Wireless and Mobile Health (mHealth): Passive Sensing Data Analytics

(COMP_SCI 397/497)

Computer Science
Winter Quarter 2020 (Jan 6 – March 21)
Tuesdays & Thursdays 5:00 – 6:20 P.M.
Tech LR4/M113 (Subject to Change)

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With the increasing research activity in the field of mobile health there has been increased interest in passive sensing and activity recognition systems. The ultimate goal of this research is to improve our understanding of human activity and behavior and to design interventions and solutions that improve health outcomes for individuals, reduce healthcare costs and improve quality of life. The number of challenges in designing, implementing and evaluating these mHealth systems is growing, and so is the need for experts in this field.

This course aims to provide hands-on introduction and experience to the field of mHealth, with a focus on passive sensing data analytics (and more specifically time-series data generated by these sensors). We will learn the concept of a Passive Sensing Data Analytic chain (PASDAC) as a general-purpose framework for designing and evaluating mHealth systems including: pre-processing, segmentation, feature extraction/selection, classification, decision fusion and performance evaluation. Students will interview faculty in Medicine to learn about how to transition their mHealth system to the real-world.

Prerequisites: One of the following:

1. EECS 214 AND (intro to ML, AI, HCI or Data Sciences);

2. EECS 214 AND EECS 212

3. EECS 214 AND (EECS 213 OR (EECS 205 & EECS 211))

Objectives:

1. Design an mHealth system or technology that can be used to solve a health problem.

2. Learn how to design an in-lab clinical trial to test your system, and prepare it for a real-life clinical trial.
3. Interview a medical faculty/industry to define and finalize your class project. You will be graded on this from both the instructor and faculty/industry partner.
4. Understand health behavior theories to empower your technology to be most effective in improving individual, community or organizational health.
5. Learn about existing mHealth problems and solutions.
6. Learn methods to use in implementing and testing your class project.
7. Implement, test, and analyze data from an mHealth system (front-end, and back-end).
8. PASDAC (heart of an mHealth system): Learn the Passive Sensing Data Analytic Chain (PASDAC).

Readings Combined from the following books:

1. Selected Papers in the field.
2. F. Hu, "Tele-Healthcare Computing and Engineering: Principles and Design," 2013.
3. M. Mehregany, "Wireless Health – Remaking of Medicine by Pervasive Technologies", 2013.
4. S. Marsland, "Machine Learning: An Algorithmic Perspective," 2nd edition, 2015.
5. Don Nutbeam "Theory in a Nutshell," 3rd edition

Datasets: Expertise will be gained from lectures, reading/reviews, and tutorials spread throughout the 10 weeks. Students will also generate their own data during their projects, and learn to develop their own mHealth project. The following are some data sets that we will be processing in class.

- Human Activity Recognition Dataset by Bulling.
- ISenseOvereat Data set
- User-generated data sets from the following sensors (smartphone-based, piezo, inertial sensors-accel, gyro, heart-rate, etc…)

Tutorials:

1. How to read, critique (write a review of a mHealth paper), and write an mHealth paper.
2. PASDAC and Machine Learning using ISenseOvereat data set.
3. How to perform an in-lab study, collect data from a wearable sensor, label/annotate, and evaluate data.
4. Wearable device video and image analysis using deep learning.
5. Building your own wearable from COTS sensors.

Topics (Schedule by week):

Tuesdays: Lectures and/or Tutorials

Thursdays: Paper Review/Discussion (30min), Group Updates (20 min, 2 minutes each group), Group Meeting and Discussion with Instructors (30 min)

Week 1	**Class logistics**	
	Introduction to mHealth	**Tuesday Lecture:** **Intro to class, Student Background Survey, Introduce Projects** **Thursday:** **1) Discussion: Ida Sim "Mobile Devices and Health" and 14 minute video.** **2) Tutorial: How to Read a Paper: http://ccr.sigcomm.org/online/files/p83-keshavA.pdf** **3) Tutorial: How to Write a Paper:https://projects.ncsu.edu/eslglobe/nmswishe/IMRAD%20Handout.pdf** **4) Questions to think about when building an mHealth system involving a wearable: https://bit.ly/3011Fdd** **5) Due: Review/Critique of Paper (5pm online Canvas)** **Friday:** **Project Due: Team names and projects identified and formed.**
Week 2	**Biophysical Sensing**	**Tuesday Lecture: Lecture on EDA/ECG/RIP and measuring heart-rate, stress, and blood pressure.** **Wednesday:** **Due: Review/Critique of Paper (5pm online Canvas)** **Thursday:** **1) Discussion: Hovsepian et al. "cStress: Towards a Gold Standard for Continuous Stress Assessment in the Mobile Environment," 2015** **2) Project Updates** **Friday:** **Project Due:** **1) Order Software/Hardware (if necessary)** **2) Identify 2-3 contributions of your research project, and how is it different from existing research.** **3) Schedule expert interview.**
Week 3		Tuesday Tutorial: PASDAC and Machine Learning using ISenseOvereat data set. Optional Reading:

		Bulling et al. "Human Activity Recognition Using Body-Worn Inertial Sensors," 2014 **Wednesday:** **Due: Review/Critique of Paper (5pm online Canvas)** **Thursday:** **1) Discussion: Holtz and Wang, "Glabella: Continuously Sensing Blood Pressure Behavior using an Unobtrusive Wearable Device," 2018** **2) Project Updates** **Friday:** **Project Due: Outline, Introduction/Related Work**
Week 4	**Behavioral Sensing**	**Tuesday Lecture:** **Lecture on Proximity, IMU, and Ambient light sensors, as well as RIP, and Wrist-based IMU.** **Optional Reading: Zhang et al. "NeckSense: A Multi-Sensor Necklace for Detecting Eating Activities in Free-Living Conditions," 2019** **Wednesday:** **Due: Review/Critique of Paper (5pm online Canvas)** **Thursday:** **1) Discussion: Chun et al. "Detecting Eating Episodes by Tracking Jawbone Movements with a Non-Contact Wearable Sensor," 2018.** **2) Project Updates** **Friday:** **Project Due: Abstract, and Methods Part 1 Study Design**
Week 5		Tuesday Tutorial: How to perform an in-lab study, collect data from a wearable sensor, and label, and evaluate data. **Wednesday:** **Due: Review/Critique of Paper (5pm online Canvas)** **Thursday:** **1) Discussion: Saleheen et al. "puffMarker: A Multi-Sensor Approach for Pinpointing the Timing of First Lapse in Smoking Cessation," 2015.** **2) Project Updates**

		Friday: **Project Due: Submit Methods Part 2 Approach and Evaluation**
Week 6	**Context and Environmental Sensing**	**Tuesday Lecture: Context and Environmental Sensing** **Optional Reading: Rachuri et al. "SociableSense: Exploring the Trade-offs of Adaptive Sampling and Computation Offloading for Social Sensing ," 2011** **Li et al. "Battery-Free Eye Tracker on Glasses," 2018** **Wednesday:** **Due: Review/Critique of Paper (5pm online Canvas)** **Thursday:** **1) Discussion: Yun and Rehg, "Watching the TV Watchers," 2017.** **2) Project Updates** **DUE: PREPARE FOR MIDTERM PRESENTATIONS**
Week 7		**Tuesday MIDTERM: Presentations** Thursday Tutorial: Video and image analysis using deep learning. **Friday:** **Project Due: Figures/Preliminary Results**
Week 8	**Affect/Emotional Sensing**	**Tuesday Lecture: Affect Sensing** **Wednesday:** **Due: Review/Critique of Paper (5pm online Canvas)** **Thursday:** **1) Discussion: Wang et al. "StudentLife: assessing mental health, academic performance and behavioral trends of college students using smartphones," 2014** **2) Project Updates** **Friday:** **Project Due: Finalize Figures and Results section**
Week 9		Tuesday Tutorial: Building your own wearable from COTS sensors. (Teensy, select sensor to detect specific activity).

		Wednesday: **Due: Review/Critique of Paper (5pm online Canvas)** **Thursday:** **1) Lascio et al., "Unobtrusive Assessment of Students' Emotional Engagement during Lectures Using Electrodermal Activity Sensors," 2018** **2) Project Updates** **Friday:** **Project Due: Improvement on Results, Finalize Discussion, and Conclusion**
Week 10	**Taking your project to the next level.**	**Tuesday Lecture:** **Example mHealth Interventions in the real world, Observational, RCT, MRT trials, Mixed effects models. Intervention design and analysis. Challenges of mHealth technology.** **Thursday:** **FINAL PRESENTATION, (Website and Final Paper due Tuesday Week 11)** **Friday:** **Project Due: Interview with Medical Faculty Summary**
Week 11	**FINAL PAPERS and Website Due: Tuesday 5pm**	**FINAL PAPERS and Website Due: Tuesday 5pm**

Grading Distribution:

40% - Final project (Paper: 15, Website: 10, Final Presentation: 15)
20% - Mid-term Presentation and First Draft of Paper (Introduction, Methods, Preliminary Results, Shell for Discussion)
10% - Class participation/Tutorials in class (readings/lectures)
20% - Project submissions/Paper reviews
10% - Interview with Faculty in Medicine and Write-up

PROJECTS: Goal is to analyze data from a wearable sensor to detect physiological or behavioral factors that may be part of a large behavioral construct.

1) ScreenExp: Develop a system that uses sensor data from a wearable RGB camera and IR sensor array to detect the time spent by an individual in front of a screen. The screen can be a mobile

phone, a TV, a laptop, a tablet or any other similar device. (Sensors: Wearable RGB Camera, IR sensor array). Interview: Dr. Angela Pfammatter.

2) SocialSense: Develop a system that uses sensor data from a wearable RGB camera and IR sensor array to monitor an individual's social interaction duration (alone or not alone). (Sensors: Wearable RGB Camera, IR sensor array). Interview: Dr. Tammy Stump.
3) SmokeMon: Developing a system that uses sensor data from a low-resolution thermal camera to monitor smoking episodes of an individual. (Sensors: IR sensor array). Interview: Dr. Bonnie Spring or Dr. Brian Hitsman.
4) StressTest: Estimating blood pressure using the ECG and PPG signal from Biostamp Pulse and Empatica E4. Validate the outcome using gold standard blood pressure monitors, and analyze the relationship between blood pressure and stressful activities. (Sensors: ECG and PPG in Biostamp pulse, Empatica E4). Interview: Dr. Laurie Wakschlag.
5) WatchYouEat: Develop a system that fuses sensor data from a wrist-worn device, a neck-worn device, and a RGB camera to detect eating episodes. (Sensors: smartwatch, NeckSense, wearable RGB camera). Interview: Dr. Andrea Graham.
6) TalkBetter: Develop a system that uses sensor data from the MA device to identify talking moments, eating moments and other moments. Validate the system using visual confirmation from a RGB camera. This system will monitor the time spent by an aphasia patient performing these activities with the goal of increasing the talking moments. (Sensors: MA device). Interview: Dr. Leora Cherney.
7) SELECT YOUR OWN PROJECT.

Interview with faculty from Medicine to address utility of the mHealth system:

1) How this device can be used in an intervention.
2) Can you define a construct or behavior model where this tech can be used.