Wearable Posture Correction Device

A wearable device for knee injury rehabilitation, utilising machine learning and sensor systems to monitor and correct posture in real-time. Visual and haptic cues provide non-intrusive assistance, allowing users to maintain correct posture during rehabilitation without stress or disruption.

Tools:

Keywords:
#Physical Computing #Machine Learning #Wearable Technology
#Bioengineering #Sensor Systems

Website:
https://canacechen.com/posturafit.html

Research

Importance of Posture in Health and Rehabilitation

Posture plays a vital role in maintaining musculoskeletal health, with poor posture being linked to pain, discomfort, and long-term damage (Kendall et al., 2005). This is particularly crucial during the rehabilitation process of knee injuries, where proper posture and movement are key to recovery. For example, patients with anterior cruciate ligament (ACL) injuries must avoid excessive knee bending to prevent strain and facilitate healing (Pamboris et al., 2023). The ability to monitor and correct knee positioning during rehabilitation is therefore essential for avoiding further damage and optimising recovery.

Lumo Lift
(tracks upper body posture)

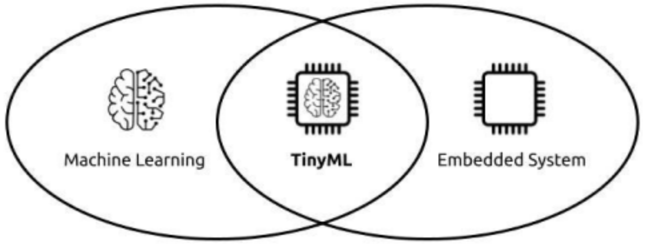
Alex Posture Tracker
(tracks head and neck posture)

Limitations of Current Posture Correction Solutions

Current posture correction solutions often struggle with high power consumption, cost, and usability (Rodgers et al., 2020). In contrast, the designed wearable system integrates both visual (LED) and haptic (vibration) feedback while remaining low power consuming and cost-effective. The wearable design also minimises cognitive load, offering simple, intuitive posture correction that doesn't disturb the user or require attention to a screen (Jain et al., 2020).

Wearables Devices for Posture Monitoring

Wearable technologies have become increasingly prevalent in health and wellness, especially for posture monitoring and correction. Devices such as smart sensors or posture-correcting wearables can provide users with continuous feedback on their body positioning (Patel et al., 2012). The use of wearable technology allows for unobtrusive tracking of posture without disrupting the user's daily activities (Huang et al., 2023). This led to my decision to develop a wearable posture correction system that provides immediate feedback and seamlessly integrates into the user's routine.



Machine Learning in Wearable Health Devices

Machine learning (ML) enhances wearable devices by enabling them to process and analyse data in real time, providing intelligent decision-making capabilities on small, low-power devices. With TinyML, machine learning models can run directly on microcontrollers, allowing for complex analysis without the need for external computing resources. This combination of ML and microcontrollers unlocks new potential for wearable health technologies, making them more accurate, autonomous, and energy-efficient. It enables advanced features in devices that are small, cost-effective, and capable of running on limited power (Srinivasan et al., 2019).

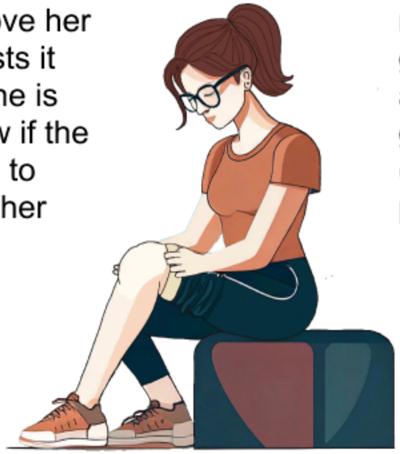
User-experience Design

Persona

Sarah, a 32-year-old software developer recovering from a knee injury, so she decided to try the wearable knee strap to help with her rehabilitation. The device monitors whether her knee is straight or bent and provides real-time feedback to help her maintain the correct knee position during her recovery process.

1. Device Setup

Sarah puts the knee sleeve just above her knee and adjusts it comfortably. She is curious to know if the device is going to assist her with her rehabilitation effectively.

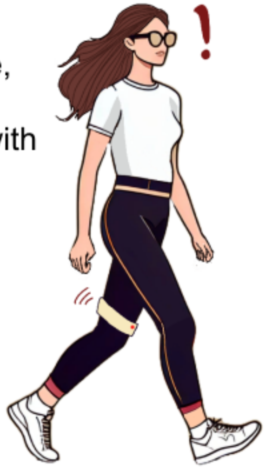


2. Powering On

She presses the button, and the device turns on, starting to monitor her knee's posture immediately.

3. Continuous Monitoring and Feedback

The device continuously monitors her knee’s posture, glowing green for correct alignment and turning red with gentle haptic feedback (vibration) when the knee position is incorrect.



4. Comfortable Wear

The knee sleeve is lightweight and non-intrusive, allowing Sarah to wear it while working, exercising, or carrying out daily activities without disruption.

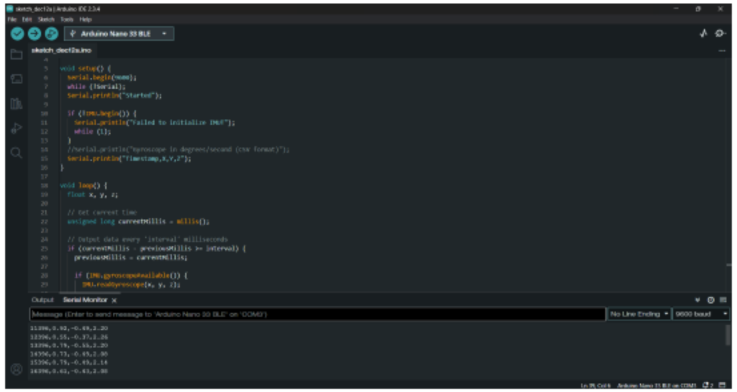
5. Simple Charging

The battery lasts throughout the day and requires only occasional recharging, which Sarah does by simply connecting it with the USB cable.

6. Accelerated Recovery

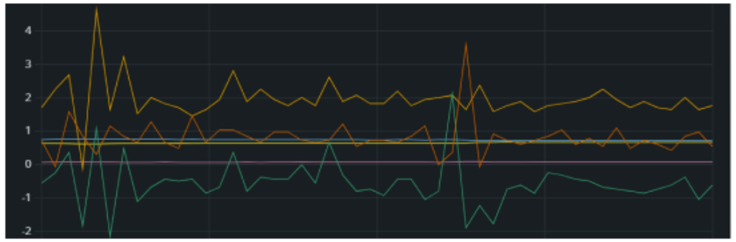
Over time, Sarah finds that the device has become an essential part of her rehabilitation process. With the device's help, Sarah maintains good posture, speeding up her recovery and released her from worrying about overbending her knee.

Data Collection



The initial data collection only collected the x, y and z axis of the gyroscope. 1000 data were collected from 5 participants. The collected data did not train the model successfully.

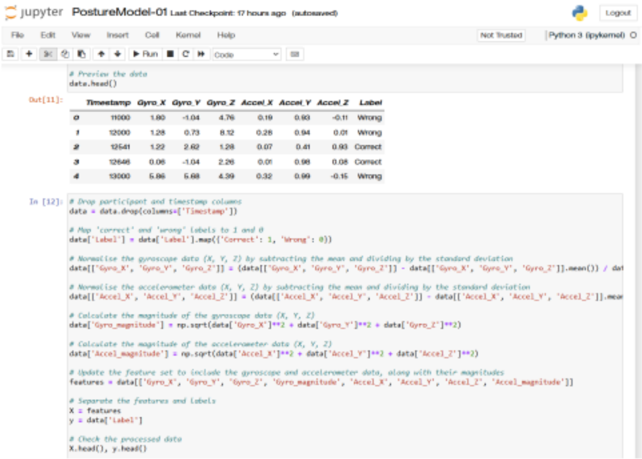
x, y, z of accelerometer and gyroscope when standing straight



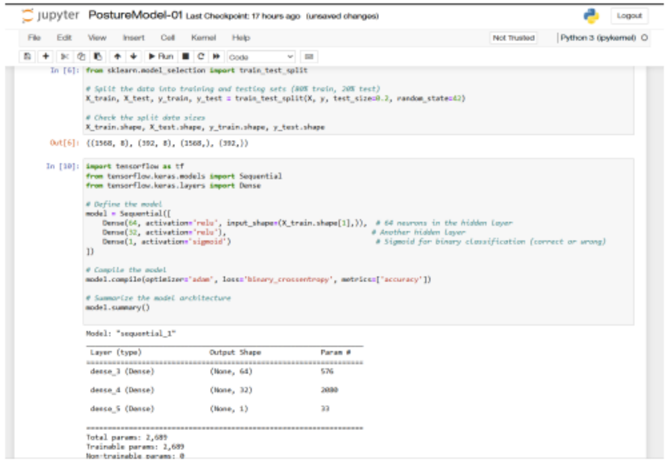
x, y, z of accelerometer and gyroscope when standing when knee bent

The second data collection collected the x, y and z axis for both the gyroscope and the accelerometer. The sensor was positioned horizontally at the front above the knee instead of vertically on the outer side. A total of 2000 data were collected.

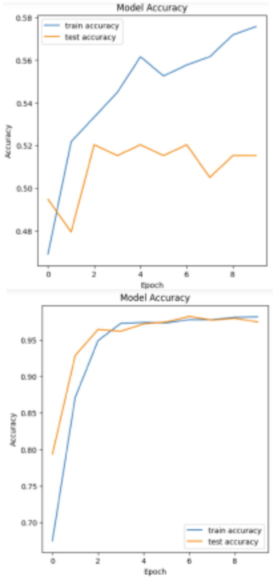
Training Model

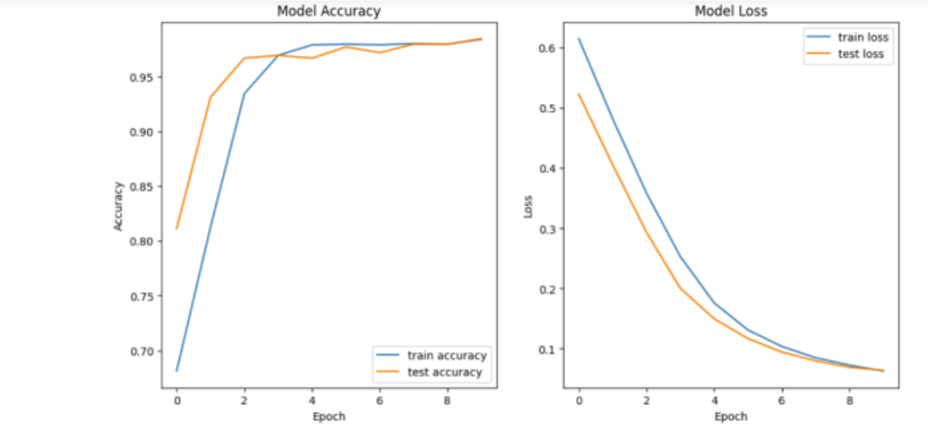


Processing data



Designing model



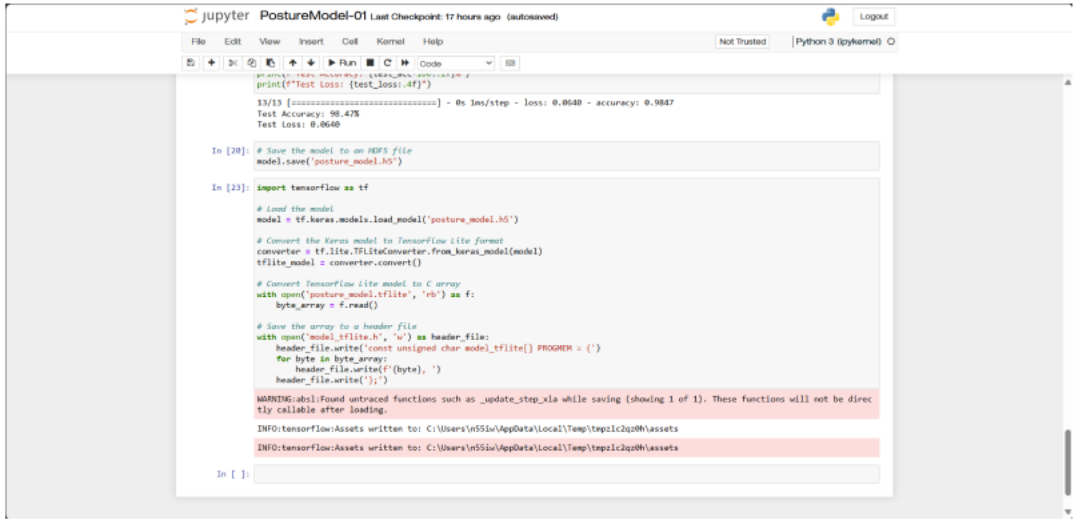



```
In [12]: # Evaluate the model on the test data
         test_loss, test_acc = model.evaluate(X_test, y_test)

         print(f"Test Accuracy: {test_acc*100:.2f}%")
         print(f"Test Loss: {test_loss:.4f}")

13/13 [==============================] - 0s 1ms/step - loss: 0.0640 - accuracy: 0.9847
Test Accuracy: 98.47%
Test Loss: 0.0640
```

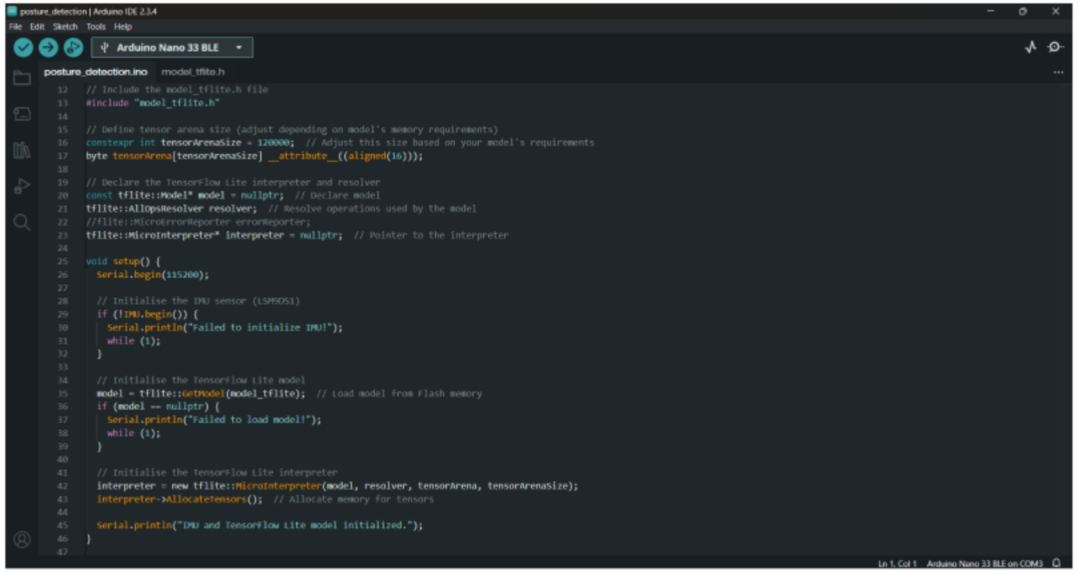
With the initial dataset, the trained mode only got 51% accuracy. With the second dataset, the model was train to 98.47% accuracy (97.54% before fine-tuning).

Feedback Communication

Implementing the trained model to microcontroller

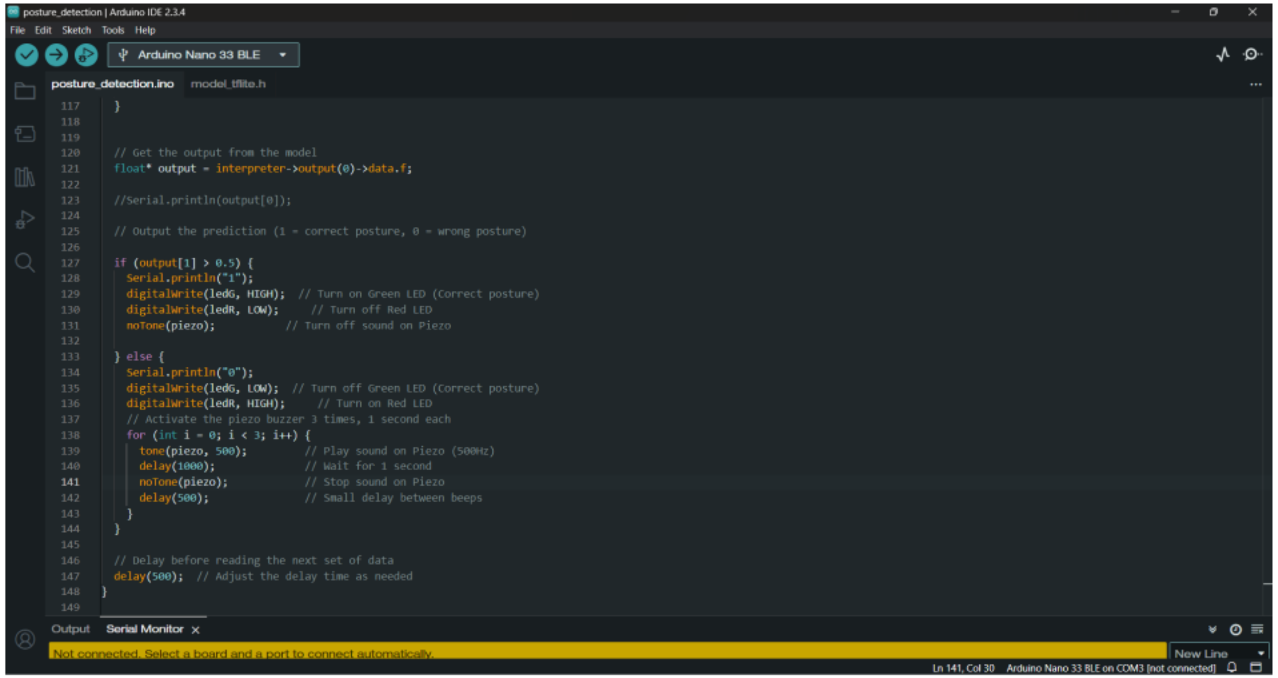


Converting the Model for Deployment (TensorFlow Lite Format)

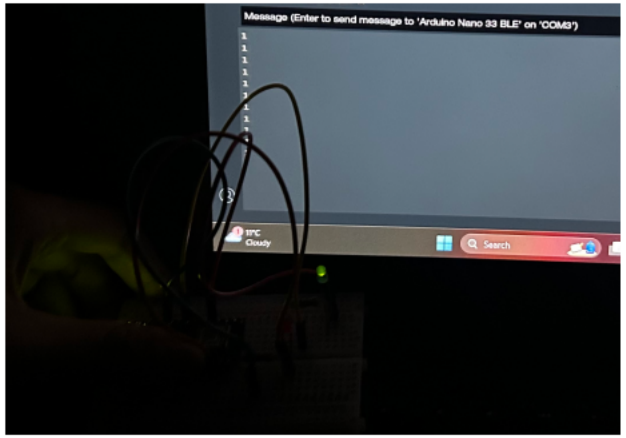


Combining the Model with IMU Sensor for Real-time Detection

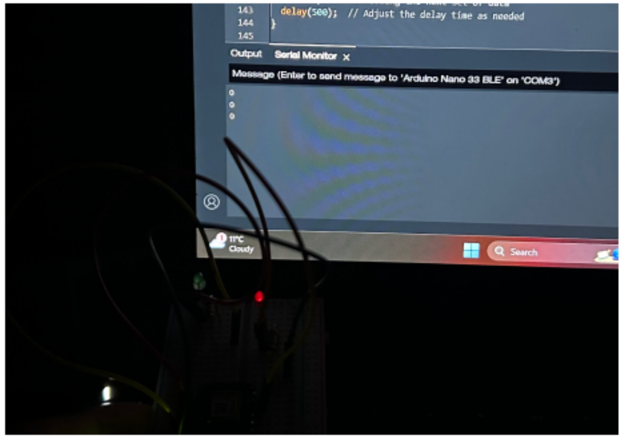
Setting Indicator Light and Haptic Feedback



Communicating Detection Result to User through Visual and Haptic Cues



Green Light for Correct Posture



Red Light + Haptic Vibration for Wrong Posture

Result Showcase