Networked Embedded and Ai sysTem Laboratory (**NEAT Lab**)

Introduction

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Prof. Warren Huang-Chen Lee

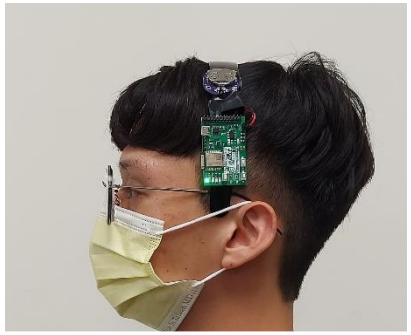
- Ph.D. in Computer Science, National Tsing-Hua University, Taiwan, 2006~2010
- Professor 2021~ Now, (Associate Professor 2015~2021, Assistant Professor 2011 ~2015)
- **Associate Editor in Chief**, IEEE Transactions on Instrumentation and Measurement (2015~Now)
  - **Outstanding Associate Editor** 2017+2018+2019+2020+2022 , IEEE Transactions on Instrumentation and Measurement
- Associate Editor, IEEE Sensors Journal (2017~) Now
- Associate Editor, International Journal on Smart Sensing and Intelligent Systems (S2IS) (2018~Now)
- Excellent Young Scholar Research Grants, Ministry of Science Technology (2018-2020)
- Research Interest: Artificial Intelligent IoT, Low power embedded system, Low power wireless communication system, Wireless mesh network.
- **Details:** **https://www.neatlab.tw/advisor**

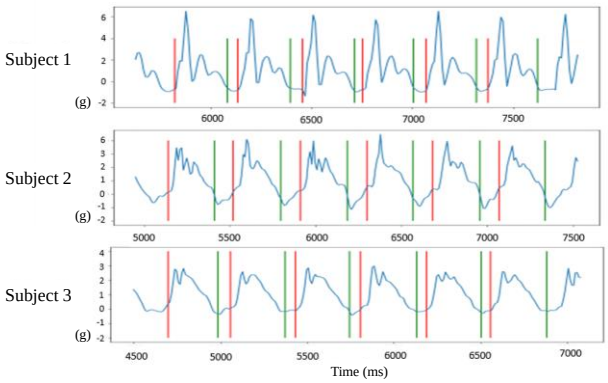
Features

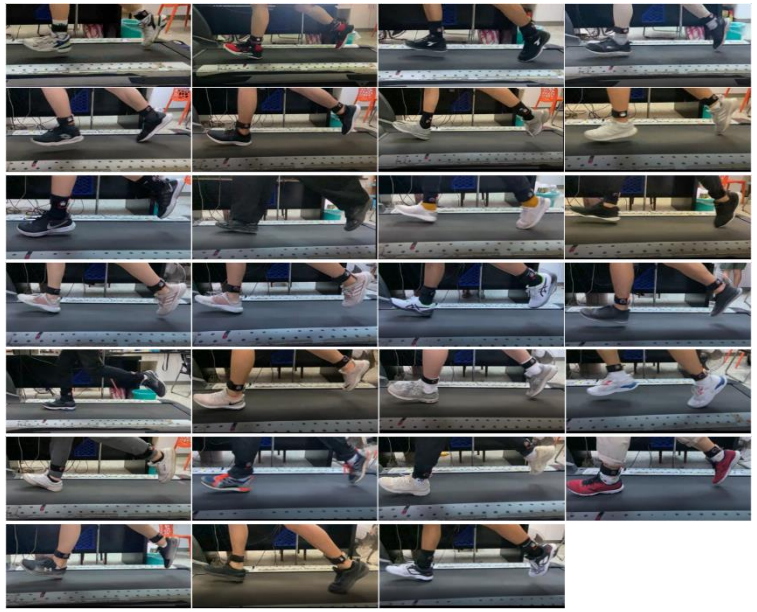
- Ability to customize embedded systems and integrate multiple sensors and communication modules.
- Ability to perform machine learning/deep learning on the MCU side, and executed in the MCU with hard-code c without tinyML and without AI accelerators.
- Ability to use embedded OS, such as FreeRTOS, Nordic Soft-Device, Zephyr, etc.
- Ability to customize IoT-grade wireless communication (BLE, LoRa, etc.) systems.

Design of a wearable sensor to measure runners' duty factor

- A runner's duty factor (DF) is defined as the ratio of ground contact time (GCT) to stride time. Fast runners tend to have short GCTs as well as a small DF. We designed a special wearable sensor system that can collect the acceleration of runners and compute DFs automatically using machine learning algorithm.



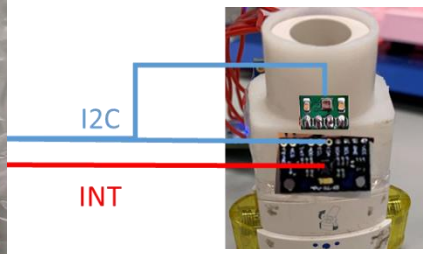




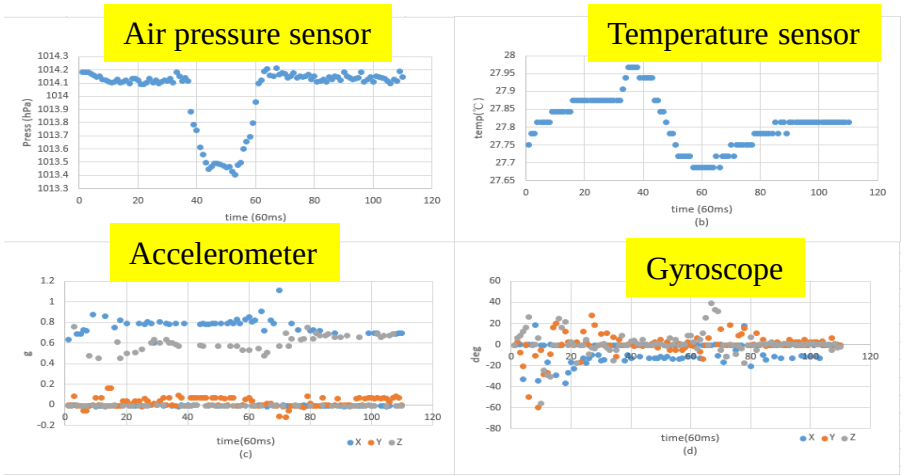
Designed to determine the correct inhalation of the drug of pharmaceutical inhalers

- The embedded system is designed to be integrated into traditional drug inhalers. This design can automatically detect and judge the inhalation status (air pressure, time and other information) of users using drug inhalers.
- Using the data from accelerometer and deep learning algorithm, the action of the "opening and closing cap" of the inhaler is determined, and the sleep mode is entered at the appropriate time to reduce the power consumption of the system.

nRF52840
embedded system



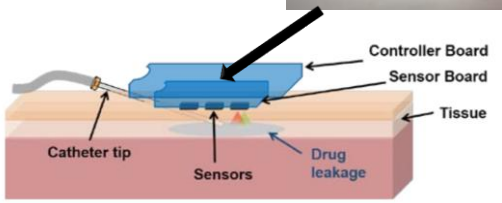
Integrated sensors on
the traditional inhaler

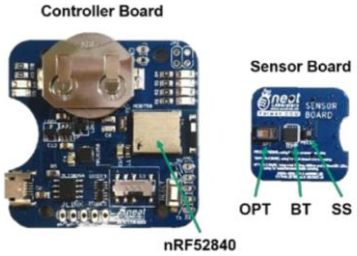


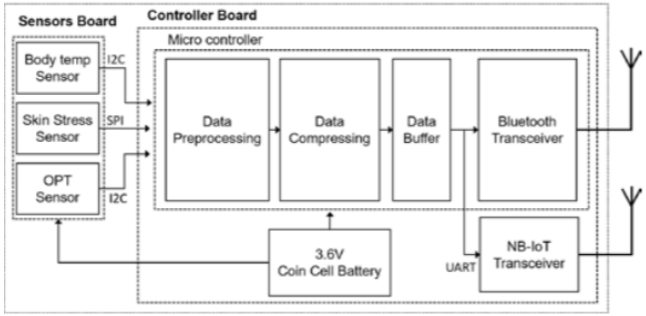
An Open-Source Wearable Sensor System for Detecting Extravasation of Intravenous Infusion

- Design a wearable device that integrates sensors of multiple physical phenomena (temperature, brightness, pressure), and performs data fusion and deep learning algorithms to determine the phenomenon of extravasation of drug solution.

Data source:
http://jerryljw.blogspot.com/2017/03/suggested-treatment-options-of.html







This sensor system will be attached to the skin in the form of a "patch", close to the needle inserted into the skin, detect the physical phenomenon of the skin during the injection of the drug, and determine whether the drug solution has extravasation.

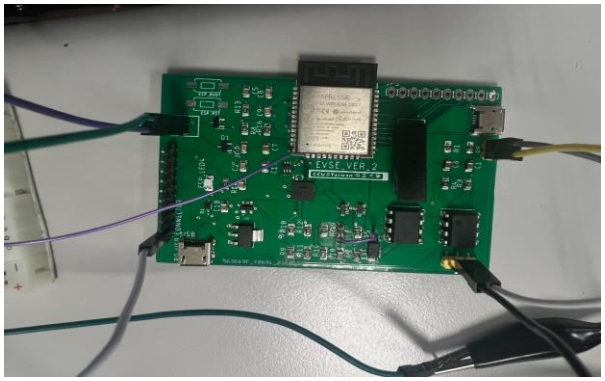
Huang-Chen Lee, Jheng-Sing Lin, An Open-Source Wearable Sensor System for Detecting Extravasation of Intravenous Infusion, IEEE Transactions on Instrumentation & Measurement, vol. 70, Sep. 2020.

DEMO video https://youtu.be/s2Znlucl8Yc

Design an EV/EVSE experiment platform for J1772 protocol

- It is difficult to study J1772 protocol without a real EV (electrical vehicle) and real EVSE (EV charger).
- This study designs an EV/EVSE simulation platform to understand how this protocol works and do experiments.
- The purpose of this platform is to provide educational purposes.

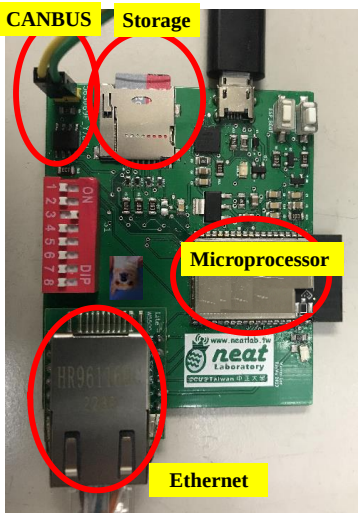
EV emulator

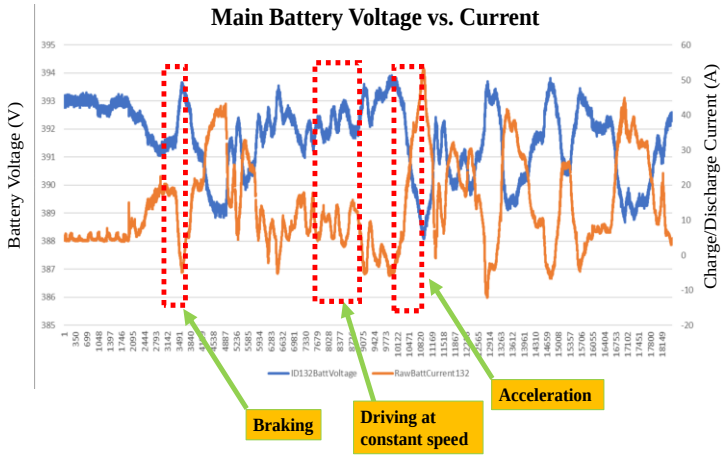


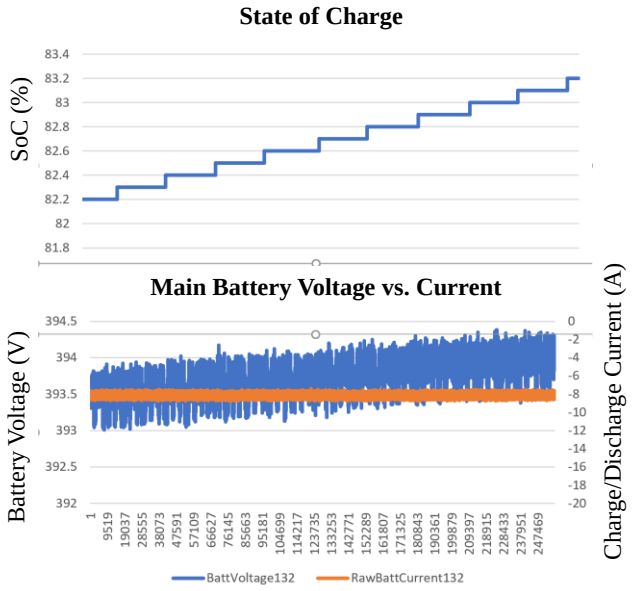
EVSE emulator

Monitoring the Health State of Electric Vehicle Battery

- After the battery of an electric vehicle starts to be used, it will be charged and discharged several times under different conditions, and the health and performance of the battery will gradually change.
- This study explores designing a battery health monitoring system for electric vehicles on both the charger side and the vehicle side.







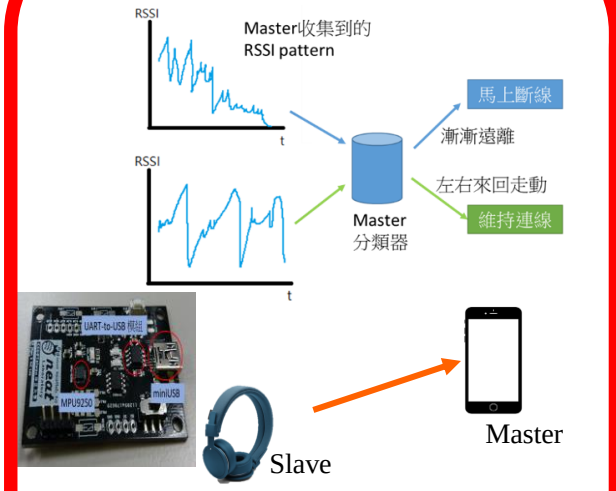
Low-cost architecture of mechanical health determination technology

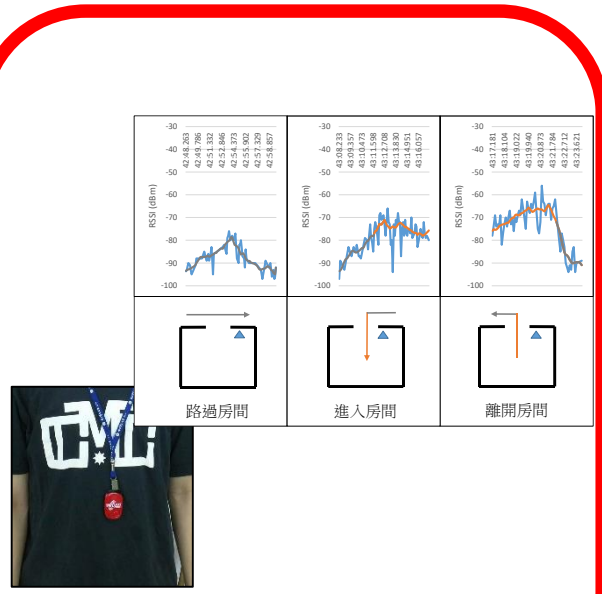
- We designed an embedded system that can analyze the health status of the pump through the physical signals. The system learns the physical signals of the pump under various conditions (normal, abnormal outlet, abnormal inlet, etc.) and is used build a machine-learning model.

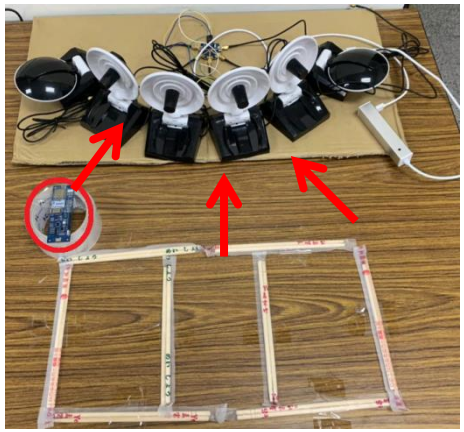
DEMO video
https://www.youtube.com/watch?v=EsXnJuUnR0g

The time domain variation of radio signal are used to analyze the characteristics of personnel movement, position and behavior

- Using changes in the time-domain of radio signals, various parameters can be determined, including (1) movement patterns, (2) positions, and (3) behaviors.



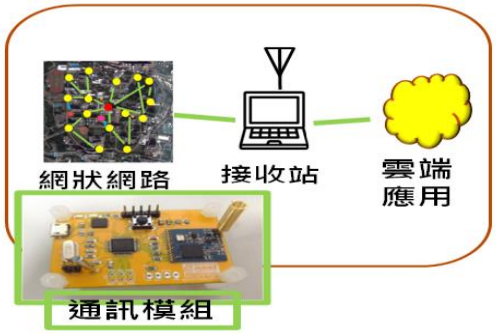


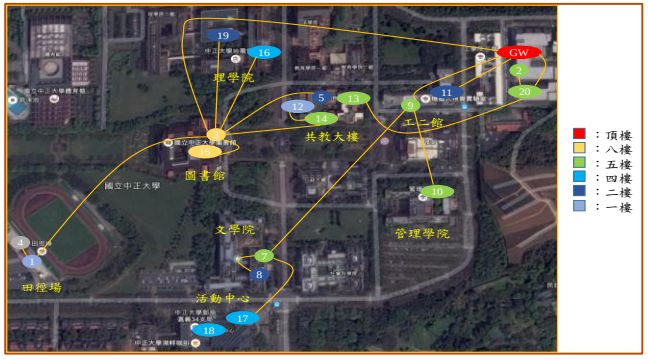


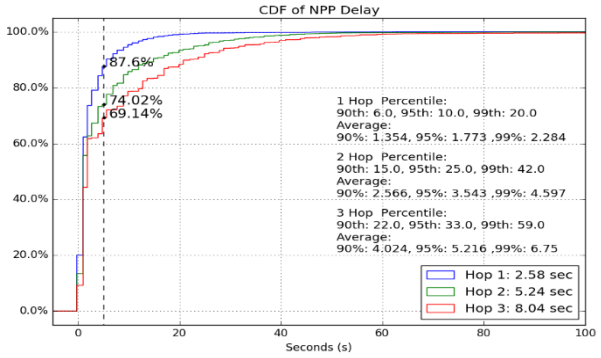
* Huang-Chen Lee, Tzu-Ting Lin, Low-Cost Indoor Human Tracking by Utilizing Fluctuation of Received Radio Signal Strength, ***IEEE Sensors Journal***, vol. 20, no. 21, pp. 13029-13036, 1 Nov.1, 2020, doi: 10.1109/JSEN.2020.3001055.

Use the LoRa mesh network for large-scale periodical and spontaneous data collection

- Sub 1-GHz wireless technologies such as LoRa have the characteristics of long transmission distance, but they still have the disadvantage of poor communication for indoor and other obstructions and interference.
- By integrating technologies such as LoRa mesh networks, this study greatly improves the communication quality of IoT devices without increasing the cost of base stations.
- This study also analyzes the scenarios in which unexpected situations require returns, and confirms that this architecture can support regular and unexpected data collection scenarios.



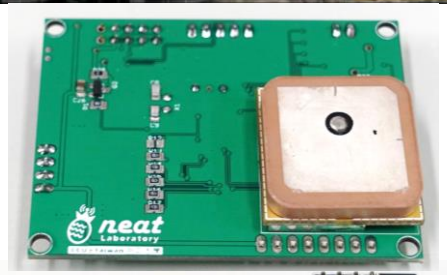




Huang-Chen Lee, Kai-Hsiang Ke, Monitoring of Large-Area IoT Sensors using a LoRa Wireless Mesh Network System: Design and Evaluation, IEEE Transactions on Instrumentation & Measurement, vol. 67, no. 9, pp. 2177-2187, Sept. 2018

In-Situ Monitoring of Debris Flow using a Wireless Sensor system

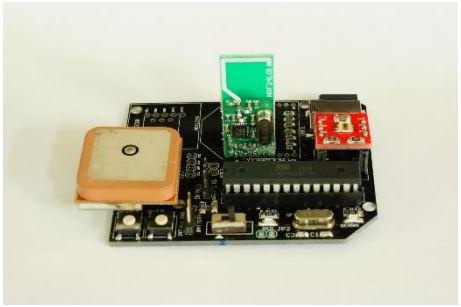
- Cooperate with the Geographic Information Center of Feng Chia University.
- A debris flow sensors are developed and installed in debris flow potential streams to monitor precursors such as low-frequency vibration when debris flows occur, so as to achieve early warning and analyze the characteristics of debris flows.

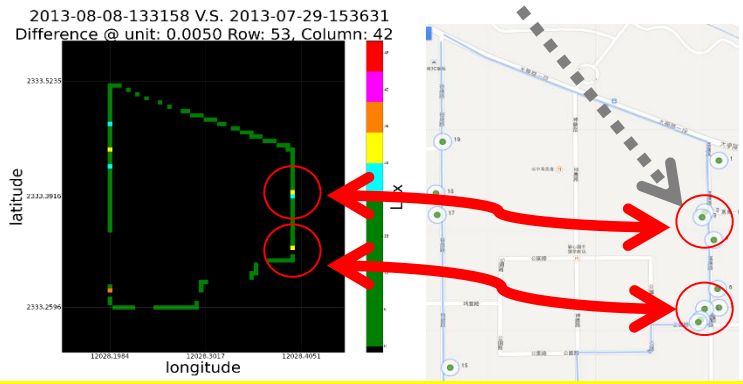


Huang-Chen Lee, Amit Banerjee, Yao-Min Fang, Bing-Jean Lee, Chung-Ta King, Design of a Multi-Functional Wireless Sensor for In-Situ Monitoring of Debris Flows, *IEEE Transactions on Instrumentation and Measurement*, vol. 59, issue 11, pp 2958-2967, Nov 2010.

Use the GPS + lux meter to generate a "lighting map" for fault street lamp detection

- Install GPS and lux meter on buses, taxis or civilian vehicles. When the vehicle is driving at night, an illuminated map of each area will be generated
- Determine whether a street light is a street light by looking for the brightness change in the "same location" between many lighting maps:
  - It turned out to be good, suddenly it broke down
  - It turned out to be faulty, but it was repaired





* Huang-Chen Lee, Huang-Bin Huang, A Low-Cost and Non-Invasive System for the Measurement and Detection of Faulty Streetlights, IEEE Transactions on Instrumentation and Measurement, Oct 2014.

Any form of cooperation is welcome

Recent research: https://www.neatlab.tw/publication

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