

Zijing Zhang



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Education

Cornell University, Ithaca, NY, USA

Aug. 2019 – (Expected) May. 2023

Ph.D. Candidate, Electrical and Computer Engineering

Thesis: **RF Sensors for Medical and Cyber-physical Intelligence**

Nominated for Best ECE Ph.D. Thesis Competition

Advisor: Edwin C. Kan

Huazhong University of Science and Technology, Wuhan, China

Sept. 2015- June 2019

Bachelor of Engineering, Optoelectronic Information Science and Engineering, GPA: 3.92/4.0

Publications

- [1] **Z. Zhang**, and E. C. Kan, "Novel muscle monitoring by radiomyography (RMG) and its application to hand gesture recognition," 2nd review, *IEEE Trans. Hum. Mach. Syst.* [link](#) [video](#)
- [2] **Z. Zhang**, J. Zhou, T. B. Conroy, S. Chung, J. Choi, P. Chau, D. B. Green, A. C. Krieger and E. C. Kan, "Objective dyspnea evaluation on COVID-19 patients learning from exertion-induced dyspnea scores," editor approval for 1st review, *Science Partner Journal BME Frontiers*. [link](#)
- [3] **Z. Zhang**, T. B. Conroy, A. C. Krieger and E. C. Kan, "Identification and prediction of sleep disorder by covert bed integrated RF sensors," *IEEE Trans. Biomed. Engr.*, 2022, doi: 10.1109/TBME.2022.3212619. [link](#)
- [4] **Z. Zhang**, and E. C. Kan, "Radiooculogram (ROG) for eye movement sensing with eyes closed," in *21st IEEE Conf. on Sensors*, Dallas, TX, Oct. 30 – Nov. 2, 2022. [link](#)
- [5] **Z. Zhang**, G. Xu, and E. C. Kan, "Outlooks for RFID-based autonomous retails and factories," *IEEE J. Radio Frequency Identification (RFID)*, 2022, doi: 10.1109/JRFID.2022.3211474. [link](#)
- [6] **Z. Zhang**, G. Xu, and E. C. Kan, "3D geometry recognition by RFID Box based on deep learning," in *16th Intl. Conf. on RFID*, Las Vegas, NV, May 16 – 19, 2022. [link](#) [video](#)
- [7] P. Sharma, **Z. Zhang**, T. B. Conroy, X. Hui, and E. C. Kan, "Attention detection by heartbeat and respiratory features from radio-frequency sensor," *Sensors*, vol. 22, no. 20, p. 8047, 2022. [link](#)
- [8] **Z. Zhang**, P. Sharma, T. B. Conroy, V. Phongtankuel, and E. C. Kan, "Objective scoring of physiologically induced dyspnea by non-invasive RF sensors," *IEEE Trans. Biomed. Engr.*, vol. 69, no. 1, pp. 432-442, 2021. [link](#)
- [9] **Z. Zhang**, P. Sharma, J. Zhou, X. Hui and E. C. Kan, "Furniture-integrated respiration sensors by notched transmission lines," *IEEE Sens. J.*, vol. 21, no. 4, pp. 5303-5311, 2021. [link](#)
- [10] X. Hui, J. Zhou, P. Sharma, T. B. Conroy, **Z. Zhang** and E. C. Kan, "Wearable RF near-field cough monitoring by frequency-time deep learning", *IEEE Trans. Biomed. Circuits & Sys*, vol. 15, no. 4, pp. 756 – 764, 2021 [link](#)
- [11] **Z. Zhang**, et al., "Wideband and continuously-tunable fractional photonic Hilbert transformer based on a single high- birefringence planar Bragg grating," *Opt. Express*, vol. 26, pp. 20450-20458, 2018. [link](#)
- [12] **Z. Zhang**, et al., "Design of a broadband achromatic dielectric meta-lens for linear polarization in the near-infrared spectrum," *OSA Contin.*, vol. 1, pp. 882-890, 2018. [link](#)
- [13] **Z. Zhang**, et al., "Micro-machining for TE/TM mode phase matching in high-birefringence planar waveguide and implementation in continuously-tunable fractional Hilbert transform," *Intl. Photonics & Optoelectronics Mtg., OSA Tech. Dig.*, OT4A.2, 2018. [link](#)
- [14] H. Sun, W. Zhou, **Z. Zhang** and Z. Wan. "A MEMS variable optical attenuator with ultra-low wavelength-dependent loss and polarization-dependent loss," *Micromachines*, vol. 9, no. 12, p. 632, 2018. [link](#)

Patent

- [1] **Z. Zhang**, and E. C. Kan, "Radiomyography (RMG) for accurate hand gesture recognition by forearm wearable radio sensors", US Patent (Provisional)

Research Areas

- Non-invasive sensing of physiological signals including respiration, heartbeat, and muscle motion.
- Diagnosis and prognosis of respiratory disorders, including dyspnea, COPD, COVID-19, and sleep apnea.
- Muscle monitoring system for hand gesture recognition, motion detection, biometrics, and muscle fatigue.
- Machine learning, deep neural network, digital signal processing, and feature extraction.

Research Experiences

- 1 ***Hand gesture recognition system by non-invasive muscle monitoring sensors*** [link](#) [pdf](#)
Proposed a novel radiomyography (RMG) for continuous muscle actuation sensing that can be wearable and touchless, with high user comfort and low time latency, capturing superficial and deep muscle groups. Experimentally demonstration of high accuracy (99%) for 23 gestures by adopting vision transformer (ViT) as the deep learning model. RMG can be applied for assessment of muscle functions, fatigue, and neuromuscular disorders, as well as human-machine interface of exoskeleton robotic control and VR/AR.
- 2 ***Non-invasive eye movement monitoring*** [link](#) [pdf](#)
Prototyped radio-oculogram (ROG), a wearable RF sensor for non-invasive eye movement with eyes open or closed, which can applied to sleep rapid EM monitoring.
- 3 ***Air-writing recognition by forearm wearable RMG*** [link](#)
Enabled the user to hand-write in the air in an intuitive and natural way with non-invasive sensor on the forearm and demonstrated accurate detection of individual alphabets from A-Z.
- 4 ***Dynamic muscle fatigue detection using RMG and sEMG*** [link](#)
Demonstrated muscle sensing in fatigue vs. non-fatigue routines on forearms and legs assisted by machine learning models.
- 5 ***Biometric authentication based on muscle recognition***
Explored the new dynamic air signature biometric by recognizing the unique muscle pattern using wearable forearm RMG. Compared with traditional signature, this new technique requires dynamic recording of muscle activities which can be robust against presentation and replay attacks.
- 6 ***3D geometry recognition by RFID Box based on deep learning*** [link](#) [pdf](#)
Employed ambient low-cost passive RFID tags for recognition of 3D shape and geometry of hand gesture and foot size. Studied the read yield rates as a function of tag deployment and antenna detuning.
- 7 ***Dyspnea evaluation on COVID-19 patients*** [link](#) [pdf](#)
Employed wireless and wearable sensors on COVID-19 patients ($N = 12$) with continuous (~16 hours) monitoring of respiratory metrics to evaluate dyspnea using machine learning models. Demonstrated diagnosis and prognosis of COVID dyspnea, which can be potentially applied to asthma and COPD.
- 8 ***Sleep apnea detection and prediction based on bed-integrated RF sensor*** [link](#) [pdf](#)
Collected data from overnight clinical study ($N = 27$) in Weill Cornell Sleep Center using covert bed-integrated sensors. Developed machine-learning algorithms that can autonomously detect and predict sleep apneic events with 90-s lead time on real patients with high fidelity.
- 9 ***Objective scoring of dyspnea with wearable respiratory RF sensor*** [link](#) [pdf](#)
Designed a testing protocol to perform human study ($N = 32$) on simulated dyspnea by exertion and airway blockage. Implemented algorithms to identify various features embedded in breathing waveforms and designed a learning model to predict objective dyspnea scores in comparison with the self-report scores.
- 10 ***Covert furniture-integrated RF sensors for respiratory pattern monitoring*** [link](#) [pdf](#)
Developed a non-invasive respiration sensor integrated into furniture that can be invisible to the user to enhance comfort, convenience and acceptance.
- 11 ***Respiration study in patients with advanced chronic obstructive pulmonary disease (COPD)***
Performed human study to identify the association between dyspnea and respiratory features of COPD patients in Weill Cornell Medicine ($N = 15$), including changes in respiratory rate, respiratory volume, lung elasticity, and inhalation/exhalation time. Collected data via wearable RF sensors in a clinical setting.

Intern Experience

Signal Processing and Machine Learning in Digital Healthcare *Analog Devices, Wilmington, MA, May – Aug. 2021*
Research Intern in Georgia Institute of Technology (Advised by Prof. Ali Adibi) *Atlanta, GA, Jun. – Oct. 2018*

Skills

Programming and tools: MATLAB; Python; PyTorch; LabVIEW; COMSOL; C/C++; CST Microwave Studio;
RF equipment: Software-defined radios; network analyzers; spectrum analyzers; RF transceivers.
Biomedical sensors: EMG; ECG; PPG; respiratory chest belt; polysomnography; IMU.