BALANCE: Towards a Usable Pervasive Wellness Application with Accurate Activity Inference

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BALANCE System
(Bioengineering Approaches for Lifestyle Activity and Nutrition Continuous Engagement)

- **Provide a way to monitor the balance between caloric intake and caloric expenditure**
- **Provide a way to log calorie intake of the user**
- **Encourage healthier lifestyles and weight loss**
- **Make it easy to use**

BALANCE Overview

- Automatically detects the user‘s physical activity via sensor data from a MSP(Mobile Sensing Platform) unit worn on the hip
- MSP data is transmitted to the mobile phone over a Bluetooth link
- Users logs food intake information through the interface of the mobile phone
- 87% accurate compared to actual results

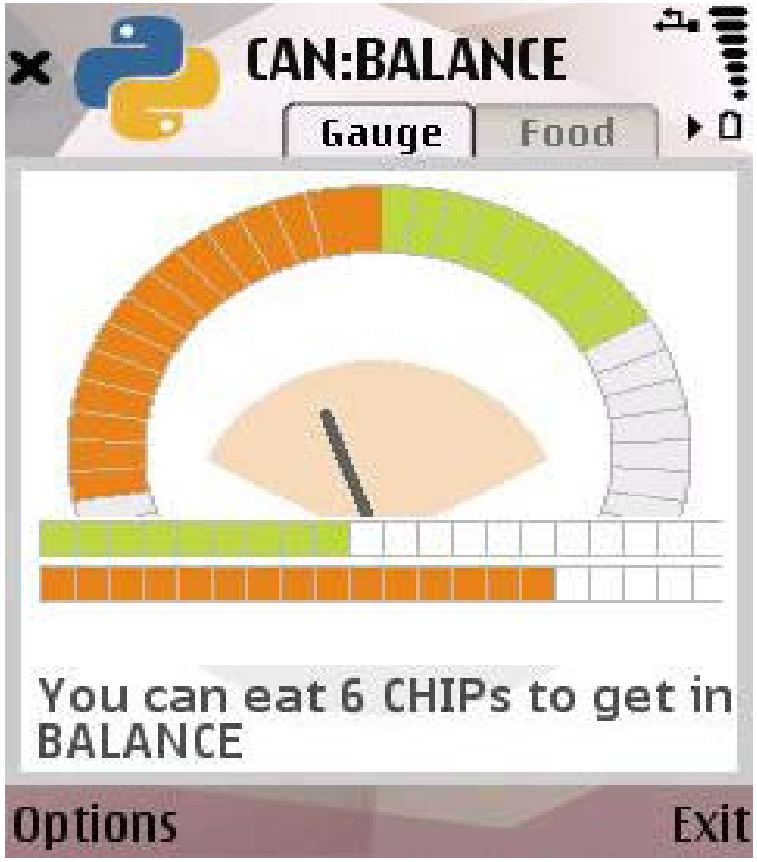
Activity Recognition - Mobile Sensing Platform (MSP)

- 3-D accelerometer
- Senses barometric pressure, light, humidity, sound, position
- Able to sense sitting, walking, running, and bicycling
- Other activities may be added by gathering training data and associating that data to the new activity (Naïve Bayes classifier)
- MSP computes the step rate and the number of steps taken
- Sends activity data to the cell phone
- Only the accelerometer was utilized in this study

BALANCE Software Interface – Main Screen

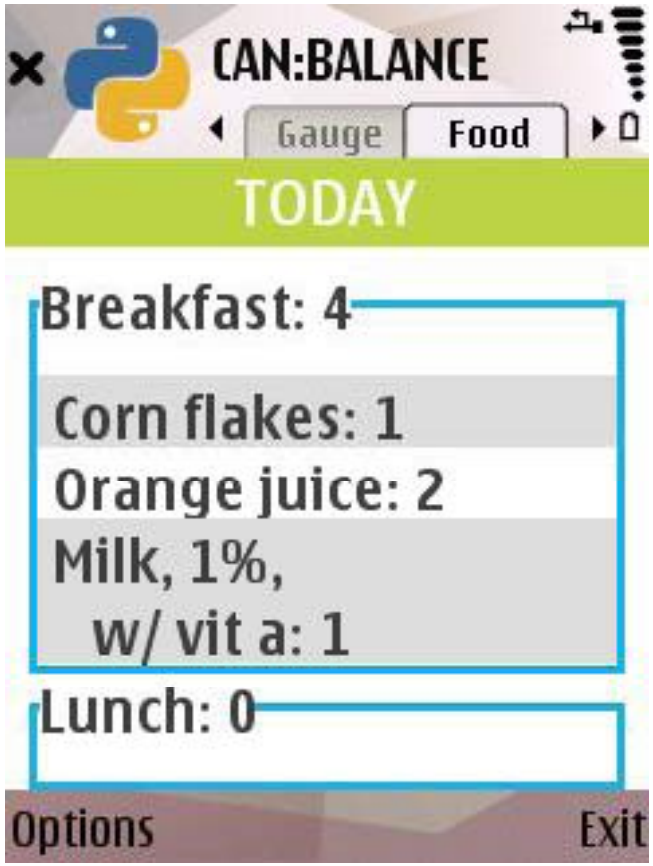
- Activity data is sent to the cell phone and the cell phone utilizes this data to determine how many calories the user has burned

- Can be adjusted to help the user lose weight in a healthy manner



BALANCE Software Interface - Summary Screen

- Serving size is measured in Calorie Hundred Impact Points (CHIPS)
- 1 CHIP = 100 calories
- Food items can be grouped for ease of use



BALANCE Software Interface – Custom Meal Screen

- Meal items comes from 2 different databases
- Can add customized meals
- People usually eat the similar things for breakfast
- Future work on adding location and time awareness features

BALANCE Software Interface – Daily Activity Screen

- Activities are automatically detected through MSP
- Activities can be customized manually
- Step count obtained from the MSP
- Future work involve adding more types of activities

Usage Scenarios

- Usage Scenario involving time awareness
  - User sits down for breakfast
  - User begins to eat
  - The time hits 6AM
  - Phone reminds the user to enter in food data based on the time
  - Balance is aware of the user's breakfast time and pulls up the food database containing breakfast items such as toast and orange juice

- Usage Scenario involving location awareness
  - User decides to eat out for lunch instead of work cafeteria
  - User drives to favorite restaurant
  - Phone is aware the user is at his favorite restaurant
  - Phone reminds the user to enter food data based on current location
  - Balance pulls up a food database containing the food items the user usually orders

Metabolic Equations

How does BALANCE calculate the amount of calories burned?

By first calculating the amount of oxygen a person uses in liters per minute

How is the amount of oxygen a person uses in liters per minute calculated?

VO2 = R + H + V

Metabolic Equations (cont)

VO2 = R + H + V

R = The resting metabolic rate of a person

R = 3.5ml * kg^{-1} * min^{-1}

Metabolic Equations (cont)

VO2 = R + H + V

H = The horizontal component of movement
V = The vertical component of movement

(walking)

H = 0.1 * speed(m/min)ml * kg^{-1} * min^{-1}
V = 1.8 * speed(m/min) * grade(as decimal)ml * kg^{-1} * min^{-1}

Metabolic Equations (cont)

(running)

$H = 0.2 \times speed(m/min) ml * kg^{-1} * min^{-1}$

$V = 0.9 \times speed(m/min) ml \times grade(as\ decimal) ml * kg^{-1} * min^{-1}$

Metabolic Equations (cont)

How do we convert oxygen consumption to calories burned?

VO2 x 5 kcal/min = caloric expenditure

Validation

Several treadmill experiments were conducted to compare the estimated caloric expenditure against the actual caloric expenditure.

How was the actual caloric expenditure obtained?

While wearing the MSP device, subjects were also connected to a metabolic cart that measured the actual oxygen consumption.

Validation (cont)

- 10 people chosen to carry out the lab tests

- Lab tests were designed to test sitting, standing, walking, and running
  - 3 minute sitting stage
  - 2 minute standing stage
  - 6 three minute walking/running stages
  - 5 minute sitting stage

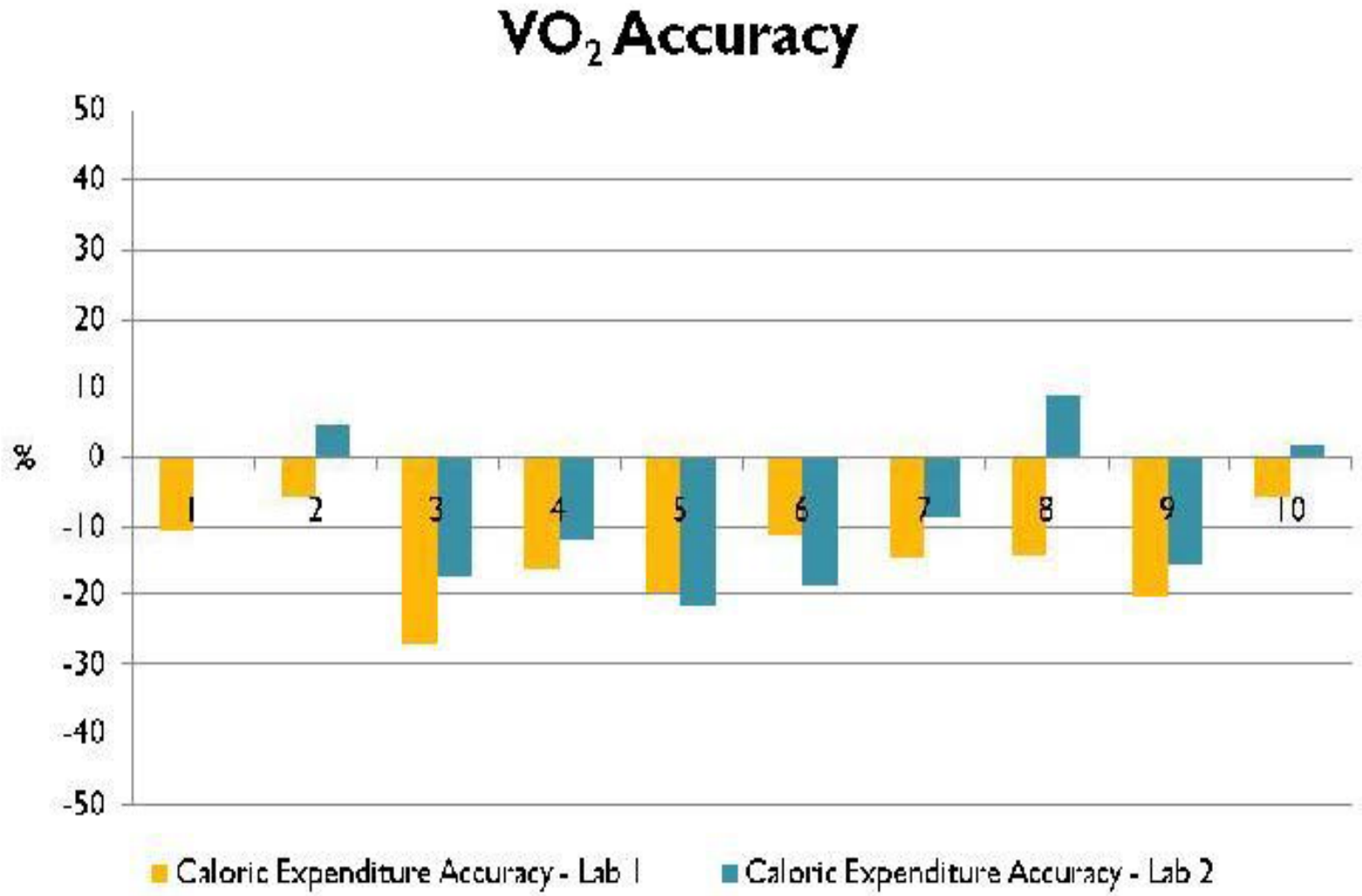
- Subjects were fitted with heart rate monitors to detect if they were being over exercised (when heart-rate exceeded 220 – age)

- Overall accuracy was 87%

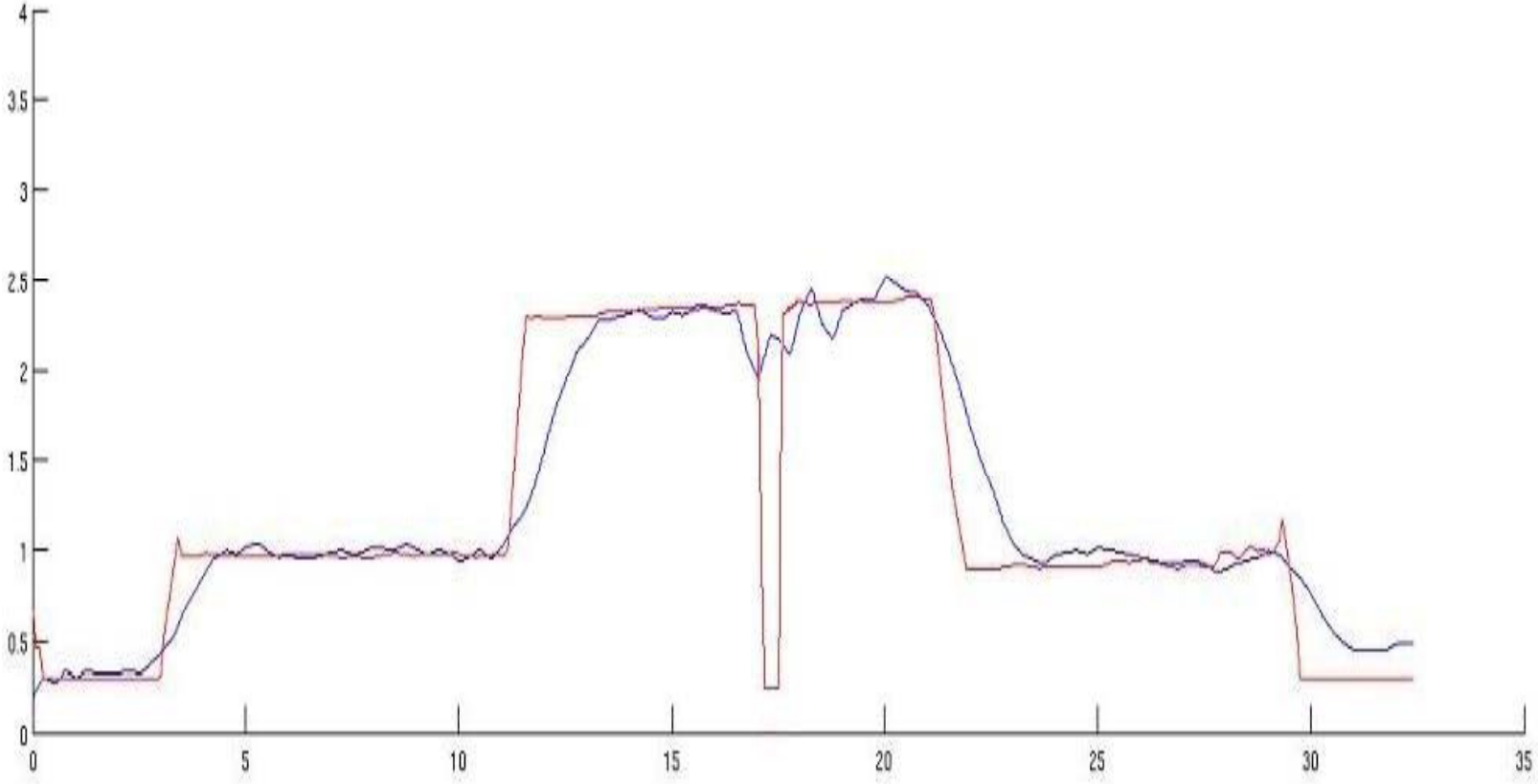
- Estimates were generally lower than the actual results

Sample Data of walking/running stages

MPH	1.8	2.5	3.0	3.5	4.5	4.5
Grade	0%	5%	0%	7.5%	0%	2.5%
Experimental Walking/Running Stages						


VO2 Accuracy
50
40
30
20
10
0
-10
-20
-30
-40
-50
%
1
2
3
4
5
6
7
8
9
10
Caloric Expenditure Accuracy - Lab 1
Caloric Expenditure Accuracy - Lab 2

Estimated (red, rectilinear) vs. actual caloric expenditure



Future Work

- Execute field tests
  - Use change in barametric pressure to calculate the incline instead of using treadmill data
  - Utilize the GPS on the phone instead of having to rely on data from the treadmill
  - Add more common daily activities for the calculations of caloric consumption
- Add 65 test subjects with varying ages and weights
- Add time, context and location awareness to improve the interface
- Conduct focus groups to obtain feedback on use of BALANCE system

Related Works

- DietTV.com – Commercial web application for managing exercise and food choices
- Keyoe – PDA-based application for recording consumed foods and exercises
- iShape and Absolute Fitness – Apps from the iPhone app store
- Wellness Diary – Application made for the Nokia S60 phone (inputs and tracks exercise and food choices)
- PmEB system – Mobile phone application also similar to BALANCE food tracking abilities

Related Works (cont)

- **UbiFit Wellness system – Automatically detects five activities from a fitness device attached to the user's hip: walking, running, bicycling, elliptical trainer, and stair stepping machine; Activities nurture an electronic garden display on the user's cell phone**

- **PDA based application - For semi-literate patients with kidney disease; system offers barcode scanning and voice recording for entering food data**

- **DietSense – Food tracking is done through photographic input from the user's cell phone camera**

- **BALANCE system is the first system to combine food tracking with real-time activity inference**

Questions?