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/disorders.
- 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 radio-myography (RMG) for continuous muscle actuation sensing that can be wearable and touchless, with high user comfort, low time latency, capturing superficial and deep muscle groups.
- Experimentally demonstrated that RMG can achieve high accuracy (99%) for 23 gestures by human study (N = 8).
- Adopted vision transformer (ViT) as the deep learning model to boost accuracy and efficiency compared with CNN.
- Developed new methods for assessment of muscle functions, fatigue, and diagnosis of neuromuscular disorders, together with future applications on human-machine interface of exoskeleton robotic control and virtual/augmented reality.

2 Non-invasive eye movement monitoring link pdf

- Prototyped radio-oculogram (ROG), wearable RF sensing for non-invasive eye movement with eyes open or closed.
- Measured accurate eye movement frequency and directions, and benchmarked with electrooculogram (EOG).
- Formulated the baseline implementation for 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.
- Demonstrated detection of individual alphabets from A-Z with accuracy over 90%.

4 Dynamic muscle fatigue detection using RMG and sEMG link

- Demonstrated muscle actuation sensing in fatigue vs. non-fatigue routines on forearms and legs.
- Fused RMG and sEMG to derive muscle stimulation-actuation correlation reflecting fatigue status.
- Implemented machine learning models to classify dynamic muscle fatigue.

5 Biometric authentication based on muscle recognition

- Explore the new dynamic air signature system by writing in the air and recognizing the unique muscle behavior pattern using wearable forearm RMG.
- Compared with traditional handwriting, this new technique requires dynamic recording of muscle activities which can be an important next generation hard-to-fake marker.

6 3D geometry recognition by RFID Box based on deep learning link pdf

- Employed ambient low-cost passive RFID tags for the recognition of 3D shape and geometry of hand gesture and foot size. Studied the read yield rates as a function of deployment and antenna detuning.

7 Dyspnea evaluation on COVID-19 patients link pdf

- Employed wireless and wearable sensors on COVID-19 patients (N = 12) to continuously (~16 hours) monitor respiratory metrics and evaluate dyspnea using machine learning models.
- Revealed the high similarity between chronic dyspnea on COVID patients and physiologically induced dyspnea on healthy subjects.
- Demonstrated diagnosis and prognosis of COVID dyspnea, which can be potentially applied to other pulmonary disorders such as asthma and COPD.

8 Sleep apnea detection and prediction based on bed-integrated RF sensor link pdf

- Collected data from clinical study (N = 27) in Weill Sleep Center of overnight recording using bed-integrated sensors invisible to the user.
- Developed machine-learning algorithms that can automatically detect and predict sleep apneic events on real patients with high fidelity.
- Demonstrated the capability to prognosticate sleep apnea events in 90 seconds earlier.

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 facemasks.
- Implemented algorithms to identify various features embedded in breathing waveforms and designed a learning model to predict objective dyspnea score 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.
- Performed a human study (N = 10) that confirmed the validity of sensing the cardiopulmonary waveforms and simulated respiratory disorders including central and obstructive sleep apnea.

11 Respiration study in patients with advanced chronic obstructive pulmonary disease (COPD)

- Performed human study to identify the association between dyspnea and respiration in COPD patients in Weill Cornell Medicine (N = 15).
- Analyze the association between changes respiratory metrics (e.g., respiratory rate, respiratory volume, lung elasticity, inhalation/exhalation time) collected via wearable RF sensor in a clinical setting.

Intern Experience

Signal Processing and Machine Learning Intern 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; CST Microwave Studio; LabVIEW; COMSOL; C/C++.
RF equipment: Software-defined radios; network analyzers; spectrum analyzers; RF transceivers.
Biomedical sensors: EMG; ECG; PPG; respiratory chest belt; polysomnography; accelerometers.