Ubiquitous and Mobile Computing CS 403X: Social Sensing for Epidemiological Behavior Change

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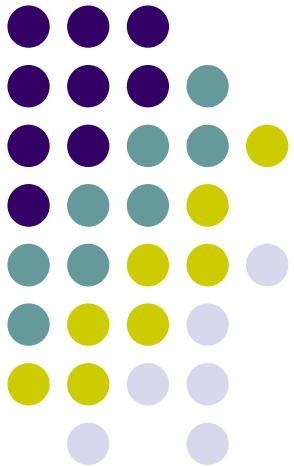
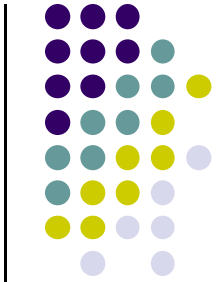
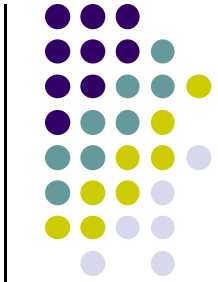


Motivation



- Use ubiquitous computing to to understand how individual behavior patterns are affected by physical and mental health symptom

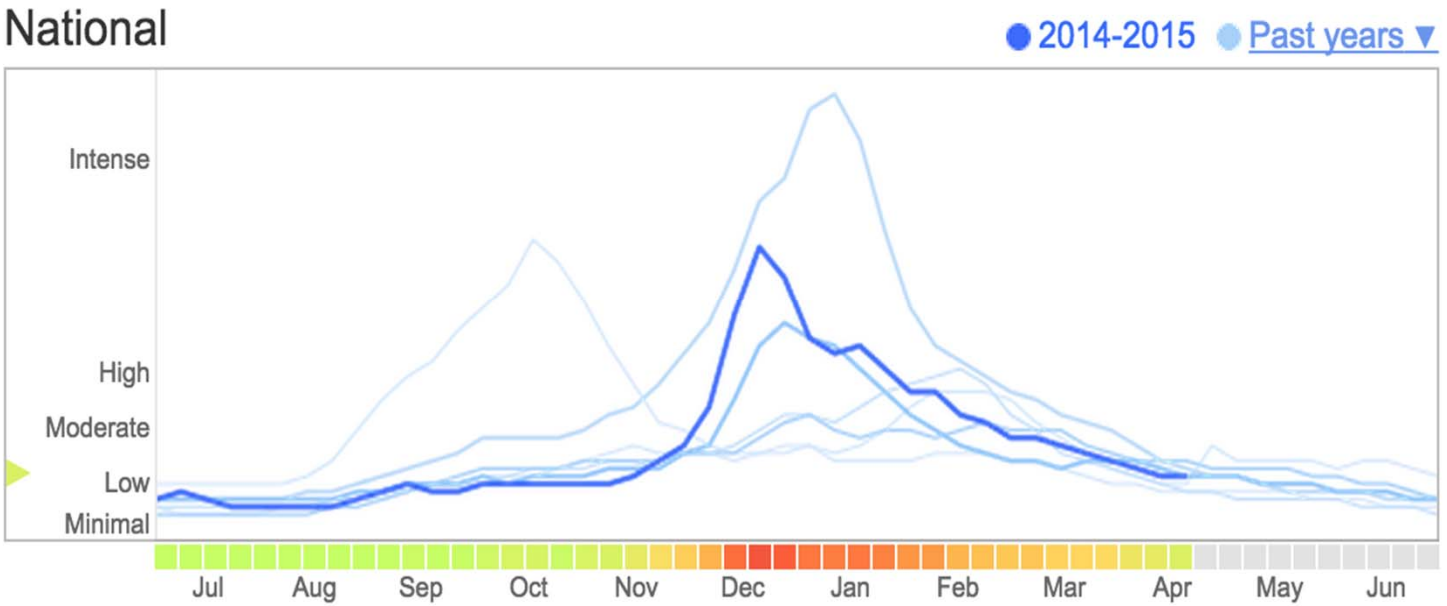
Vision



- Use mobile phone based co-location and communication sensing to measure behavioral changes
- Predict health status of an individual

Related Work

- Google Flu Trend

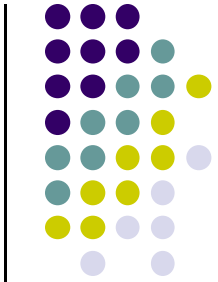


Flu Trend in the U.S. in 2014 - 2015

Related Work (Cont'd)

- Sociometric badge (sociometer)

Methodology



- Population
  - 70 participants (38 M and 32 F)
  - Same residence hall
  - 66 undergraduate and 4 graduate students

Methodology (Cont'd)

- Device
  - Windows Mobile 6.x device
  - Primary phones

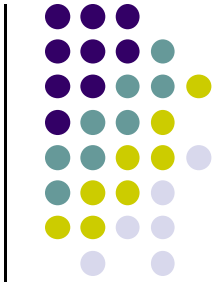
- Data collection
  - Call and SMS logs
  - Bluetooth scans
  - WLAN scans
  - Daily Survey

Methodology (Cont'd)

Survey Question (as shown on mobile phone)
Do you have a sore throat or cough?
Do you have a runny nose, congestion or sneezing?
Do you have a fever?
Have you had any vomiting, nausea or diarrhea?
Have you been feeling sad, lonely or depressed lately?
Have you been feeling stressed out lately?

Symptom survey questionnaire

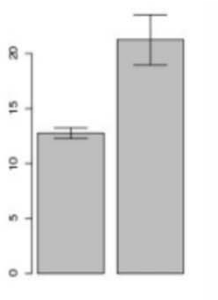
Data Analysis



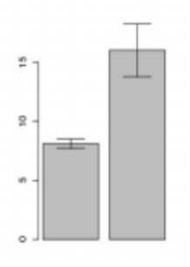
- Date: 02/01/2009 - 04/15/2009
- Peak influenza months in New England
  - 1.4 million scanned Bluetooth devices
  - 201,000 WLAN APs
  - 15,700 calls and 11,269 SMS records
  - 2994 survey responses

Data Analysis (Cont'd)

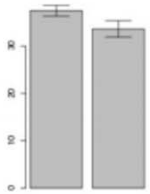
- Behavior effects of runny nose, congestion, sneezing symptom



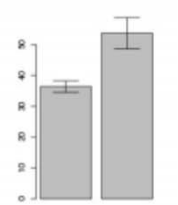
(a) Total communication increases ***



(b) Late-night early morning communication increases **



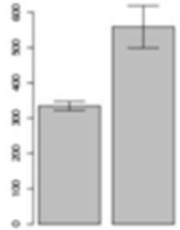
(c) Overall Bluetooth entropy decreases *



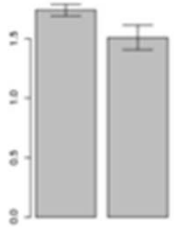
(d) Total WLAN APs detected increase **

Data Analysis (Cont'd)

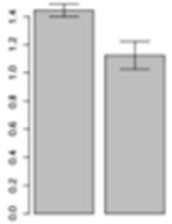
- Behavior effects of sore throat and cough symptom



(a) Bluetooth entropy with respect to other dorm residents increases ***



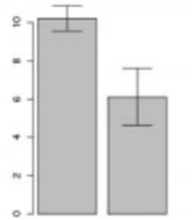
(b) WLAN entropy with respect to university WLAN APs reduces *



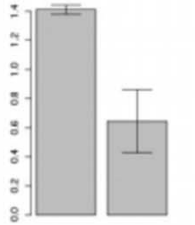
(c) WLAN entropy with respect to external WLAN APs reduces **

Data Analysis (Cont'd)

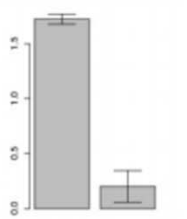
- Behavior effects of fever



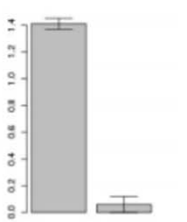
(a) Late night early morning calls and SMS decrease **



(b) Late night morning Bluetooth counts and entropy decrease*



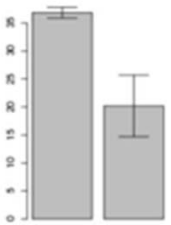
(c) WLAN based entropy with respect to university WLAN APs decreases ***



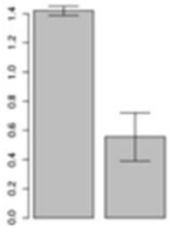
(d) WLAN Entropy with respect to external WLAN APs decreases ***

Data Analysis (Cont'd)

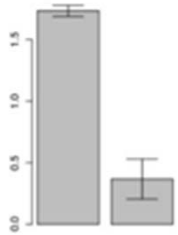
- Behavior effects of CDC-defined influenza



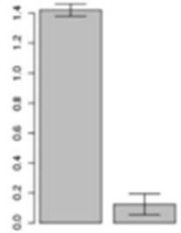
(a) Total Bluetooth interactions and entropy decrease **



(b) Late night early morning Bluetooth entropy with respect to other participants decreases **



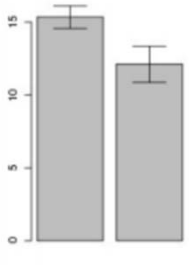
(c) WLAN based entropy with respect to university WLAN APs decreases ***



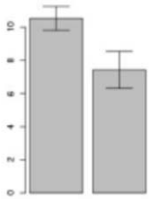
(d) WLAN Entropy with respect to external WLAN APs decreases ***

Data Analysis (Cont'd)

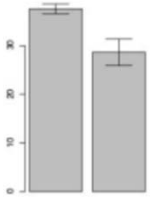
- Behavior changes with self-reported sad-lonely-depressed responses



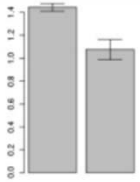
(a) Total communication decreases *



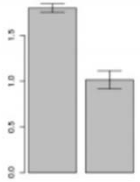
(b) Late-night early morning communication decreases *



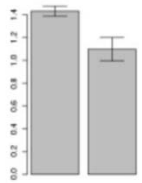
(c) Overall Bluetooth entropy decreases *



(d) Late night early morning Bluetooth entropy with respect to other experiment participants reduces **



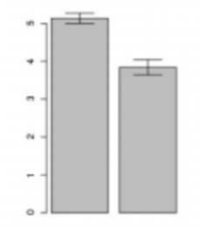
(e) WLAN based entropy with respect to university WLAN APs decreases ***



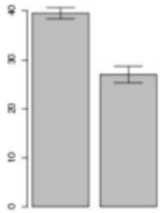
(f) WLAN Entropy with respect to external WLAN APs decreases ***

Data Analysis (Cont'd)

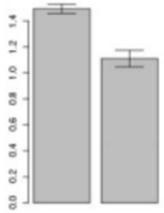
- Behavior changes with self-reported often Stressed responses



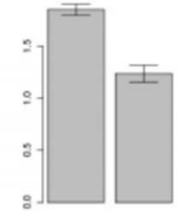
(a) Communication diversity decreases **



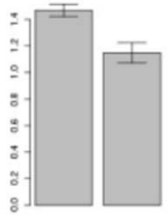
(b) Overall Bluetooth entropy decreases **



(c) Late night early morning Bluetooth entropy with other experiment participants reduces **



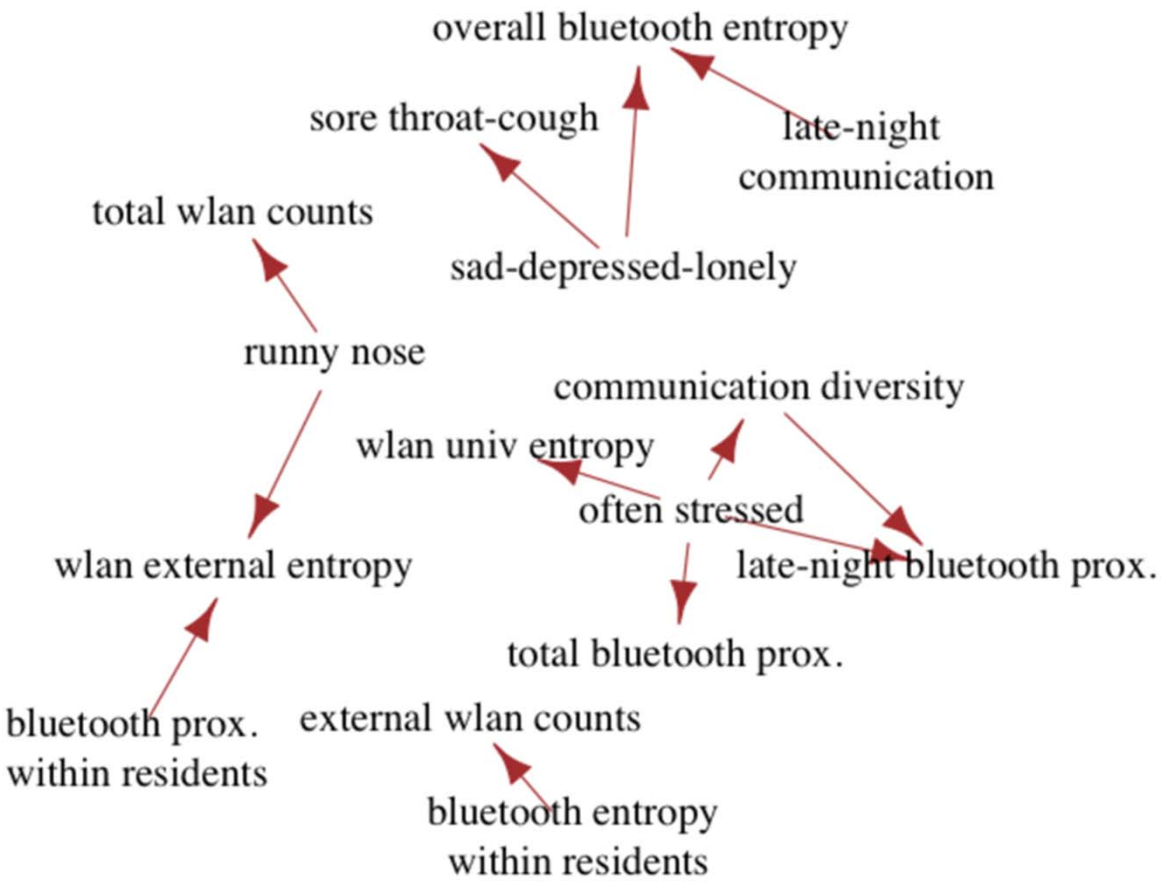
(d) WLAN based entropy with university WLAN APs decreases ***



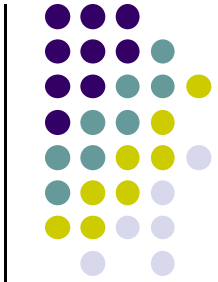
(e) WLAN Entropy with external WLAN APs decreases ***

Data Analysis (Cont'd)

- PSI

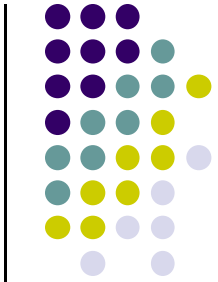


Conclusion



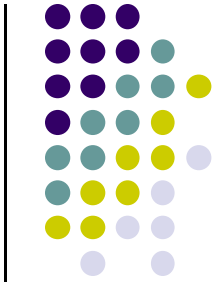
It’s possible to determine health status of individuals using information gathered from mobile phones

Significance



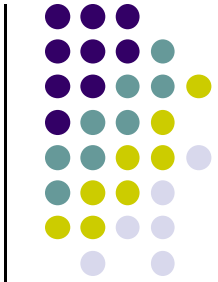
- Model epidemiological contagion in social networks without medical health measurements
- Improve doctor-patient interaction model

Potential Improvements



- Samples not independent
- Exams and events
- Bluetooth signal strength
- GPS instead of WLAN-based location

Critique



- Bluetooth not enabled
- Device may not be carried all the time
- Battery impact of the phone

References

- ***Social Sensing for Epidemiological Behavior Change,*** Anmol Madan, Manuel Cebrian, David Lazer, Alex Pentland, in Proc Ubicomp 2010
- https://www.google.org/flutrends/us/#US
- https://www.google.org/flutrends/about/how.html
- http://hd.media.mit.edu/badges/