CONTEXT AWARENESS AND LOCALIZATION

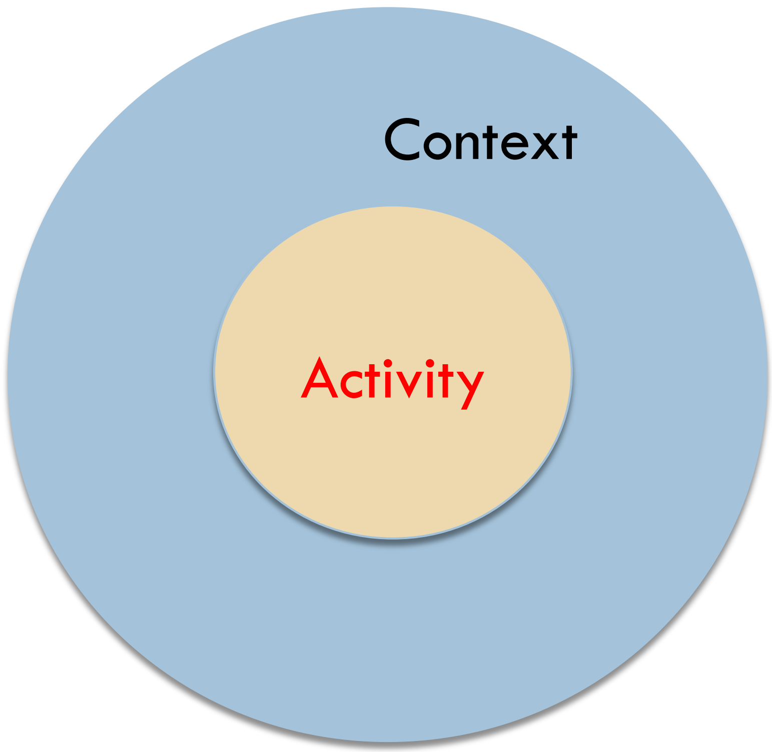
Context-aware computing

- How computation can be made sensitive and responsive to its context
  - What context?
  - How to represent/evaluate/detect?
  - How to respond?

What is Context?

- Dictionary definition: "the interrelated conditions in which something exists or occurs"
- The representational view
  - "Context encompasses more than just the user's location, because other things of interest are also mobile and changing. Context includes lighting, noise level, network connectivity, communication costs, communication bandwidth and even the social situation (e.g., who you are with)

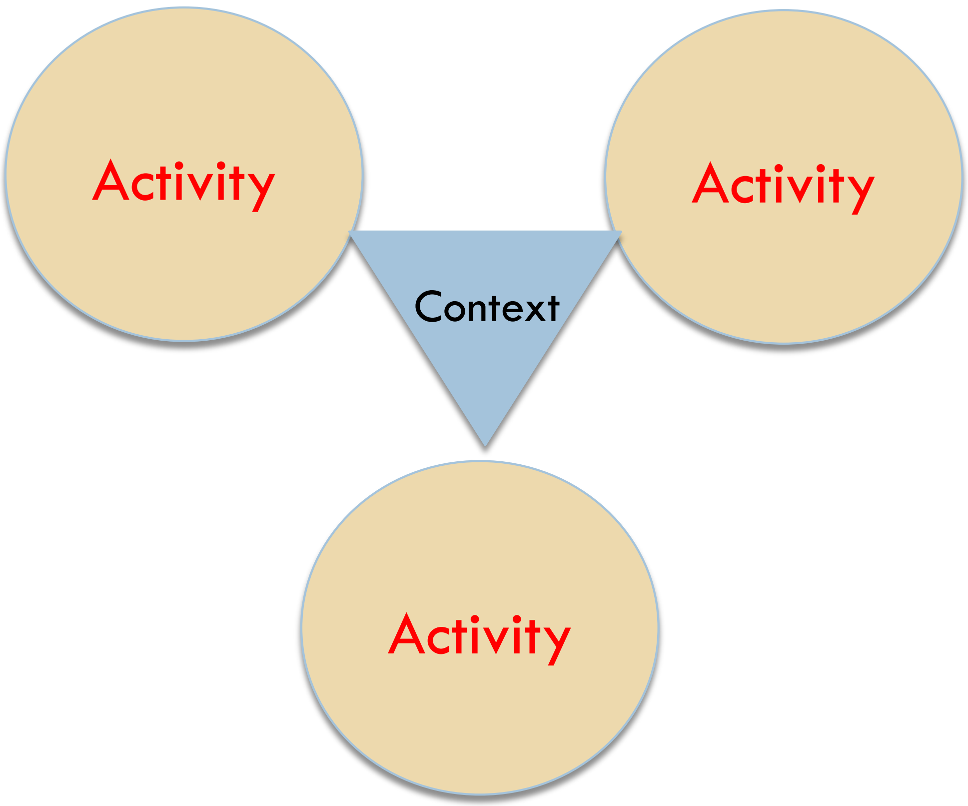
The representational view



- Example: adaptive ring tone
  - Activity: ring
  - Context: noise level of the environment, location
  - Relation: noise level of the environment decides the volume of the ring tone

The key question is thus how to encode and represent *relevant* context

The interactional view

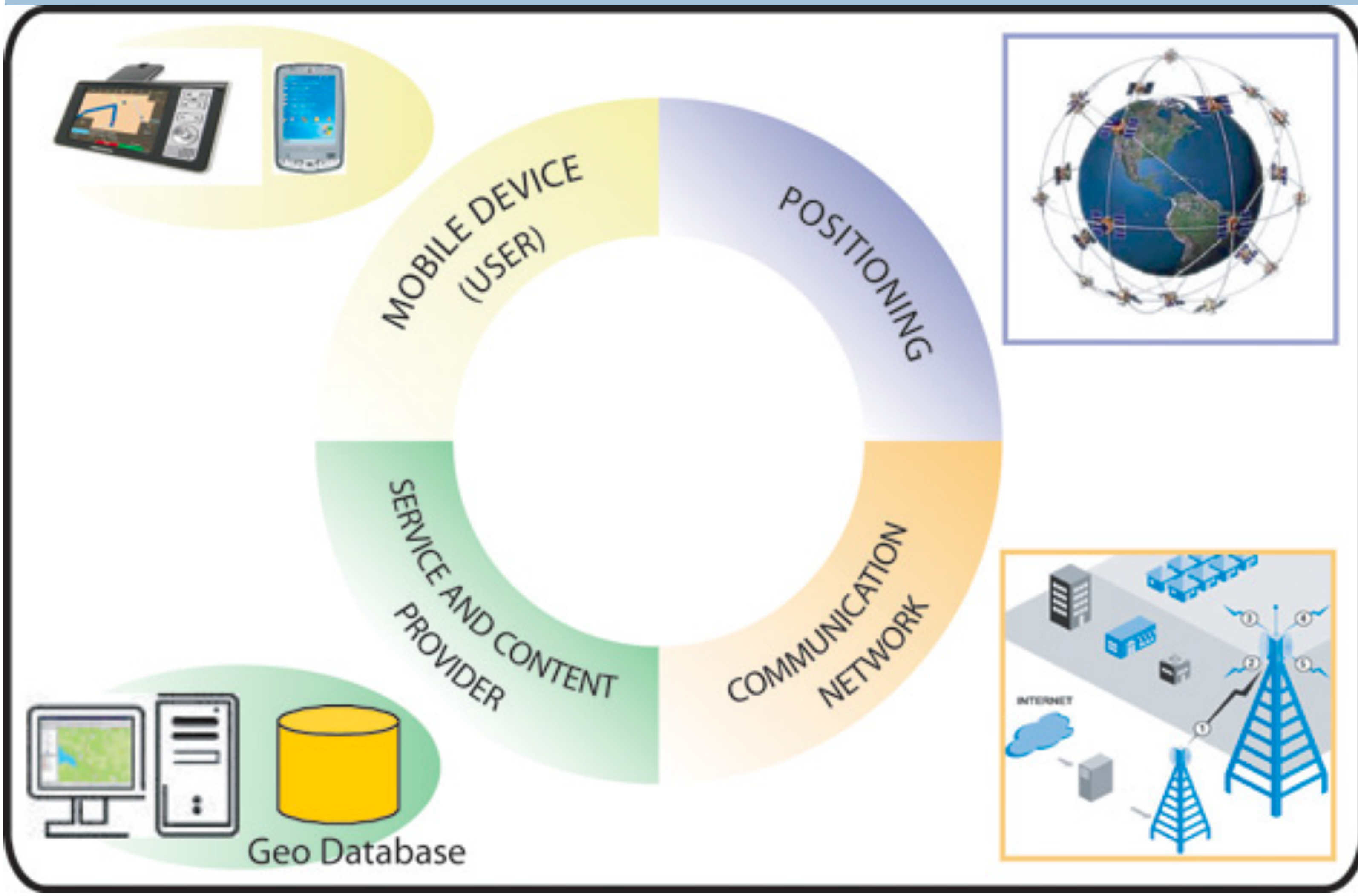


- *contextuality is a relational property* that holds between objects or activities
- Dynamic and evolving through the interactions
- Example: adaptive ring tone
  - Activity: people's activity, mobile ring
  - Context: The interaction among activities determine "the norm" – keep quiet

how and why, in the course of their interactions, do people achieve and maintain a mutual understanding of the context for their actions

Location, location, location

Components of LBS



Steiniger et al. "Fundation of Location Based Services"

Usage of LBS

Action	Questions	Operations
orientation & localisation locating	where am I? where is {person|object}?	positioning, geocoding, geodecoding
navigation navigating through space, planning a route	how do I get to {place name| address| xy}?	positioning, geocoding, geodecoding routing
search searching for people and objects	where is the {nearest | most relevant | &}{person | object}?	positioning, geocoding, calculating distance and area, finding relationships
identification identifying and recognising persons or objects	{what | who | how much} is {here | there}?	directory, selection, thematic/ spatial, search
event check checking for events; determining the state of objects	what happens {here | there}?	

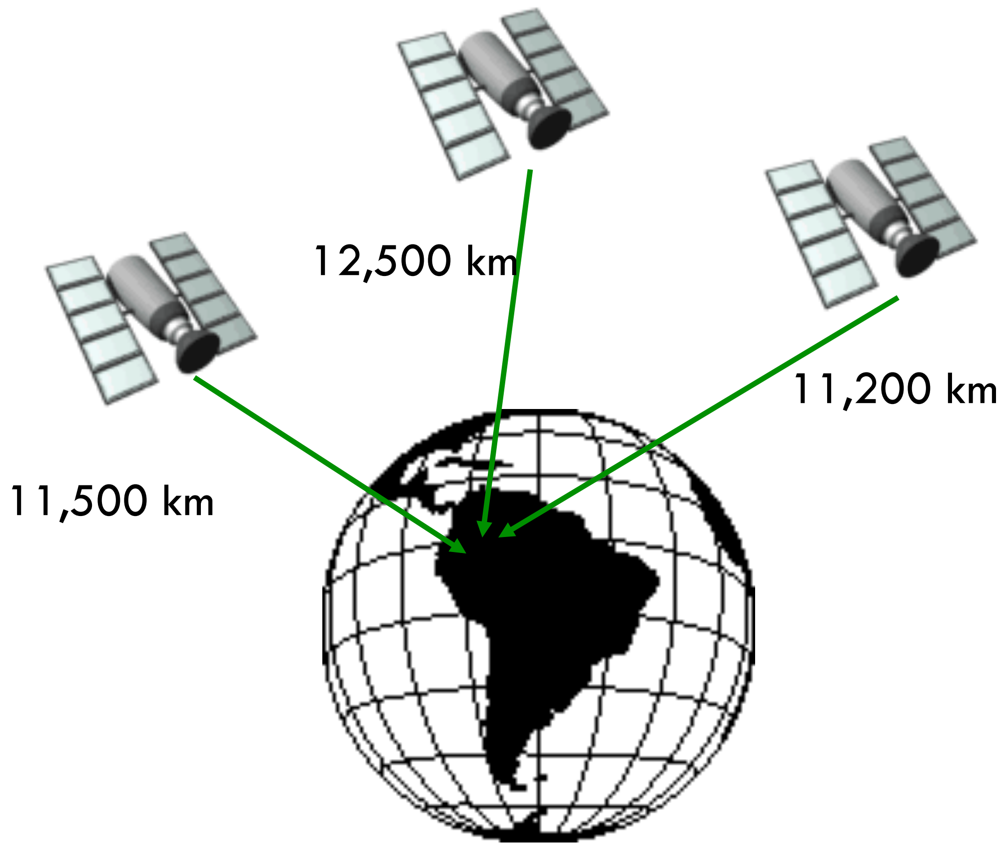
A Taxonomy of Localization Techniques

- Types of location (physical, symbolic, relative)
- Granularity of location
- How is infrastructure involved
  - Infrastructure provides the location
  - Mobile devices determine the location
- Indoor vs outdoor
- Signal used
  - **Wireless**
  - **Inertial**
  - Optical
  - Acoustic
  - …

Some localization techniques

- GPS
- WiFi-based indoor localization
- Inertial navigation

How does GPS work?

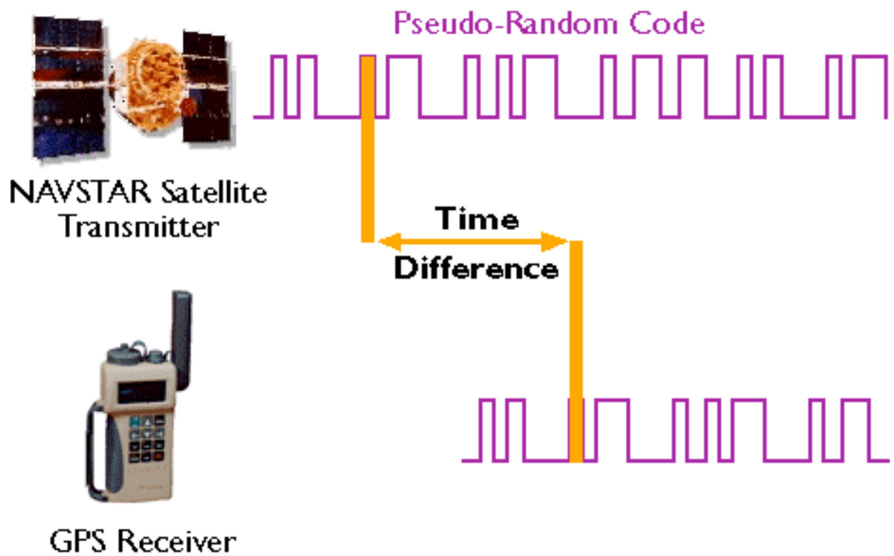


How to measure the distance

- Solution 1
  - Generate the same copy of the signal at the exactly the same time on the satellites and the ground unit
  - Measure the time difference

delayed:"I cant fight this feeling any more,"

Local: "I can't fight this feeling any more,"

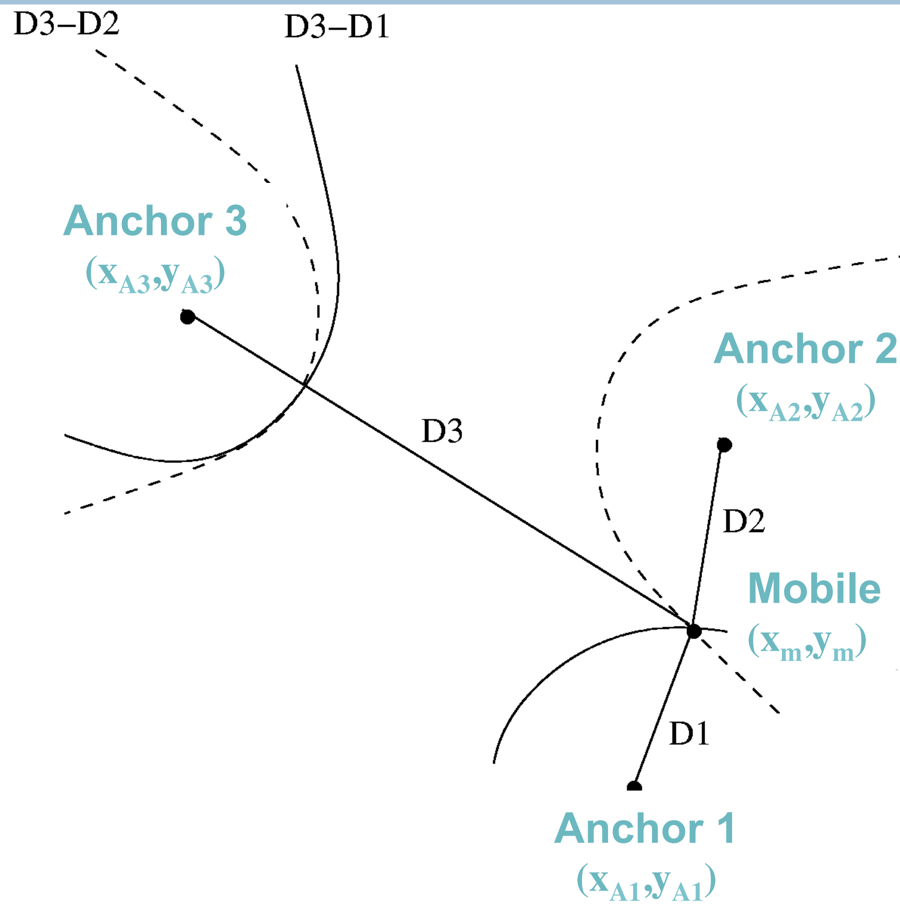


Distance = Speed of Light • Time Difference

Time Difference of Arrival (TDOA)

3 anchors with known positions (at least) are required to find a 2D-position from a couple of TDOAs

In 3D, needs the 4th satellite!

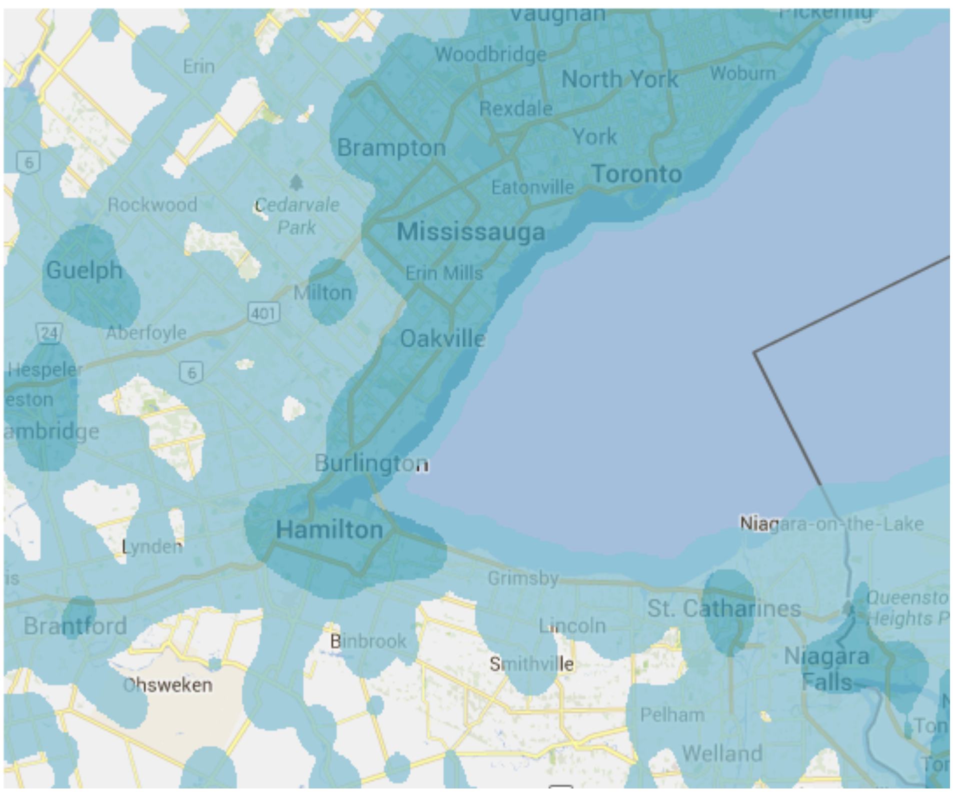


4 unknowns (x, y, z, time) and 4 knowns

Have the added benefit of synchronizing the clock on the ground unit

WiFi-based Indoor Localization

- Weaker signal and rich multipath indoor make GPS highly inaccurate or inaccessible
- WiFi infrastructure abundant

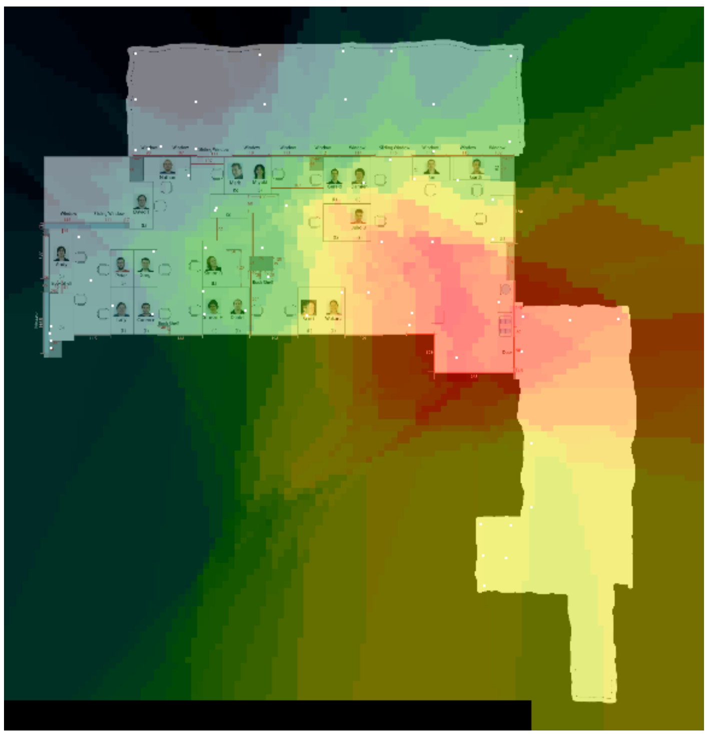


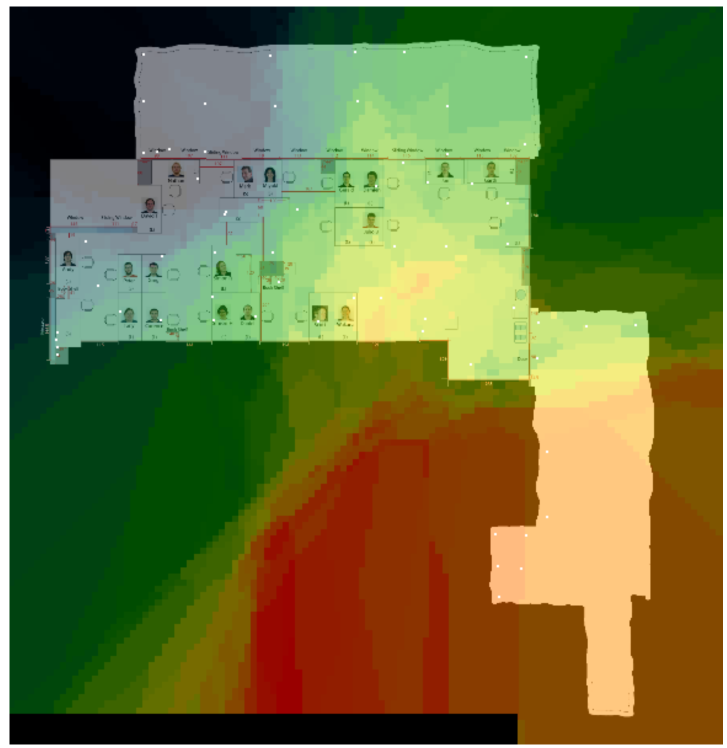
Skyhook has 275 employees, 240 of whom are drivers recording Wi-Fi signals (2008)

(why not yet killed by Google and Apple?)

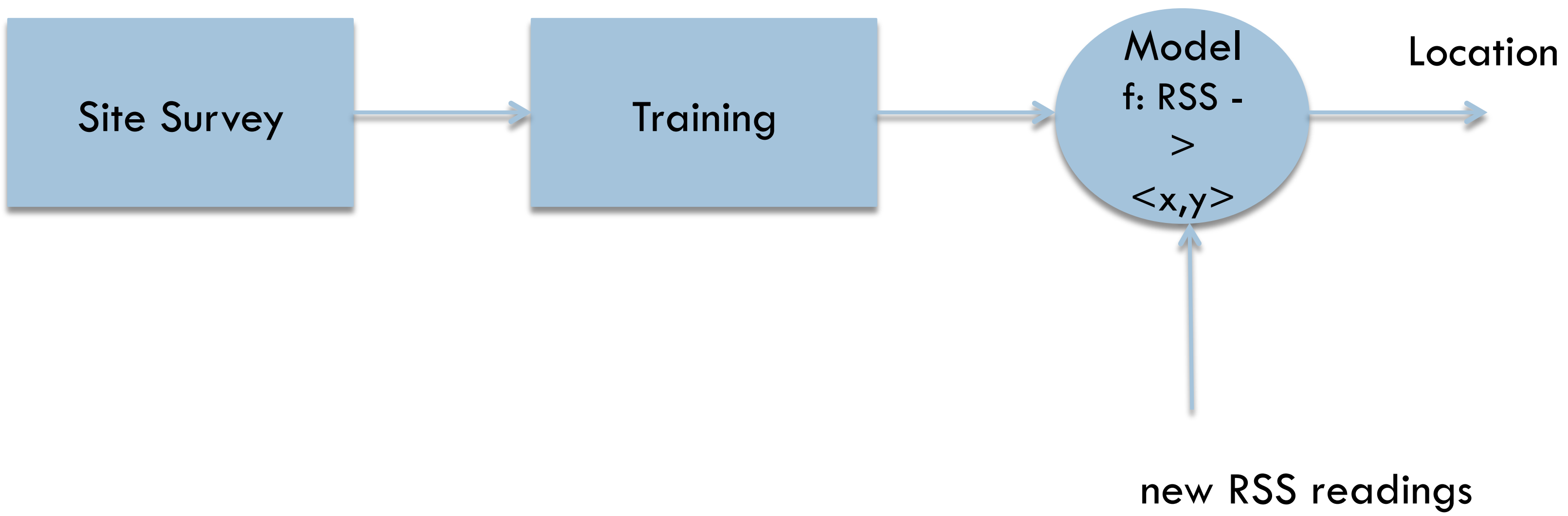
WiFi Fingerprinting

- TOA, TODA, AOA are generally difficult to be estimated accurately with WiFi devices
- Small-scale fading leads to large variations of received WiFi signal even when the device is stationary





Solution approach

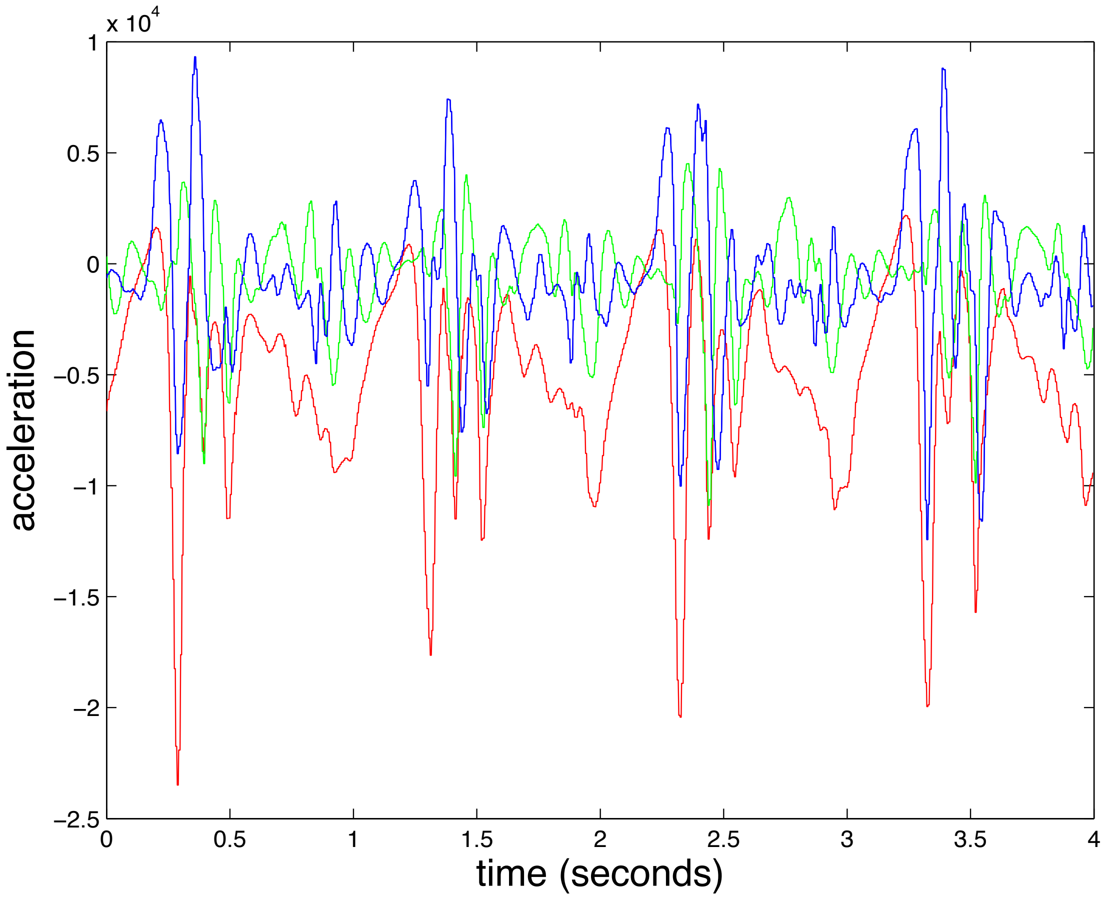


Other signatures can be used, e.g., CSI

Challenges with FP-based Approaches

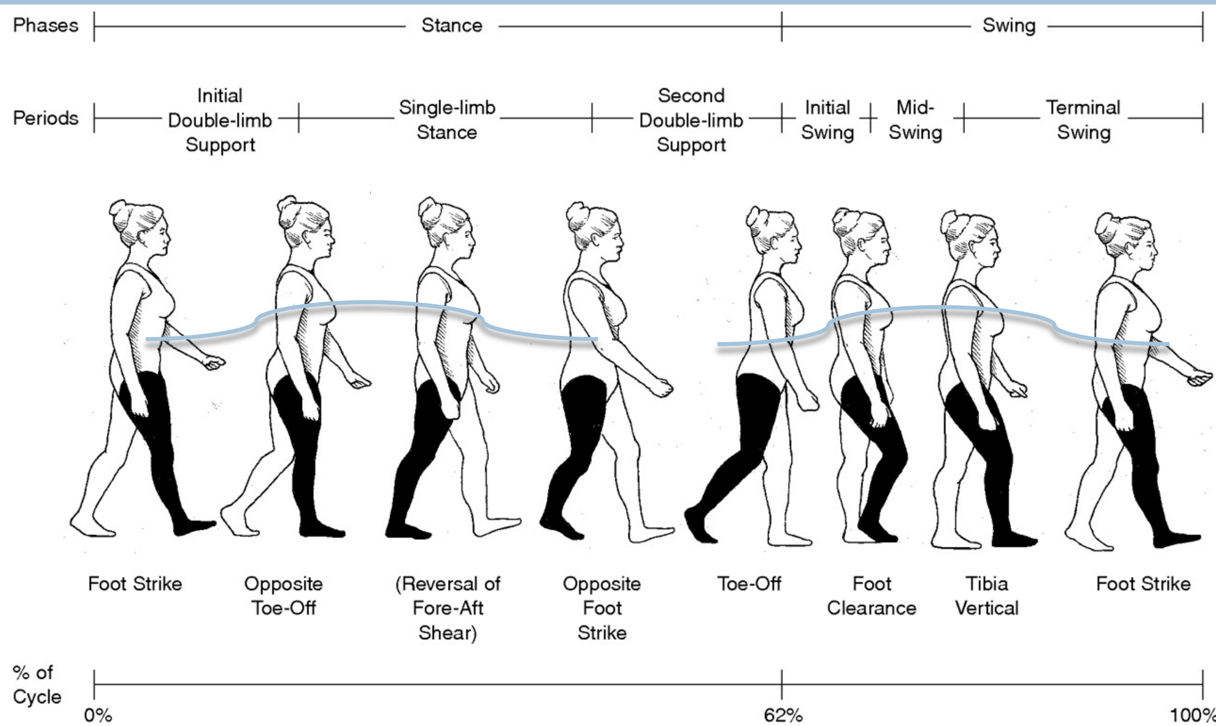
- Time-varying
- Boils down to a supervised clustering approach
- Device heterogeneity
- Needs site survey
  - Subject to changes
- Room-level accuracy
- Map required to determine the symbolic locations
- Solution: Other sensing modalities
  - Inertial sensors: accelerometers, gyro sensor, magnetometer/compass
  - Ranging sensors: acoustic, infrared, ultra-wide band RF, laser

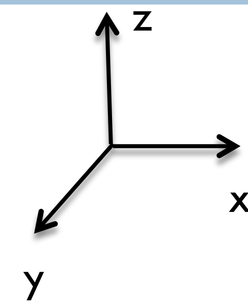
Accelerometer readings while walking



- Potential energy to/from kinetic energy

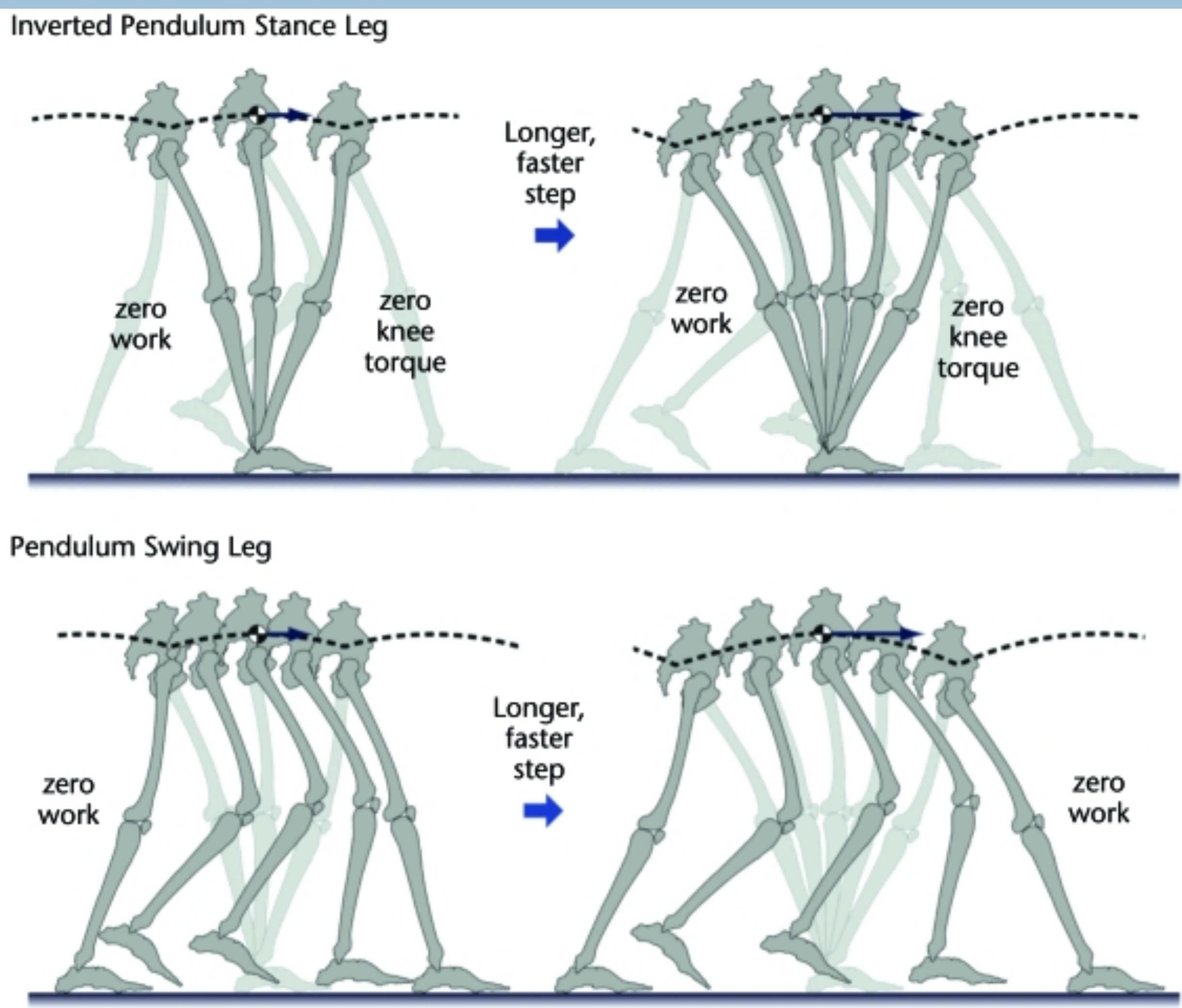
Gait cycle





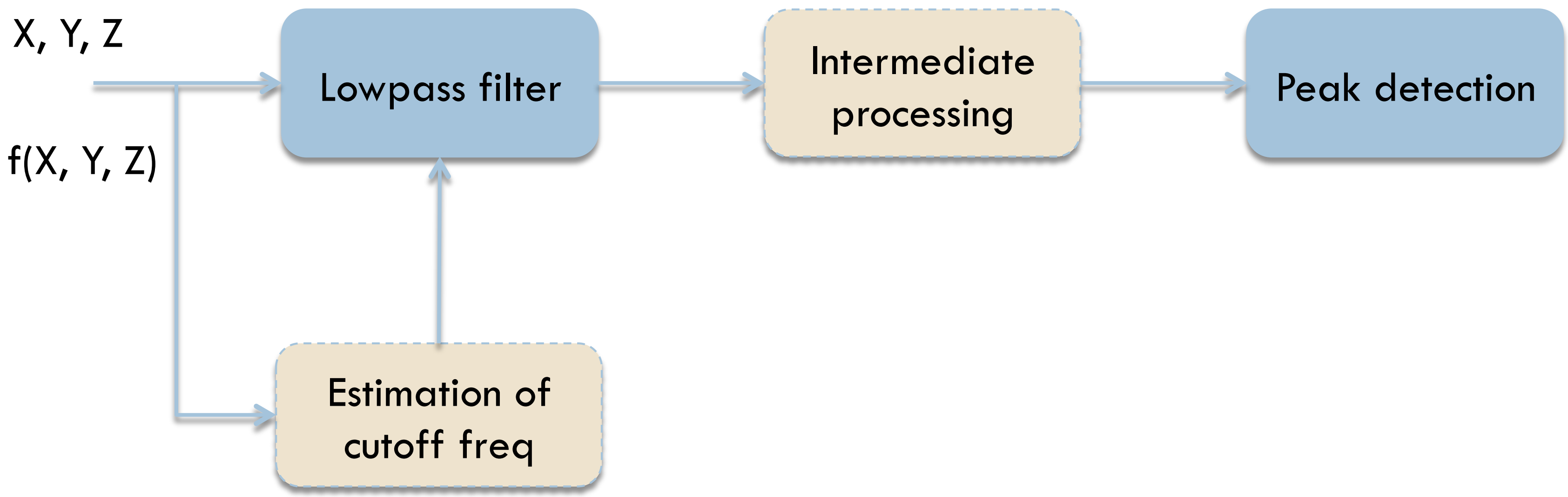
X	-	+	+	-	-	+	+	0
Z	+	-	-	+	+	-	-	+
Y	+	0	-	-	0	+	+	+

Inverted pendulum model



*AD Kuo, JM Donelan, Dynamic Principles of Gait and Their Clinical Implications

Step counting



Stride length estimation

- Height based
  - Height x .413 (female)
  - Height x .415 (male)
- Speed related
  - $S = av^b$, where $a = 1.22 \pm 0.11$, $b = 0.54 \pm 0.10$*
- Estimated online
  - From height, length of leg, acceleration**

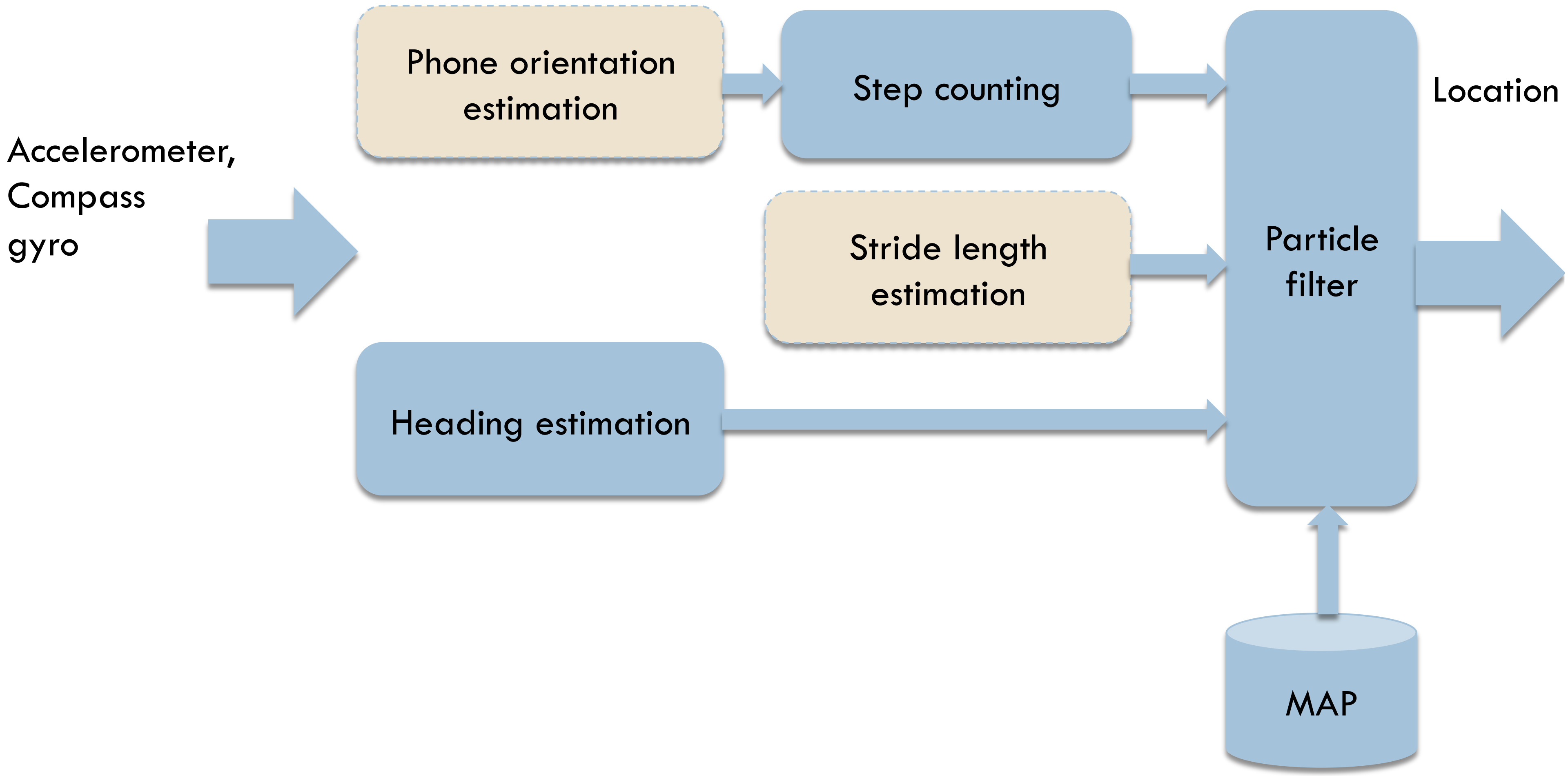
*Steven H. Collins and Arthur D. Kuo, Two independent contributions to step variability during over-ground human walking

**Valérie Renaudin*, Melania Susi and Gérard Lachapelle, Step Length Estimation Using Handheld Inertial Sensors

Issues

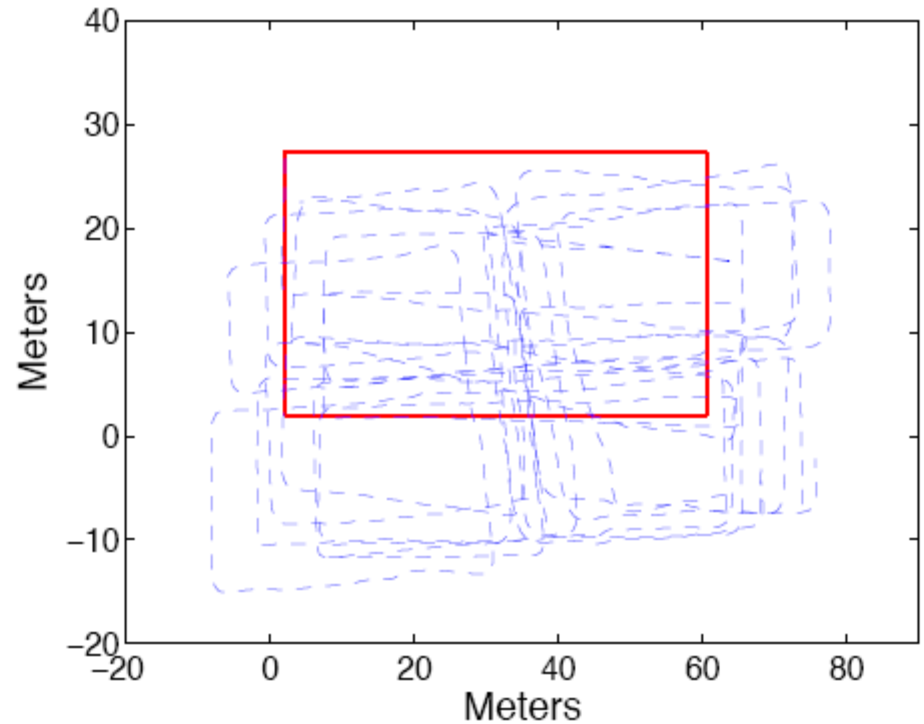
- Miscount (over/under-estimation) occurs
- Sensor placement (on the body) matters
- Stride length estimation may be inaccurate
- Healthy vs unhealthy subject
- Age and gender matters

Location estimation using inertial sensors



Challenges with inertial sensing

- Noise is cumulative
- Need to start from a known location



Hybrid approaches