The Emerging Role of Mobile Phones Healthcare

Shwetak N. Patel
WRF Endowed Professor
Allen School of Computer Science & Engineering
Electrical & Computer Engineering
Ubicomp lab
University of Washington

Director of Health Technologies
Google
Quick Research Overview

Energy monitoring

Low-power wireless sensing

Health

New interaction techniques
Personal Health Monitoring
Point of Care Diagnostics
Another Paradigm Shift in Health Care
Opportunities with Mobile Health

- New screening tools
- Population health
- New discoveries in diagnostics
- Improvement in treatment
- Possibly leapfrog traditional approaches through global health applications
Continuous Measurements
The Modern Smartphone

- Headphone jack
- Wireless Antenna/Signal
  GSM/LTE/WIFI/BT
- Speakers
- Capacitive touch
- Camera/Flash
- Accelerometer/Gyro
- Microphone
Mobile Health Sensing

- Using existing sensors on mobile phones for health sensing
Using Mobile Phones for Diagnostics

**Pulmonary**
- Spirometry
- Cough analysis

**Blood screening**
- Hemoglobin
- Bilirubin

**Cardiovascular**
- SP0₂
- Blood pressure

**Disease Specific**
- Sleep
- Osteoporosis

**Cardiovascular Disease Specific**
Measuring Lung Function

- Spirometry
  - Mainstay of monitoring respiratory conditions (Asthma, COPD, CF)

Clinical Spirometers

Home Spirometer
Measuring Lung Function
SpiroSmart: Mobile Phone Spirometer

- No additional hardware needed
  - All done with software
SpiroSmart: Mobile Phone Spirometer
How it Works

- Traditional spirometers use a flow sensor (e.g., turbine) – we only have the microphone
- Vocal tract resonances to infer flow
  - The “noise” in speech recognition
Vocal tract model
SpiroCall
SpiroSmart and SpiroCall Clinical Trials
Detecting and Studying Cough

- Cough is a common symptom, but not quantifiable
- Might be useful for studying the spread of disease
- Cough may tell us a lot about a disease
- Human ears miss subtle characteristics
Sound Analysis from Microphones

- Frequency based analysis with associated glottis model
Sound Analysis from Microphones

- Frequency based analysis with associated glottis model
Studying Tuberculosis

- Highly infectious lung disease
- The spread of TB spreads is still being studied
- Coughing is a major symptom
TB Study in South Africa
Cough Identification

Cough Identification

![ROC Curve for Cough Identification](image)

- GTFB CNN AUC: 0.98
- GTFB RF AUC: 0.96
- GTFB SVM AUC: 0.96
- MFCC KNN AUC: 0.93
- MFCC SVM AUC: 0.94

*False Positive Rate vs True Positive Rate*
BiliCam

- Using mobile phones to monitor newborn jaundice
Current Technology

- Total serum bilirubin (TSB)
- Transcutaneous Bilirubinometer
Absorption Properties of Bilirubin
Trial of 530 Newborns

BiliCam

0.91 correlation

TcB

0.92 correlation
Bilirubin in Adults: Pancreatic Cancer

5-YEAR SURVIVAL 6%
Observable Jaundice in the Sclera

Current Bilirubin Level: 0.5 mg/dl
Mobile Phone Hemoglobin
Mobile Phone Hemoglobin
Hemachrome Analysis

Absorbance vs. Wavelength

\( I_0 \) and \( I_m \)

\( \alpha_{Hb,\lambda} \) and \( \alpha_{Plasma,\lambda} \)

500 nm, 700 nm, 900 nm

\( \lambda \)
Isolate Blood Absorption
Hemachrome Analysis

Absorbance

Time

Blood

Tissue

Resting

Heart Beat

Resting

$I_0$

$I_0$

$I_0$

$I_m$

$I_m$

$I_m$
Evaluation

- **HbApp**
  - 0.81 correlation

- **Pronto**
  - 0.82 correlation

![Graph showing Estimated Hb (g/dl) vs Ground Truth Hb (g/dl) with residuals](image-url)
Peru Deployment
OsteoApp

- Inferring bone density with resonance tracking for osteoporosis
OsteoApp

Healthy bone

Osteoporosis

Sub 400 Hz Resonance

High frequency resonance

Lack of low resonance
Considerations in Mobile Health

- Regulatory
- Safety and trust
- Patient - provider interaction
- Inform new advances in medical devices
- Still need to take into accounts other factors such as social determinants
Advice to the Young Researchers
Thanks!

Morelle Arian
Computer Science & Engineering

Alex Ching
Computer Science & Engineering

Lilian de Greef
Computer Science & Engineering

Josh Fromm
Electrical & Computer Engineering

Mohit Jain
Computer Science & Engineering

Xin Liu
Computer Science & Engineering

Alex Mariakakis
Computer Science & Engineering

Farshid Salemi Parizi
Electrical & Computer Engineering

Chunjong Park
Computer Science & Engineering

Ruth Ravichandran
Electrical & Computer Engineering

Manuja Sharma
Electrical & Computer Engineering

Edward Wang
Electrical & Computer Engineering

Matt Whitehill
Computer Science & Engineering

Eric Whitmire
Computer Science & Engineering

Parker Ruth
Computer Science & Engineering

Varun Viswanath
Computer Science and Engineering

Alvin Cao
Electrical & Computer Engineering

Yiran Zhao
Biomedical & Health Informatics

Keyu Chen
Research Scientist at Apple

Gabe Cohn
Researcher at Microsoft Research

Jon Froehlich
Assistant Professor at the University of Washington

Mayank Goel
Assistant Professor at Carnegie Mellon University

Sidhant Gupta
Researcher at Microsoft Research

Matthew Kay
Assistant Professor at the University of Michigan

Eric Larson
Assistant Professor at Southern Methodist University

Tien-jui Lee
Engineer at Google

Hanchuan Li
Researcher at Microsoft Research

Eliot Saba
Senior Research Engineer at Julia Computing

Shwetak N. Patel - University of Washington
Questions?

ubicomplab.cs.washington.edu