

# eButton: A Wearable Computer for Evaluation of Diet, Physical Activity and Lifestyle

Wenyan Jia, Ph. D.

Department of Neurosurgery  
University of Pittsburgh



August 28, 2015



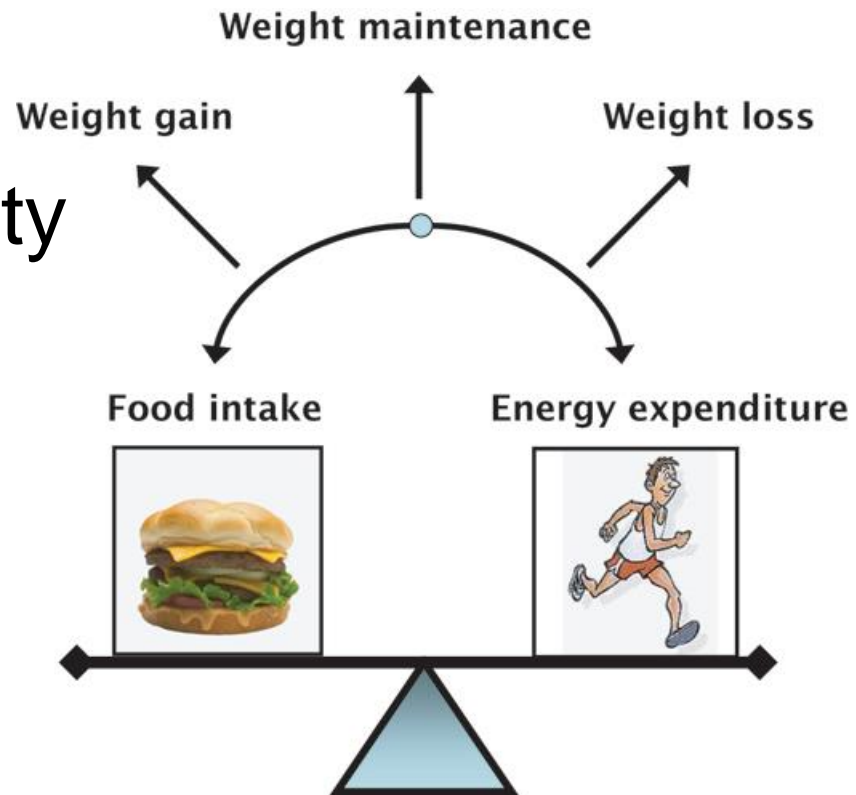
# Overweight and Obesity

- ~65% of American adults are overweight (body mass index (BMI)  $\geq 25$  kg/m<sup>2</sup>)
- ~ 20% of the US population are obese (BMI  $\geq 30$  kg/m<sup>2</sup>)
- Obesity has become an increasing public health problem for almost all developed countries and many developing countries



# What causes obesity

- Energy imbalance over a long time
- Energy in  $>$  Energy out
- Too much calories
- Too less physical activity



Despite the rapid advances in technology, diet and physical activity evaluation still relies on self-reporting instruments (e.g., 24-hour recalls and FFQ)



# Problems of Self-Reporting

- Limited memory of recalling consumed foods
- Inaccurate portion size recall and estimate bias
- Unwillingness in reporting
- High respondent burden

**We need an objective device  
for the assessment that does not  
fully depend on subjects' words**







Record meals to be eaten using cell phones





Lenore Arab et al., Eur J Clin Nutr,  
2011, 65(10):1156-1162



L Gemming, et al., Eur J Clin Nutr,  
2013, 67, 1095-1099

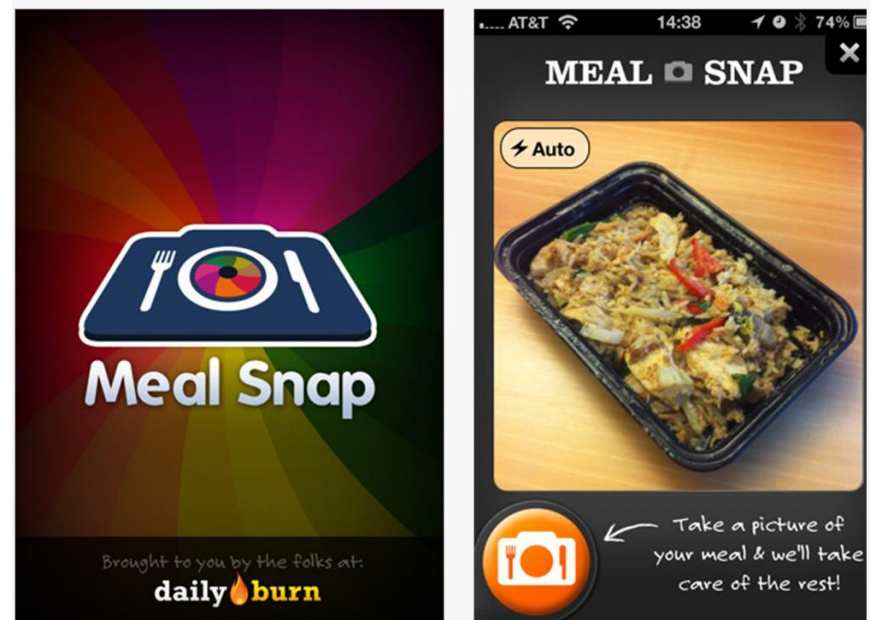
# Dietary assessment based on digital pictures

- Taking pictures before meal (and after meal if there is a left-over)
- Providing an electronic memory
- Low cost (when subject has a cell phone)
- Allowing portion size estimate
- Nutrient and calorie analysis is difficult

# iPhone app “MealSnap” by Daily Burn

“Use **Mechanical Turk** to identify the foods at anywhere from \$0.02-\$0.05 per picture and then use the data returned from Mechanical Turk to search for calorie information in a database of food”

<http://www.quora.com/How-does-Daily-Burns-Meal-Snap-application-work>



# Physical activity assessment based on accelerometer



# Problems

- Accelerometer based devices cannot monitor diet
- They are very limited in behavioral monitoring

**Our Approach: Wearable Device**

# We built a wearable computer **eButton** to document lifestyle and events





# Sensors within eButton

- **Video camera(s)** - to look around (e.g., food)
- **GPS** - to find the wearer's location
- **3-axis accelerometer** - to study motion
- **Daylight/UV sensor** – to detect indoor or outdoor
- **3-axis gyroscope** - to measure body orientation
- **Barometer** – to determine body position/floor level

# eButton vs. smartphone

- can look around by itself
- is much smaller and lighter
- can be worn naturally on the chest
- lasts longer between recharging
- supports flexible designs for specific healthcare applications

# What can Button evaluate?

**Objective** assessments of:

- Food intake (**in kcal**)
- Physical activity (**in kcal**)
- Living and built environments (**descriptive**)
- Diet and PA related behavior (**descriptive**)
- Lifestyle (**descriptive**)

# Typical Videos



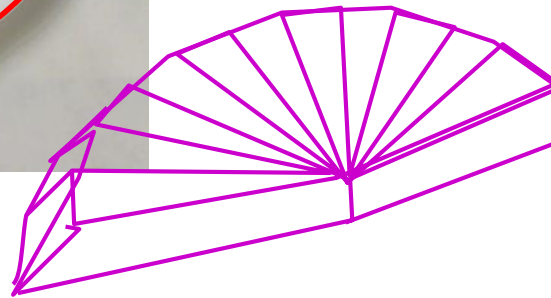
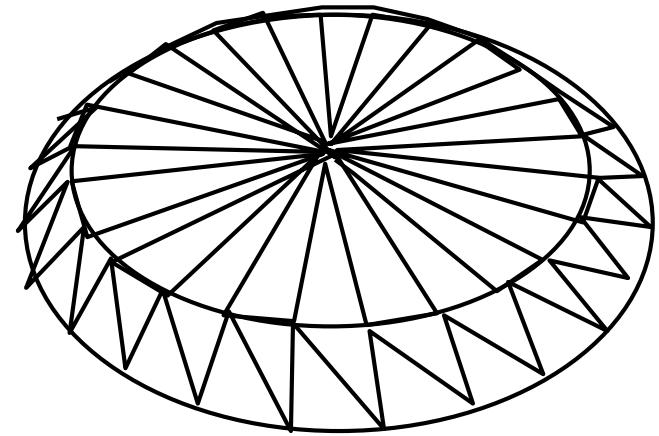
# **eButton Application 1:** **Diet Assessment**

How does eButton evaluate diet?

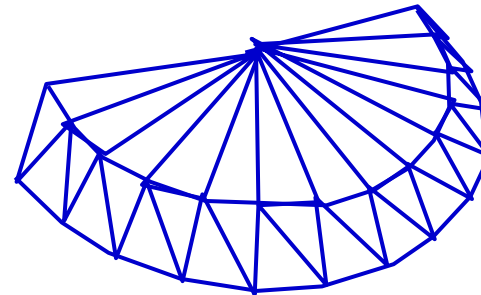








Volume  
of rice

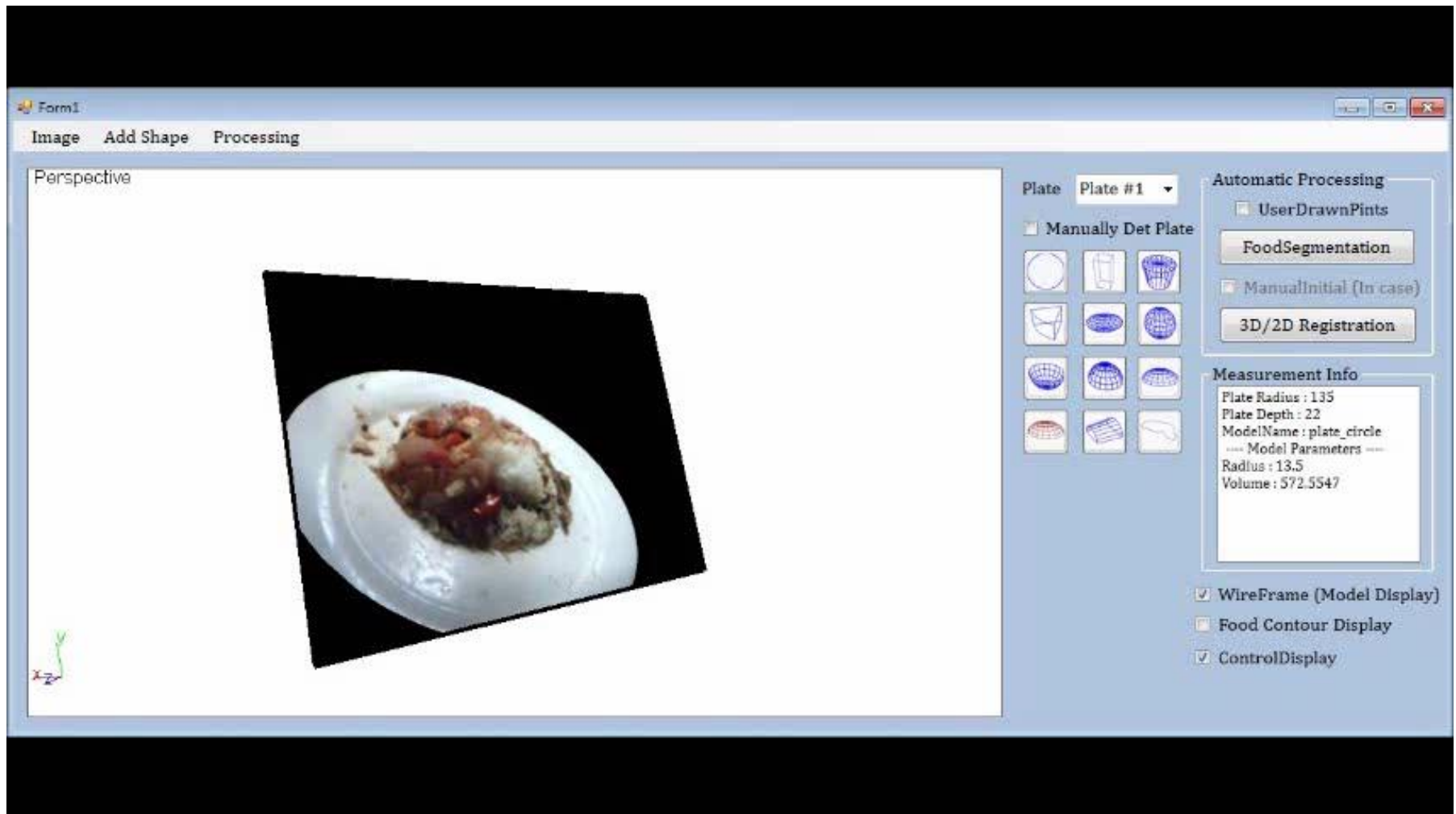


Volume of  
egg with  
pepper



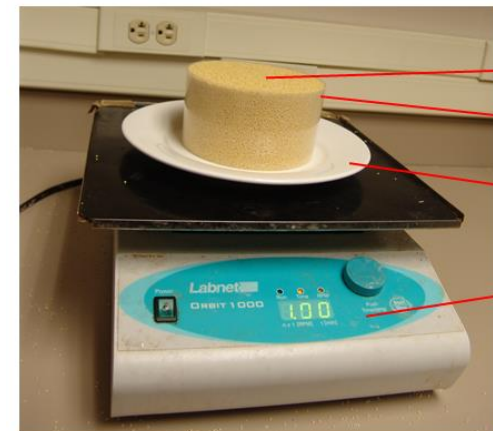
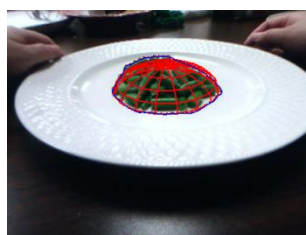
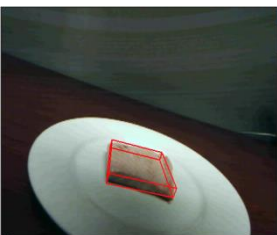
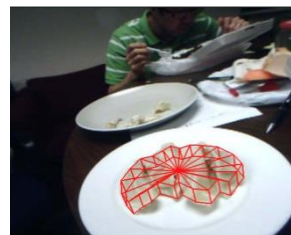
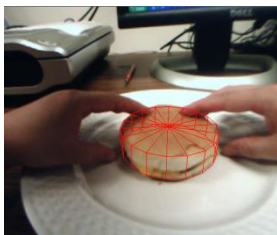
Calories / Nutrients

# Food volume estimation based on virtual reality (VR)



# A study on food volume estimation

- Participants wore an eButton during their lunch
- Images of 100 food samples (fifty Western and fifty Asian foods) were collected
- The volume of food in each eButton picture was calculated using our software
- The actual volume was determined by physical measurement using seed displacement



Millet

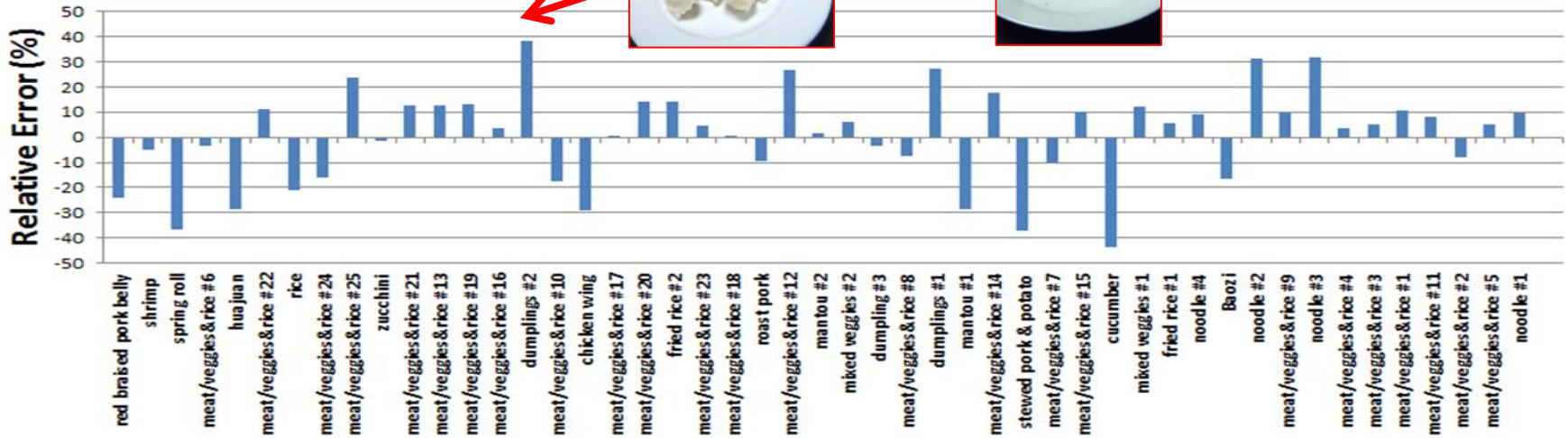
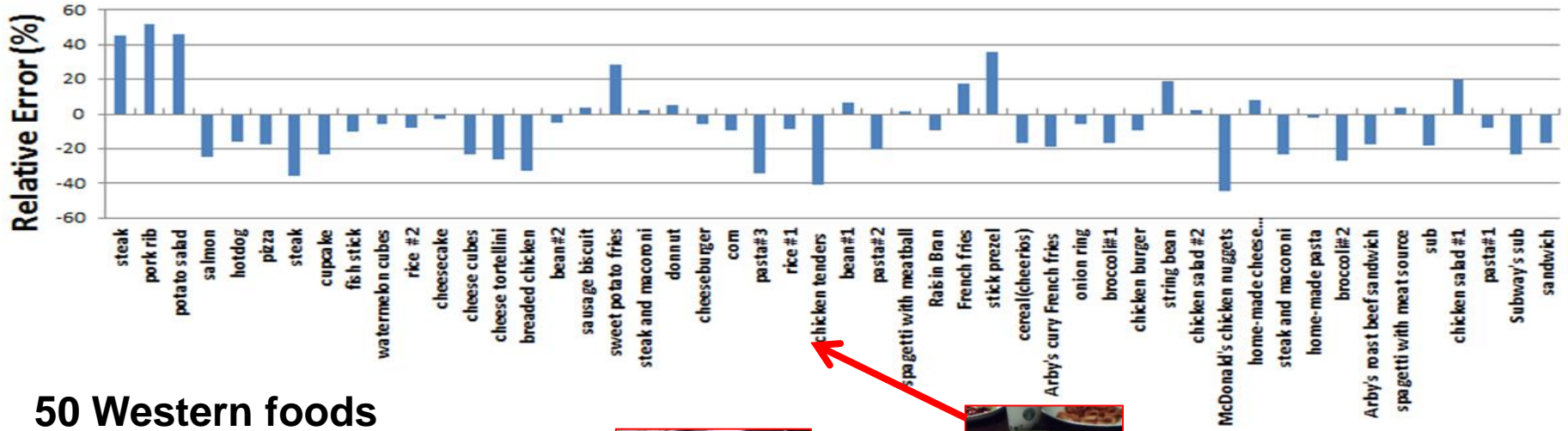
Fence

Plate

Shaker



# Measurement results - lunch



## 50 Asian foods

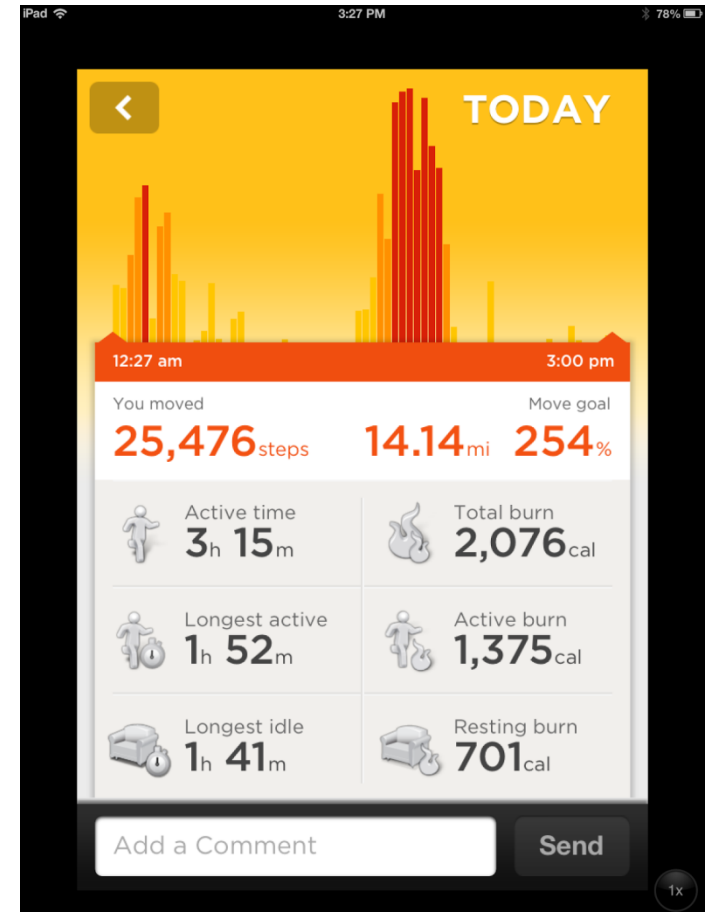
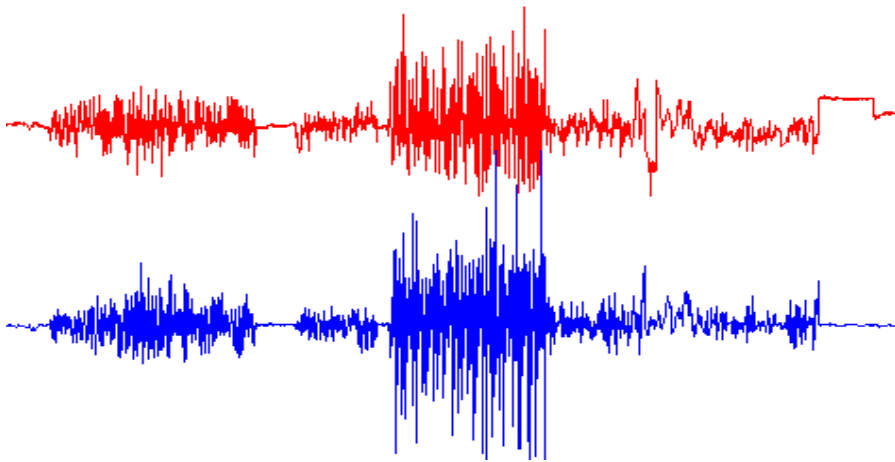
# **eButton Application 2:**

## **Physical Activity Assessment**

# Methods to measure calorie expenditure

- **Method 1: based on accelerometer**

Calculate from the magnitude of the accelerometer output

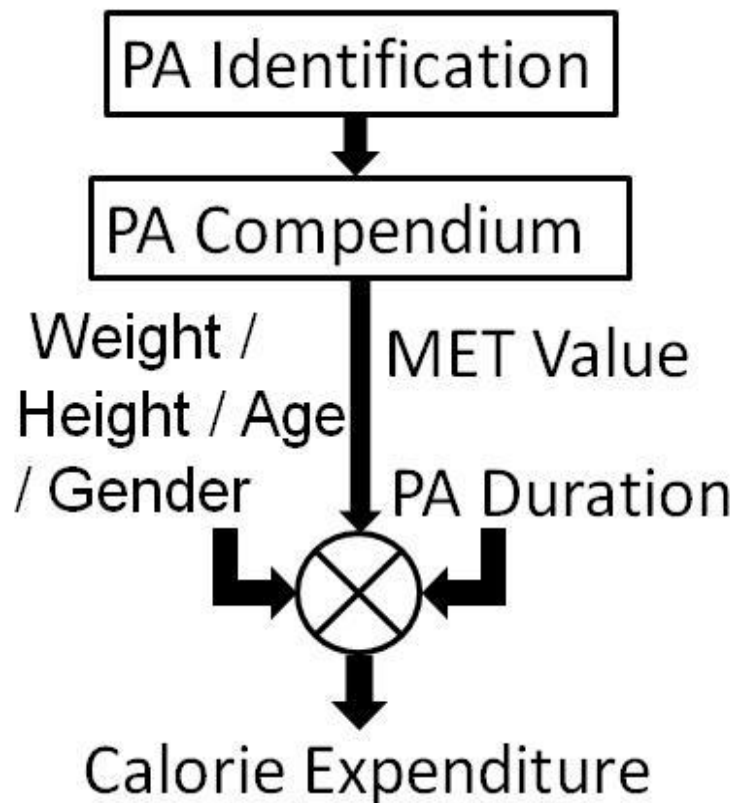


<http://www.eightsandweights.com/2013/11/jawbone-up-vs-fitbit-flex.html>



## Method 2: based on images

Manually recognize physical activity(PA) event from images, and then use a table look up (PA Compendium) to get MET value



Physical activity	MET
<b>Light intensity activities</b>	<b>&lt; 3</b>
sleeping	0.9
watching television	1.0
writing, desk work, typing	1.8
walking, 1.7 mph (2.7 km/h), level ground, strolling, very slow	2.3
walking, 2.5 mph (4 km/h)	2.9
<b>Moderate intensity activities</b>	<b>3 to 6</b>
bicycling, stationary, 50 watts, very light effort	3.0
walking 3.0 mph (4.8 km/h)	3.3
calisthenics, home exercise, light or moderate effort, general	3.5
walking 3.4 mph (5.5 km/h)	3.6
bicycling, <10 mph (16 km/h), leisure, to work or for pleasure	4.0
bicycling, stationary, 100 watts, light effort	5.5
<b>Vigorous intensity activities</b>	<b>&gt; 6</b>
jogging, general	7.0
calisthenics (e.g. pushups, situps, pullups, jumping jacks), heavy, vigorous effort	8.0
running jogging, in place	8.0
rope jumping	10.0

MET: [Metabolic Equivalent](#)

<https://sites.google.com/site/compendiumofphysicalactivities/>

# **eButton Application 3:** **Lifestyle Assessment**

# Automatic event segmentation

Input Image Sequence



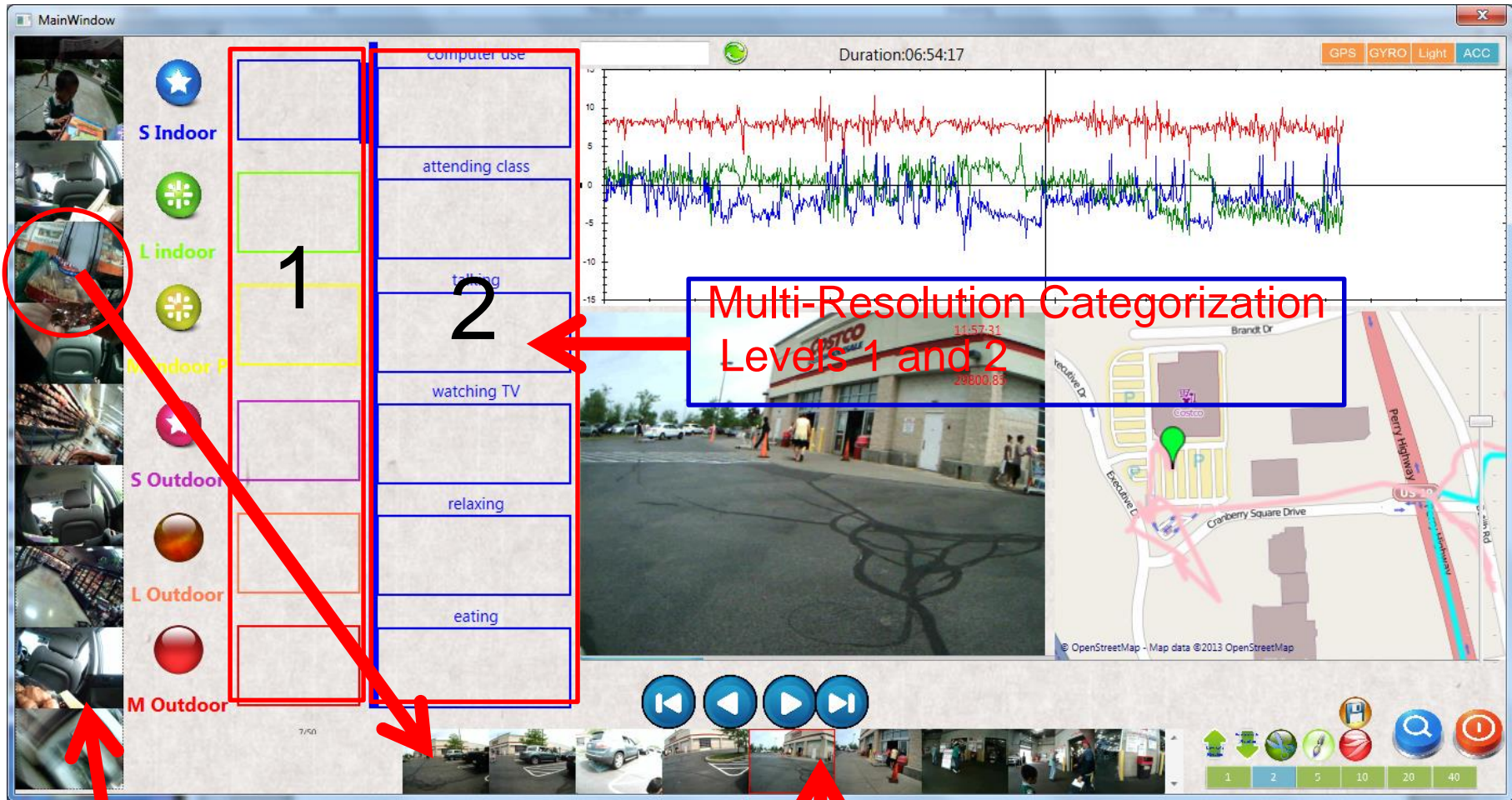
Group of Similar Images



Key Frames



# Manual categorization of daily events



Key Frames

Images of selected segment



# Categorization of activities

## Indoor Activities

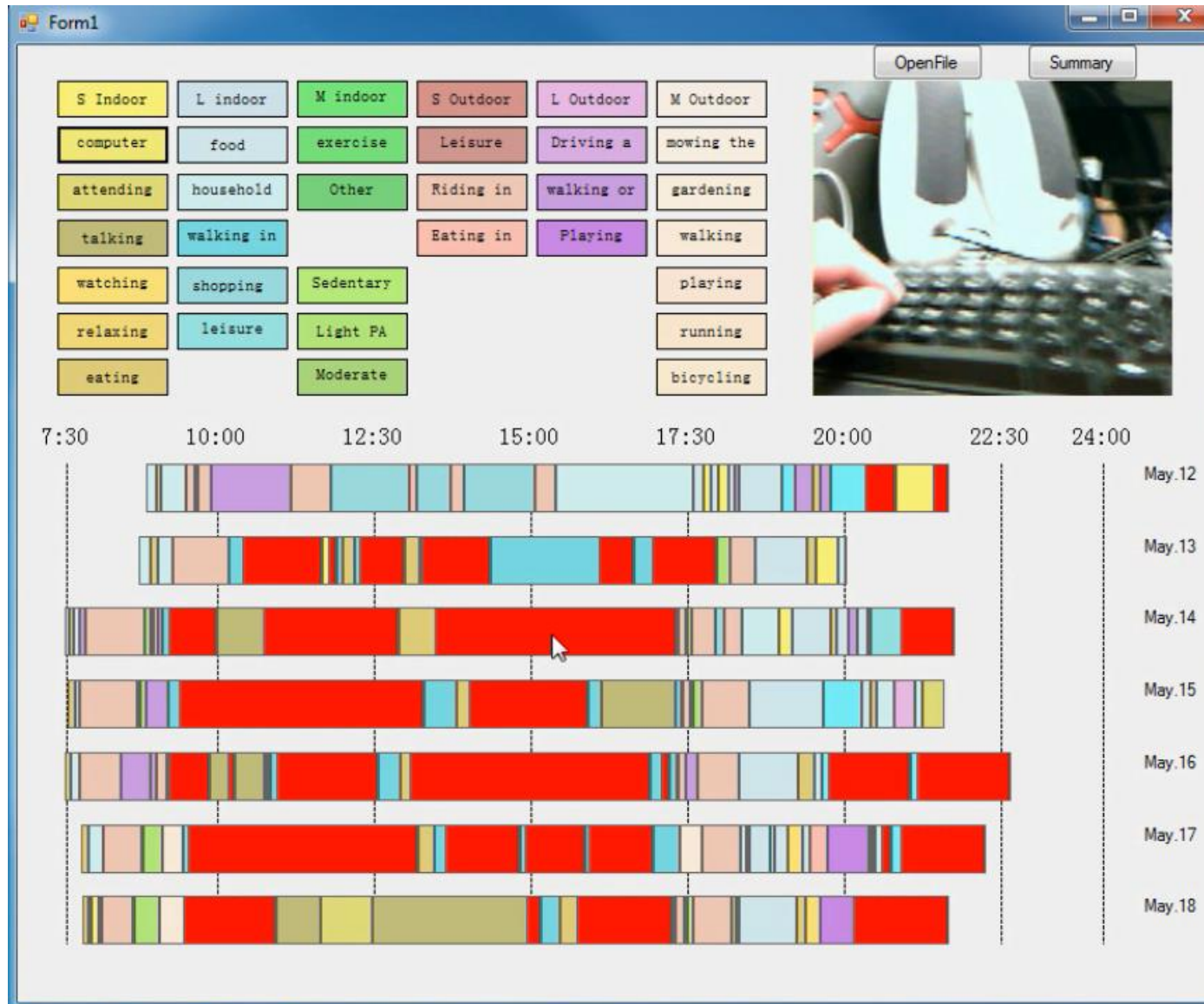
- Sedentary activities
- Light activities
- Moderate to vigorous activities

## Outdoor Activities

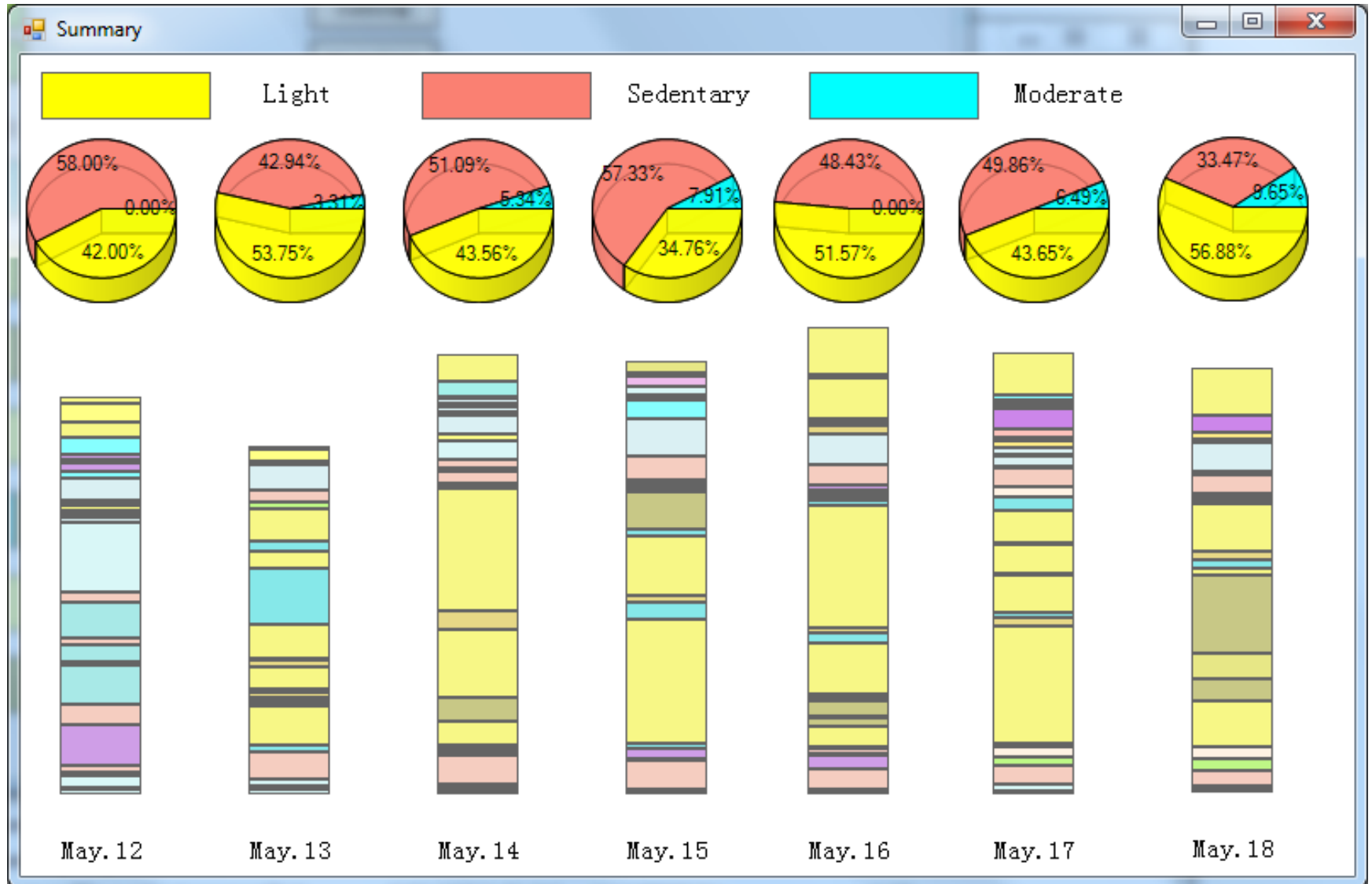
- Sedentary activities
- Light activities
- Moderate to vigorous activities



# Lifestyle summary (one week)



# Summary





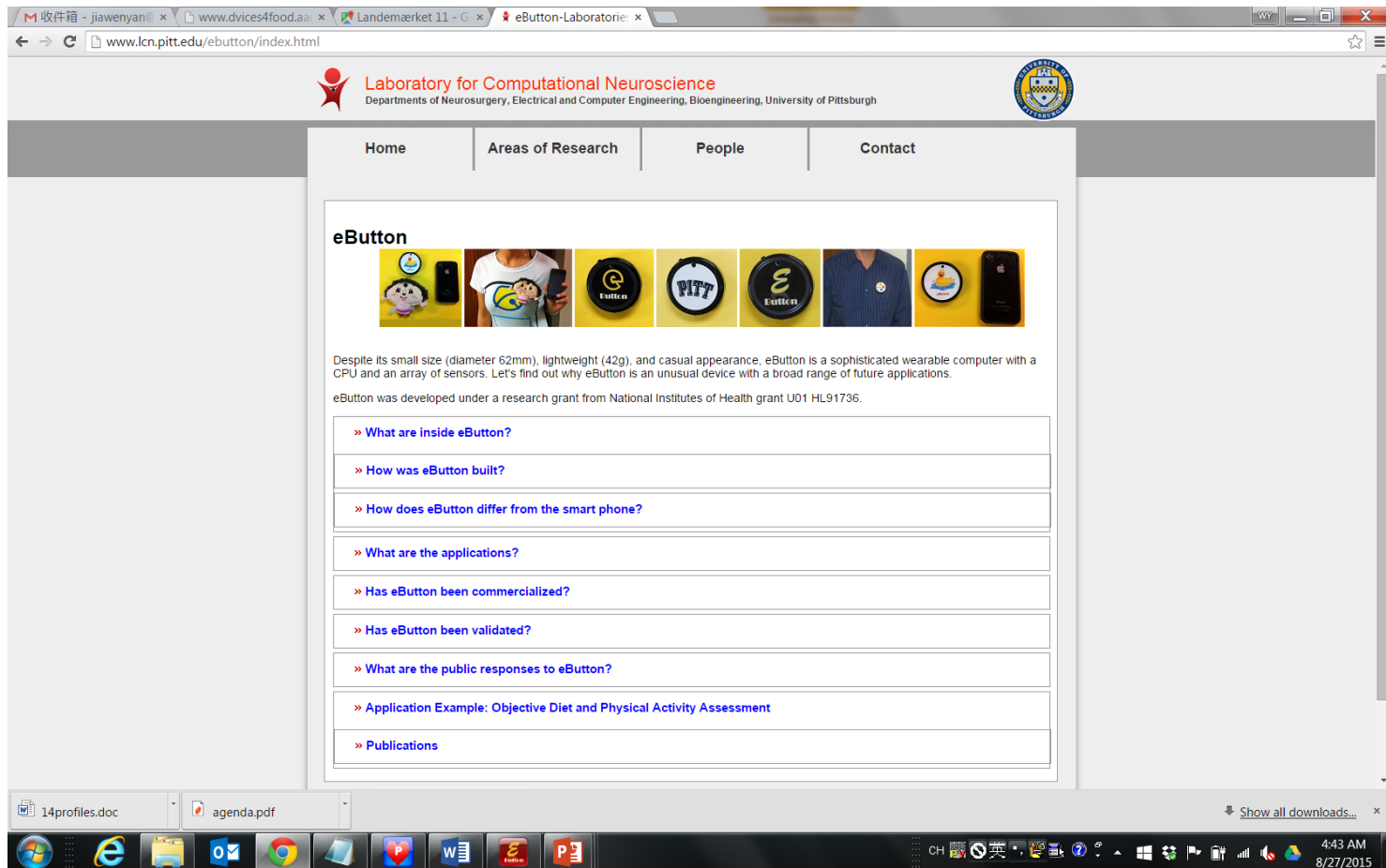
# Inventor

- Professor Mingui Sun, Ph.D.
  - [drsun@pitt.edu](mailto:drsun@pitt.edu)
  - 412-802-6481



# Our Website

- [www.lcn.pitt.edu/eButton](http://www.lcn.pitt.edu/eButton)




The screenshot shows a web browser window displaying the homepage of the Laboratory for Computational Neuroscience. The browser's address bar shows the URL [www.lcn.pitt.edu/ebutton/index.html](http://www.lcn.pitt.edu/ebutton/index.html). The website header includes the laboratory's name and logo, along with navigation links for Home, Areas of Research, People, and Contact. The main content area features a section titled "eButton" with a row of images showing the device and its use. Below the images, there is a paragraph describing the device's features and a list of links for more information.

**Laboratory for Computational Neuroscience**  
Departments of Neurosurgery, Electrical and Computer Engineering, Bioengineering, University of Pittsburgh

Home | Areas of Research | People | Contact

## eButton



Despite its small size (diameter 62mm), lightweight (42g), and casual appearance, eButton is a sophisticated wearable computer with a CPU and an array of sensors. Let's find out why eButton is an unusual device with a broad range of future applications.

eButton was developed under a research grant from National Institutes of Health grant U01 HL91736.

- » [What are inside eButton?](#)
- » [How was eButton built?](#)
- » [How does eButton differ from the smart phone?](#)
- » [What are the applications?](#)
- » [Has eButton been commercialized?](#)
- » [Has eButton been validated?](#)
- » [What are the public responses to eButton?](#)
- » [Application Example: Objective Diet and Physical Activity Assessment](#)
- » [Publications](#)

14profiles.doc | agenda.pdf | Show all downloads...

4:43 AM 8/27/2015

# Acknowledgments

**Funding:** NIH U01HL091736 (PI: Mingui Sun)  
NIH R01CA165255 (PI: Mingui Sun)  
NIH R21CA172864 (PI: Tomas Baranowski, Co-PI: Mingui Sun)

## Participated Institutes and Professors:

### University of Pittsburgh:

John Fernstrom

Lora Burke

Janice Zgibor

Robert Sclabassi

Madelyn Fernstrom

Steven Albert

Zhi-Hong Mao

James DeLany

Gibbs Bethany

**Baylor College of Medicine:** Tomas Baranowski

**University of Michigan:** Juliet Lumeng

**University of Rochester:** Diana Fernandez

**Furtwangen University(Germany):** Stefan Selke & Iris Menke

...

**Numerous undergraduate, graduate students and postdoctoral fellows**

Thank you for your attention