

# Varun Viswanath

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I develop **novel machine learning techniques** to study **longitudinal time-series** in **real-world health contexts**. Currently, I am using a dataset of 60,000 real-world wearable device users to explore methods of reducing false positives when detecting anomalies in wearable time series. I have broad experience in across ubiquitous computing, design research, deep learning, computer science, and bioengineering. In the future, I hope to further explore how deep learning and other statistical methods can augment wearable and ubiquitous technology to improve peoples' health and lifestyle.

## Education

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- 2019 - Now **University of California, San Diego** La Jolla, CA  
Ph.D. in Electrical and Computer Engineering, Machine Learning and Data Science  
Advisors: Edward Wang (Design Lab, Electrical Eng.); Benjamin Smarr (BioEng, Halicioğlu Data Science Institute)
- 2015 - 2019 **University of Washington** Seattle, WA  
B.S. in Computer Science and Engineering, Paul G. Allen School of Computer Science and Engineering  
Senior Research Thesis: Using Confidence in Smartphone Spirometry  
Advisor: Shwetak Patel (UbiComp Lab, Computer Science and Engineering, Electrical and Computer Engineering)

## Publications

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- Nov 2023 **Variability of temperature measurements recorded by a wearable device by biological sex**  
Lauryn Keeler Bruce, Patrick Kasl, Severine Soltani, Varun K. Viswanath, ..., Ashley E. Mason\*, Benjamin L. Smarr\*  
Biology of Sex Differences
- Aug 2023 **SpecTracle: Wearable Facial Motion Tracking from Unobtrusive Peripheral Cameras** [PDF]  
Yinan Xuan\*, Varun Viswanath, Sunny Chu, Owen Bartolf, Jessica Echterhoff, Edward Wang  
ArXiv
- Apr 2023 **Detecting Periodic Biases in Wearable-Based Illness Detection Models** [PDF]  
Amit Klein\*, Varun Viswanath, Benjamin Smarr, Edward Wang  
ICLR 2023, Time-Series Representation Learning for Health
- Sep 2022 **Smartphone Camera Oximetry in an Induced Hypoxemia Study**  
Varun Viswanath\*, Jason S. Hoffman\*, ..., Eric C. Larson, Shwetak N. Patel, Edward Wang  
npj Digital Medicine
- Mar 2022 **Detection of COVID-19 using multimodal data from a wearable device: results from the first TemPredict Study**  
Ashley Mason\*, Frederick L. Hecht..., Varun Viswanath..., Benjamin L. Smarr (80+ Authors)  
Scientific Reports
- Mar 2022 **Stepping into the Next Decade of Ubiquitous and Pervasive Computing: UbiComp & ISWC 2021**  
Rahul Majethia, Shreya Ghosh, Hanna Nolasco, Farhana Shahid, Varun Viswanath, Ibrahim Shehi Shehu, Yiran Zhao  
IEEE Pervasive Computing
- Dec 2021 **Dynamical clustering of U.S. states reveals four distinct infection patterns that predict SARS-CoV-2 pandemic behavior** [PDF]  
Joseph Lane Natale, Ph.D.\*, Varun Viswanath..., Benjamin L. Smarr  
ArXiv
- Dec 2021 **TemPredict: A Big Data Analytical Platform for Scalable Exploration and Monitoring of Personalized Multimodal Data for COVID-19** [PDF]  
Shweta Purawat\*, Subhasis Dasgupta..., Varun Viswanath..., Benjamin Smarr, Amarnath Gupta, and Ilkay Altintas.  
IEEE BigData 2021
- Jul 2018 **SpiroConfidence: Determining the Validity of Smartphone Spirometry using Machine Learning** [PDF]  
Varun Viswanath\*, Jake Garrison, Shwetak Patel  
EMBC 2018

## Honors, Accolades, Services

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- Sep 2023 **Organizing Committee, Student Volunteer Chair, UbiComp 2023** Cancun, Mexico  
Managed 48 Volunteers, organized a 5-day 600-person conference in a Latin-American country.
- Mar 2023 **Network Award Winner, Center for Circadian Biology Symposium 2023** La Jolla, CA
- Sep 2021 **Student Volunteer, UbiComp 2021**, Supported Sessions in Health, Sensing, and HCI Online: Gather.town
- Sep 2020 **Student Volunteer, UbiComp 2020**, Accessibility and Conference Summary Visualization Online: Gather.town
- Jul 2018 **Session Chair**, Session: Deep Learning Imaging II, EMBC '18 Honolulu, HI

## Research

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- Oct 2023 – Now **Graph Neural Networks for Modeling Cross-Modal Relationships in Wearable Time-Series**
- Oct 2023 – Now **Priming Large Language Models with Expert Medical Explanations**
- Feb 2023 – Now **Quasi-Periodicity in Wearable Time-Series**
- Jun 2023 – Now **Passive Screening for Diabetes with Non-CGM Wearables**  
Diabetes is chronic disorder that is goes undiagnosed in millions of people. Wearable devices tracking heart rate, skin temperature may be able to identify the physiological effects of diabetes in the nervous and cardiovascular systems. With their widespread adoption, we could passively screen over 40% of the population. We show the feasibility of a passive screening algorithm that extracts key heart rate, HRV, and circadian rhythm features, using skin temp. and sleep parameters, and achieves AUC=0.88, AUPRC 0.80 on a binary classification task.
- Jun 2022 – Now **Five Million Nights: Temporal Dynamics of Human Sleep Phenotypes**  
An increasing number of people are using wearable devices to monitor their sleep. However, algorithms that use wearable sleep data struggle because of how human sleep differs between people and within people over time. We develop a novel representation that uses a topological data analysis pipeline and temporal dynamics graph to better captures these differences. We characterize the temporal sleep dynamics of a population of 33,152 individuals monitored over 3-6 months and test whether temporal dynamics give us more information about individuals who have chronic or acute illnesses. We show how our model represents several key patterns in how an individual's sleep changes longitudinally and find that these changes in sleep give 2-10 times as much information about the presence of sleep apnea, diabetes, flu, fever, and COVID-19. We are submitting this manuscript to top tier journals in digital health and medicine.
- 2020 - 2022 **SpO2: Tracking Blood Oxygen Levels with a Mobile Phone**  
Respiratory illnesses like Covid-19 often attack our lung's ability to bring oxygen into our blood stream. People can appear unaffected until their blood oxygen reaches dangerous levels (<84%) where they can suddenly faint or lose consciousness. Tracking blood oxygen with a readily available smartphone device can bring safety and peace of mind for those with such respiratory conditions. We collect a novel dataset and develop a novel deep learning algorithm which tracks blood oxygen concentrations ranging from 70-100% within 5% mean absolute error. We published our Patented model alongside further analysis of viability of this approach in Nature Publishing Journal: Digital Medicine.
- 2020 - 2021 **TemPredict: Predicting COVID-19 from Continuous Physiological Data**  
Continuously measured heart rate, respiratory rate, and skin temperature provide a rich view of our internal state from illness onset to recovery. Through the TemPredict project, we collected data from 63,153 participants and developed a Gradient Boosting-based algorithm using data collected by a consumer wearable (Oura Ring) that predicts the onset of COVID-19 an average of 2.75 days before participants sought diagnostic testing with receiving operating characteristic (ROC) **area under the curve (AUC) of 0.819** (95%CI [0.809, 0.830]). We published this work in the Scientific Reports Journal.
- 2016 - 2019 **SpiroSmart: Using a Smartphone Microphone to Measure Lung Function**  
Access to spirometry, a noninvasive test for lung function fundamental in the diagnosis of most respiratory illnesses, is limited in rural areas where clinics are less equipped or accessible. We develop a deep learning algorithm to perform spirometry using audio clips from smartphone microphone, leveraging machine learning to clean ~40,000 spirometry audio clips and novel techniques for incorporating user metadata in the architecture. Our model regresses a Flow vs. Volume curve and achieves 98% precision and 88% recall in severity classification of the FEV1 score. This research is published in my mentor's master's thesis and the data cleaning machine learning model I developed is published at the IEEE EMBS conference.

## Mentorship

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- 2022 – 2023 **Detecting Periodic Biases in Wearable-Based Illness Prediction Models**  
Wearable health devices allow us to continuously track physiological indicators such as heart rate, enabling the development of Wearable-Based Illness Detection (W-BID) models, which aim to detect the onset of illness by identifying shifts in heart rate and other signals. While W-BID models accurately detect illness, they often over-predict illness during healthy time periods due to variance caused by seemingly random human choices. However, it is because W-BID models treat each input window as independent and identically distributed samples that we are unable to account for the weekly structure of variance that causes false positives. Towards preventing this, we proposed a system for identifying structural variance in wearable signals and measuring the effect they have on W-BID models. We demonstrate how a simple statistical model that does not account for weekly structure is strongly biased by weekly structure, with a Pearson correlation coefficient of 0.9. This work was one of six top accepted works that gave oral presentations at the ICLR Time-Series Representation Learning for Health Workshop.
- 2022 - 2023 **Deep Learning for Fever Detection using Wavelet Transforms of Oura Ring Wearable Data**  
Continuously measured heart rate, respiratory rate, and skin temperature provide a rich view of our internal state from illness onset to recovery. Previously proposed fever detection models used small datasets on the order of a

couple thousand instances across 100+ individuals. We propose performing transfer learning from pre-trained object recognition models on the wavelet power in the form of an image. We currently achieve 0.74 AUC and are working to improve the performance and interpretability this algorithm.

Oct - Feb 2022 **Detecting Motherese speech in Freeform Audio**

Infant reactions to Motherese, or the high-pitched voice people often use to talk to babies and infants, has been shown to be a potential early indicator of autism. Towards a potential autism detection system, my mentees develop a novel machine learning and signal processing approach to detect adult vs. motherese vs. baby or infant speech or sound production.

Jun - Nov 2021 **ENLACE Summer Research Program: Dynamical clustering of U.S. states reveals four distinct infection patterns that predict SARS-CoV-2 pandemic behavior**

ENLACE is a summer research program where researchers from UC San Diego closely mentor undergraduate and research students from school across Mexico and Brazil in various research projects. Our five students scraped and cleaned 8+ months of data on COVID-19 infection, mask use, vaccination across the US. They then explored hierarchical clustering models to show that states can use infection rates in geographically collocated states to guide their own public health guidelines. We published this research through ArXiv and are submitting to other venues.

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### Internship Experience

Jun - Sep 2018 **Uber Elevate Intern** San Francisco, CA

Explored a range of novel algorithms and heuristics for finding high optimality paths for building aircraft flight plans. Showed our algorithm could find high quality solutions in 1 min while current brute force solution took 30 min.

Jun - Sep 2017 **Zealery Research Intern** Boston, MA

Researched models to transfer clothing worn in one image onto the body of a person in another image. Built model that used Poison Image Editing to segment clothes and Image Style Transfer to transfer it to new image.

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### Skills

Java | Python | Swift | JavaScript | C/C++ | SQL | R | Keras | PyTorch | FastAI | Arduino | Bash | Vim | Git | Raspberry Pi | Google Cloud Platform

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### Poster Presentations

Feb 2023 **Center for Circadian Biology Symposium, Poster Session, RhyPredict: Detecting Periodic Biases in Wearable Time-Series** La Jolla, CA

Discovered a correlation of 0.9 between weekend heart rate perturbations and heightened model predictions.

Nov 2021 **UCSD Design Innovation Building Grand Opening, Tempredict DL: Using Deep Learning to Analyze Longitudinal High Granularity Signals** La Jolla, CA

Illustrated 12% difference in performance of CNN model on high- versus low- variance physiological data.

Oct 2018 **UW Industry Affiliates Poster Session, SpiroConfidence** Seattle, WA

Achieved 98% precision and 88% recall on binary classification of spirometry audio using a Gated-CRNN.

Dec 2018 **CSE 590gI Intro to Deep Learning, Pneumonia Classifier Using Darknet Architecture** Seattle, WA

Achieved 83% accuracy on Stanford dataset of chest X-rays of normal and pneumonia patients using Darknet model.

Dec 2018 **CSE 455 Computer Vision, Puppy.CV: Classifying Puppy Breed** Seattle, WA

Achieved 85% accuracy on 6 classes of Stanford Dog Dataset using 5-layer CNN.

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### Relevant Coursework

UCSD Unsupervised Learning, GPU Programming, Deep Generative Models, Statistical Learning I, Probability and Statistics, Neural Networks/Pattern Recognition, Mobile Health Sensing

UW Deep Learning, Natural Language Processing, Artificial Intelligence, Computer Vision, Machine Learning

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### Software Development Side Projects

Sep 2021 - Now **Larry Smarr Gut-Biome Research Dashboard** Earth 2.0, UCSD

Developing interactive dashboard of gut microbiome organisms over 20 years to facilitate gut-biome research.

March - April 2020 **COVID Dashboard** Earth 2.0, UCSD

Helped to design and build a ReactJS + NodeJS citizen science webservice to deliver and collect useful COVID data

Jan - March 2020 **Facial Tracking Glasses** Ubiquitous Data Computing Lab, UCSD

Constructed device that uses quad-cam Raspberry Pi setup to record wearer's facial expressions through daily living.

Jun - Aug 2017 **FreshAir** UbiComp Lab, UW

Built Swift iOS app, asynchronous server with Tornado, and Docker system for a server and database, as well as a prediction algorithm that performs real time SpiroSmart tests, both for use in a 2-year international clinical study.

Jun - Sep 2017 **SpiroSound** UbiComp Lab, UW  
Ran study and analyzed data to identify polynomial relationship between audio and human breath air flow.  
Built visual feedback for study participant. Built data pipeline and data processing functions in python.

Aug 2017 **PupilScreen** UbiComp Lab, UW  
Built prototype app in Swift and tornado server for collecting and uploading video data.

### Extra-Curricular

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2015 - 2019 **UW Chess Club**, President  
Organized weekly meetings and 4 tournaments with Amazon, Microsoft, and Allen Institute of Artificial Intelligence.  
Grew club size from just 1 member to 60-70 members. Built website and social media platforms. [[Link](#)]

2016 - 2018 **CodeDay Seattle Mentorship Team**, Hackathon Mentor for iOS and Web programming

2015 - 2017 **Human Powered Submarine**, Embedded Systems Architect, Web Developer

### Hackathons

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Oct 2018 DubHacks, University of Washington Seattle, WA

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Apr 2017 DefHacks, Microsoft Redmond, WA

Feb 2016 ZooHackathon, Woodland Park Zoo Seattle, WA

Oct 2016 DubHacks, University of Washington Seattle, WA

Oct 2016 FishHackathon, Impact Hub Seattle, WA

Oct 2015 DubHacks, University of Washington Seattle, WA

May 2015 LAHacks, University of California, Los Angeles Los Angeles, CA