BMI 500: mHealth informatics

Gari Clifford

Associate Prof. @ Emory (BMI) / GATech (BME)

Interim Chair BMI

Honorary Professor, University of Oxford

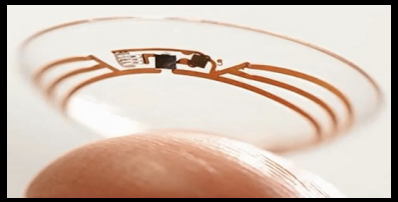
Adjunct Prof., Morehouse School of Medicine

Distinguished Guest Prof., Tsinghua Univesrity

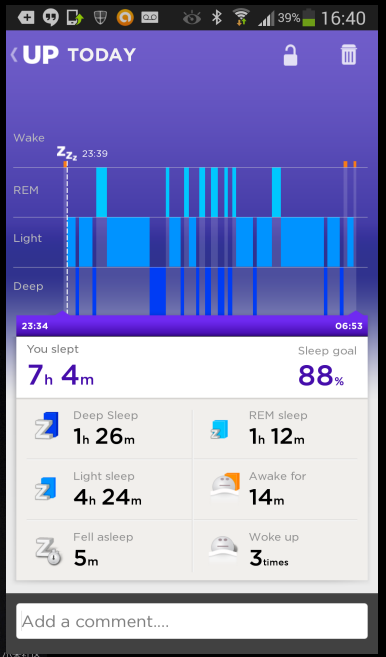
Deputy Editor, Journal of Physiological Measurement, Institute of Physics.

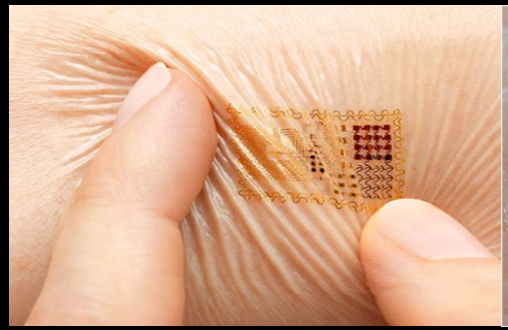
mHealth taxonomy

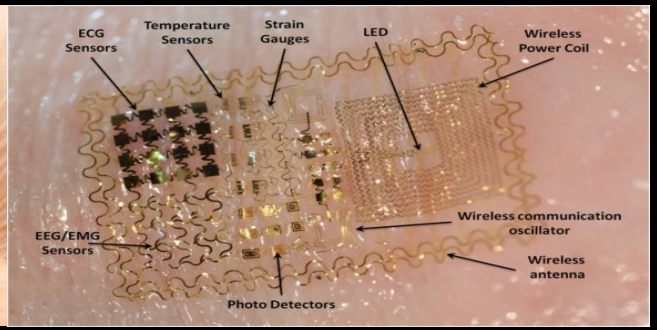
- Low hanging fruit (limited)
  - Text message reminders (not particularly effective)
  - Surveys
  - Making a standard device wirelessly connect to your phone (e.g. glucometer, BP cuff) to track data
- Taking advantage of the phone
  - Using onboard sensors (microphone for snoring, accelerometer for movement, video camera for sleep)
- Adding sensors designed for the phone
  - ECG (arrhythmias), lenses (cataracts), location bands (Alzheimer's), contact lenses (diabetes), smart pills (compliance) …



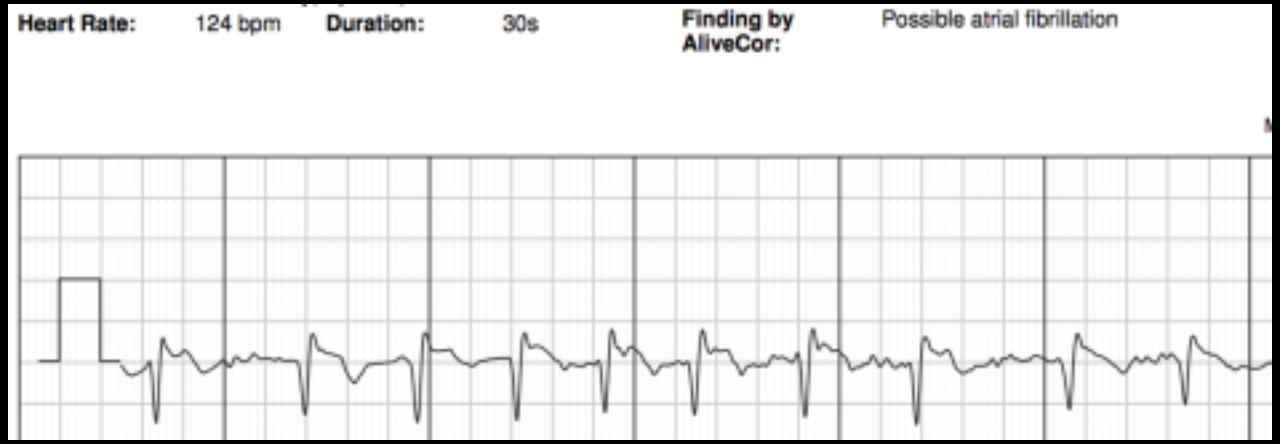
The Next Generation of Wearables







How do we use this information to detect changes in health?



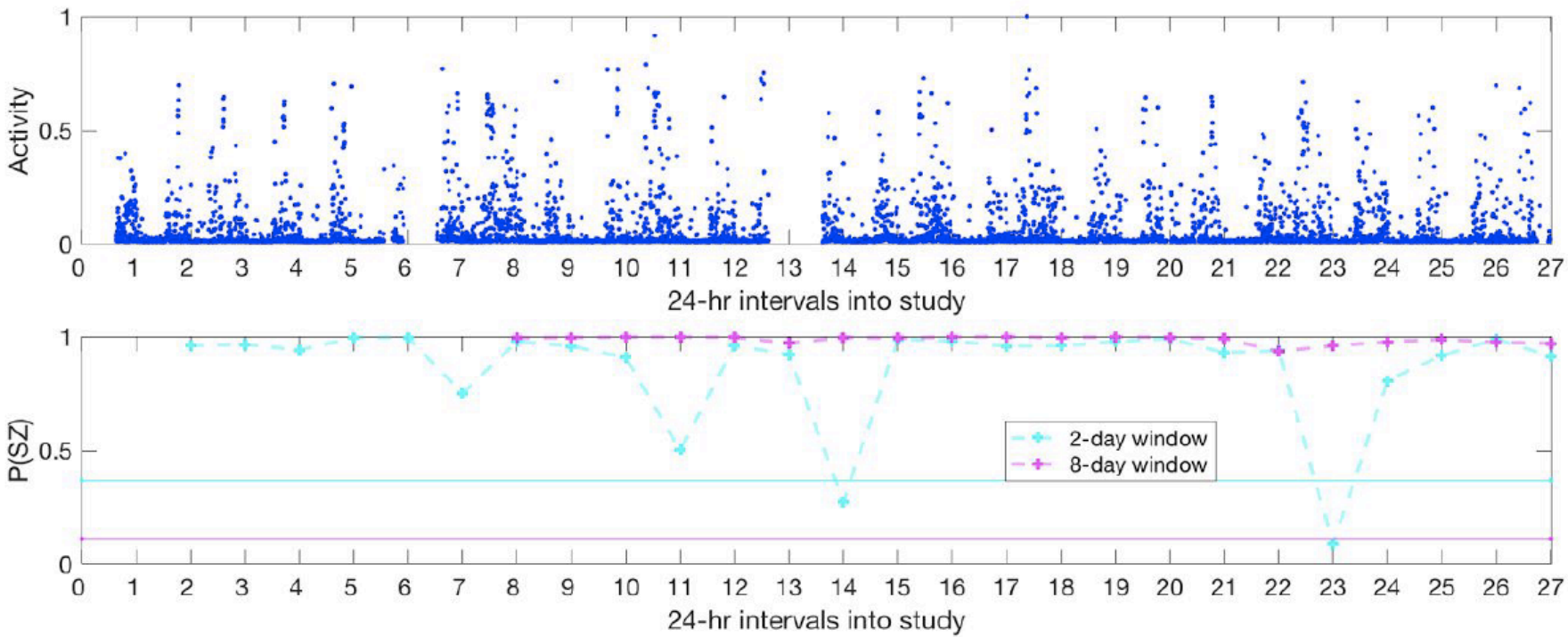
J Ment Health. 2015;24(5):276-82. doi: 10.3109/09638237.2015.1019048. Epub 2015 Jul 20.

Objective identification and analysis of physiological and behavioral signs of schizophrenia.

Osipov M[1], Behzadi Y[2], Kane JM[3], Petrides G[3], Clifford GD[1].

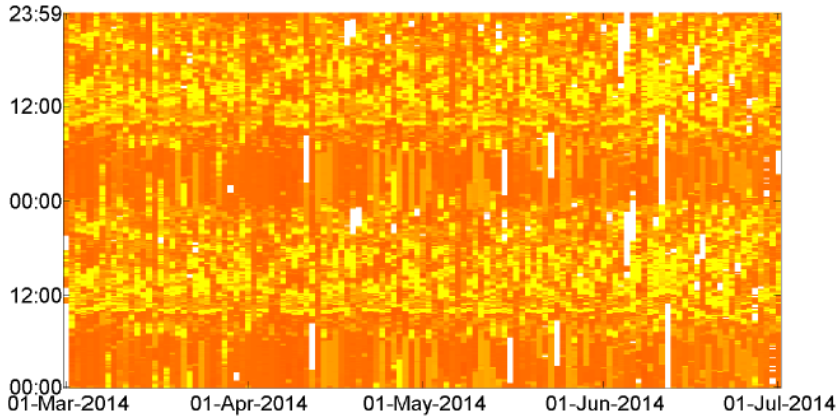
⊕ Author information

Abstract

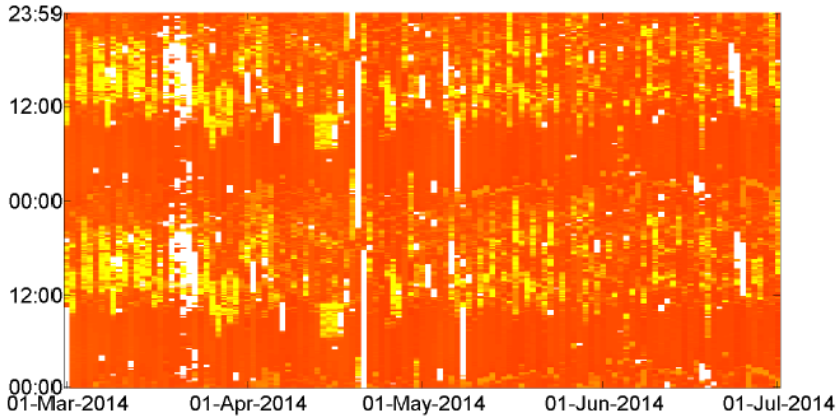


What about other mental health issues?

Borderline personality disorder …

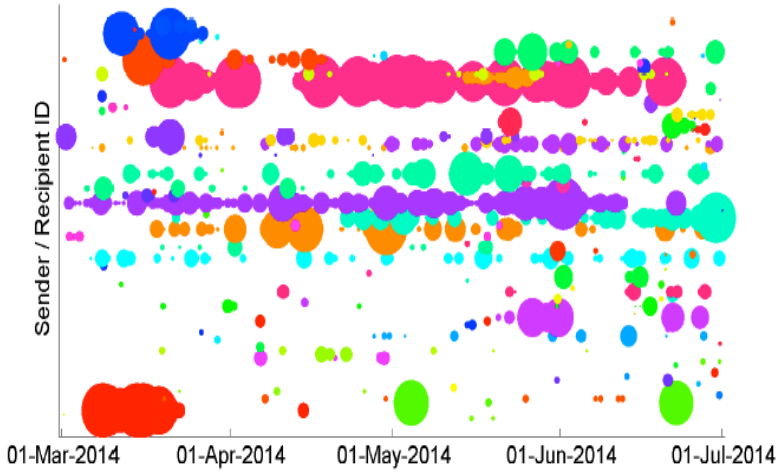


(a) Actigraphy levels (healthy control).

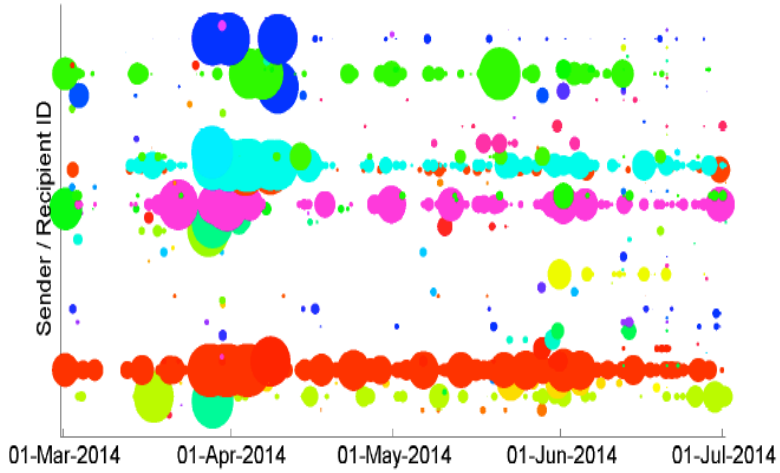


(b) Actigraphy levels (borderline personality disorder).

Bipolar Patients ….



(c) Social network activity levels by contact (healthy control).

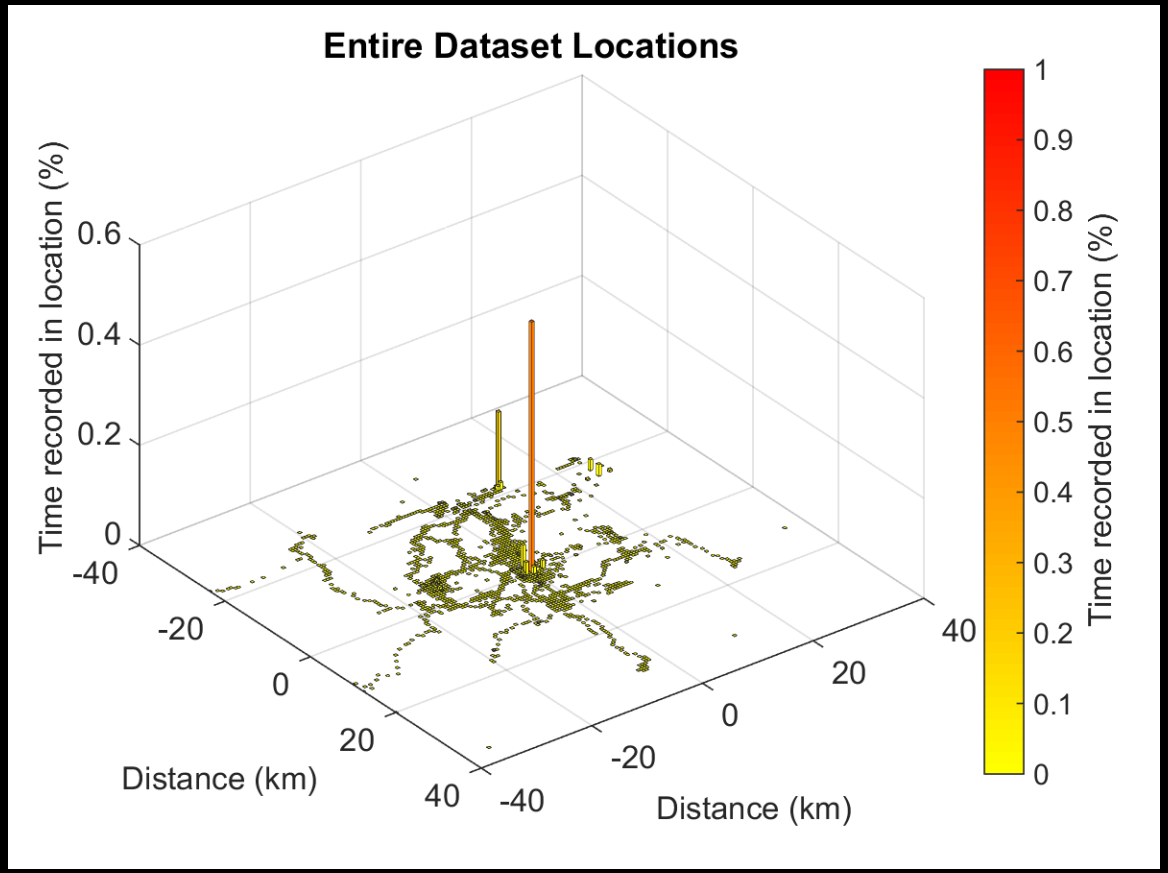


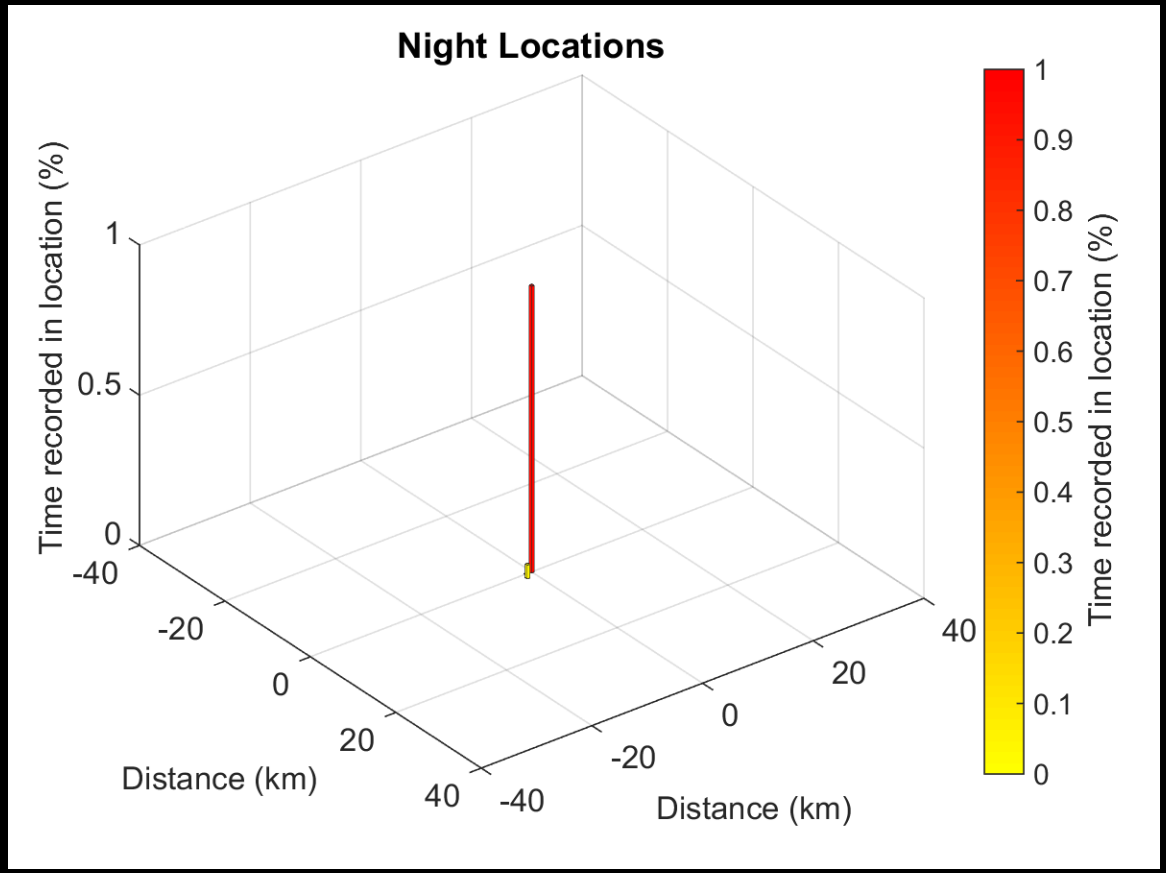
(d) Social network activity levels by contact (bipolar).

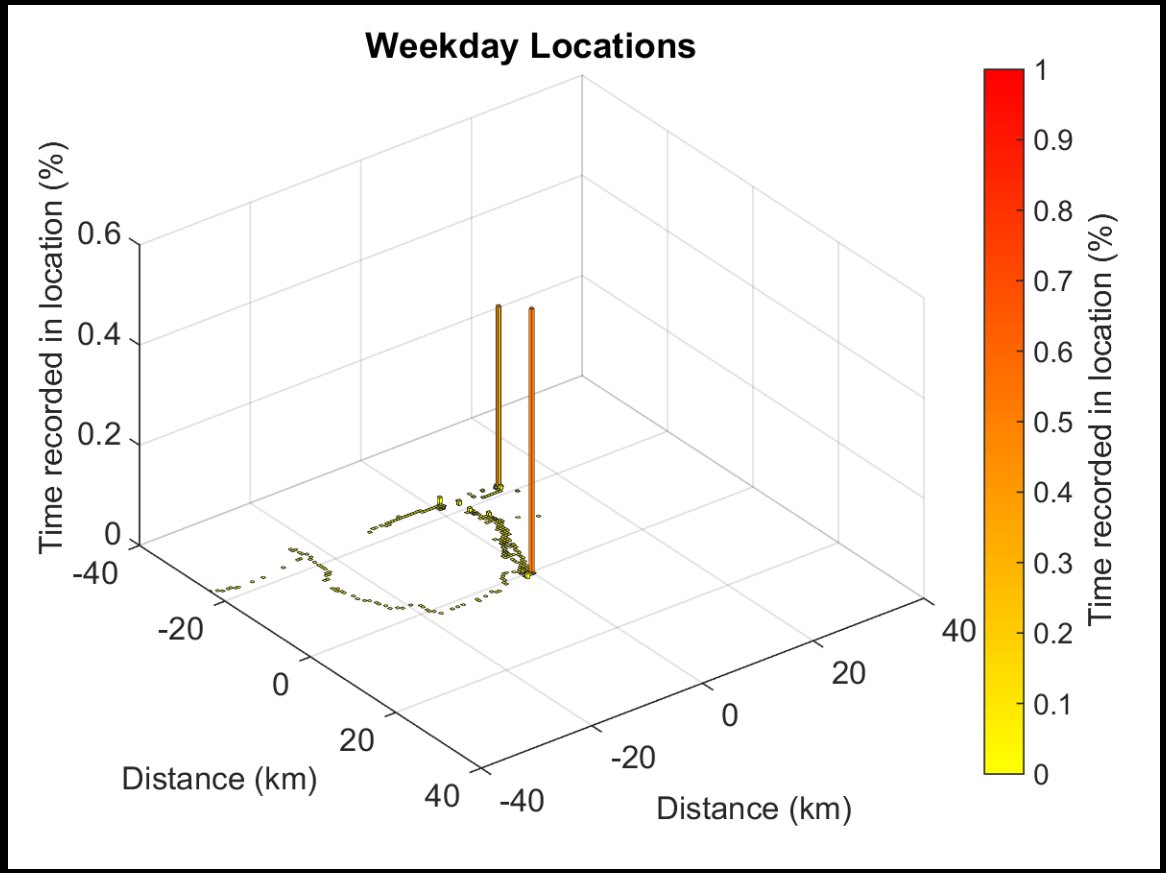
↑social network & ↓activity = physical illness

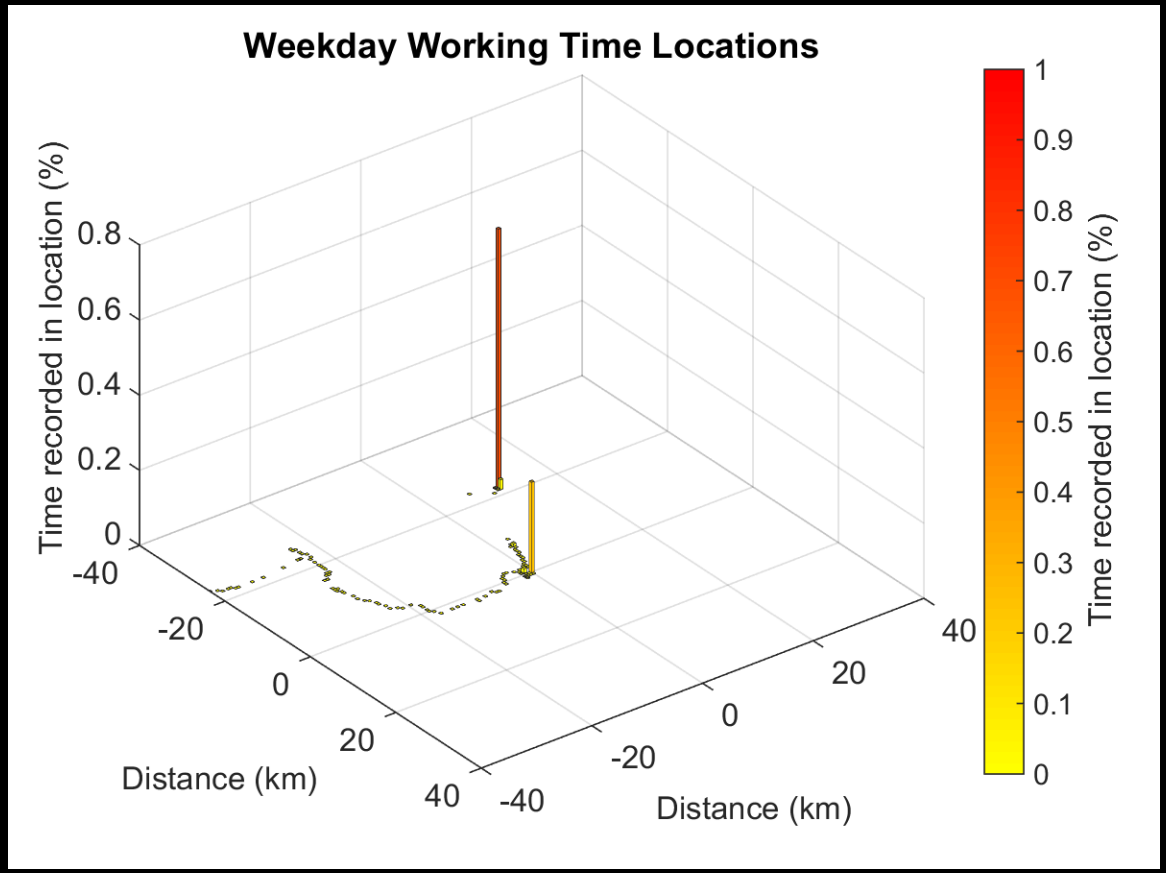
↓social network & ↓activity = mental illness

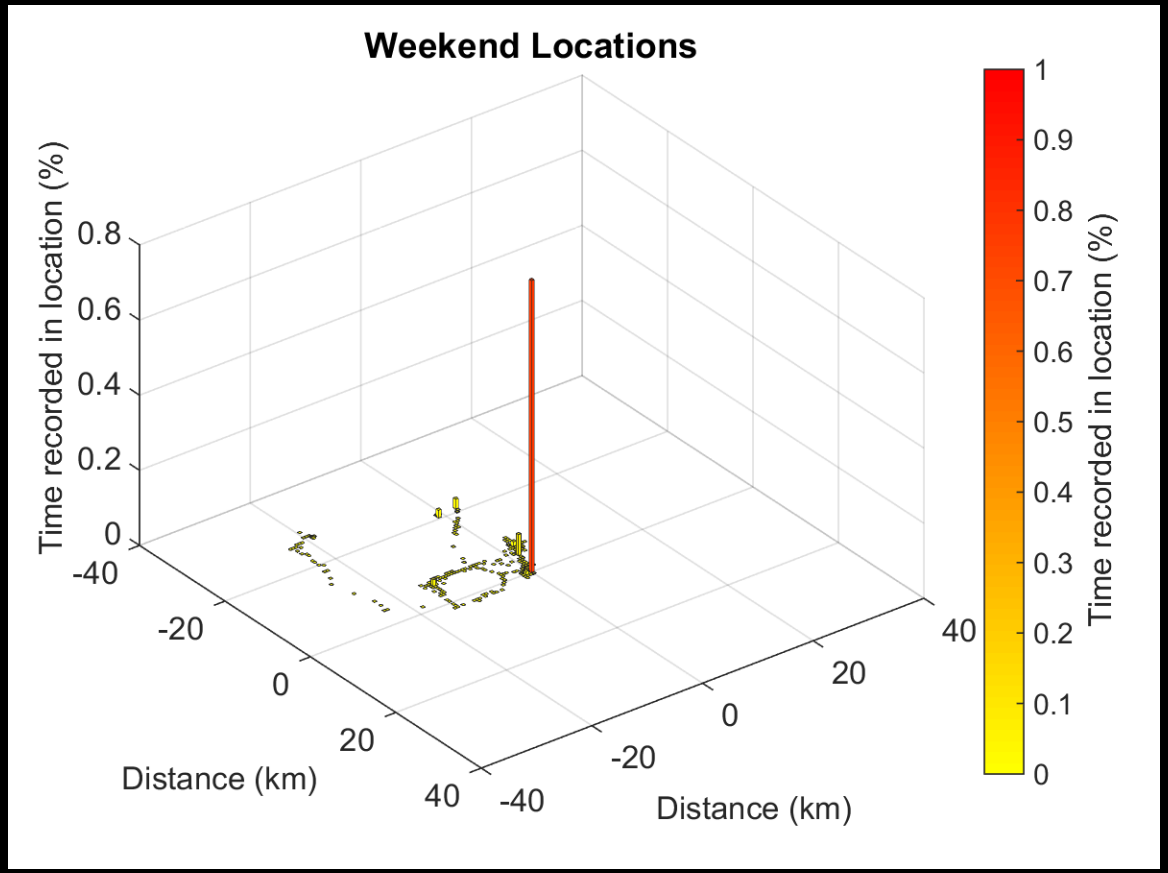
Location: Context is essential




Night Locations
Time recorded in location (%)
1
0.5
0
-40
-20
0
20
40
Distance (km)
-40
-20
0
20
40
Distance (km)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Time recorded in location (%)

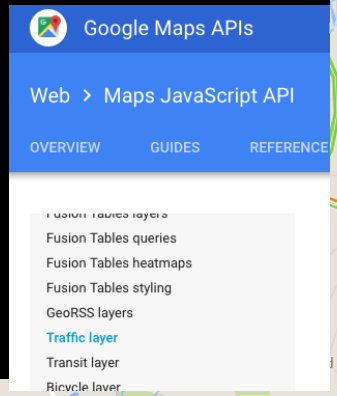

Weekday Locations
Time recorded in location (%)
0.6
0.4
0.2
0
-40
-20
0
20
40
Distance (km)
-40
-20
0
20
40
Distance (km)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Time recorded in location (%)

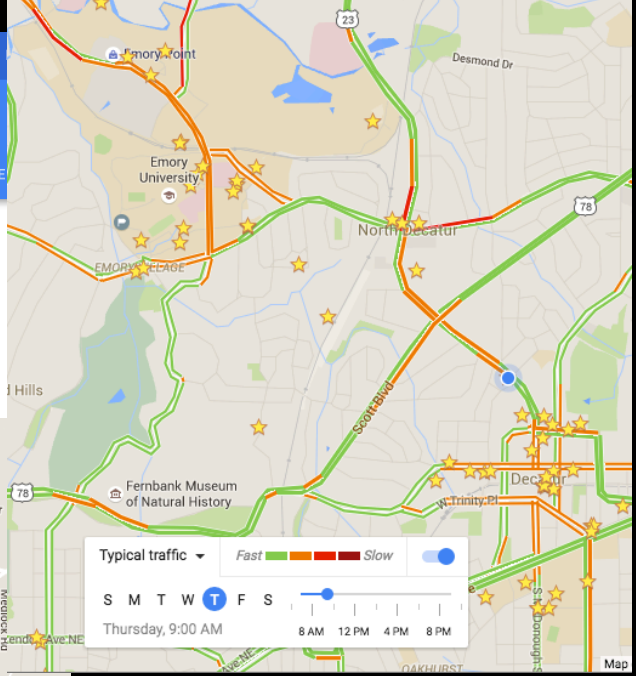

Weekday Working Time Locations
Time recorded in location (%)
0.8
0.6
0.4
0.2
0
-40
-20
0
20
40
Distance (km)
-40
-20
0
20
40
Distance (km)
Time recorded in location (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

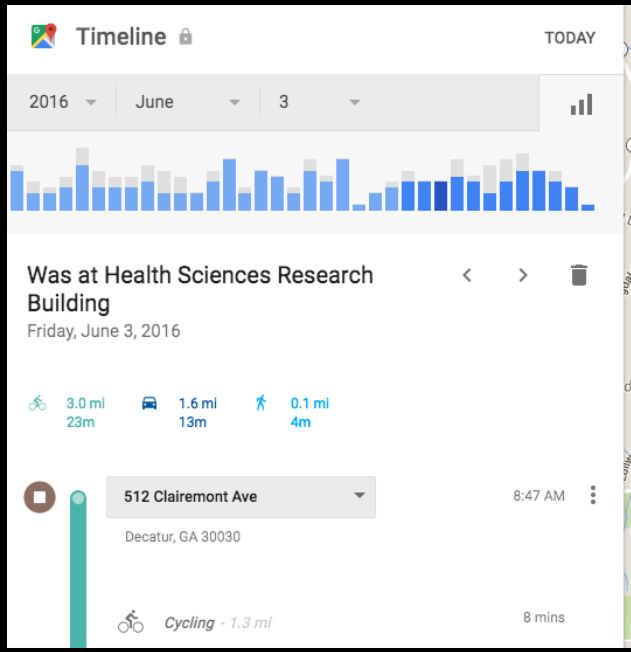

Weekend Locations
Time recorded in location (%)
0.8
0.6
0.4
0.2
0
-40
-20
0
20
40
Distance (km)
-40
-20
0
20
40
Distance (km)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Time recorded in location (%)

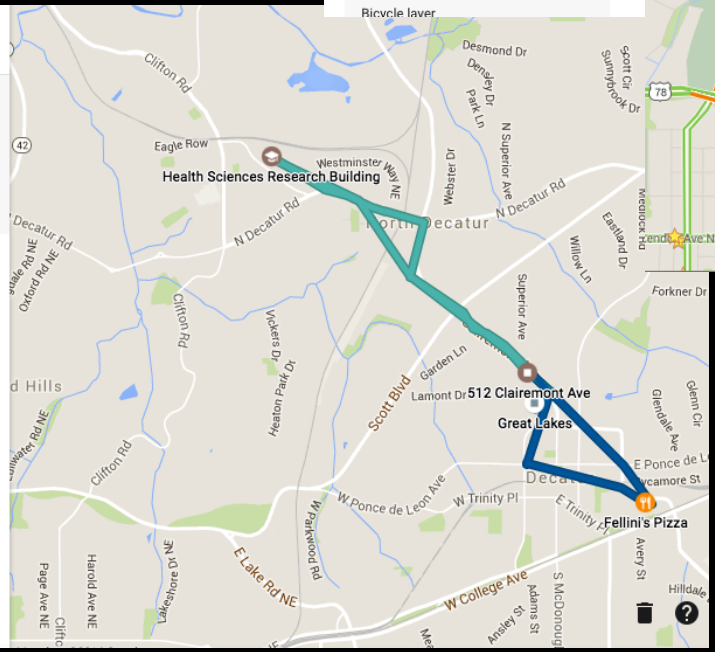
Can Google help?

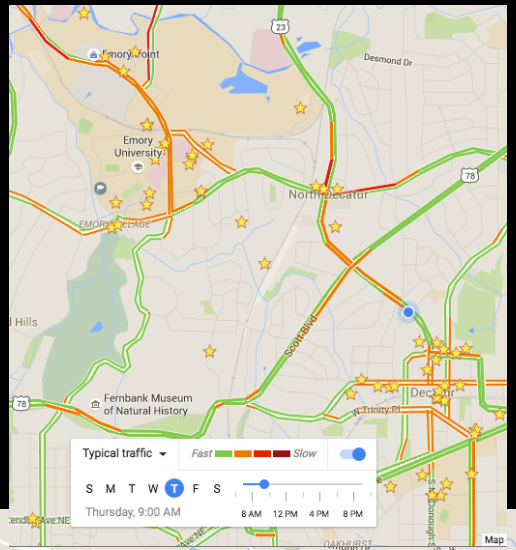
www.google.com/maps/timeline

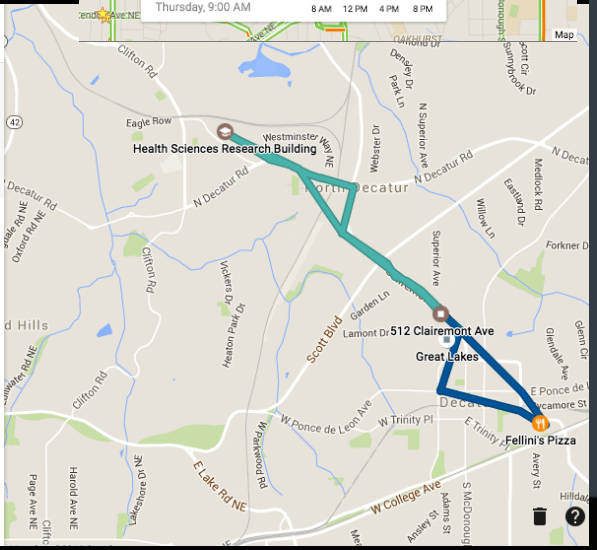


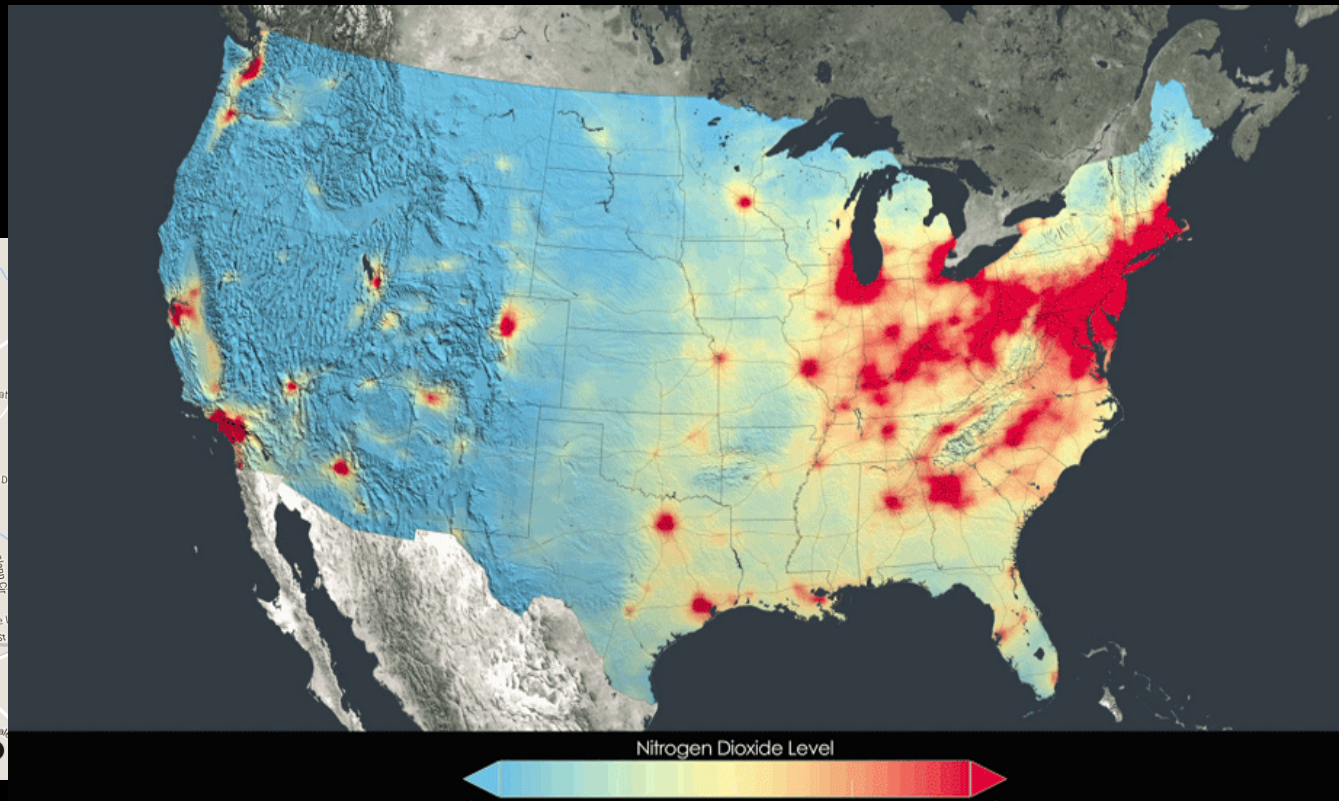







Emory University
Desmond Dr
North Decatur
Scott Blvd
Fernbank Museum of Natural History
Typical traffic
Fast
Slow
S M T W T F S
Thursday, 9:00 AM
8 AM
12 PM
4 PM
8 PM
Map


Health Sciences Research Building
Eagle Row
Westminster Way NE
N Decatur Rd
North Decatur
Clifton Rd
Scott Blvd
Lamont Dr
512 Clairemont Ave
Great Lakes
Fellini's Pizza
W Ponce de Leon Ave
W Trinity Pl
E Lake Rd NE
W College Ave


Nitrogen Dioxide Level

The Future is now: ‘Big’ *mHealth* …

Use physiology patches and actigraphy meters –

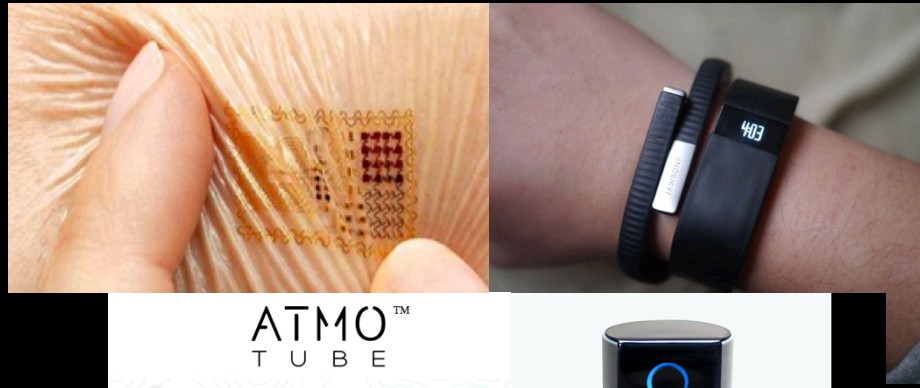
- Jawbone, Simband, Pebble, etc

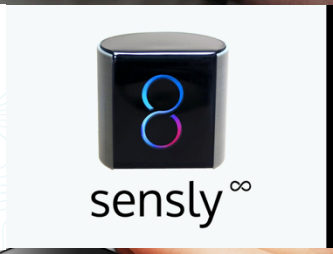
Natural behavioral data scraping

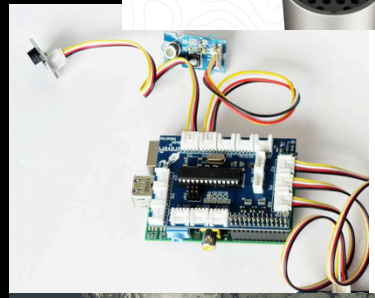
- Smartphone (accelerometer, gyro, GPS, SMS)
- Telecom records (H1N1)

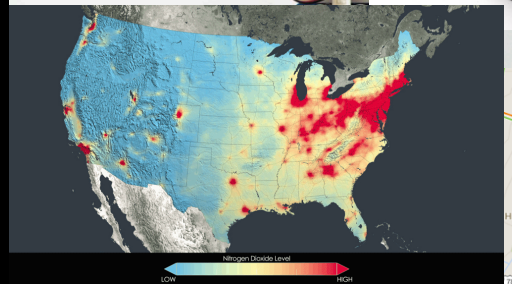
‘Off body’ sensors

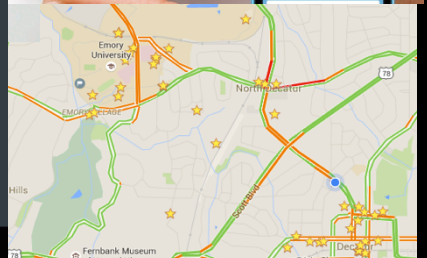
- Video cameras – sleep, gait, activity
- ‘Exposomes’ – Pollution from sensors
- Google – Traffic exposure, activity, food deserts?
- Satellite data - Pollution





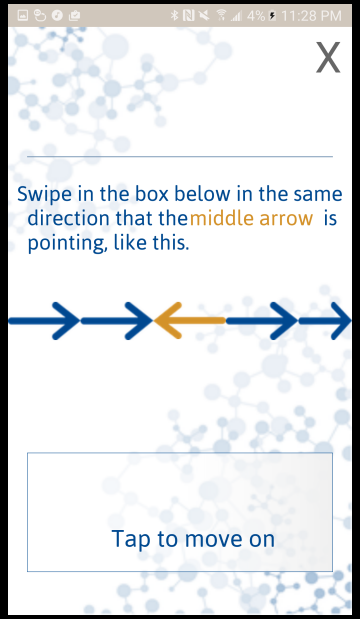


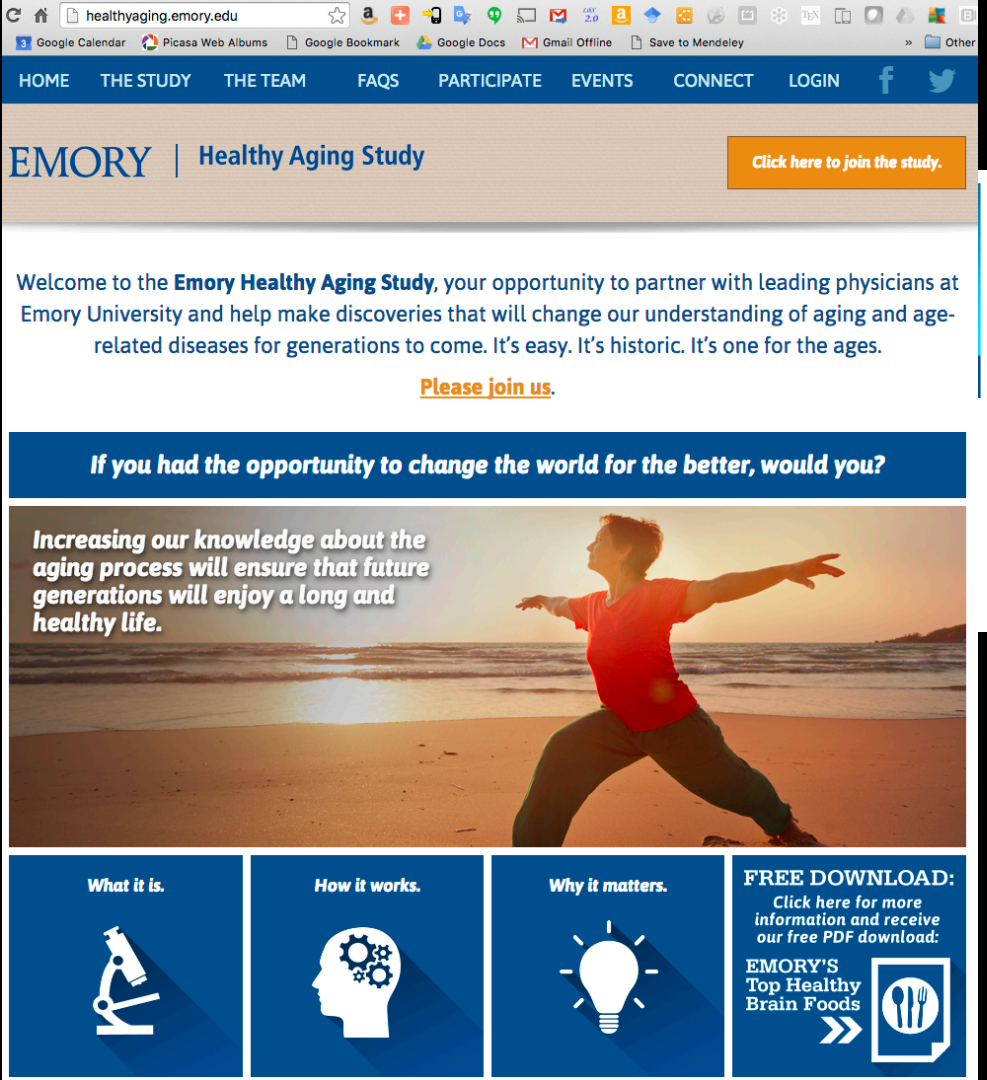




Healthy Aging Study

- 100,000 patients …



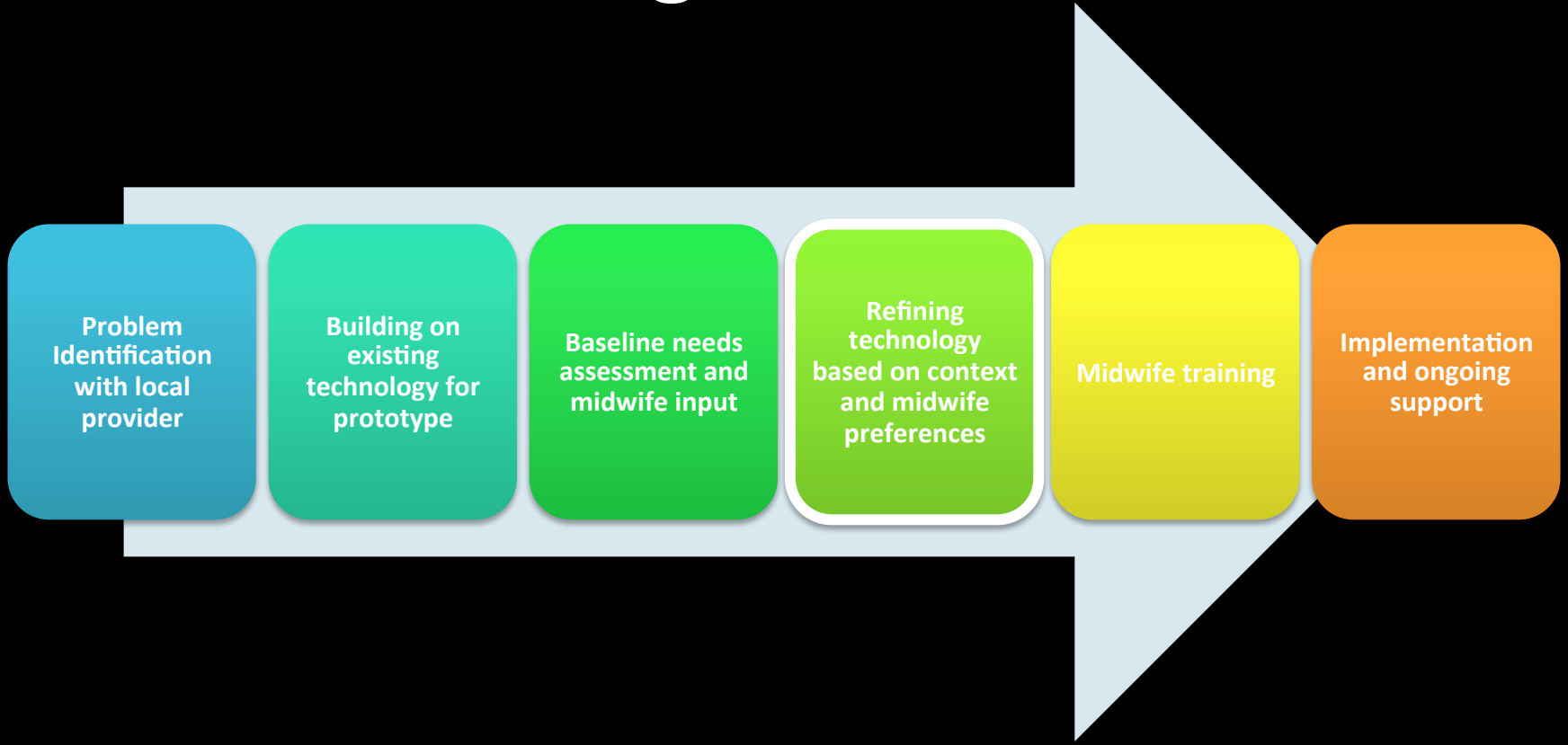


But … Issues for healthcare technology efficacy

1. Unreliable/costly supply chains & infrastructure
2. Information is not portable
3. Compliance
   - Lack of evaluation in long term
   - Humans like recreation, not health

4. High false positive rate inherent in medicine: not scalable
   - High FP rate will overwhelm healthcare system
5. Humans are fallible (medical errors ~ 20%)

Design Process



The mHealth Lab

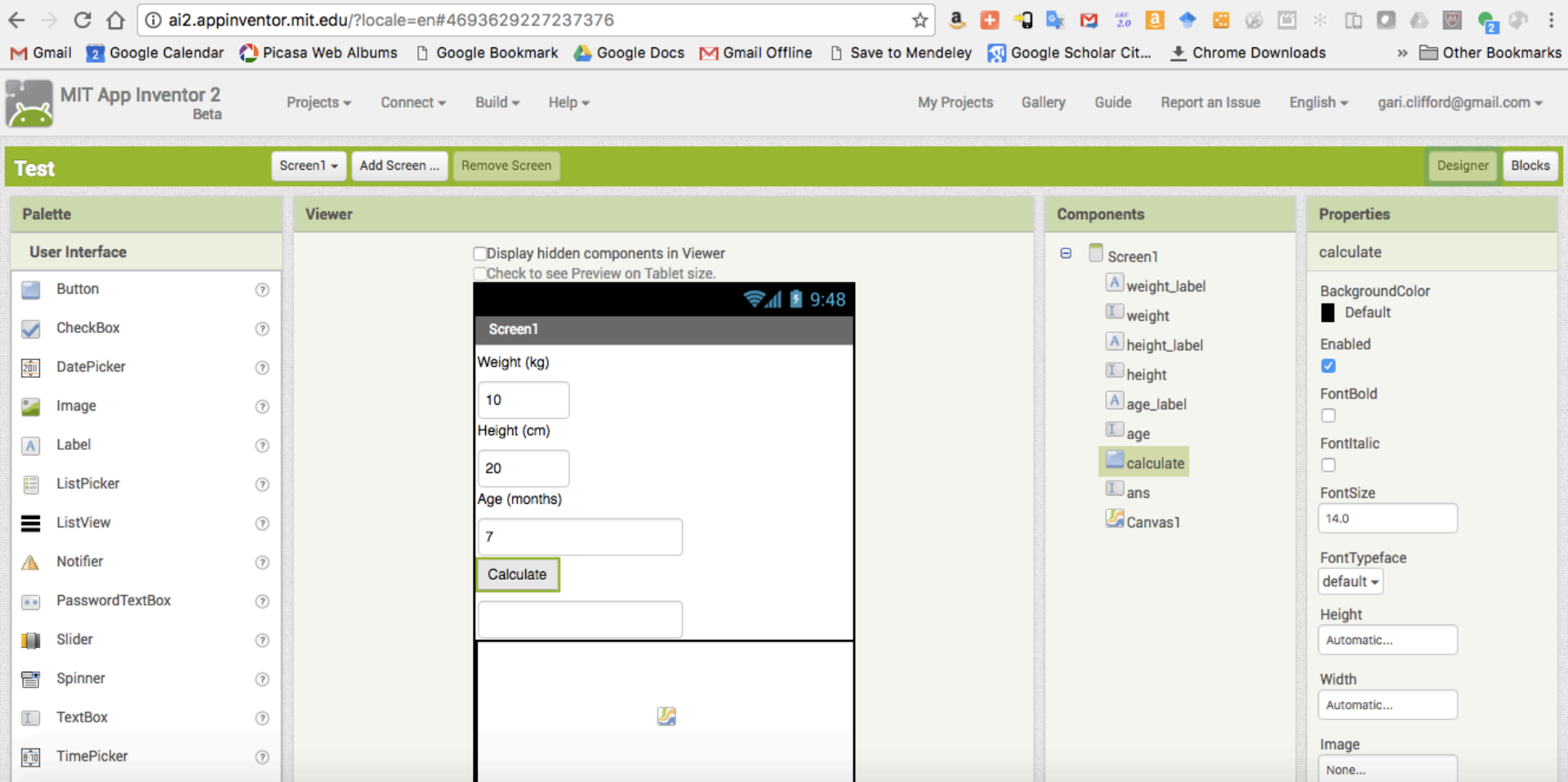
- http://appinventor.mit.edu/explore/sites/all/themes/appinventor/logo.png
  http://appinventor.mit.edu/explore/about-us.html

http://ai2.appinventor.mit.edu/

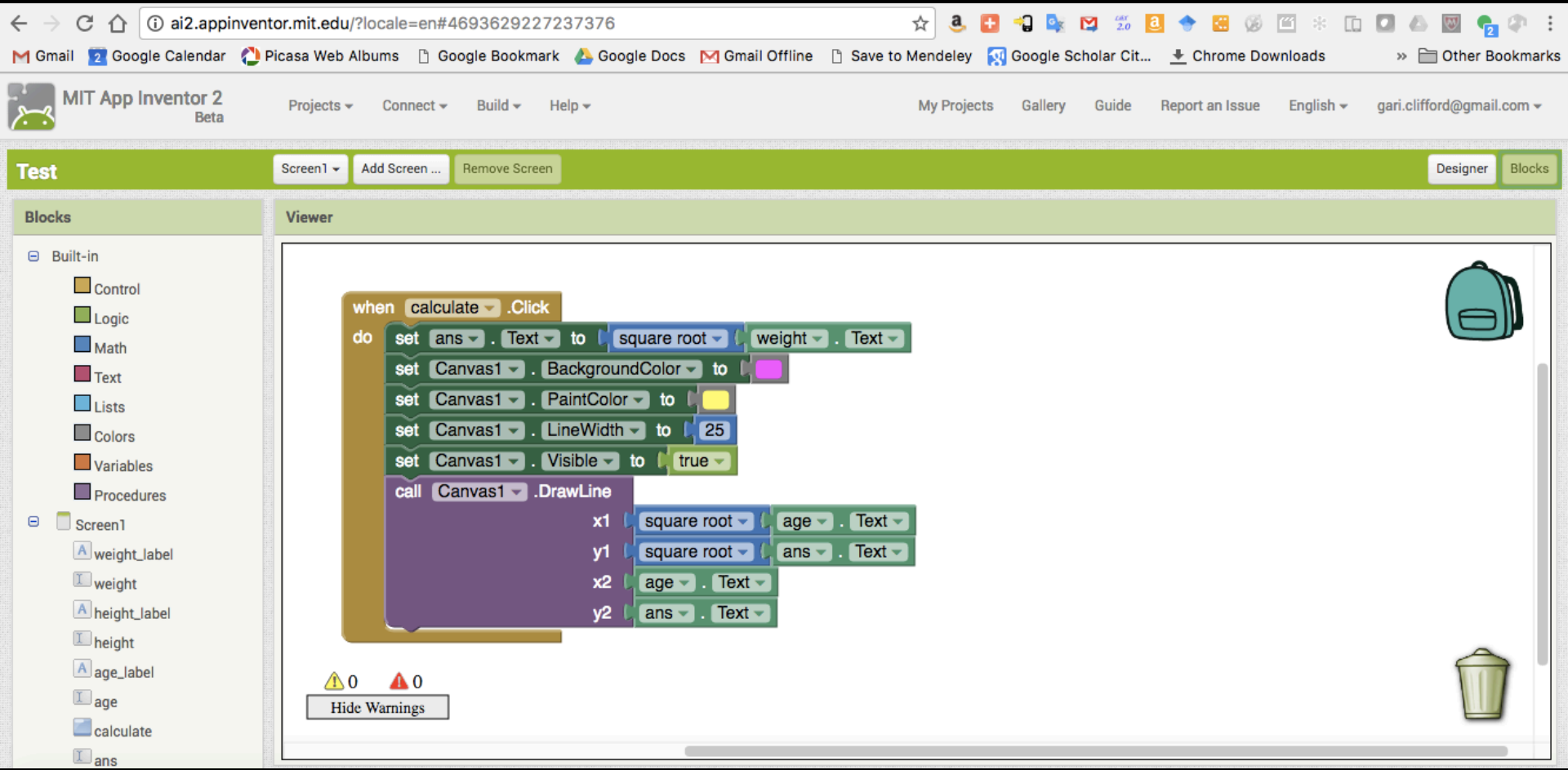
Use emulator or Android phone:

http://appinventor.mit.edu/explore/ai2/setup

MIT App Inventor interface



Logic Block Based Design



MIT App Inventor

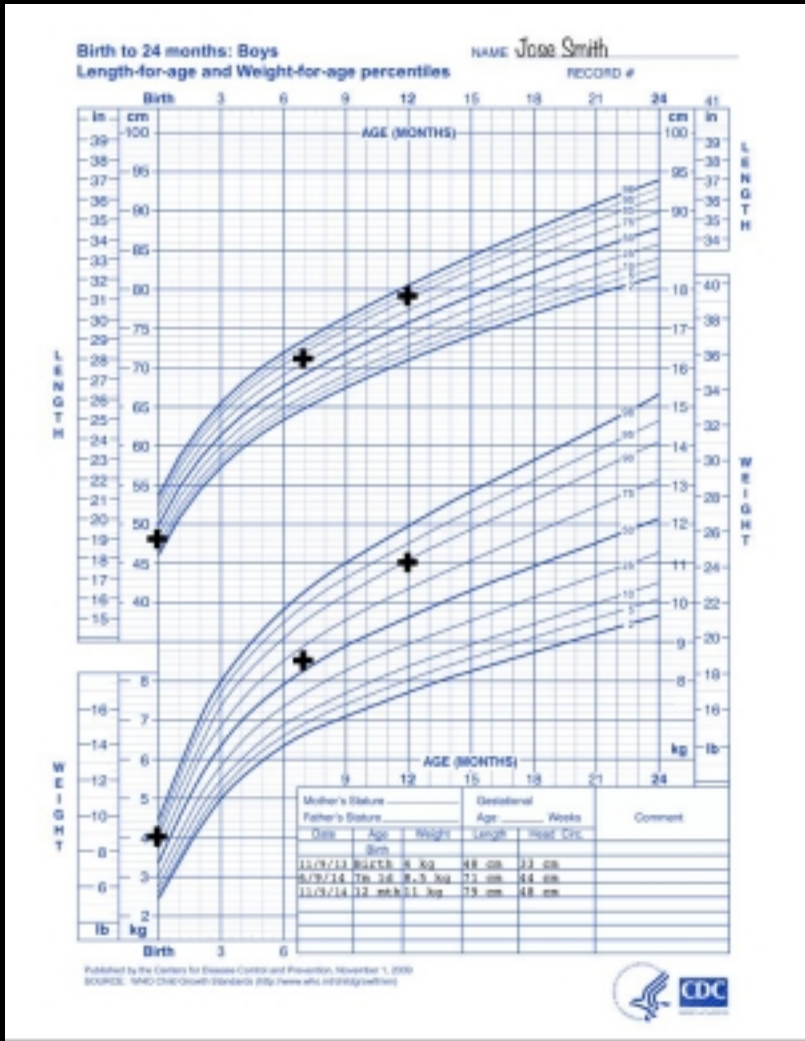
Task today: Create a z-score for pediatric growth …

Inputs:

- Weight, height (length), head circumference, age

Outputs:

- Z score, percentile and plot on growth curve



In statistical terms, *Z*-scores are a special application of transformation rules. The *Z*-score for a measure (e.g., height or BMI), indicates how far and in what direction (positive vs. negative) a measured value deviates from the population mean, expressed in units of the population SD. It is a dimensionless quantity derived from dividing the difference between individual value (x) and the population mean (μ) by the population SD (σ). The transformed *Z*-scores' distribution will have a mean of zero and a SD of one (i.e., mean = 0, SD = 1). This conversion process is called standardizing or normalizing.

$$Z = \frac{x - \mu}{\sigma}$$

Z-scores are sometimes called "standard scores". The *Z*-score transformation is especially useful when seeking to compare the relative standings of different measures (e.g., height vs. BMI, or the measures of boys' vs. girls') from distributions with different means and/or different SDs. *Z*-scores are especially informative when the distribution to which they refer is normal. In every normal distribution, the area under the curve between the mean and a given *Z*-score value corresponds to a fixed proportion of the total area (Fig. 2.3). Based on this characteristic, statisticians have created tables indicating the value of these proportions for various *Z*-scores.

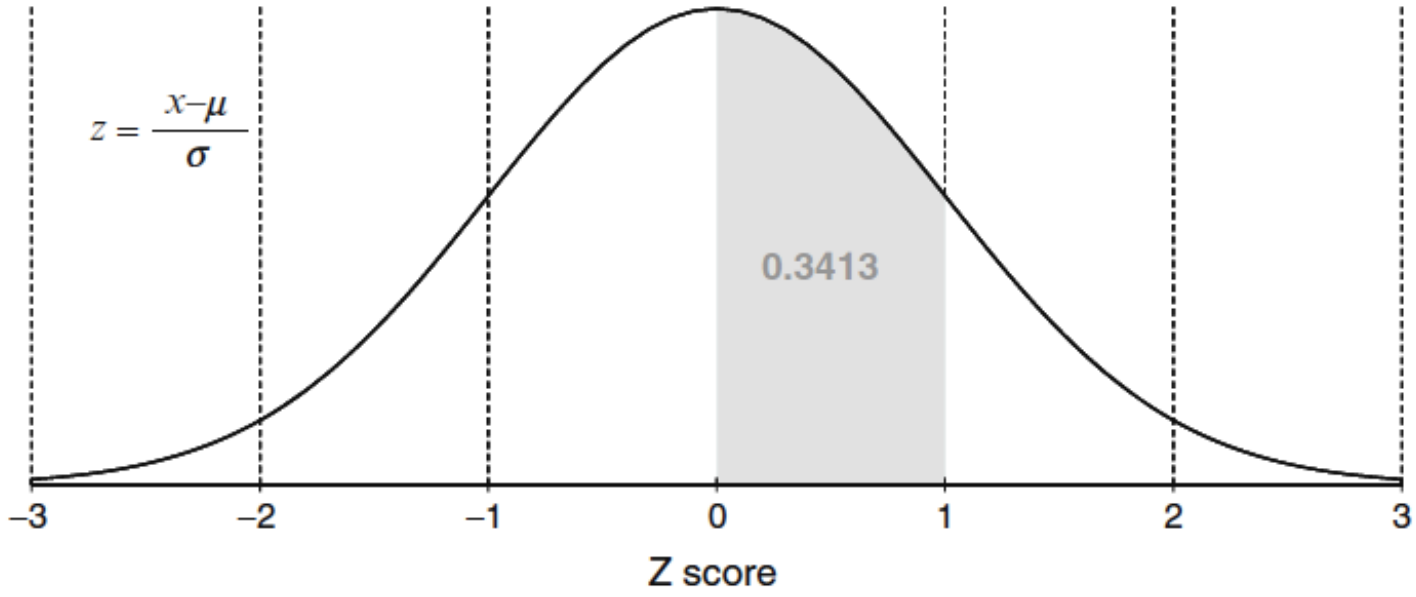


Fig. 2.3 *Z*-score and the corresponding cumulative probability and percentile (proportion). For normal distribution, the *Z*-score of 0 divides the total area into two equal halves. Thus, the *Z*-score of 1 corresponds to the 84th percentile (=0.5 + 0.34), i.e., 84% of the population are measured lower than *z*-score of 1. A *Z*-score is calculated as dividing the difference between measured value (x) and the mean (μ) by standard deviation (σ)

Task today: Create a z-score for pediatric growth

Deliverable:

Email gari@gatech.edu an apk called [your_name_zscore.apk] before 5pm on Friday 9th December.

MIT App Inventor

OK – get started!

http://ai2.appinventor.mit.edu/

Hint:
http://www.statisticshowto.com/percentile-z-score/