Predicting quality of life with multimodal data

Organizers

Valeria De Luca, Novartis Institutes for Biomedical Research
Ieuan Clay, Evidation

Short description

The field of digital health has become a multi-billion dollar market, powering a paradigm shift in the continuous capture of multimodal data including activity, sleep, heart rate variability and contextual information. Novel machine learning applications are pioneering the conversion of these multimodal data into measures for quality of life-relevant symptoms like fatigue, stress, and depression. These insights will result in better understanding of the patient's lived experience and better medicines.

Join us in this workshop at BHI-BSN 2021 to join and contribute to the discussion with experts in the field on groundbreaking work at the intersection of machine learning, multimodal data and cutting-edge multi-sensor solutions.

Content

½ day workshop (15:40 - 18:15 CET)
Virtual Room 3

Agenda

15:40 - 15:50: Welcome by workshop organisers

Session 1: Disease detection

15:50 - 16:10: Keynote 1 - Luca Foschini (Evidation Health)

16:10 - 16:20: Presentation 1 - Florian Lipsmeier (Roche)
16:20 - 16:30: Presentation 2 - Ben Vandendriessche (ByteFlies)
16:30 - 16:40: Presentation 3 - Benjamin L. Smarr (UCSD & Oura)

16:40 - 16:55: Session 1 Q&A

16:55 - 17:00: Break

Session 2: Wellbeing

17:00 - 17:20: Keynote 2 - Akane Sano (Rice University)

17:20 - 17:30: Presentation 4 - Giovanni Gentile (University of Padua & SENSEDAT)
17:30 - 17:40: Presentation 5 - Francesca Cormack (Cambridge Cognition & University of Cambridge)
17:40 - 17:50: Presentation 6 - Chris van Hoof (imec & OnePlanet Research Center)
17:50 - 18:00: Presentation 7 - Szymon Fedor (MIT Media Lab)

18:00 - 18:15: Session 2 Q&A

18:15: Closing remarks by workshop organizers

Speaker Biographies and Abstracts

Session 1

Luca Foschini, Evidation Health

Bio: Luca is the Co-founder and Chief Data Scientist at Evidation Health, responsible for data analytics and research and development. At Evidation he has driven research collaborations resulting in numerous publications in the fields of machine learning, behavioral economics, and medical informatics. Previously, Luca held research positions in industry and academic institutions, including Ask.com, Google, ETH Zurich, and UC Santa Barbara. He has co-authored several papers and patents on efficient algorithms for partitioning and detecting anomalies in massive networks. Luca holds MS and PhD degrees in Computer Science from UC Santa Barbara, and ME and BE degrees from the Sant'Anna School of Pisa, Italy.

Title: Person-generated Health Data (PGHD): A New Ally for Public Health

Abstract: Person-Generated Health Data (PGHD) from smartphones, wearables and other sensors have the potential to transform the way health is measured, with broad-ranging applications from clinical research to public health and health care at large. This talk will survey examples of applications of PGHD across therapeutic areas, including post-op monitoring, screening for cognitive impairment, and a particular focus on public health applications for flu and COVID-19 detection and quantification. Finally, I will discuss lessons learned in translating PGHD research into benefits for the individual, with emphasis on the importance of evaluating analytics performance (e.g., AUROC, sensitivity, specificity, …) within a specific context of use of a real-world application.

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Florian Lipsmeier, Roche Pharma Research and Early Development, F. Hoffmann-La Roche Ltd.

Bio: Dr. Florian Lipsmeier is a group leader for Digital Biomarker data analysis in Pharma Research and Early Development at F. Hoffmann-La Roche Ltd.. Following his PhD in Biomathematics at Bielefeld University in 2010, he has worked in different capacities as a data scientist at Roche. After four years supporting the research and development of large molecules such as antibodies in drug development he turned his attention to the novel field of research around digital health technology tools. As of 2015, starting with hands-on signal processing and statistics on accelerometer, gyroscope and audio data collected in Parkinson's disease, he has since then built up a team around operational data analysis, biomedical engineering, ML/AI and statistics on digital health data. He is the (co-)author of more than 35 publications and patent applications, most of them in the field of digital health.

Title: Digital Health technology tools and quality of life - examples from current studies in neurological disorders

Abstract: In recent years digital health technology tools (DHTTs) such as smartphones and wearables are becoming an integrated part of clinical research. Augmented by novel, often AI-powered signal processing, they enable continuous and very precise measurements of disease symptoms. It is therefore becoming very important to link these measures to the different aspects of quality of life (QoL) of patients to make them meaningful tools for drug-decision making. In this talk I will highlight examples from DHTTs we are developing for neurological disorders such as Parkinson's disease, Multiple Sclerosis and Huntington's disease. Leveraging active testing and patient questionnaires, accompanied by passive, continuous monitoring in daily life these tools offer rich sets of data. General signal processing as well as dedicated ML/AI solutions are used to unlock these data sets and relate them back to standard clinical scores of disease severity. I will show how resulting measures relate to patients' self-perceived health-related quality of life, how DHTTs used during Covid-19 induced lockdowns can offer new insights on QoL perception and how we envision to strengthen the link between novel sensor measurements and patient relevant symptoms and impacts.

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Benjamin Vandendriessche, Byteflies

Bio: Benjamin Vandendriessche is Chief Medical Officer at Byteflies, the Belgian-American company behind Sensor Dot, a powerful platform for 24/7 capture of medical insights to deliver care at home and augment clinical trials with real-world data. He is specialized in molecular biology, systems physiology, and data analytics for physiologic waveform and vital sign processing. He completed a PhD in Molecular Biology at Ghent University as an IWT Fellow, followed by a postdoc in Computer Science at Case Western Reserve University (CWRU) as a BAEF Fellow. He currently is an adjunct assistant professor at CWRU.

Title: Leveraging multimodal sensor data to assess complex chronic conditions at home

Abstract: Byteflies's Sensor Dot platform enables continuous acquisition of physiologic and behavioral data. We leverage this multimodal data to move diagnostic tests typically performed in a specialized environment to the home of the user, and to make longitudinal assessments of chronic conditions possible. In both cases, an understanding of the continuous changes in activities of daily living is crucial for safe and accurate clinical interpretation of the data.

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Benjamin L. Smarr, UCSD Department of Bioengineering and the Halicioglu Data Science Institute; Oura

Bio: Dr. Benjamin L. Smarr, Ph.D. Neurobiology, is an assistant professor at UCSD's Department of Bioengineering and the Halicioglu Data Science Institute. His work leverages his domain expertise in biological rhythms and neuroendocrinology to uncover patterns in diverse sets of time series data that carry actionable information to impact health and cognitive performance. In 2020 he became the technical lead of the global collaborative TemPredict study, which developed algorithms for early detection of COVID-19 infection, and unique cyberinfrastructure to serve rapid, collaborative explorations of population-scale, personal time series data. Beyond the pandemic, Dr. Smarr contributes broadly through science outreach, popular media, and industry liaisons. His personal passions lie in advancing women's health, and in increasing participant engagement to map physiological diversity in service to precision individual and public health.

Title: The future of health and wellness discovery is democratic

Abstract: Engineered solutions for personal data generation (wearable sensors, apps, etc.) and analysis are proliferating rapidly, but health services served by these technologies continue to lag behind. Complexity in human diversity stymies algorithm generalizability, and hampers successful wide adoption of any specific solution. We propose that efforts at expanding engagement in discovery will achieve two complementary goals: 1) promote mapping of biological diversity beyond demography and genetics into physiology and behavior, so that algorithms can be developed on empirically determined subpopulations, and 2) fertilize natural experiments that will reveal communities sharing needs and goals, for whom solutions can then be tailored. Efforts to expand engagement may enable a virtuous cycle where iterative improvement and expansion in precision wellness technologies go from intractable to standard in personal, community, and clinical settings.

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Session 2

Akane Sano, Rice University

Bio: Akane Sano is an Assistant Professor at Rice University, Department of Electrical Computer Engineering, Computer Science, and Bioengineering. She directs the Computational Wellbeing Group. She is also a member of Rice Scalable Health Labs. Her research focuses on affective, ubiquitous, and wearable computing, and biobehavioral sensing and analysis/modeling. She received her Ph.D. at the Massachusetts Institute of Technology. Her recent awards include the NSF Career Award, the Best Paper Award at IEEE BHI 2019 conference, and the Best Paper Award at the NIPS 2016 Workshop on Machine Learning for Health.

Title: Multimodal sensor data analysis and modeling for health and wellbeing

Abstract: Digital phenotyping and machine learning technologies have shown a potential to measure objective behavioral and physiological markers, provide risk assessment for people who might have a high risk of poor health and wellbeing, and help better decisions or behavioral changes to support health and wellbeing. I will introduce a series of studies, algorithms, and systems we have developed for measuring, predicting, and supporting personalized health and wellbeing. I will also discuss challenges, learned lessons, and potential future directions in health and wellbeing research.

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Giovanni Gentile, Department of Neuroscience, University of Padua, Italy; SENSEDAT Srl, Padua, Italy

Bio: A clinical psychologist and cognitive science enthusiast, his primary expertise is in clinical research, digital health, wearables, and biomarkers for CNS diseases (especially Parkinson's, anxiety, and MDD, with an emphasis on cognition, emotion, and physiological response to stress. He is the founder of SENSEDAT, a startup-company that provides digital biomarkers in psychiatry clinical trials. He is currently a research fellow at the Department of Neuroscience, University of Padua, Italy, working on the EU H2020 project on chronic CNS conditions. He holds a PsyD in clinical psychology and family therapy applying systems theory and cybernetics to human and biological systems such as families, groups, organisations as well as to individuals.

Title: Unsupervised wearable and machine learning approach to identify depression, anxiety and stress physiological phenotypes

Abstract: BACKGROUND. Anxiety and depression are defined with clinical interviews in randomized controlled trials (RCT), possibly inflating interventions/placebo's effects. We here introduce an algorithm to identify anxiety and depression with wearable-measured physiological biomarkers.
OBJECTIVES. To validate a machine learning-based algorithm using wearable unsupervised measurements of Autonomic Nervous System, physiological parameters to classify clinical anxiety and depression according to validated questionnaires.
METHODS. Included were physically healthy workers from the general population, wearing an arm-band wearable device equipped with photoplethysmogram (PPG) and electrodermal activity (EDA) sensors, for 24 hours. Participants answered to validated self report questionnaires for mental health, including PSS-10, GAD-7 and PHQ-9. Wearable recordings were subject to artefact removal, signal pre-processing, and split in 30 seconds blocks for which physiological indexes and related features were extracted. A feature fusion approach was implemented together with C5.0 machine learning algorithm which was run on 70% randomly selected pre-processed blocks, and on the remaining 30% for external validation. Co-primary outcomes were anxiety (GAD-7 ≥ 10), and depression (PHQ-9≥10).
RESULTS. We included 95 subjects (yielding 237,778 monitoring blocks), 47.7% females, mean age 37.2 (±15.5). Overall, 13.7% had anxiety, 12.6% had depression, and 7.4% had both. In the main sample, the wearable-machine learning algorithm showed excellent accuracy for co-primary outcomes, namely AUC=0.928 for anxiety, and AUC=0.959 for depression.
DISCUSSION. Limitations of the study include self-report questionnaires to assess primary outcomes, and its cross-sectional nature. Potential implications of this work include biomarker-based inclusion criteria in RCT testing interventions for anxiety and depression, as well as screening and monitoring tool of mental health issues in general population. Further studies should replicate the proposed algorithm against structured interviews-based diagnoses, with different wearable devices, on clinical samples, possibly with a longitudinal design.

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Francesca Cormack, Cambridge Cognition; Department of Psychiatry, University of Cambridge

Bio: Francesca Cormack is Director of Research and Innovation at Cambridge Cognition. She has worked to develop and validate novel cognitive testing methodology to support high-frequency, near patient testing using wearable, mobile and voice technology, providing insights into cognitive health in a range of patient groups. Francesca obtained

a PhD in Dementia with Lewy Bodies at Newcastle University, followed by post-doctoral and academic positions at University College London and at the Medical Research Council in Cambridge. She is an Honorary Research Fellow at the University of Cambridge Department of Psychiatry and maintains academic collaborations focused on neurological disorders, ageing and psychiatry.

Title: Characterizing fatigue using digital technologies

Abstract: Fatigue is both common and burdensome across a range of patient groups. The manifestation of fatigue is complex, comprising both subjective and objective changes to cognitive and physical performance, and is determined by a range of factors, including sleep, mood, time of day, competing demands and environmental context, as well as disease-specific variables. These factors, and consequently the patient's experience of fatigue, vary with time, meaning that infrequent in-clinic assessments are likely to be of limited sensitivity. Given this complexity, we have been interested in exploring the potential role of digital technologies in capturing and characterising fatigue, particularly the impact of fatigue on cognitive performance, across a range of clinical conditions. This talk will focus on methods of data collection such as brief active assessments, voice capture and passive data from wearable technology, and describe insights these data provide us into this complex symptom.

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Chris Van Hoof, Connected Health Solutions, imec; OnePlanet Research Center

Bio: Chris Van Hoof is General Manager of the OnePlanet Research Center in Gelderland. He is also Vice President R&D at imec. Chris believes preventive health, personalised nutrition, sustainable food production and reduced waste are essential enablers of improving our world for the generations to come. And he is convinced that technology (hardware and AI) are key tools to make that happen. After receiving a PhD in Electrical Engineering from the University of Leuven in 1992, Chris has held positions as manager and director at imec in highly diverse fields spanning technology, circuits, systems, data and applications. Apart from delivering industry-relevant innovative solutions to customers, his work also resulted in five startups (four in the healthcare domain). He is also full professor at the University of Leuven and imec Fellow. Although OnePlanet Research Center started just over 2 years ago, it has already built up a team of 70 scientists and engineers, who create innovations in close collaboration with teams from the founding organizations imec, Radboud University and Medical Center and Wageningen University and Research.

Title: Nanoelectronics and AI for Our (and our planet's) Health

Abstract: We are faced with global challenges related to health, food, sustainability and the environment. While these are formidable challenges, they also represent a gigantic opportunity to improve people's lives on a global scale while at the same time creating new economic opportunities. We are convinced nanoelectronics and digital technologies are the key tools for disruptive solutions. With that purpose in mind, the OnePlanet Research Center was created as a multi-disciplinary collaboration between imec, Radboud University & Medical Center, and Wageningen University & Research. In OnePlanet we apply nanoelectronics and analytics innovations to solve problems related to personalized health, personalized nutrition, mental wellbeing, and also sustainable food production and reduced environmental impact. The sensors and data innovations are working towards the creation of digital twins for prevention, early detection or interception of disease.

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Szymon Fedor, MIT Media Lab

Bio: Szymon Fedor leads several studies at MIT Media Lab where he uses Affective Computing and body-worn devices to study wellbeing and good mental health. He has over a decade of research related to wearable technologies and embedded systems. Prior to his current appointment, he carried out research in Ericsson and United Technologies Research Center, contributing to commercial solutions based on consumer electronics. He holds a M.Sc. in Telecommunications with First Class Honours and a Ph.D. in Computer Science. He published a book, a book chapter and over 50 papers in peer reviewed journals and conferences. He also holds five patents.

Title: Monitoring wellbeing using longitudinal passive data

Abstract: The boundaries between the consumer and clinical devices markets are becoming leaner every year. This trend is driven by a number of factors including consumer demand for ubiquitous and constantly accessible healthcare, increased presence of chronic conditions (such as high blood pressure, diabetes, depression and obesity) and a corresponding need for preventive healthcare, an increasingly aging global population, availability of cost-effective, wearable technology and remote access to storage and computation resources. This trend enables tremendous opportunities for providing healthcare services to larger populations at lower cost. It will also pave the way to personalized medicine where prevention, diagnosis and treatment of a disease can be tailored to individuals' characteristics and behavior. In this presentation Szymon Fedor will talk about recent developments of wearable technologies at MIT Media Lab and their application to diagnosis of mental health diseases and overall well-being.