(AAL-2009-2-129)

Activity Level Estimator on a Commercial Mobile Phone

feasibility study

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Motivation

- Lack of physical activity which is increasing the risk of chronic diseases
  - How to unobtrusively monitor the physical activity of people?
  - How to ensure that user carries the designated device continuously?
- How to motivate people to be more active daily?
  - Preventive care
- How to present the physical activity to the user?
  - Intensity levels?
  - Energy expenditure (EE) and burned calories estimation?
  - Counting steps?

Foerster and Fahrenberg 2000; Fogg 2002; Barralon, Vuillerme et al. 2006; Connelly, Faber et al. 2006

The Smartphone Factor

- Unobtrusive – carried around along the day
  - 3D accelerometer and other built-in sensors
  - Possible continuously running background services

- Activity Level Estimator (ALE)
  - Android-based software
  - Physical activity level duration, EE estimation
  - Assumes that the phone is in the person's pocket

http://www.android.com

Activity Level Estimator (ALE)

- Estimation of the calories burned
  - Per activity level
  - Overall estimation for 24 hours
  - 5 activity levels, from sedentary to vigorous
- Estimation based on
  - Metabolic Equivalent Task (MET) table
  - Resting Metabolic Rate (RMR)

Harris and Benedict 1918; Ainsworth, Haskell et al. 2000; Byrne, Hills et al. 2005

Prototype


13:16
ALE
Live monitoring
Past results
FAQ
calorie for activities
529
Calories burned in 24h
2023
Very low: 1:0:50
Low: 0:31:30
Moderate: 0:35:0
Vigorous: 0:1:5
Current scale: 1h30
htc

Algorithm: Raw Data & Sample Median

Raw data — Thresholds

- Signals from the accelerometer with gravity compensation → acceleration vector
  - Sample: 1.5 seconds time window (~60 data points)
- Filtering
  - Keeps the high values of the sample
  - Smooth the signal
- Sample median value
  - Median compared to thresholds that matching to a MET value

Algorithm: Thresholds & MET

Raw data — Thresholds — Matching MET — EE estimation

- Threshold defined via user study
  - 15 participants
  - 30 steps at 3 levels
- 5 thresholds corresponding to 5 activities levels
  - Sedentary = 1 MET
  - Very low = 2.5 MET
  - Low = 4.5 MET
  - Moderate = 6 MET
  - Vigorous = 9 MET
- Influence of height, weight and gender?
  - Main variable: gender
- Other variables
  - Clothes
  - Shoes

First ALE Validation

- SenseWear from BodyMedia
  - MET values calibrated
- Study Design
  - Short terms study
    - 7 participants walk at least 15 minutes
  - Long term study
    - 1 participant for 3 days, daily activities

Jakicic, Marcus et al. 2004; St-Onge, Mignault et al. 2007; BodyMedia Inc 2010

Results

Short term study

- Average 14% MET difference per minute
- Overestimation 7% of MET for the whole test duration

Long term study

- Average 23.4% MET difference per minute for all kinds of activity levels
- Underestimation of calories by 27.9%
- Driving a car or working on a computer not detected by ALE

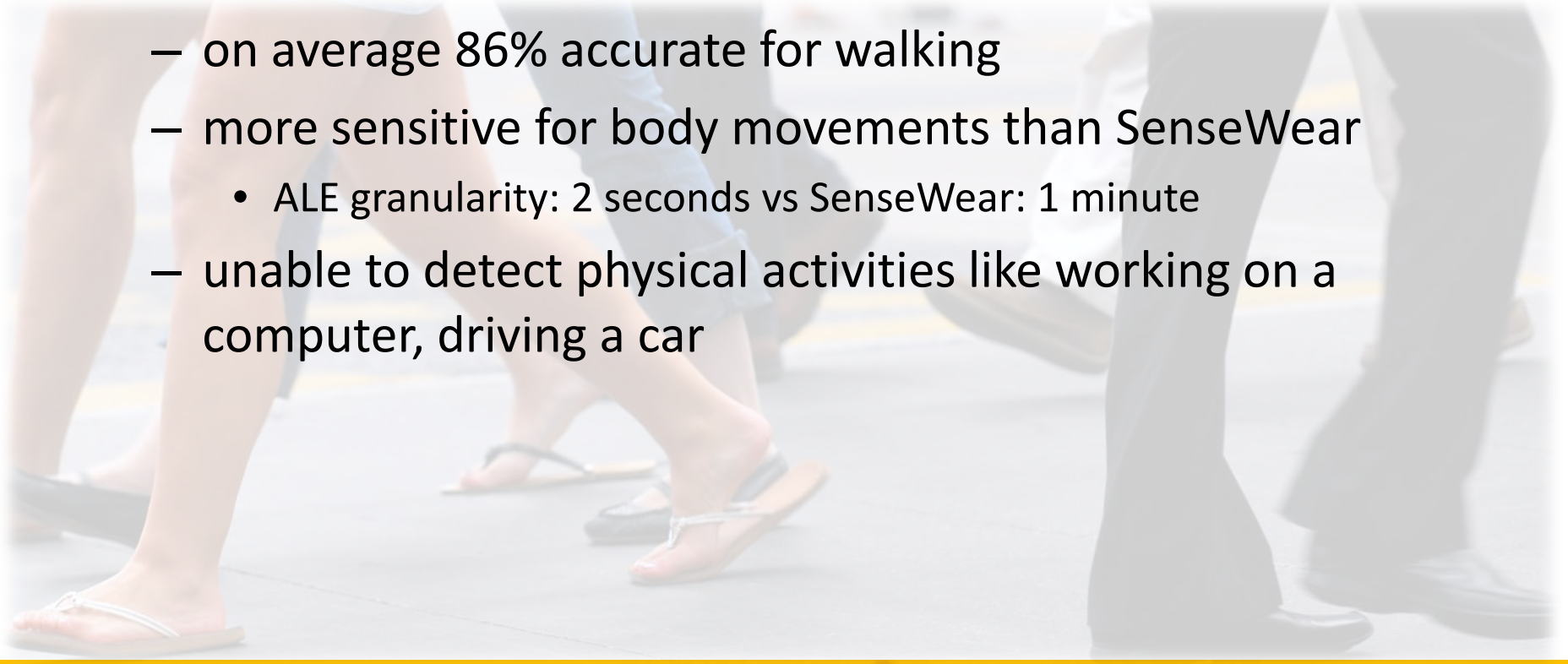
Wac and Hausmann 2011

Example Result

- 42 minutes walk on a road forest with small hills and irregular ground, user stopped several times

Results Discussion

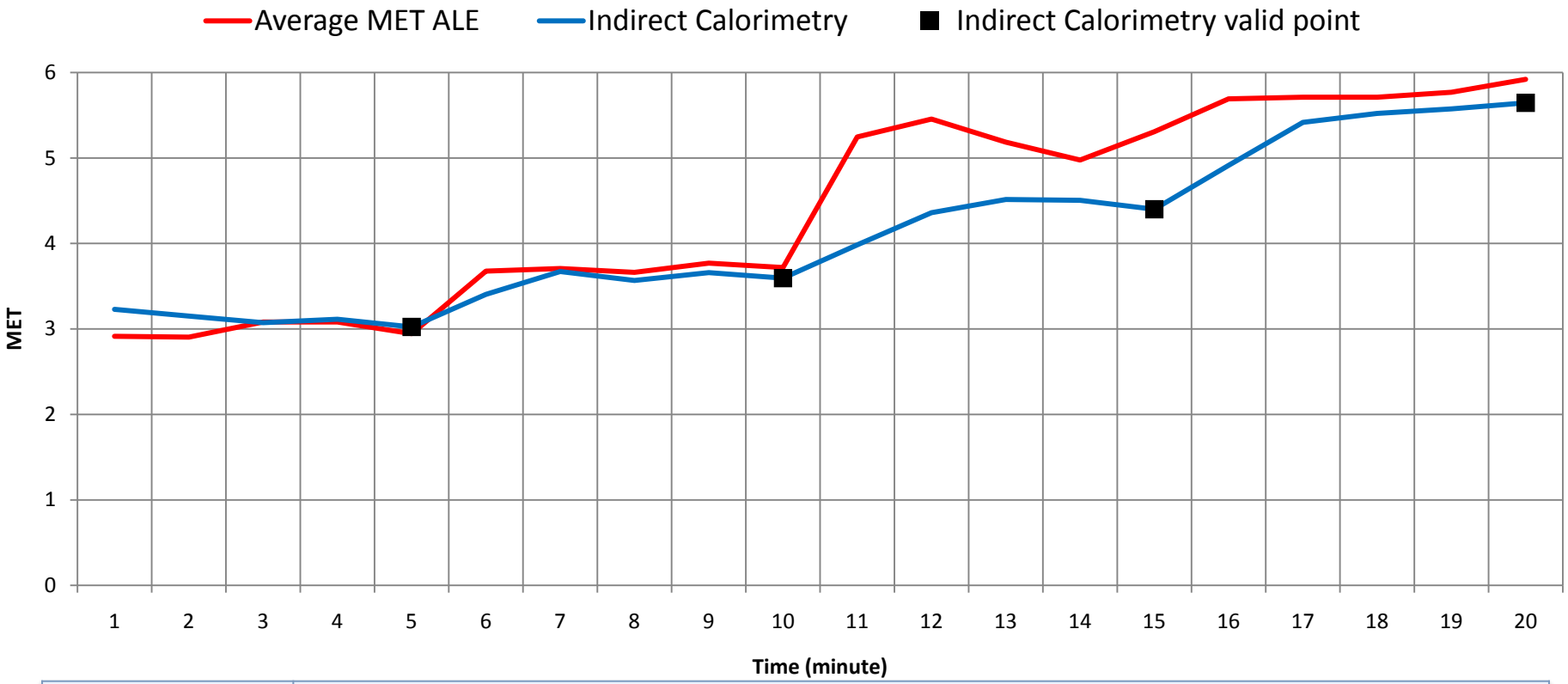
- ALE
  - on average 86% accurate for walking
  - more sensitive for body movements than SenseWear
    - ALE granularity: 2 seconds vs SenseWear: 1 minute
  - unable to detect physical activities like working on a computer, driving a car



Second ALE Validation: In Progress

- Institute of Science of Movement and Sports Medicine at University of Geneva
- Indirect Calorimetry and treadmill
- Study Design
  - 12 participants
  - Walk on a treadmill
  - 4 thresholds speed (3 – 6 km/h)
  - 5 minutes per threshold speed

Preliminary Results



Participants	MET error per minute				
N = 12	3 km/h	4 km/h	5 km/h	6 km/h	Average
	10.01%	7.81%	9.15%	12.10%	9.77%

Conclusion and Future Work

- Work in progress with promising results
  - Accurate EE estimation with a commercial mobile phone
    - Avg accuracy 86% with BodyMedia
    - Avg accuracy 90.3% with Indirect Calorimetry (in progress)
  - Ongoing user study and a new one in real terrain conditions (September)
- Future Work
  - Add GPS to get altitude (e.g., hill) and other forms of transport (bike)
  - User interface design and feedback to user
  - Social network factor
- Overall goal
  - behavioral change for sedentary people

Questions ?

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