

Libo Wu

EMBEDDED SYSTEM DEVELOPMENT

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Summary

- Proficient in embedded system design, hardware integration, infrared sensor technologies, and indoor human localization.
- Strong skills with machine learning, PCB design, wireless communication, circuit design, and signal processing.
- Hand-on experiences in 3-D printing, CAD design, product design, and troubleshooting.

Education

Texas A&M University

PH.D. CANDIDATE IN MECHANICAL ENGINEERING (TRANSFER STUDENT)

College Station, TX, USA

Aug. 2018 - Dec. 2020

Stony Brook University

PH.D. CANDIDATE IN ELECTRICAL AND COMPUTER ENGINEERING

Stony Brook, NY, USA

Aug. 2015 - Jul. 2018

University of Science and Technology of China

B.S. IN APPLIED PHYSICS

Hefei, Anhui, China

Aug. 2011 - Jun. 2015

Skills

Programming Embedded C, Python, C/C++, Matlab, Assembler, \LaTeX

Technical Skills

ARM Cortex-M microcontroller driver & application development, RTOS, SolidWorks, Machine learning, ML frameworks (Tensorflow, Keras), Wireless Communication (BLE, Zigbee), Labview, PCB design, Circuit design

Experience

SLEEPPIR Sensor Network for Human Presence Detection in Residential Buildings

College Station, TX, USA

RESEARCH ASSISTANT, ADVISOR: DR. YA WANG

Dec. 2019 - Present

- Built a Zigbee/BLE based wireless sensor network. Each end device contains multiple sensors, including SLEEPPIR presence sensor, temperature/humidity sensor and light sensor.
- Implemented a hub that receives report from end devices and controls smart thermostats via a cloud service.

Liquid Crystal Optical Shutter on Passive Infrared Sensor for True Presence Detection

College Station, TX, USA

RESEARCH ASSISTANT, ADVISOR: DR. YA WANG

Aug. 2018 - Present

- Solved the common issue that all commercial motions sensors (PIR sensors) could not detect stationary occupants.
- Created a liquid crystal (LC) infrared shutter that can modulate long-wave infrared radiation with low driving voltage and ultra low power consumption (4.8V driving voltage with $<10\text{nA}$) **[patent pending]**.
- Manufactured Polymer Dispersed Liquid Crystal (PDLC) infrared shutter with 8% modulation degree.
- Developed a synchronized low-energy electronically-chopped PIR sensor for true presence detection by applying the created LC shutter to a PIR sensor and being packaged in an extremely low power embedded system ($\sim 20\mu\text{W}$).
- Designed realistic protocols for being packaged which cover most regular daily actions and activities.
- Implemented the machine learning algorithm on the microcontroller. Extracted statistical features and ran machine learning algorithms (NN, SVM, Random Forest, etc.) for presence detection in real time.
- Reached 99.9% accuracy for true presence detection and over 97.7% accuracy for realistic protocols in a long-term test.

Compressive Sensing for Human Localization Using Single Thermopile Pixel Sensor

College Station, TX, USA

RESEARCH ASSISTANT, ADVISOR: DR. YA WANG

Aug. 2018 - Mar. 2019

- Designed a random binary mask to compress the radiation within the field of view (FOV) **[patent pending]**.
- Integrated one thermopile sensor and rotating optical mask to acquire compressive infrared signals from human.
- Built a physical model that shows the linear relationship among the output signal of sensor, the rotating mask and radiation distributions. Found the relationship could be solved by compressive sensing theory.
- Reconstructed spatial radiation distributions using basis pursuit denoising algorithm to recover localization information.
- Reached over 90% accuracy for localization of indoor the human object with a very low cost (less than \$10).

Co-Mentor of Senior Design Project: Occupant-centered Light and HVAC Control Using Machine Learning for Human Comfort and Energy Efficiency

College Station, TX, USA

RESEARCH ASSISTANT

Fall 2019

- Guided and managed the team to build a lighting and HVAC control system under \$100 budget.
- Generated a Gantt chart to track the progress of the project. Assigned different tasks based on the skills of the team members.
- Gave guidance of selecting proper hardware (MCU, sensors, wireless communication), design concepts (mechanical and electrical), user-centered product development, and software development (reinforcement learning).

Passive Infrared Sensor for Indoor Localization and Tracking

Stony Brook, NY, USA

RESEARCH ASSISTANT, ADVISOR: DR. YA WANG

Sept. 2017 - Mar. 2018

- Used a single passive infrared (PIR) and an optical shutter embedded with micro-controller unit (MCU) in the device to analyze the occupancy status of the indoor environment, such as presence, localization, and facial direction.
- Utilized an innovative rotating optical shutter in front of the PIR sensor to modulate the infrared radiation in a nonlinear manner. Built a physical model that shows the relationship between the output signal and the mechanical shutter.
- Extracted two features from the output signals from PIR sensors (peak to peak value, and pulse width).
- Applied machine learning methods (SVM and Neural Network) to improve the performance in predicting and classifying occupancy situations that reached 98% accuracy in localization.
- Extended the functionality of PIR sensors in indoor occupancy detection with high performance, such as human tracking with 0.44 m RSME, localization with 98% accuracy and facial direction detection with 83% accuracy.

Long-term True Presence Detection Platform

Stony Brook, NY, USA

RESEARCH ASSISTANT, ADVISOR: DR. YA WANG

Jan. 2018 - Jun. 2018

- Utilized the low-power Lavet stepper motor ($< 10\text{mA}$) to drive a mechanical optical shutter on PIR sensors for true presence detection that could detect both stationary and moving occupants [patent pending].
- Built a long-term experiment platform consists of Raspberry Pi, Pi camera, Shutterd PIR sensors and MCU.
- Used computer vision algorithms (YoLo and R-CNN) on videos to extract presence information as groundtruth.
- Reached 97% accuracy for classifying occupied and unoccupied scenes from 31-hour experiment.

VLSI Course Project: VLSI Design for 8-bit Adder

Stony Brook, NY, USA

INSTRUCTOR: DR. EMRE SALMAN

Fall 2016

- Developed an 8-bit CSA adder with 45nm CMOS technology using Cadence software. The final design showed low power of 1.184 mW, low area of $1257\ \mu\text{m}^2$, and high speed of 4.34 GHz.

Stony Brook University, Department of ECE

Stony Brook, NY, USA

TEACHING ASSISTANT

Aug. 2015 - Dec. 2017

- Embedded Microprocessor Systems Design (Fall 2016), Digital Systems Design (Spring 2016), Digital Signal Processing: Theory (Fall 2015)

Publications

JOURNAL PUBLICATIONS

- **Libo Wu**, Fangwang Gou, Shin-Tson Wu and Ya Wang, "Liquid Crystal Infrared Shutter for True Human Presence Detection Using Pyroelectric Infrared Sensors", *submitted to IEEE Sensors Journal*, 2020.
- **Libo Wu**, Fangwang Gou, Shin-Tson Wu and Ya Wang, "SLEEPIR: Synchronized Low-Energy Electronically-Chopped PIR Sensor for True Presence Detection", *to appear on IEEE Sensors Letters*, 2020.
- **Libo Wu**, and Ya Wang, "Compressive Sensing Based Indoor Occupancy Positioning Using A Single Thermopile Point Detector with a Coded Binary Mask", *IEEE Sensors Letters*, 3(12), pp. 1-4, 2019.
- **Libo Wu**, Ya Wang and Haili Liu, "Detection and Localization of Individuals by Monitoring Nonlinear Energy Flow of a Shuttered Passive Infrared Sensor", *IEEE Sensors Journal*, 18(21), pp. 8656-8666, 2018.
- **Libo Wu** and Ya Wang, "A Low Power Electric-Mechanical Driving Approach for True Occupancy Detection Using a Shuttered Passive Infrared Sensor", *IEEE Sensors Journal*, 19(1), pp. 47-57, 2018.

CONFERENCE PROCEEDINGS

- **Libo Wu** and Ya Wang, "Compressive Sensing Based Indoor Human Positioning Using A Single Thermopile Point Detector", *12th International Workshop on Structural Health Monitoring, September 10-12, 2019, Stanford, California, USA*.
- **Libo Wu** and Ya Wang, "Shuttered Passive Infrared Sensor for Occupancy Detection: Exploring A Low Power Electro-Mechanical Driving Approach", *ASME SMASIS conference*, 2018 (Oral presentation).

Patents

- **Libo Wu** and Ya Wang, "Shuttered Passive Infrared Sensor Apparatus with A Low Power LWIR Liquid Crystal Optical Modulator for Stationary and Moving Occupancy Detection", *U.S. Patent Application No. 62/880,058*, July 29, 2019.

- **Libo Wu** and Ya Wang, “A Single Thermopile Point Sensor Apparatus with A Set of Coding Masks (Compressive Sensing Matrix) for Indoor Human Positioning”, *U.S. Patent Application No. 62/863,823*, June 19, 2019.
- **Libo Wu** and Ya Wang, “Shuttered Passive Infrared Sensor Apparatus with A Low Power Lavet Motor Driving Approach for Stationary and Moving Occupancy Detection”, *U.S. Patent Application No. 62/863,808*, June 19, 2019.

Certification

Online Course Certificate Machine Learning (Cousera), Deep Learning Specialization (Cousera), Mastering RTOS: Hands on FreeRTOS (Udemy), Mastering Microcontroller with Driver Development (Udemy)

Honors & Awards

- 2019 **Graduate Student Travel Award**, J. Mike Walker '66 Department of Mechanical Engineering
- 2019 **Graduate Excellence Scholarship**, J. Mike Walker '66 Department of Mechanical Engineering
- 2013 **Bronze Medalist**, Outstanding Undergraduate Scholarship