Delirium Detection: On Wrist Actigraphy

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Why detecting derilium is important?

1.Delirium is a neuropsychiatric syndrome characterized by an acute onset of altered consciousness, cognitive impairment, and inattention that fluctuates in severity over time[1]

2. It is reversible [2]

3. Affects 50% of elderly people (ie, those aged 65 years or older) in hospital, and costs more than US$164 billion per year in the USA1 and more than $182 billion per year in 18 European countries combined[3]

4. 35.4% of patients with delirium were not recognized by the treating team[2]

Recent Research Limitations

Detection derilium relies on bedside analysis using screening tools and test **like CAM(confusion Assessment Method)[**4]

Require a large effort and spending for training the staff

Bedside analysis require 2-3 times per day which is time consuming for doctors and nurses.

Early postoperative wrist actigraphy[5]:
Weak predictive power: mobility detection indicates not clear signs between patients and normal ppl

Signal noise and artifacts: Movement caused by nurses or repositioning introduces false activity signals

Low diagnostic ability: cannot confirm if signs of delirium happened from the data of screening

Only measures the motion of the wrist using ZCM and PIM algorithms

Possible improvements

CAM assessment

1. there is no need for the assessment if the physical statistic of the patient is normal.

2. Use of actigraphy can do the job as a monitor[4]

Early postoperative wrist actigraphy[5]

1. this require the pre-wearing the device before surgery
Use of machine learning to learn the pattern of the patient's movement. Not comparing the data to other people, but rather learn from the patient's own data:

2. use three variables instead of one,
If three are different than daily normal readings in a scale, abnormality is found.

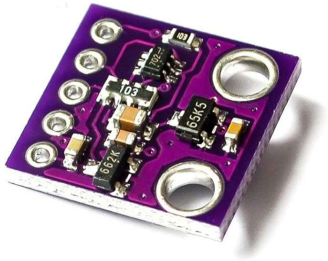
3. Allowing the nurses to stop the measurement to the patient to eliminate the big noise in accelerometer.

Solution : Wristband--Delirium Status Monitor

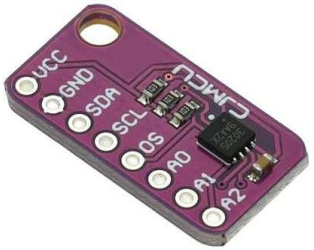
- 1. Provide the real time analysis of the likelihood of delirium of patient to the doctors and nurses
- 2. Build actigraphy used for monitoring body temperature, heart rate and movement of wrist
- 3. Use of machine learning to actively learn the pattern for patient's data to predict likelihood of delirium.
- 4. Introducing dashboard to show real-time data and analysis of patient's delirium status.

Hardware List

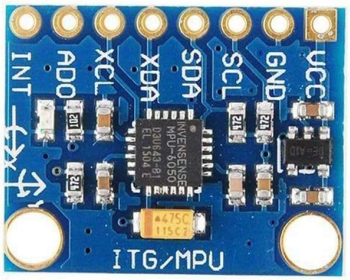
Seeed Studio XIAO ESP32-C6 Microcontroller (~$15)



MAX30102 (Heart Rate Pulse Oximeters Development Board Sensor Module for Wearable Health Fitness Assistant Devices Medical Monitoring Devices)(~$19)



MAX30205 (High Accuracy Human Body Temperature Sensor Module)(~$16)



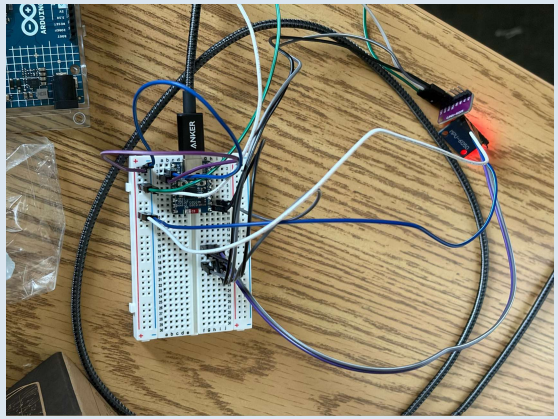
GY-521 3 Axis Accelerometer(~$16)

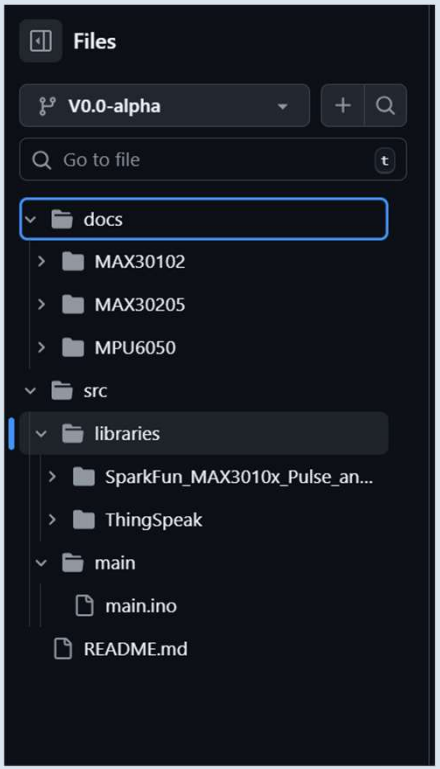
Progress

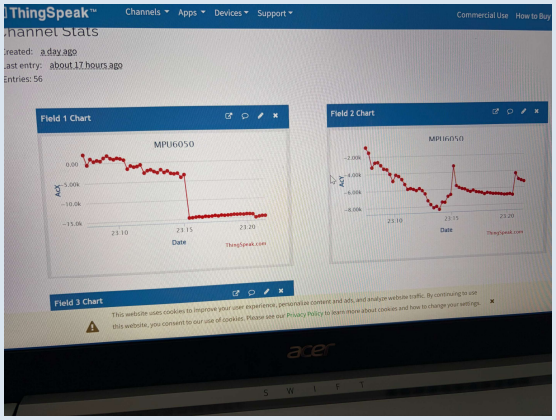
Successfully implemented MAX30205 and accelerometer onto ESP32-C6.

Implement the heart rate sensor on Arduino.

Upload the data onto ThinkSpeed website for accelerometer







The remaining work

Firmware side:

1. integration of three sensors on the ESP32

2. Assembly of a 3D printed box to contain all the components

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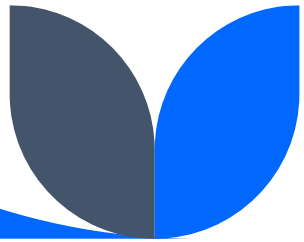
Hardware side:

1. adding battery to ESP32 to power the device

Software side:

1. creating web interface for nurses to monitor the data

2. implement machine learning algorithms on cloud server and connect the server to the webpage



Limitation of our project

- 1. The speed of uploading data to ThinkSpeed has a time delay of 1 min.
- we wouldn’t worry about it as delirium is a chronic disease

2. Restricted data set
due to limited patient data. The device will primarily learn typical activity patterns over a short period and only identify deviations as potential abnormalities

3. Repositioning of the body and movement of the nurse will disturb the reading from the accelerometer
preference of user given to hypoactive patients
allow the nurses to input the number of visit to the patient

Reference

- [1] J. Oh, D. Cho, J. Kim, J. Heo, J. Park, S. H. Na, C. S. Shin, J.-J. Kim, J. Y. Park, and B. Lee, "Changes in heart rate variability of patients with delirium in intensive care unit," *Proc. IEEE Eng. Med. Biol. Soc. (EMBC)*, pp. 3118–3121, 2017, doi: 10.1109/EMBC.2017.8037552.
- [2] P. H. Liem and W. J. Carter, "Cystocerebral syndrome: A possible explanation," *Arch. Intern. Med.*, vol. 151, no. 9, pp. 1884–1886, 1991.
- [3] E. Pauley *et al.*, "Delirium is a robust predictor of morbidity and mortality among critically ill patients treated in the cardiac intensive care unit," *Am. Heart J.*, vol. 170, no. 1, pp. 79–86.e1, 2015.
- [4] R. S. Al Farsi *et al.*, "Delirium in medically hospitalized patients: Prevalence, recognition and risk factors: A prospective cohort study," *J. Clin. Med.*, vol. 12, no. 12, p. 3897, Jun. 2023, doi: 10.3390/jcm12123897.
- [5] A. Ahmed *et al.*, "Delirium detection using wearable sensors and machine learning in patients with intracerebral hemorrhage," *Front. Neurol.*, vol. 14, pp. 1135472, 2023, doi: 10.3389/fneur.2023.1135472.

Thank you!