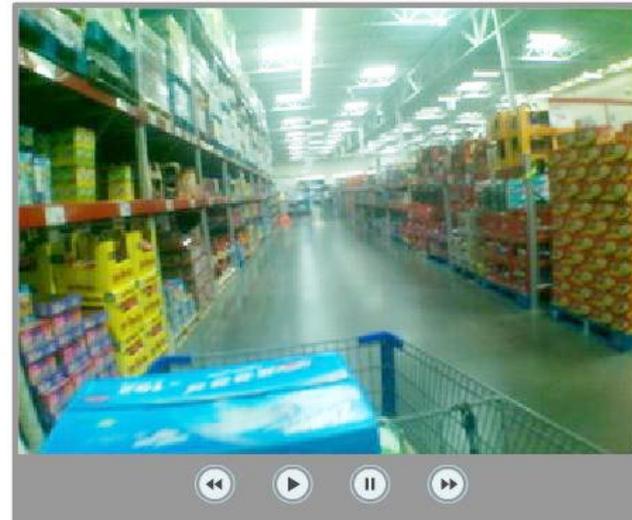
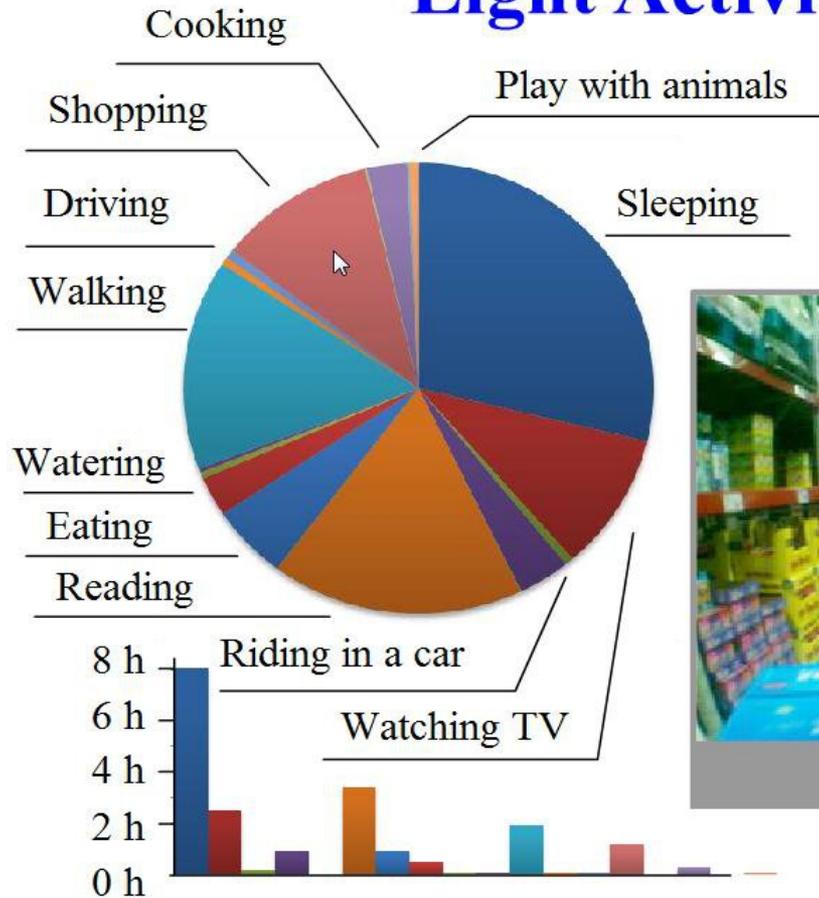
Food portion size measurement using virtual reality



Design Concepts

- A wearable computer that looks like a chest button (eButton) for objective measurements of diet and physical activity;
- eButton contains a central microprocessor surrounded by an array of sensors (a camera, an accelerometer, a GPS, etc.);
- Subject wears eButton for a number of days;
- The device is returned to the lab for data analysis;
- The device features with a very low user respondent burden

Light Activity



Field acquired data are provided to researchers/clinicians in a condensed form in videos and graphics

Integrated Sensor Technology for Real-Time Recording of Food Intake

PI: Alan Kristal, Fred Hutchinson Cancer Research Center

- Develop an extensively modified mobile phone to:
 - Capture 3-dimensional food image
 - Record self-report of food description
- Develop coder interface to:
 - Segment image into individual foods
 - Quantify food volume
 - Transfer data to Nutrient Data System for Research (NDSR, University of Minnesota) for nutrient analysis

TADA Mobile Application

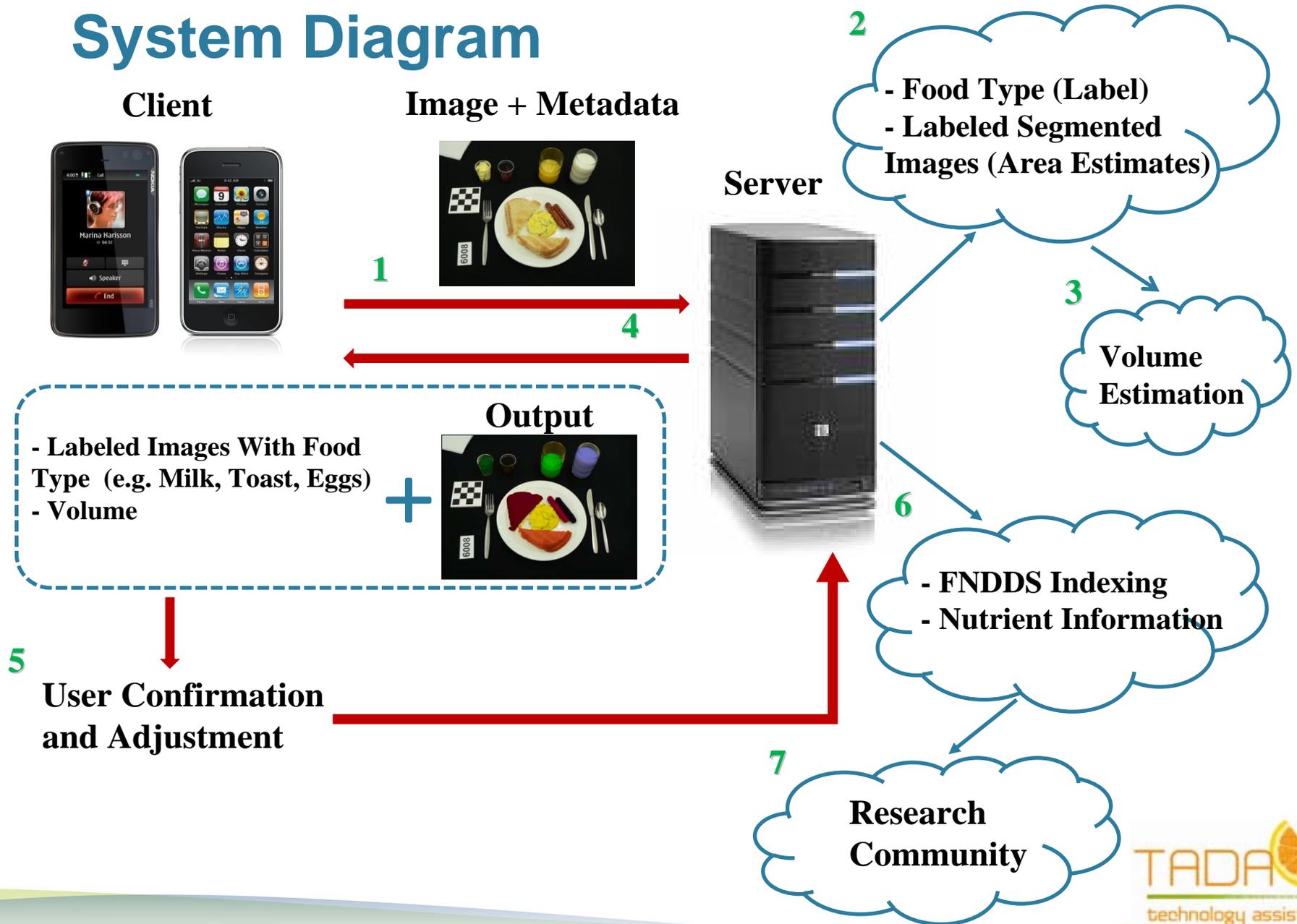
Carol Boushey, Edward Delp, David Ebert, Martin Okos

- Mobile Telephone Food Record (mpFR)
 - Record Eating Events
 - Capture a series of before/after food/beverage images
 - Review Meal
 - Review food items in images, confirm and adjust food identification and food volume
 - Alternate Method
 - Manage eating events when food images are not captured (e.g., driving a vehicle, user forgets to take an image), recall and enter foods eaten using integrated mobile application
 - Complemented by
 - Universal Product Code (UPC)
 - Quick notes to aid alternate method
 - Voice recorded reminders to aid alternate method



PURDUE
UNIVERSITY

System Diagram



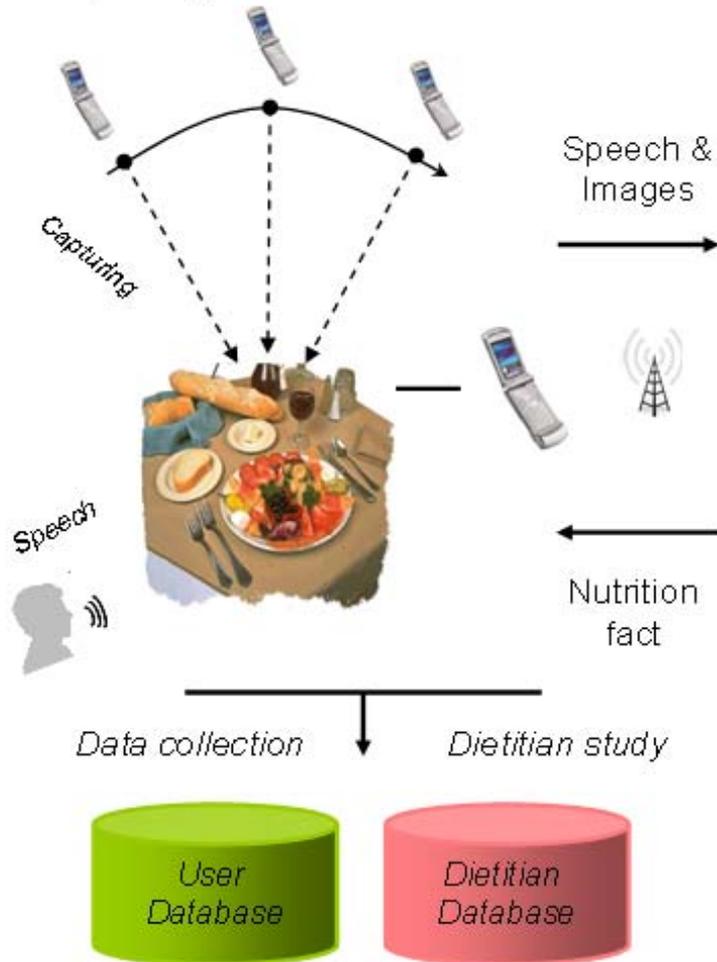
Mobile Food Intake Visualization and Voice Recognizer (FIVR)

PI: Rick Weiss, Viocare, Inc.

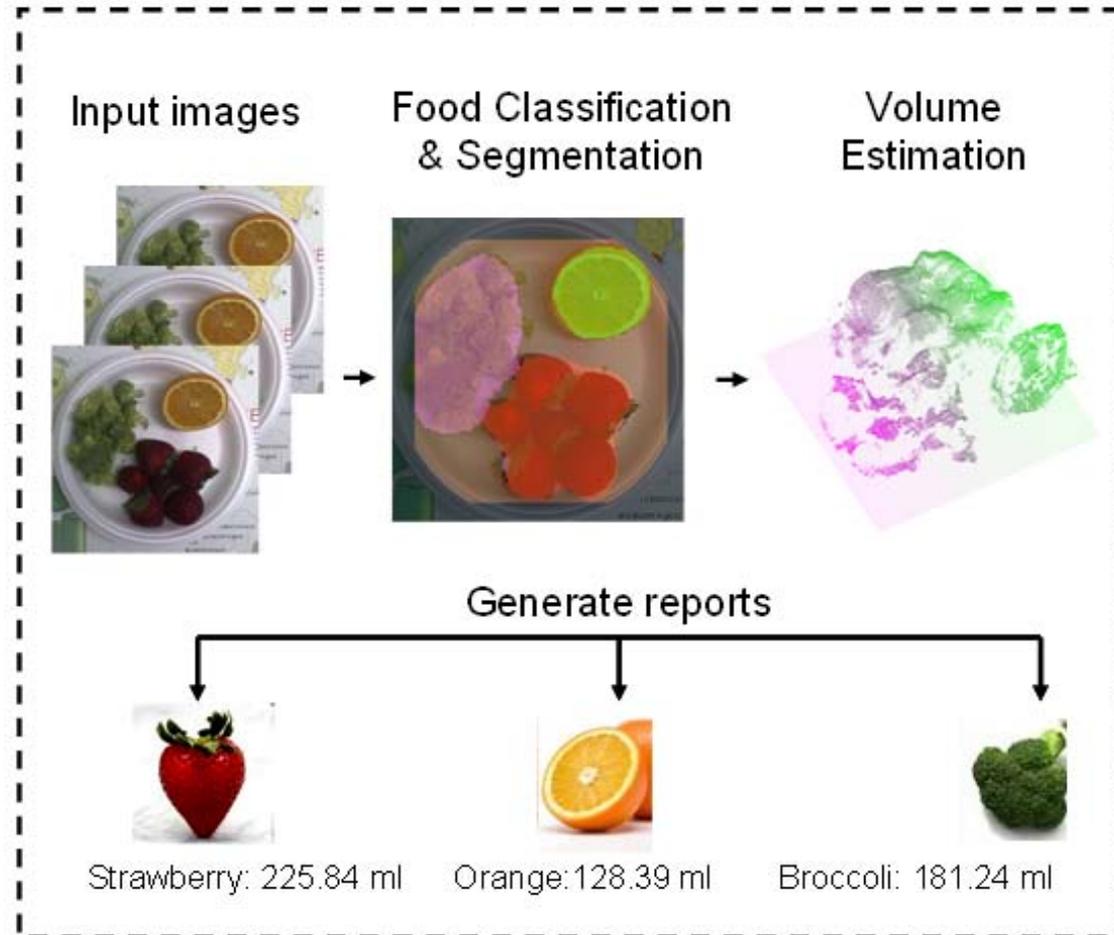
- Mobile phone app to capture intake in real-time
- Use camera and voice recording before and after eating
- Use speech recognition, personalized database, and computer vision techniques to determine the food items and portions eaten
- Provide an exceptional user experience
- Fast, cheap, robust, non-repetitive

FIVR System

Speech Input & Image Capturing from Cell Phone



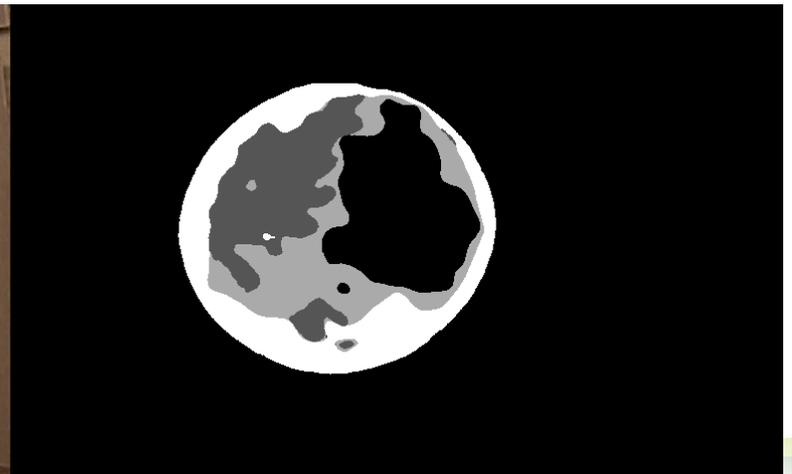
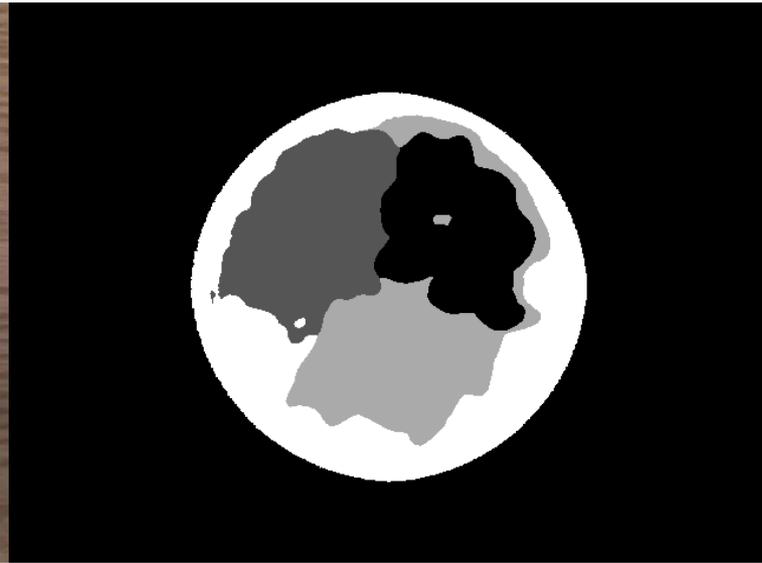
Computer Vision Processing on Servers



Segmentation Description

- Plate finder to localize recognition space
- Utilize texture, color, shape, etc to segment image according to local-area similarities
 - Many foods can assume different shapes but maintain constant color / texture
 - green beans, mashed potatoes, chili, ...
 - But, some foods have little texture yet characteristic color and / or shapes
 - hot dog, bowl of tomato soup
- Aided by speech recognition
- Characterize every pixel in the image

Segmentation Examples

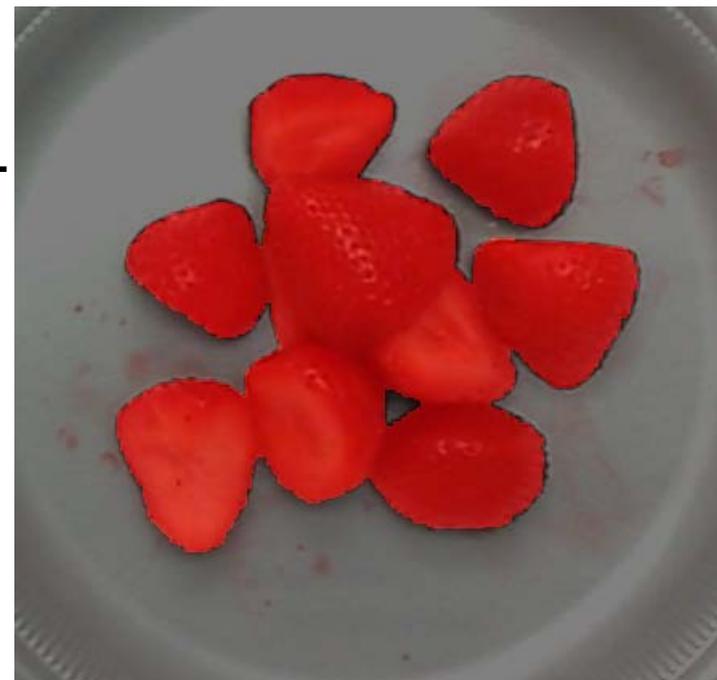


Classification-driven Segmentation

Input Image



Minimize data cost +
smoothness cost



Segmentation output

Classification
Output



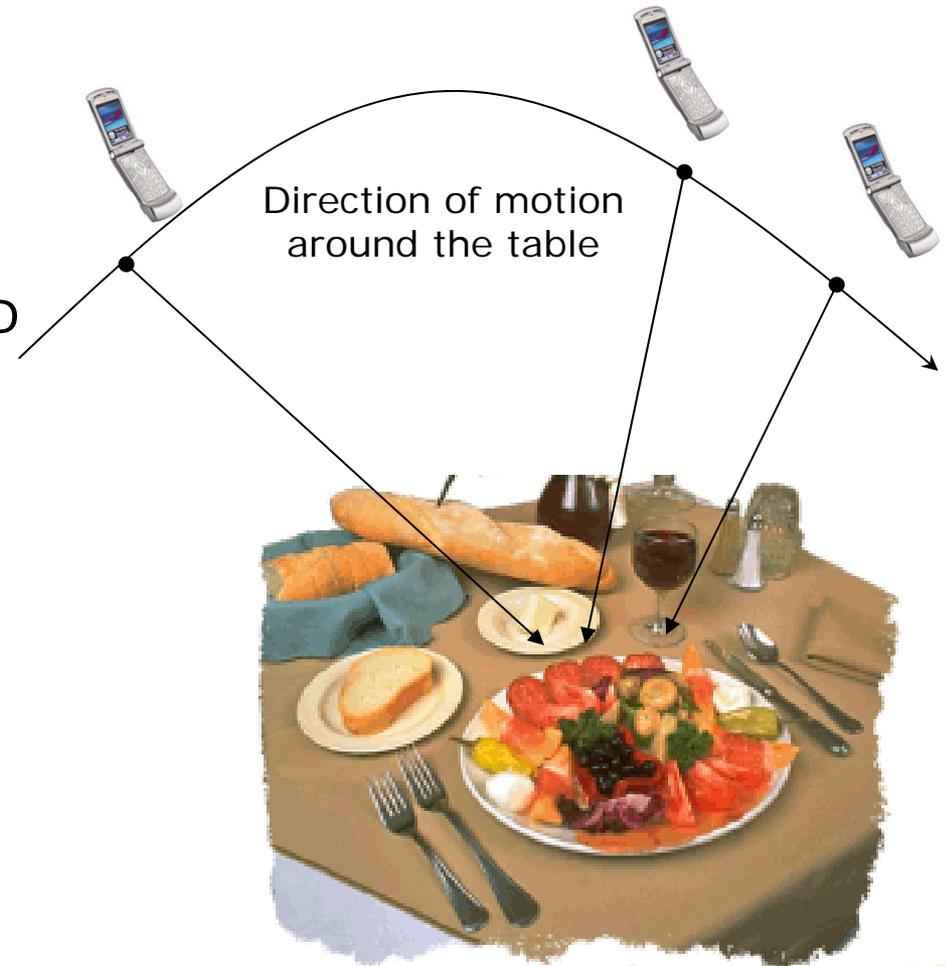
Classification

Automated food item “classification” is a hard problem. FIVR uses two complementary technologies:

- Speech recognition
 - Subject speaks/records meal components to greatly reduce classification problem
- Computer vision and image signal processing
 - Image segmented by local-area similarities in color, texture,
 - Classify by comparing against images in DB
 - However, preparation, lighting, and natural variations from “ground truth” images in DB still complicate the classification

Portion Estimation

- Volume and portion estimation
 - Create 3D model of food items and measure against known fiducial to get volume
 - Before and after images determine amount eaten
- 5 images are used to compute the 3D structure of a meal
- Many things affect accuracy
 - Absence or presence of food texture
 - Image view (tall foods hide short foods)
 - Food placement and layering
 - Angle between images
 - Sharpness (blur)
- ...for all but texture, reasonable restrictions can be made



Pictures Taken



Image 1



Image 3



Image 5

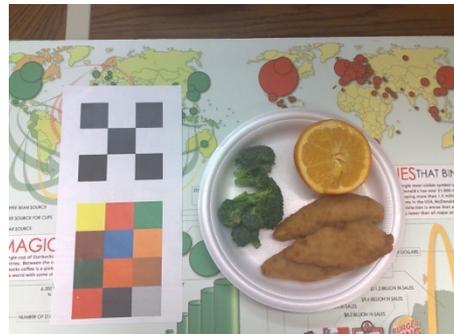


Image 2

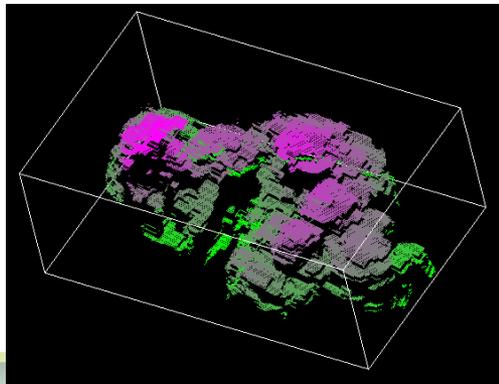


Image 4

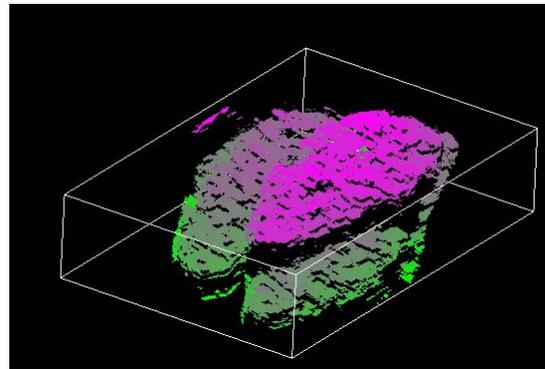
Individual Food Surfaces Extracted



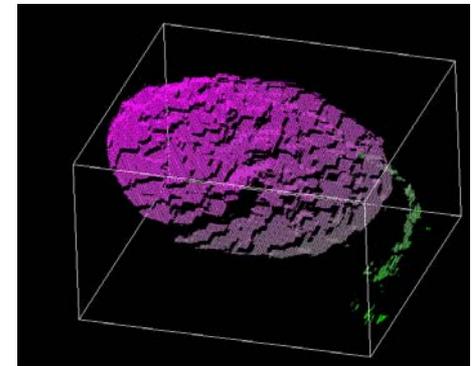
Food Item Masks



Broccoli

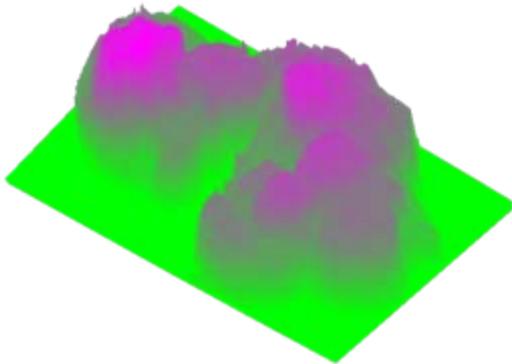


Chicken patties



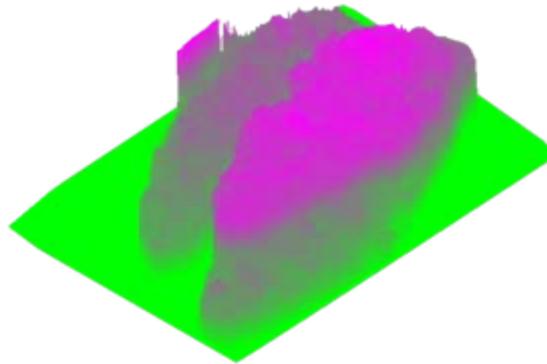
Orange

Food Volumes Estimated



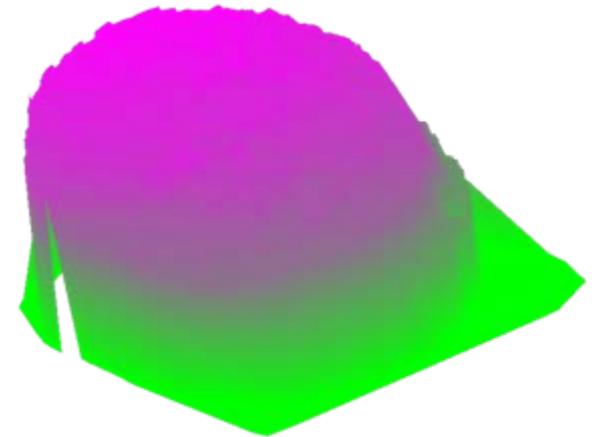
124.3 ml

Broccoli



182.3 ml

Chicken patties



232.6 ml

Orange

Comparative Evaluation

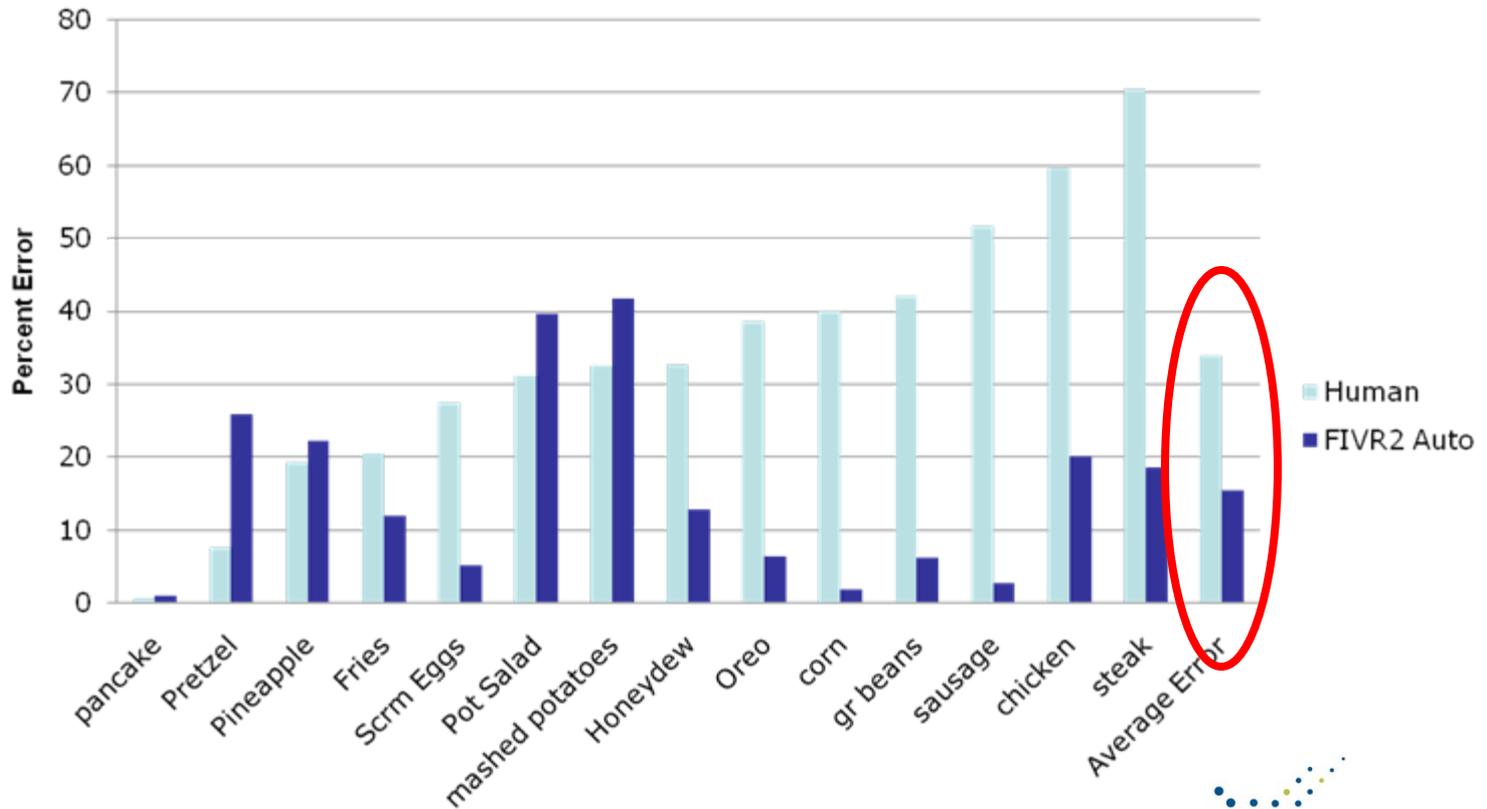
- Dataset
 - 14 foods over 6 categories
 - Captured under different lighting variations
 - 101 sets(each set contains 5 images)
- Comparison
 - FIVR system (manual, auto)
 - Human
- Ground truth measure
 - Water displacement

Testing dataset is independent of the training set.

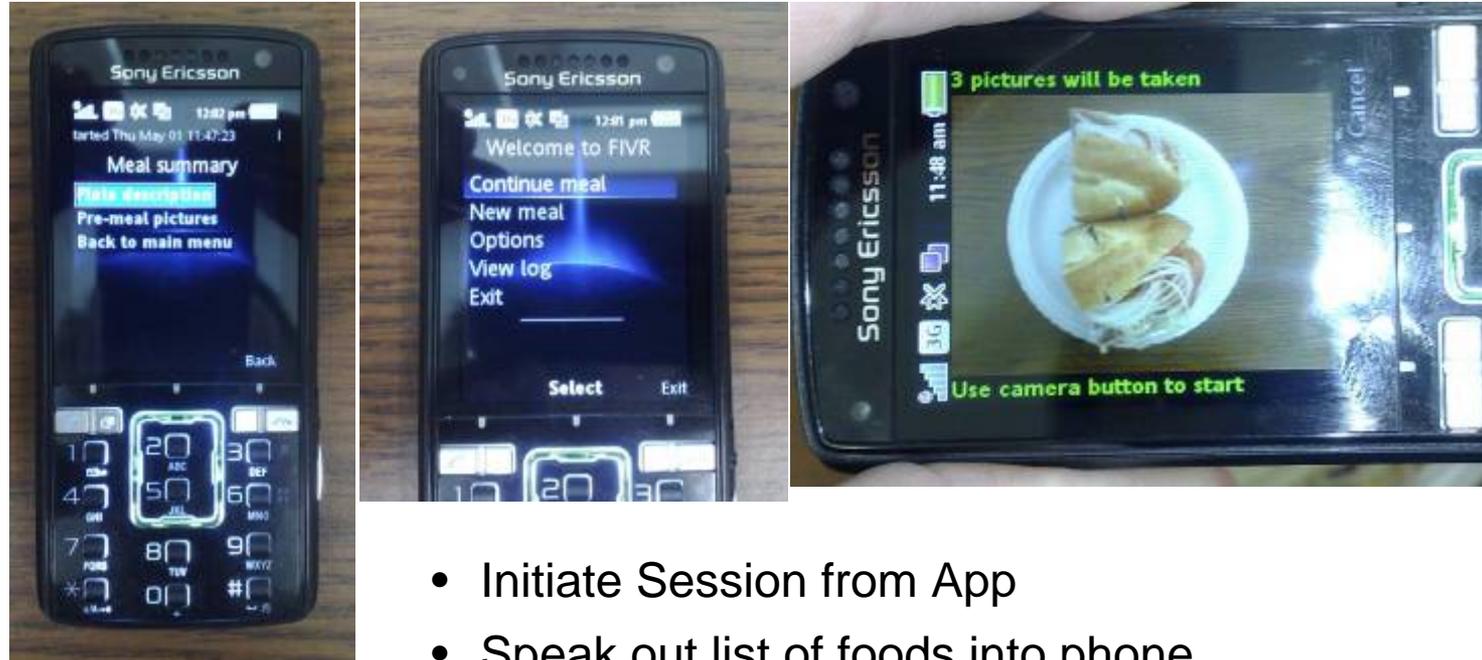
- **Breakfast**
 - *Scramble eggs*
 - *Pancake*
- **Snack**
 - *Oreo cookies*
 - *Pretzels*
- **Meat**
 - *Sausage links*
 - *Steak*
 - *Chicken finger*
- **Lunch / Dinner Carbs**
 - *French fries*
 - *Mashed potatoes*
- **Veggie**
 - *whole kernel corn*
 - *green bean*
 - *potato salad*
- **Fruits**
 - *Honeydew chunks*
 - *Pineapple chunks*
 - *Strawberry (cut)*

Comparison with Humans

Internal Volume Estimation Evaluation
FIVR: Automatic; Average Error = 15.50%



Cell Phone Interface



- Initiate Session from App
- Speak out list of foods into phone
- User approves list echo from speech recognition
- System passes list to visual classification

Migration to Smart Phones

Daily food track

Friday, July 23, 2010

	Ate	Cal	Carb	Prot	Fat	Fat%
+ Breakfast						
+ Morning Snack						
+ Lunch						
+ Afternoon Snack						
+ Dinner						

- Food >
- Meal >
- Identify Foods
- Food Amounts
- CompareEstimation

Close

Daily food track

Friday, July 23, 2010

	Ate	Cal	Carb	Prot	Fat	Fat%
- Breakfast(1)						
Total	302	359.4	12.1	16.8	27.6	68.2
egg omelet, with	302	359.4	12.1	16.8	27.6	68.2
+ Morning Snack						
+ Lunch						
+ Afternoon Snack						
+ Dinner						
+ Evening Snack						
Total	302	359.4	12.1	16.8	27.6	68.2

Diet

Close

Food:

Description:

search full database

search within result

Description

- egg, scrambled/omelet, plain
- egg omelet, with cheese
- egg omelet, with vegetables
- egg omelet, with meat (Western)

Find Add Oops Close

FIVR Food Identification

- Currently, our system is trained to recognize over 200 different food types
- We have tested the system with 322 plates
- The classification and segmentation of foods is performed using both color and texture features

VioWell

Nutritional Based Wellness Technology Platform that empowers health professionals to efficiently and effectively deliver personalized programs



Identify counseling personality type

- Increases engagement in program and effectiveness of counseling

Identify risk (focused on dietary habits)

- Ensures adequate level of interaction

Highlight counseling concerns

- Immediate personalization & targeted counseling

Defined Work Flow

- Participant self-directed during assessment phase, minimizes participant's frustration
- Maximizes health coach time

Established Protocol

- Telephonic or face-to-face multi-visit with coach
- Consistent program quality delivery

Generation & Publishing of Action Plan

- Easy plan generation w/ immediate online access

Online Assessments

- Validated suite of assessments – health screener, barrier, physical activity, dietary

Proprietary & Customizable

- Proprietary analytics engine, NDSR database, configurable for any dietary guidelines

Tracking Tools and Calculators

- Physical activity, food, weight tracker

Food Tracking Tool

Food Tracking

◀ 12/28/2008 ▶ 

Total Calories: 576

KCal	Fat (g)	Carb (g)	Prot (g)	Fiber (g)
576	28	57	26	4

Breakfast	Amount	Measure	576	28	57	26	4
egg, scrambled/omelet, pl...	3	1 large egg	281	20	4	19	0 
bread, whole-wheat, toast	2	1 regular slice	138	2	26	5	4 
butter	1	1 pat (1" sq, 1...	36	4	0	0	0 
coffee, brewed	1	1 mug (8 fl oz)	9	2	0	0	0 
Orange juice	1	1 cup	112	0	27	2	0 

 Add Item

Lunch	Amount	Measure	0	0	0	0	0
--------------	--------	---------	---	---	---	---	---

 Add Item

Dinner	Amount	Measure	0	0	0	0	0
---------------	--------	---------	---	---	---	---	---

 Add Item

Snack	Amount	Measure	0	0	0	0	0
--------------	--------	---------	---	---	---	---	---

 Add Item

Web-based Food Frequency Questionnaire Technology

VioScreen: Food Frequency Questionnaire

PI: Rick Weiss, Viocare, Inc.

- Developed through a National Cancer Institute grant (R44 CA097560)
- Based on the Fred Hutchinson Food Frequency Questionnaire (WHI, Select)
- Features a graphical, web-based, food frequency questionnaire (FFQ)-based method for data collection
- Prohibits mismarked or incomplete questionnaires
- Self-administered by participant, takes 20 – 30 minutes to complete
- Analysis using University of Minnesota NDSR food database

VioScreen Innovations

- Only system using food & beverage images for increased accuracy
 - Uses pictures of each food item to improve comprehension for persons with low literacy
 - Uses pictures to improve and standardize reporting portion sizes
- Uses complex branching algorithms to collect details about selection and preparation of foods requiring additional specification to apply correct nutrient values
- Reduces response burden by collecting information only about those foods that are regularly consumed

VioScreen Diet Assessment

Mixed Dishes and Pasta

Section 4 of 20

Food selection... Back Next

i Select those foods you eat at least once a month.
Press the "Next" button if you did not eat any of these foods.

 <p>Packaged mixed dishes with soy or tofu</p>	 <p>Stew, pot pies, curries and casseroles with meat and chicken</p>	 <p>Chili with meat and beans</p>
 <p>Spaghetti, lasagna or other pasta with tomato and meat sauces</p>	 <p>Spaghetti, lasagna or other pasta with tomato sauce (no meat)</p>	 <p>Spaghetti and other pasta with oil, cheese or cream sauce, including macaroni and cheese</p>
 <p>Pizza</p>		

Back Next

Done Internet | Protected Mode: On 100%

VioScreen Diet Assessment

Mixed Dishes and Pasta

Section 4 of 20

How often did you eat ... Back Next

Spaghetti, lasagna or other pasta with tomato sauce *made without meat*?

1 per month **2-3** per month **1** per week **2** per week **3-4** per week **5-6** per week **1** per day **2+** per day

Usual portion size?

1/2 cup (small bowl)

1 cup (medium bowl)

1 1/2 cups (large bowl)

2 cups

2 1/2 cups

3 cups

Back Next

Done Internet | Protected Mode: On 100%

VioScreen Output

- Generates reports on nutrient intake and food use patterns suitable for a variety of clinical counseling and research applications
- Benchmarks dietary behaviors vs. recommended guidelines
- Analyzes by food types, e.g. sweets, for simplified planning
- Suggests foods to overcome identified dietary deficiencies
- Creates personalized dietary profile

VioScreen Nutrient Profile

Nutrients and Fiber

This chart estimates the percent of your energy coming from each component compared to the Dietary Reference Intakes (DRIs) recommended percent for adults from the Institute of Medicine (IOM) of the US National Academy of Sciences. Other recommendations are based on USDA guidelines or recent nutritional research.

Nutrients and Fiber	Your Avg Daily Intake	Your % of Calories	Recommended Intake	Your % Compared to Recommended % of Calories			
				25	50	75	100
Average Energy (kcal)*	2798 kcal						
Energy Components			% of Calories				
Total Fat	134 g	43 %	20 - 35%				
Protein	120 g	17 %	10 - 35%				
Carbohydrate	231 g	33 %	45 - 65%				
Alcohol	30 g	7 %	0%				
Fat Intake			% of Calories				
Saturated Fat	50.8 g	17 %	< 10%				
Trans Fat	6.6 g	2 %	0%				
Unsaturated Fat Intake							
Monosaturated Fat	50.6 g	17 %	10 - 25% of Calories				
Polyunsaturated Fat	21.3 g	7 %	<= 10% of Calories				
Omega-3 (DHA & EPA)	0.11 g		0.65 g				
Omega-6 (LA & ARA)	19.3 g		5 - 10% of Calories				

Protocol Management

VioCenter
Administration Tool

Welcome, you are logged in as, **admin**. ([Logoff here...](#))

Folder View Protocol

Summary
Edit
Sessions
Import
Export
Back to Protocol List

Protocol Edit - Default Protocol for Your Research Organization

General Reports Welcome HTML Review HTML Finish HTML

Title: *

Abbreviated Title:

Description:

Reference Text:

Example: During the year before [refdate], did you eat...

Questionnaire: *

Default Database: *

Display Units: Standard Metric

Style Sheet:

Start Page:

Code: *

Number:

Approved Date: (mm/dd/yyyy)

Start Date: (mm/dd/yyyy)

End Date: (mm/dd/yyyy)

Visits: *

Visit Span: * (days between visits)

Active:

There are 7 sessions in this protocol.

Note: Fields marked with a * are required

OK Cancel Apply

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Session Export

VioCenter Administration Tool

Welcome, you are logged in as, **admin**. ([Logoff here...](#))

Folder View | **Protocol**

- Summary
- Edit
- Sessions
- Import
- Export
- Back to Protocol List

Protocol Export - Default Protocol for Your Research Organization

[Search / Filter](#)

Visit Number:

Finished Date Range: (mm/dd/yyyy) through (mm/dd/yyyy)

Note: Hit the 'Search' button after you change search / filter criteria.

[Export Data](#)

Database:

Key Field:

Action:

<input type="checkbox"/>	Description	SubjectId	Time	Created ^Δ	Started	Finished	
<input type="checkbox"/>	New patient registration session.		125	3/11/2009	3/11/2009	3/11/2009	Report
<input type="checkbox"/>	New patient registration session.		23	2/26/2009	2/26/2009	2/26/2009	Report

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VioScreen Validation

- VioScreen Phase I Usability & Validation Study – Ohio State University
 - Demographics: 34 Females, 40 Males; African-American, White, Asian
 - Age 18-29 – n=30 ; age 30-49 – n=25; age 50-69 – n=19
 - Highly accurate, high correlation coefficients between macronutrient intake of two VioScreen sessions and six 24-hour recalls:
 - 0.82 Total Fat
 - 0.84 Saturated Fat
 - 0.79 Carbohydrate
 - 0.67 Protein
 - 0.90 Alcohol
 - 93% rated VioScreen as either great or excellent
 - 100% thought the VioScreen was easy to use
 - 99% agreed they would complete this questionnaire if asked by a doctor
 - 95% agreed that the food pictures helped in selecting portion sizes
- VioScreen Phase II Efficacy Study – Ohio State University
 - In process, quantify dietary change of enhanced interactive feedback system



Rick Weiss

President, Founder &

Chief Wellness Engineer

weiss@viocare.com

609.497.4600 x10

WELLNESS THROUGH SCIENCE