Hydration Monitoring System for Everyday Use

Geethika Hemkumar
ECE382V, Spring 2024

Motivation

- Hydration is important to overall well-being
- Easy to forget to hydrate throughout the day
- Hydration reminders are useful to ensure that people are drinking enough water, especially during/after:
    - Working in extreme temperatures for a long period of time
    - Vigorous physical activity for a long period of time

Prior Work - Academic

- AutoHydrate: mobile application connected to a wearable throat microphone to track hydration and a watch to track physical activity
- Utilizing physiological signals to estimate hydration levels:
  - Classifying hydration level based on PPG signals from videos of a person's fingertip
  - Classifying volume depletion/dehydration based on ECG signals
- Detecting drinking gestures from smartwatch

Prior Work: Commercial

HidrateSpark water bottle

Project Scope

- iOS application to track hydration and physical activity
- Goal: remind users to drink water periodically based on a variety of factors, including:
  - Intensity of physical activity
  - Ambient temperature
  - Time since last hydration event
- Hydration tracking: drinking gesture detection using inertial data
- Physical activity tracking: activity recognition using inertial data

Implementation - Hardware

Arduino Nano

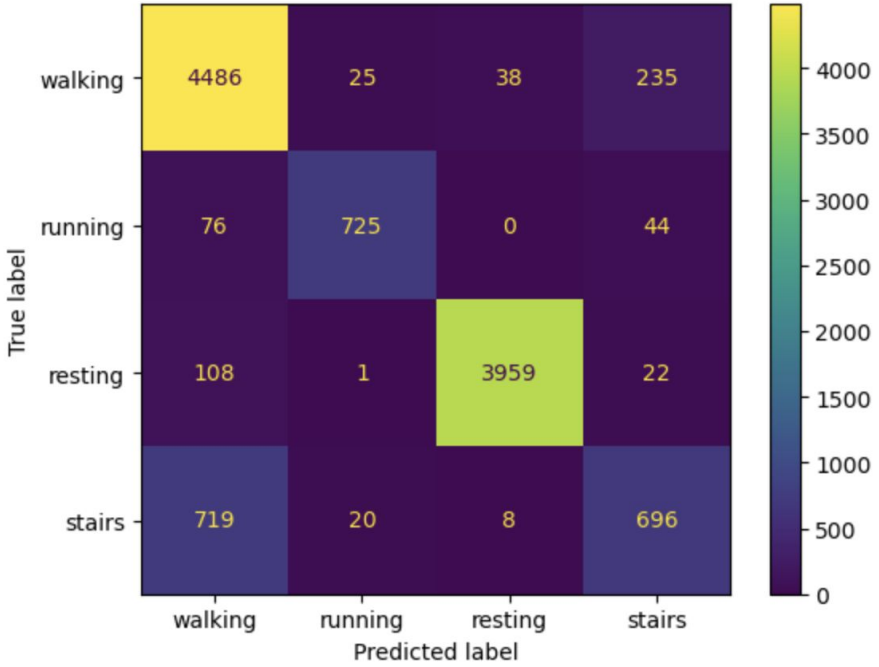
iPhone with
custom iOS app

Implementation - Activity Recognition Model

- Four-class classification between: resting, walking, climbing stairs, and running
- Collected accelerometer and gyroscope data from 8 participants while they performed some or all of these activities
- Features extracted (per frame): mean, variance, energy, RMS from each axis of accelerometer data

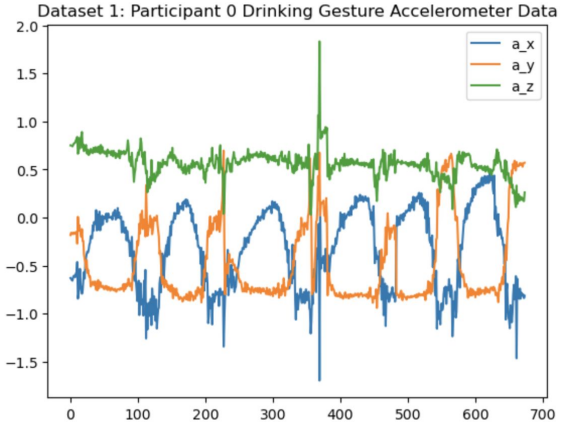
Activity Recognition Model - Results

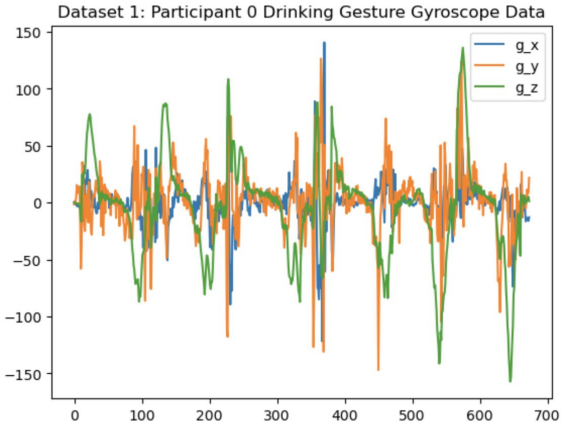
- Random Forest model, 100 trees
- Accuracy: ~88.4%
- Precision: ~87.3%
- Recall: ~87.6%



Implementation - Gesture Recognition Model: Strategy 1

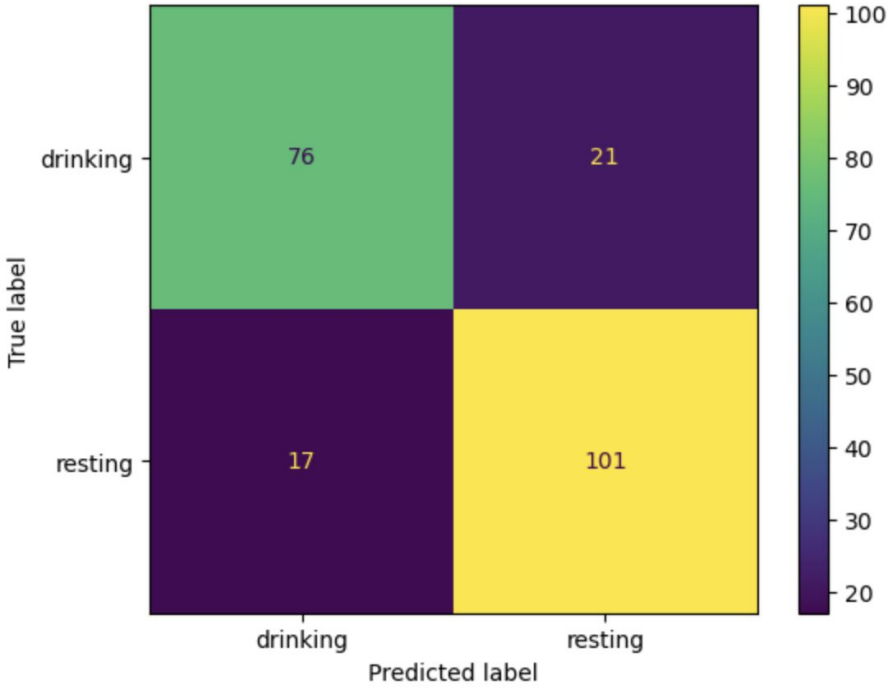
- Binary classification between drinking and non-drinking gestures
- Collected accelerometer and gyroscope data from 7 participants
- Features extracted (per frame): mean, variance, energy, RMS from each axis of accelerometer data





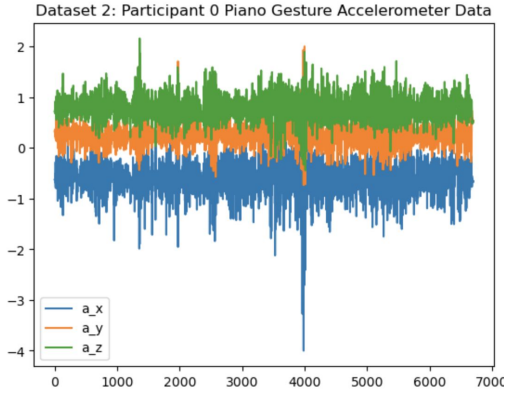
Strategy 1 Results

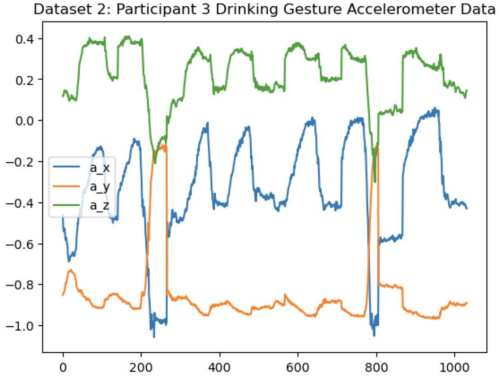
- Random Forest model, 100 trees
- Accuracy: ~85.1%
- Precision: ~84.1%
- Recall: ~83.7%

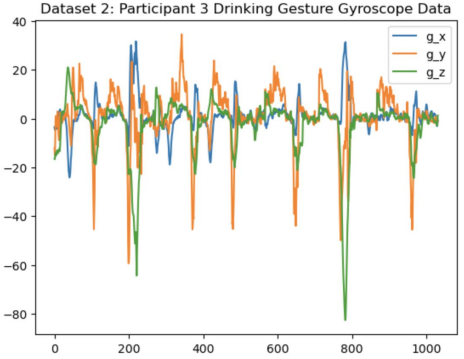


Implementation - Gesture Recognition Model: Strategy 2

- Four class classification between playing piano, typing, drinking, and resting gestures
- Collected accelerometer and gyroscope data from 5 participants
- Features extracted (per frame): mean, variance, energy, RMS from each axis of accelerometer data

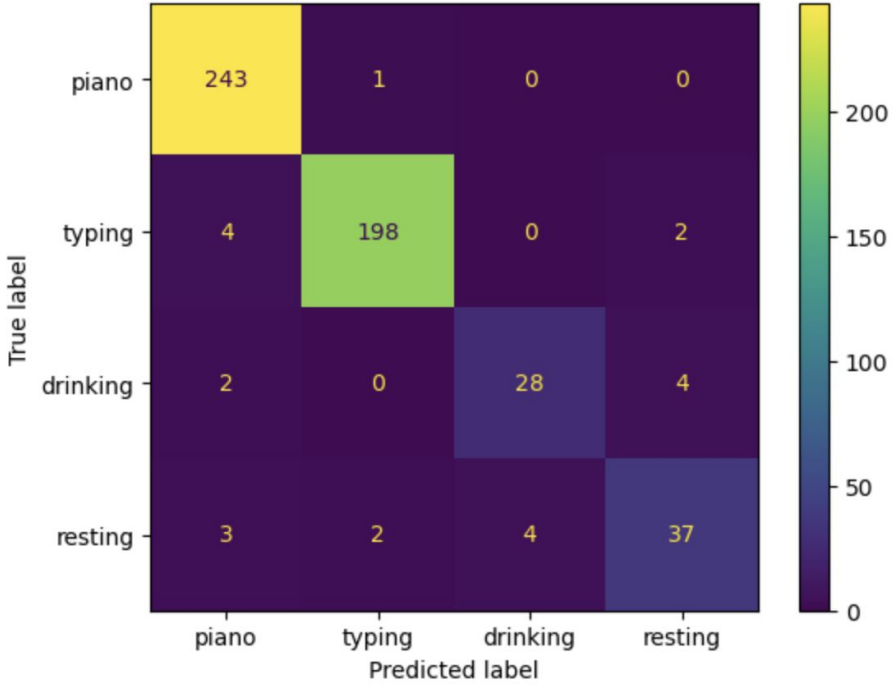






Strategy 2 Results

- Random Forest model, 100 trees
- Accuracy: ~96.2%
- Precision: ~97.3%
- Recall: ~97.2%



Key Takeaways

- Multi-class drinking gesture recognition model performs better than that of the binary-class model
- Key learning: exposure to the entire process of data collection, preprocessing, feature engineering, and model training

Future Directions

- Tracking volume of water consumed
- Training activity/drinking gesture recognition models on more relevant data classes
- In-the-wild testing of app

Thank You!

References

- Mengistu, Yehenew, et al. "AutoHydrate: A wearable hydration monitoring system." *2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE, 2016.
- Kaveh, Anthony, and Wayne Chung. "Classification of hydration status using electrocardiogram and machine learning." *AIP Conference Proceedings*. Vol. 1559. No. 1. American Institute of Physics, 2013.
- Alaslani, Rose, et al. "You can monitor your hydration level using your smartphone camera." *arXiv preprint arXiv:2402.07467* (2024).
- HidrateSpark water bottle: https://hidratespark.com/pages/why-hidrate-spark-works
- Amft, Oliver, et al. "Towards wearable sensing-based assessment of fluid intake." *2010 8th IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops)*. IEEE, 2010.