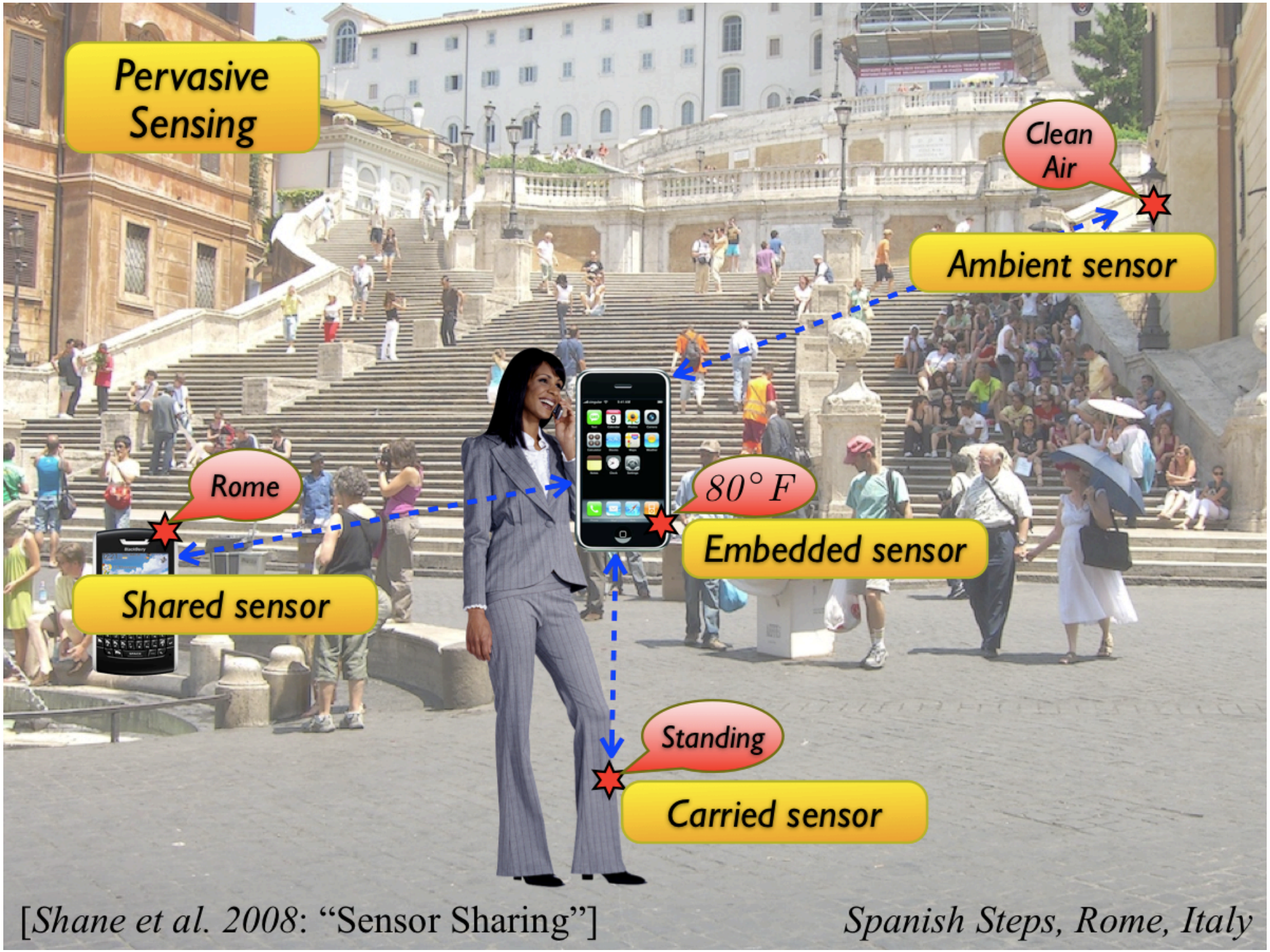
Mobile Sensing & Accelerometer

Mobile Computing

Minho Shin

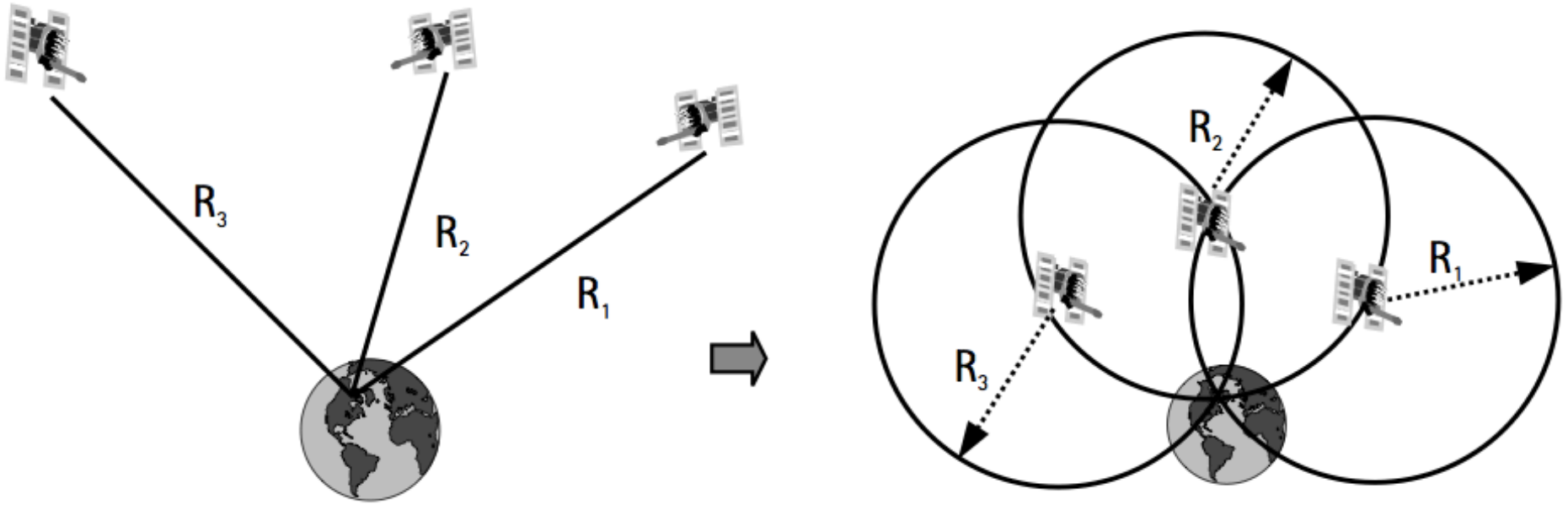
2012. 9

REVIEW: SENSORS


Pervasive Sensing
Clean Air
Ambient sensor
Rome
80° F
Embedded sensor
Shared sensor
Standing
Carried sensor
[Shane et al. 2008: "Sensor Sharing"]
Spanish Steps, Rome, Italy

How GPS works?

- Given distances of three (or more) satellites and their locations, calculate my position
  - Location: from the Navigation Message



GPS data

- Time: time information from atomic clocks
- Location:
  - Latitude (x coordinate)
  - Longitude (y coordinate)
  - Elevation
- Speed: your moving speed.
- Direction of travel: direction of travel if you're moving.

GPS: Pros & Cons

- Pros:
  - Free of service
  - Fairly accurate
- Cons
  - Energy starving
  - Outdoor only
  - No semantics

Quiz

- Explain four different types of physical sensors based on the location of sensors

Quiz

- Explain how GPS receiver can obtain its location
- What is the pros & cons of GPS technology?

9:41 AM
Messages
Calendar
Photos
Camera
YouTube
Stocks
Maps
Weather
Notes
Utilities
iTunes
App Store
Settings
Phone
Mail
Safari
iPod
Ambient light
Proximity
Dual cameras
GPS
Accelerometer
Dual microphones
Compass
Gyroscope

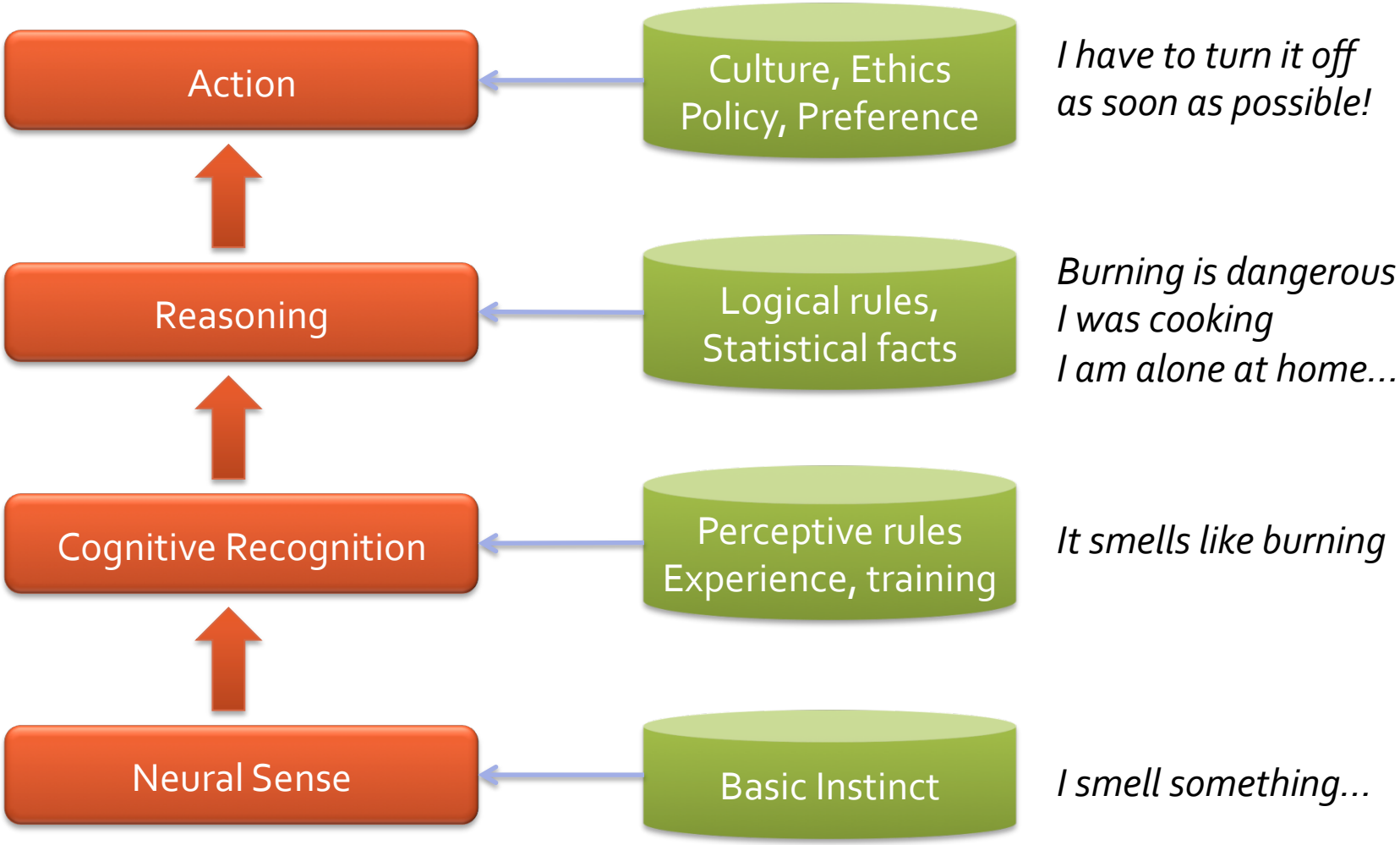
Sensor is useful

- Proximity
  - Disables screen when talking on the phone
- Accelerometer
  - Enlarge fonts when moving
- GPS
  - Notifies the user when approaching destination

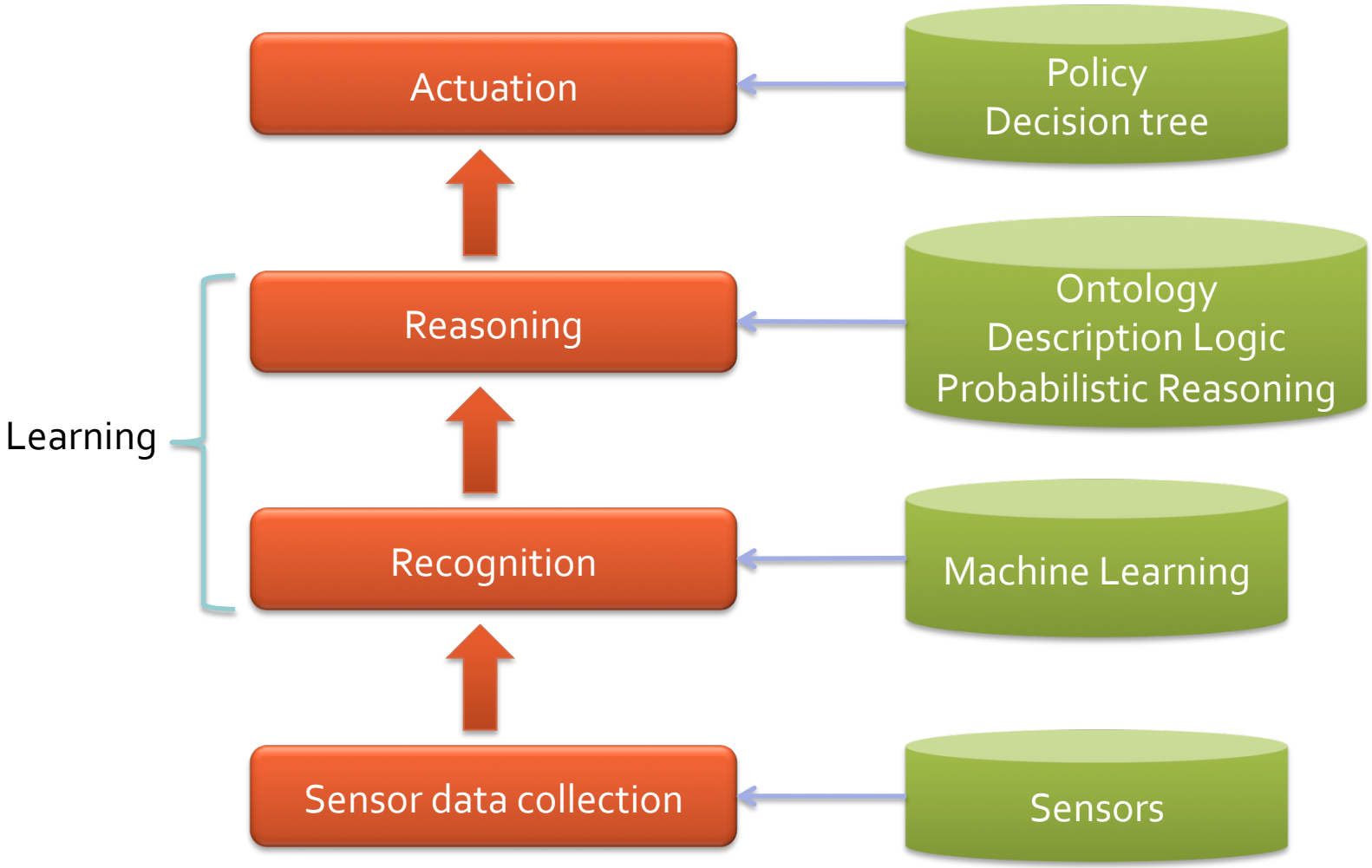
For more sophisticated services,

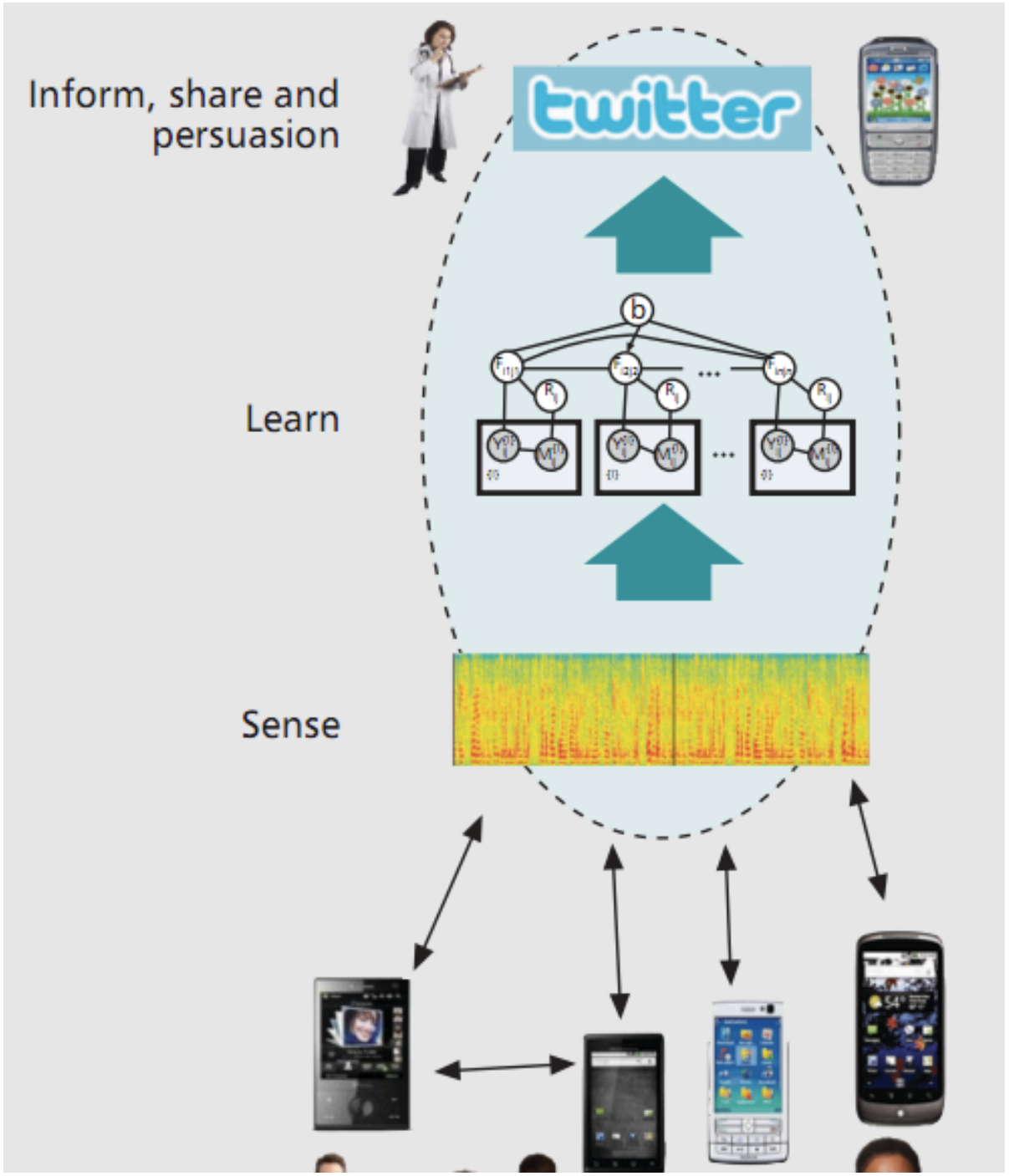
sensing is not enough

Data processing of Human



Data processing of HMC




Inform, share and persuasion
twitter
Learn
Sense

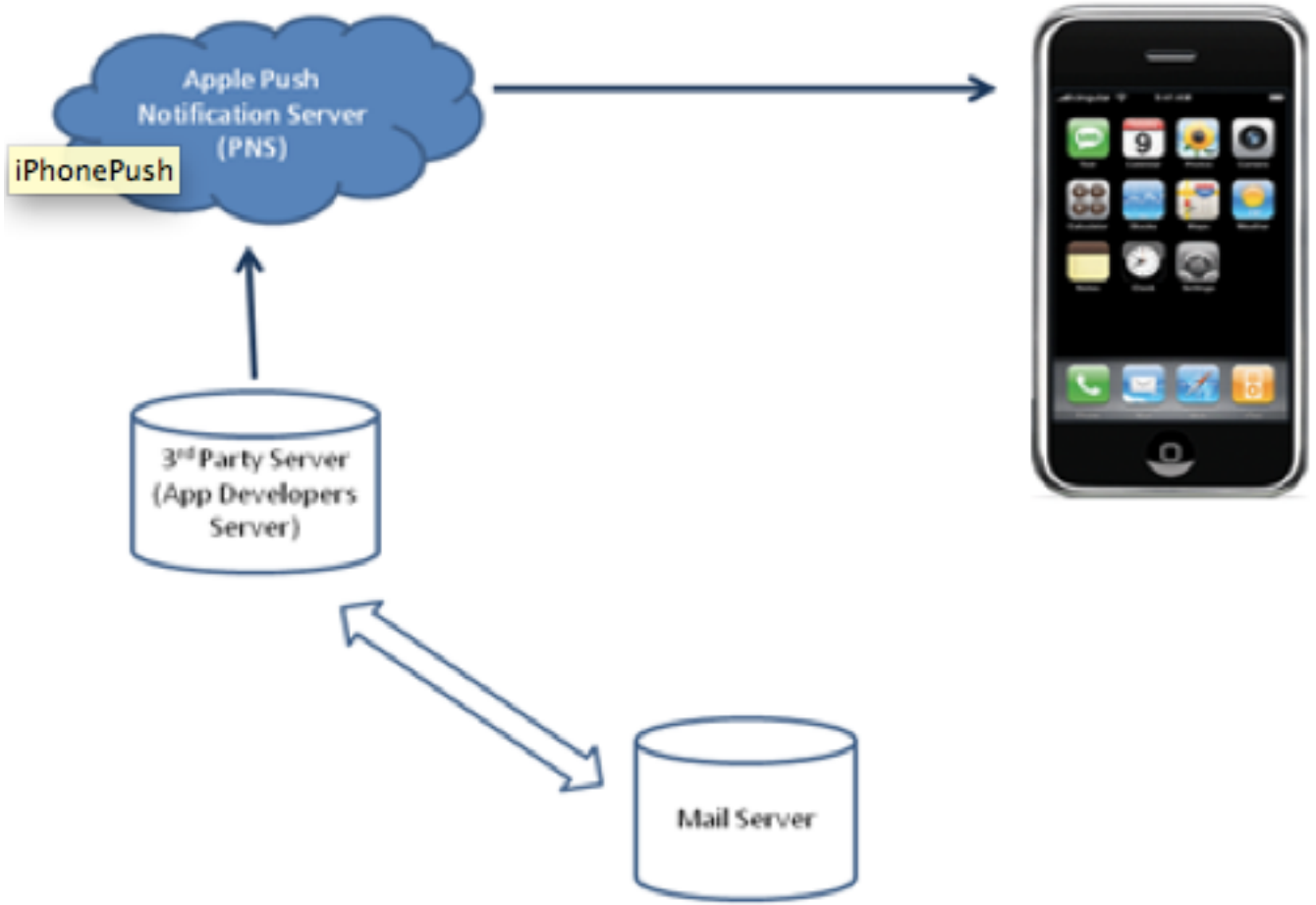
Challenges: Sensing

- Programmability
  - Most smartphones offer software development kits (SDK), APIs, and software tools
  - Lack of fine-grained sensor control
  - Lack of common sensing abstractions and APIs that could run on different platforms

Challenges: Sensing

- Continuous Sensing
  - Require multitasking and background processing
    - e.g., continuous accelerometer sampling

iPhone Push Service

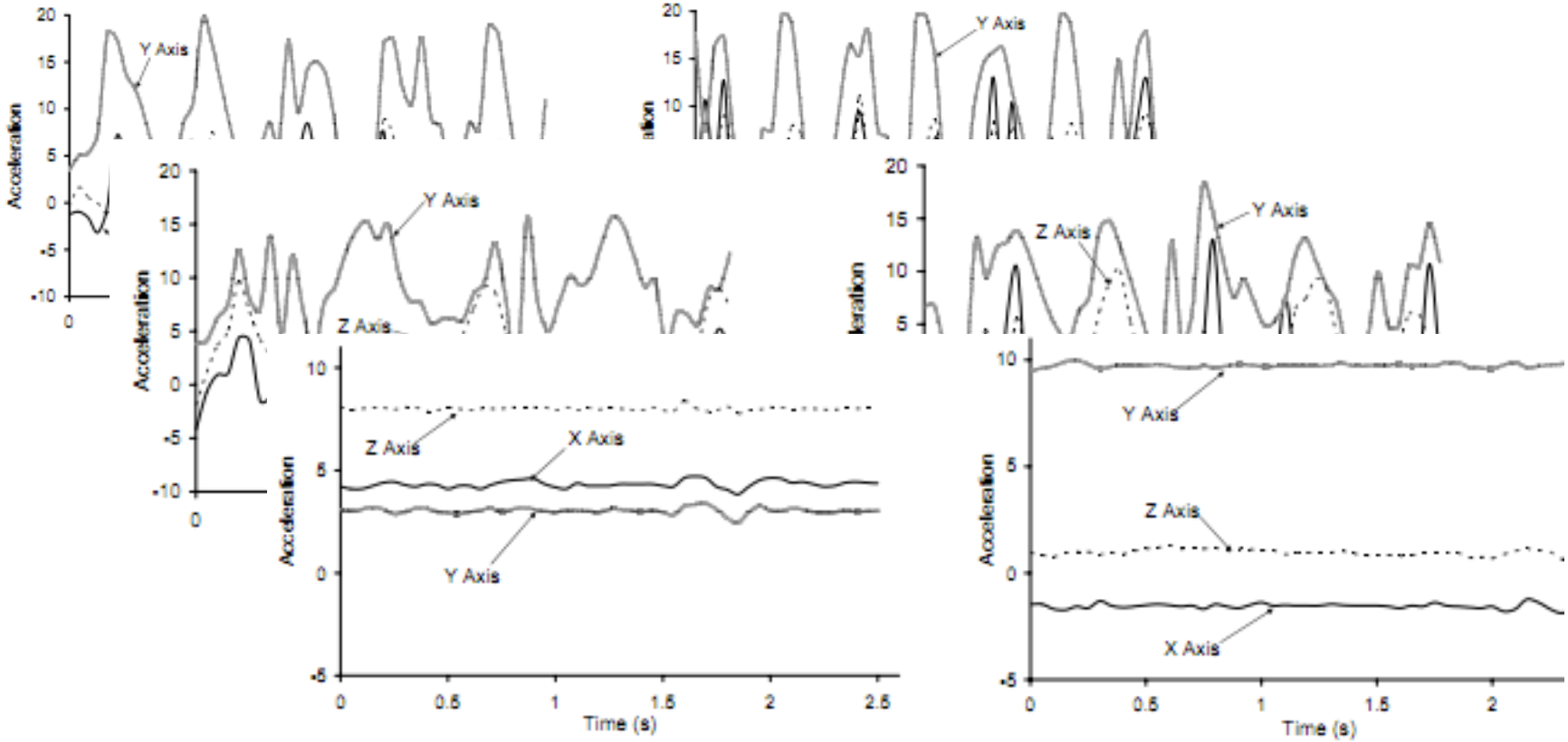


Challenges: Sensing

- Continuous Sensing
  - Require multitasking and background processing
    - e.g., continuous accelerometer sampling
  - Heavy computation load
    - Interpreting audio data
  - Energy consuming
    - GPS reading requires a lot of energy (20 hrs down to 6 hrs)
    - Cloud-helped sensing
    - Duty cycling
    - Special processor architecture for continuous sensing (by Microsoft)

Challenges: Learning

- Raw sensor data is worthless without interpretation

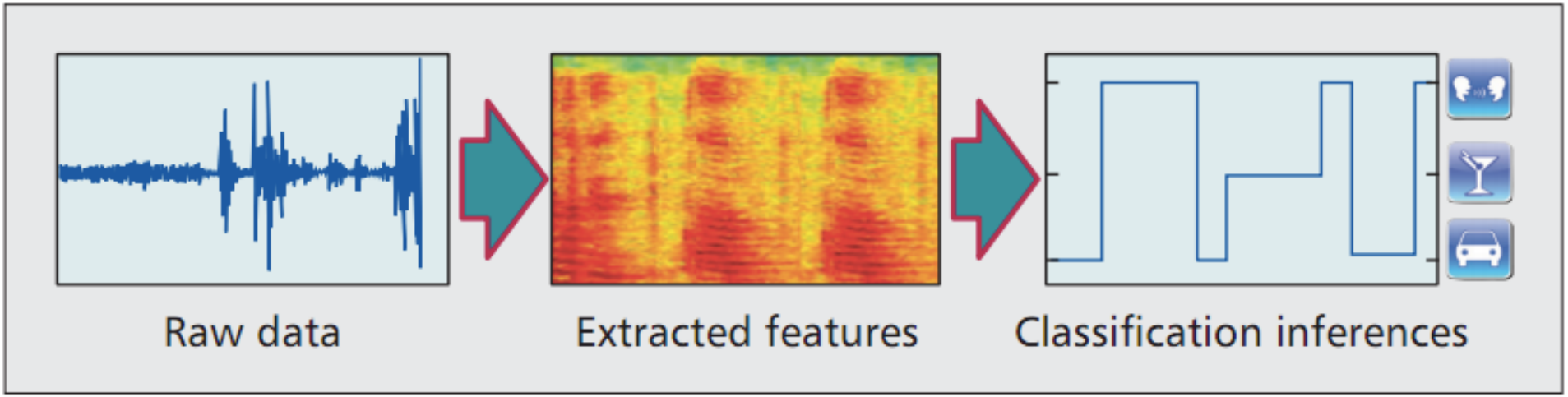


Challenges: Learning

- How can a mobile phone interpret human behavior from low-level sensor data?
  - Supervised Learning

Supervised Learning

- Modeling → Training → Testing
- Modeling: decide a statistical model
- Training: Learn model parameters from training data
- Testing: Apply this model to the real data



Supervised Learning

- Modeling → Training → Testing
- Modeling: decide a statistical model
- Training: Learn model parameters from training data
- Testing: Apply this model to the real data
- Data labeling
  - Supervised: all data is labeled
  - Semi-supervised: some data is labeled
  - Unsupervised: no data is labeled

Improving Learning

- Multimodal sensing
  - Use different types of sensors to learn a situation
  - Microphone, Accelerometer, GPS can infer more complex human behavior
- Active learning
  - selectively queries the user for labels
- Social network
  - combine learning procedure based on social network
- Community-guided learning
  - combines data similarity and crowd-sourced labels

Use of mobile sensing

- Sharing
  - Social networking provides attractive ways to share sensed information
  - *Nike+*
- Personalization
  - Voice recognition
  - Monitor daily activities, profile preferences/behavior
  - Personalized recommendation

Use of mobile sensing

- Persuasive technology
  - persuades user to make positive behavioral changes
  - (nudge users to exercise more, smoke less)
  - Befit Garden, UbiGreen
  - Community persuasion (Carbonrally.com)
  - Exploit social network
    - Game, Competition, Feedback
    - PatientsLikeMe.com

ACCELEROMETER

AT&T
9:42 AM
RED HOT CHILI PEPPERS
STADIUM ARCADIUM
Red Hot Chili Peppers
Dani California
Stadium Arcadium

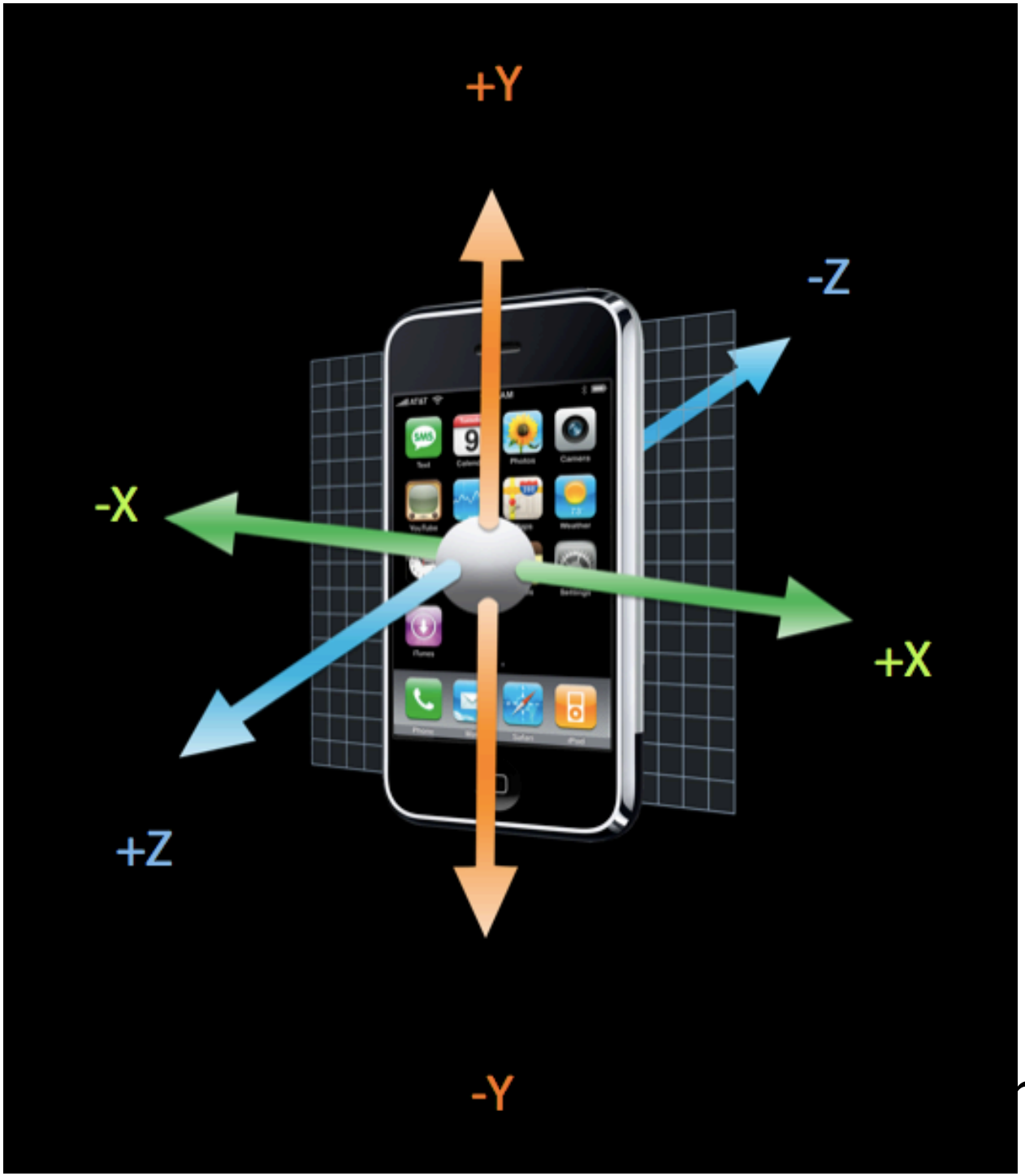
Introducing
iRaptor 3Gs Android
The Raptor iPhone
Playing Accelerometer 3D Racing Game
Find us on Facebook

What is Acceleration?

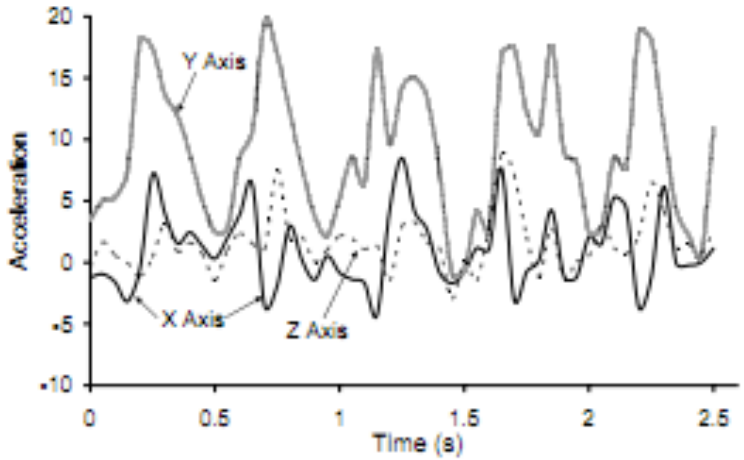
- Acceleration
  - The time rate of change of velocity
  - The time rate of change of the time rate of change of distance
- Unit
  - m/s/s, m/s^2
  - g: multiple of the acceleration equal to Earth's gravity at sea level
  - negative value: the opposite direction

What is accelerometer?

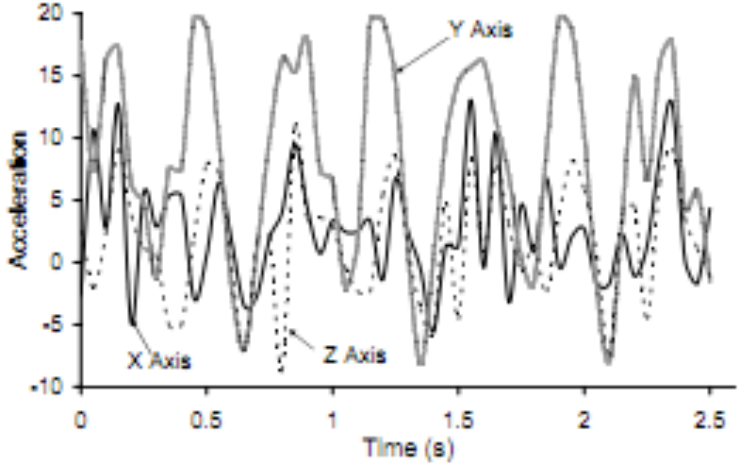
- An electromechanical device that measures acceleration
  - Static: gravity
  - Dynamic: moving, shaking, vibrating…
- Used for
  - Tilt: check the direction of the gravity
  - Acceleration to a particular direction
    - IBM/Apple use accelerometer to protect hard disk from scratch when falling
    - Launch an air bag in a car



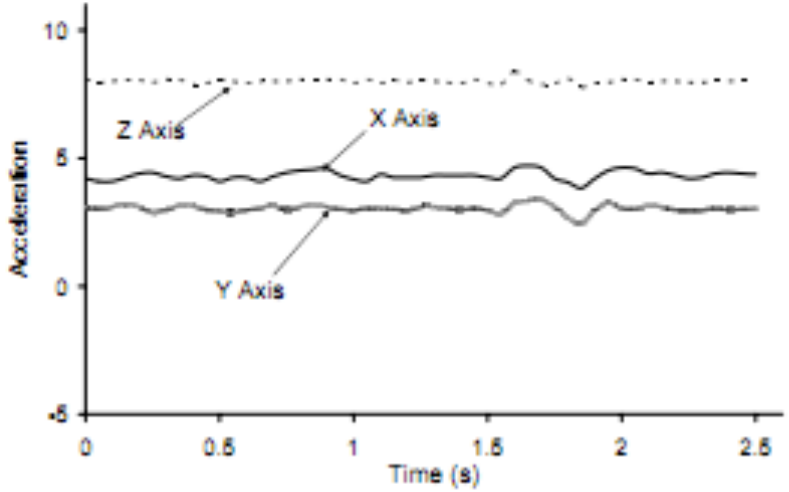
rometer



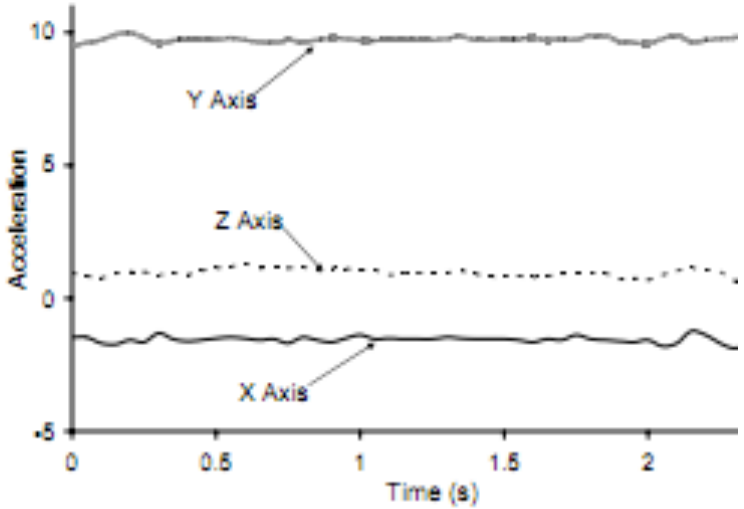
(a) Walking



(b) Jogging



(e) Sitting



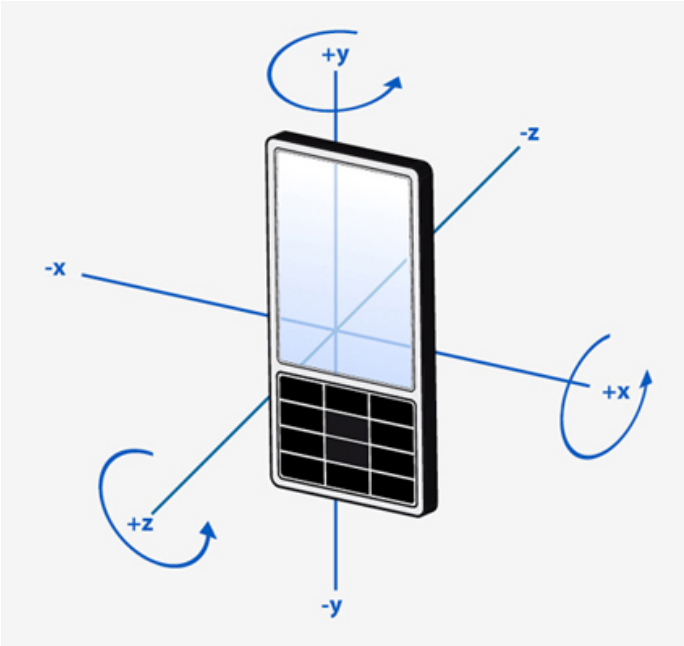
(f) Standing

What is Gyroscope?

- Gyroscope is a toy, which maintains the direction while the wheel spins
- Video
- Used for detecting an attempt to tilt
  - Aircraft
  - Helicopter

What is Gyroscopic sensor?

- Measures the rotational movement around the three axes
- Combined with accelerometer, it senses detailed orientation
- Accel. vs Gyroscope
- Gyroscope & iPhone

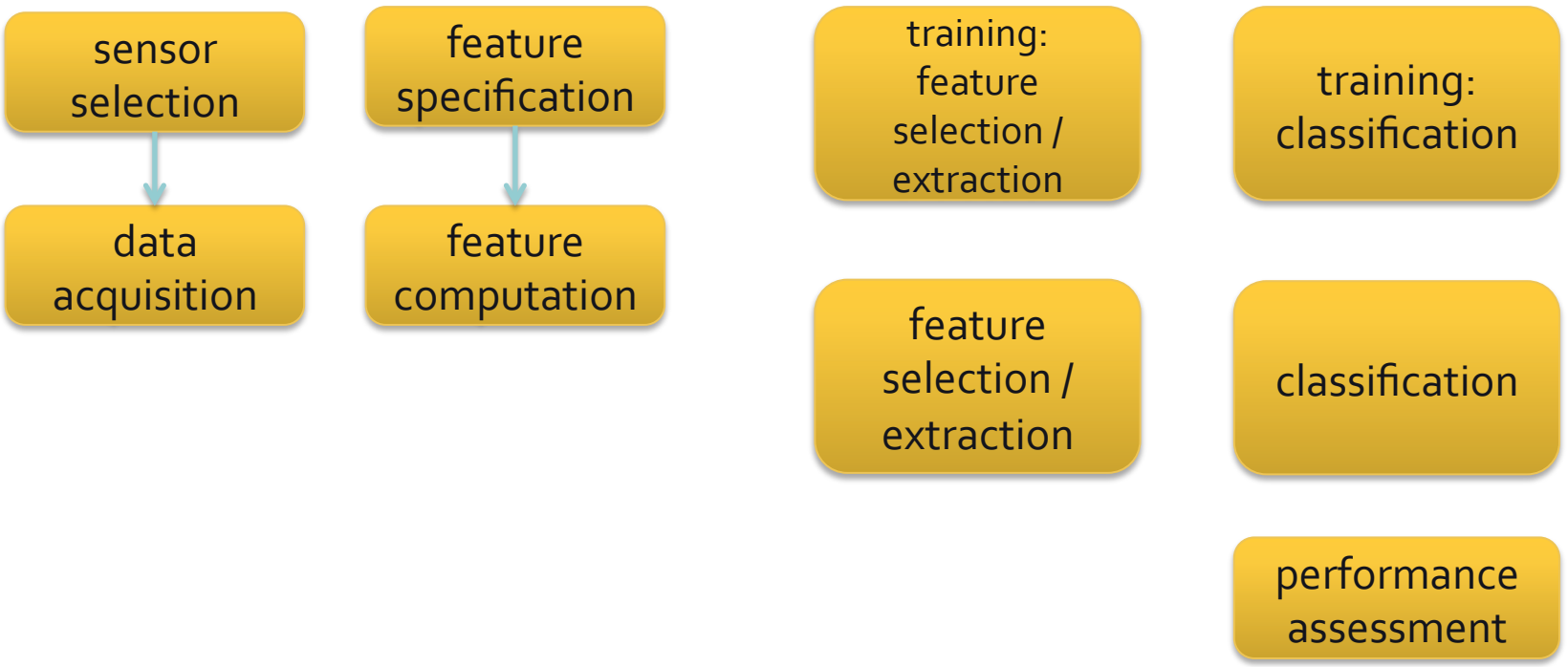


What can we do with accelerometer?

- Activity recognition
- Transportation recognition

Activity Recognition

- Physical activity
  - static posture: standing, sitting, lying
  - dynamic motions: walking, running, stair climbing, cycling
- Useful for
  - Bio-medical
    - metabolic energy expenditure
    - rehabilitation engineering: walking aid
  - Contextual knowledge
    - Human-computer interaction
    - Behavior prediction

Classification with supervised learning

- Classification: determine the type of activity