Ananta Narayanan Balaji

Personal Information

UNIVERSITY:	National University of Singapore
MAJOR:	Electrical and Computer Engineering
SPECIALIZATION:	Signal Processing and Machine Intelligence
EMAIL:	ananta@comp.nus.edu.sg
ADDRESS:	Systems and Networking Lab 6, School of Computing, NUS
PERSONAL WEBPAGE:	https://anantabalaji.github.io
LINKEDIN PAGE:	https://www.linkedin.com/in/anantabalaji/

Research Interests

Low-power Mobile/Wearable computing, On-body AI accelerator-based architectures for smart-textiles, and Next-generation wearable applications.

Education

2018-NOW	Ph.D. Candidate in Electrical and Computer Engineering
	National University of Singapore
	Advisor : Prof. Peh Li-Shiuan
	Expected graduation date: April 2023.
	CAP: 4.65/5
2015-2016	M.Sc. in Computer Engineering
	National University of Singapore
	Thesis title: Segmentation of Femoral head in 3D ultrasound images of infants
	Advisor : Prof. Ashraf Kassim
	CAP : 4.45/5
2011-2015	B.E. in Electronics and Computer Engineering
	Thiagarajar College of Engineering, India
	CGPA: **9.9/10 (1st of 150)**

Work Experience

May 2022 - Aug 2022	**Research Scientist Intern** @ Meta Reality labs, Redmond
	Advisors : Dr. Morteza Khaleghimeybodi, Dr. Jennifer Monti, Dr. Anurag Kumar, Dr. Thomas Lunner
	Singe PPG only in-ear hearable hardware prototype development along with accompanying motion-resilient dehydration sensing techniques based on signal processing and deep learning
Sep 2021 - Nov 2021	**Research Intern** @ Nokia Bell labs, Cambridge
	Advisors : Dr. Alessandro Montanari, Senior Research Scientist
	Dr. Fahim Kawsar, Founding Director of Pervasive Systems research
	Stereo In-ear PPG based Blood Pressure sensing and Systematic Characterization of Facial motions in In-ear PPG signals(under submission)
Mar 2020 - Jun 2020	**Research Intern** @ Google Daydream, San Francisco
	Advisors : Dr.David Kim, Research Scientist and Software Manager
	Dr. Ruofei Du, Research Scientist
	Low-power, Low-compute and user-friendly interaction input methods for future Augmented reality devices

Jan 2019 - Jun 2019	**Software Engineer** @ Portcast, Singapore Developed an optimal route prediction algorithm for marine logistics
Oct 2016 - Dec 2017	**R&D engineer** @ Works Applications, Singapore Worked on Automatic form filling from PDF's for payment invoices
Apr 2016 - Jul 2016	**Research Intern** @ Temasek Labs, NUS Advisor: Dr. Garrick Orchard (Now Sr. Research Scientist @ Intel) Noise filtering and UAV tracking with Neuromorphic camera
Dec 2015 - Mar 2016	**R&D Intern** @ Panasonic R&D Center, Singapore Mentor: Mr. WEI Zheng (Now R&D Director @ Deep North Inc.) Developed deep learning based Sentence Classification for Chatbots

PUBLICATIONS

1. pH Watch - Leveraging Pulse Oximeters in Existing Wearables for Reusable, Real-time Monitoring of pH in Sweat
   Ananta Narayanan Balaji*, *Chen Yuan*, Bo Wang, Li-Shiuan Peh, Shao Huilin*
   ACM International Conference on Mobile Systems, Applications, and Services (MobiSys) 2019
   Media Coverage : Straitstimes, NUS News, Healthtech Insider, ACM news etc.

2. AI-on-skin: Enabling On-body AI Inference for Wearable Artificial Skin Interfaces
   Ananta Narayanan Balaji, *Li-Shiuan Peh*
   CHI EA '21: Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems, May 2021
   Media Coverage : Hackster.io **Project webpage** : `https://aionskin.github.io/`

3. RetroSphere: Self-Contained Passive 3D Controller Tracking for Augmented Reality
   Ananta Narayanan Balaji, *David Li, Clayton Kimber, Shenghzhi wu, Ruofei Du and David Kim*
   Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies 2022 (IMWUT/ACM Ubicomp'23)
   Project webpage : `https://retrosphere.github.io/`

4. AI-on-skin: Towards enabling On-body AI Inference for Wearable Artificial Skin Interfaces
   Ananta Narayanan Balaji, *and Li-Shiuan Peh*
   Proceedings of the ACM on Human-Computer Interaction 2023 **(To appear)**

5. Stereo-BP: Non-invasive Blood pressure sensing with earables
   Ananta Narayanan Balaji, *Andrea Ferlini, Alessandro Montanari and Fahim Kawsar* 24th ACM International Workshop on Mobile Computing Systems and Applications (HotMobile 2023) **(To appear)**

6. 1.7pJ/SOP, 0.5V Scalable Neuromorphic Processor with Integrated Partial Sum Router for In-Network Computing
   B. Wang, M. M. Wong, D. Li, YS. Chong, J. Zhou, W. F. Wong, **Li-shiuan Peh**, *A. Mani, M. Upadhyay*, **Ananta Narayanan Balaji**, *and A. T. Do* IEEE International Symposium on Circuits and Systems 2023 (ISCAS 2023) (To Appear)

7. SeRaNDiP - Leveraging Inherent Sensor Random Noise for Differential Privacy Preservation in Wearable Community Sensing Applications
   Ayanga Kalupahana, **Ananta Narayanan Balaji***, Xiaokui kui and Li-shiuan Peh* Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies 2023 (IMWUT/Ubicomp) **(Under revision)**

MANUSCRIPTS UNDER REVIEW

1. VitalBuds: A Comprehensive Evaluation of Hydration Sensing Techniques With Hearables

Ananta Narayanan Balaji, *Morteza Khaleghimeybodi, Jenniffer Monti, Anurag Kumar and Thomas Lunner*

2. EarSet: A Multi-Modal Dataset for Studying the Impact of Head and Facial Movements on In-Ear PPG Signals
Andrea Ferlini*, Alessandro Montanari*, **Ananta Narayanan Balaji**, *Cecilia Mascolo and Fahim Kawsar*

3. StressScope: Real-time, non-invasive and reusable cortisol sensing from sweat
Ananta Narayanan Balaji, *Chen Yuan, Goh Teck Lun, Li-Shiuan Peh, Shao Huilin*

RESEARCH PROJECTS (IN MY PH.D.)

1. **pH sensing from sweat using smart watches [Mobisys'19]**
Advisors: Prof. Peh Li Shiuan, Dept. of computer Science and Prof. Shao Huilin, Dept. of Biomedical Engineering, NUS
pH Watch is the first ever prototype for sweat pH (indicator of dehydration risk) sensing using PPG sensors found in existing wearables. We also implemented a robust noise removal algorithm to aid in accurate pH sensing even during the presence of motion artifacts.

2. **Faster AI-inference enabled body-worn tactile wearable interaction systems (under submission)**
Advisors: Prof. Peh Li Shiuan, Dept. of computer Science
AI-on-skin is a wearable artificial skin interface integrated with a neural network hardware accelerator that can be reconfigured across diverse neural network models and applications. AI-on-skin is designed to scale to the entire body, comprising tiny, low-power, accelerators distributed across the body.

3. **Sensing Cortisol from sweat with PPG sensors in existing wearables (on-going)**
Advisors: Prof. Peh Li Shiuan, Dept. of computer Science and Prof. Shao Huilin, Dept. of Biomedical Engineering, NUS

PATENTS

1. Wearable sweat sensor
Ananta Narayanan Balaji*, *Chen Yuan*, Bo Wang, Li-Shiuan Peh, Shao Huilin*
WO2021107871A1 2019

2. A Self-Contained Passive 3D Controller Tracker
Ananta Narayanan Balaji, *Clayton Kimber, Ruofei Du, David Kim* **(Google)**
(Patent Pending) 2022

3. In-ear sensing device
Ananta Narayanan Balaji, *Morteza Khaleghimeybodi, Jennifer Monti, Thomas Lunner* **(Meta Reality Labs)**
(Patent Pending) 2022

4. Multimodal Silent speech Interfaces with future AR/VR devices
Ananta Narayanan Balaji, *Morteza Khaleghimeybodi, Melinda Anderson, Thomas Lunner* **(Meta Reality Labs)**
(Patent Pending) 2022

5. Head-worn apparatus for cuffless blood pressure sensing
Ananta Narayanan Balaji, *Alessandro Montanari, Andrea Ferlini, Fahim Kawsar* **(Nokia Bell Labs)**
(Patent Pending) 2023

Demo

1. pH Watch - Leveraging Pulse Oximeters in Existing Wearables for Reusable, Real-time Monitoring of pH in Sweat
   Ananta Narayanan Balaji*, *Chen Yuan*, Bo Wang, Li-Shiuan Peh, Shao Huilin*
   ACM International Conference on Mobile Systems, Applications, and Services (MobiSys) 2019

Reviewer

2020	IMWUT, CHI
2021	IMWUT, CHI, TEI, DIS, Ubicomp/ISWC, EICS
2022	IMWUT, CHI, TEI, Transaction on Computers(TC), Ubicomp/ISWC, MobileHCI
2023	IMWUT, CHI, CSCW, EICS (Program committee member of Late Breaking work), World Haptics Symposium, MobileHCI, DIS

Invited talks

1. "Making Smartwatches to sense dehydration" – Systems and Networking Seminar Series – NUS School of Computing.

2. Next generation Low power Wearable applications - Biosensors seminar series, Meta Reality Labs

Awards and Scholarships

2018-2022	NUS Research Scholarship Award
2015	Best outgoing student - Medal of Excellence, Thiagarajar College of Engineering
2011-2015	Academic Proficiency Award, Thiagarajar College of Engineering
2014	Top 10 Finalists in Honeywell Young innovators challenge

Programming Skills

Proficient:	C/C++ (Embedded software development), Python, Java, JavaScript, SystemVerilog
ML/DL libraries:	PyTorch, TensorFlow, Tf-lite, CMSIS (Arm neural network library), Mxnet etc.
Basic Knowledge:	VHDL, Matlab, Synopsis, SQL, Cassandra
Development Boards:	Raspberry Pi, Pynq FPGA, Ultra96 FPGA etc.
Sensors:	PPG, EMG, EEG, ECG, Temperature sensors, Cameras, Depth cameras, GSR and microphones

References

1. Dr. Li-Shiuan Peh
   Provost's chair professor, School of Computing, National University of Singapore.

2. Dr. David Kim
   Staff Research Scientist, Google AR.

3. Dr. Ruofei Du
   Senior Research Scientist, Google AR.

4. Dr. Morteza Khaligameybodi
   Research Scientist , Meta Reality Labs.