R.U.M. Recognizing Unsafe Motions

By Ben Chu, Joshua Chung, Zain Khan

Team Intros

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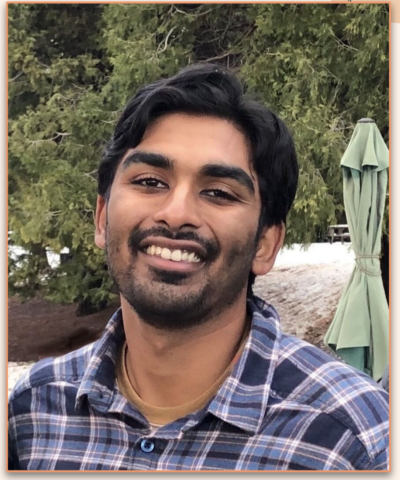
Joshua Chung

Lead ML/Data Scientist



Zain Khan

Lead Developer, Data Engineer

Problem Statement

- Current State of Alcohol Consumption
- When drinking, nearly half of American drinkers typically consume 4 or more alcoholic beverages
- Research shows individuals do not realize they are impaired over 50% of the time while drinking
- Highly Expensive Modern Solutions

https://www.greenfacts.org/en/alcohol/l-2/01-number-people-affected.htm#0

Solution

We aim to create an efficient machine learning model to classify inebriation levels utilizing accelerometer data.

Global Impact

- **2 billion** active alcohol consumers
- **6.4 billion** smartphone users in the world
- **$1.36 billion** breathalyzer market size by 2026

https://www.greenfacts.org/en/alcohol/l-2/01-number-people-affected.htm#0
https://www.oberlo.com/statistics/how-many-people-have-smartphones

Target Audience

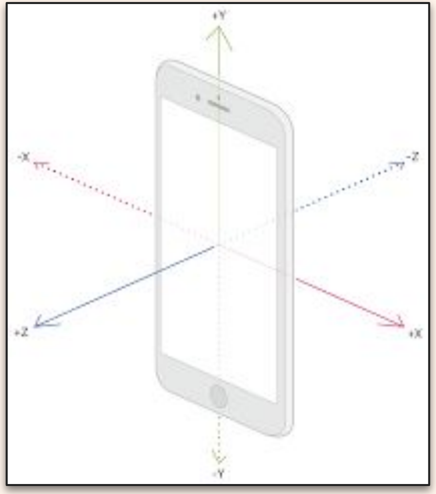
- Young professionals transitioning from college into their careers
- Smartphone users at bars, birthdays, weddings, or anyplace looking to stay aware while drinking

Product Demo

Highlights of Technical Approach

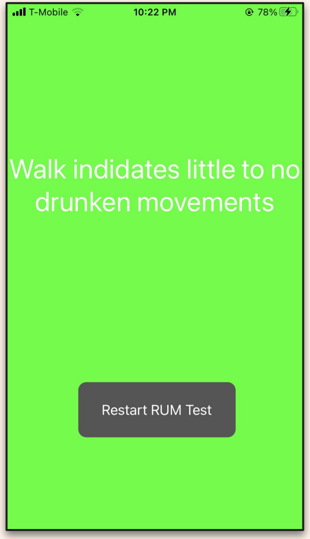
- Real-time processing of data
- Low computational cost
- Offline availability
- Privacy

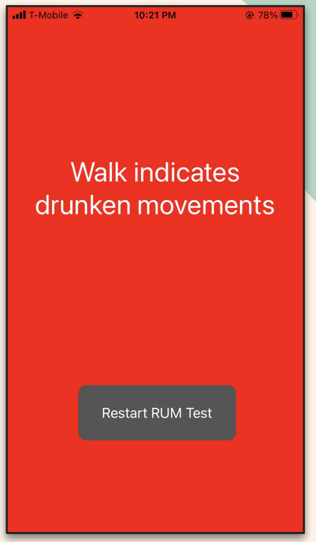
Model Input/Output



Input

iPhone Accelerometer Data





Output

Predicted Intoxication

Data Pipeline

1. Accelerometer data is collected in real time
2. Data is passed into coreML model for prediction
3. The prediction is output instantaneously to the user in-app

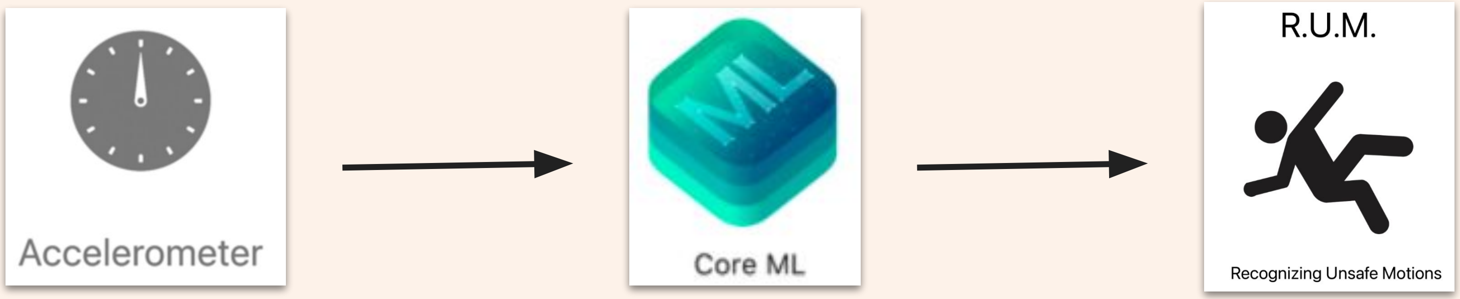


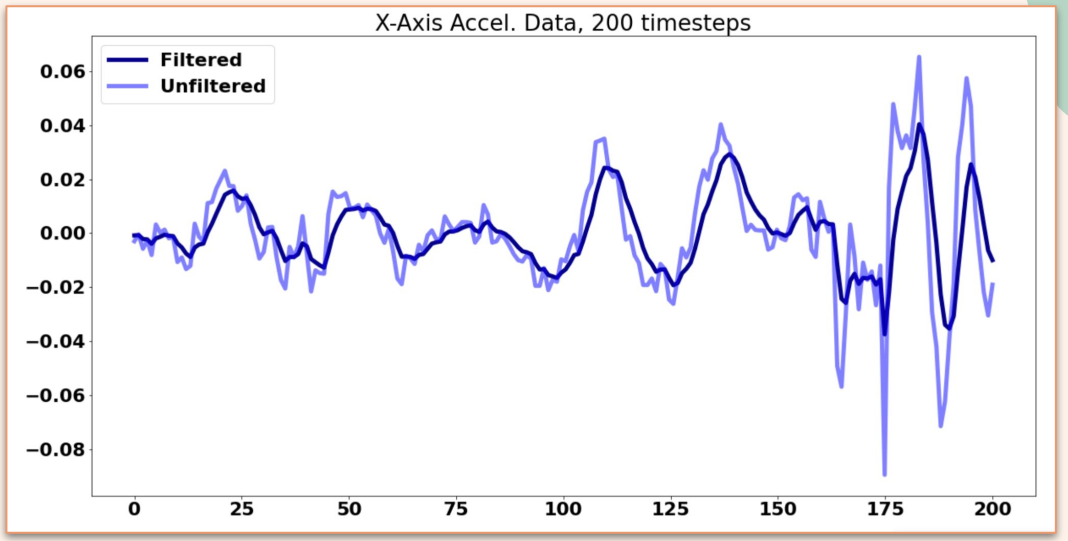
Image Source: Apple

Our Training Data

- UC Irvine Study
- 13 Participants tracked
- Accelerometer data sampled at 40hz
- Alcohol consumption tracked by TAC via SCRAM ankle monitors every 30 minutes
  - TAC: Transdermal Alcohol Concentration, similar units as BAC

Noise Reduction with Low-Pass Filter

- Common in signal processing
- Dampen Noise
- Preprocessed training data with Python
- Implemented in-app with Swift



Training Stabilization Using Virtual Realignment

- Accelerometer data’s mean and variance are affected by the orientation of the phone

- Based on the autocorrelation, the data can be virtually realigned

- Unable to port to CoreML, citing dependencies issues

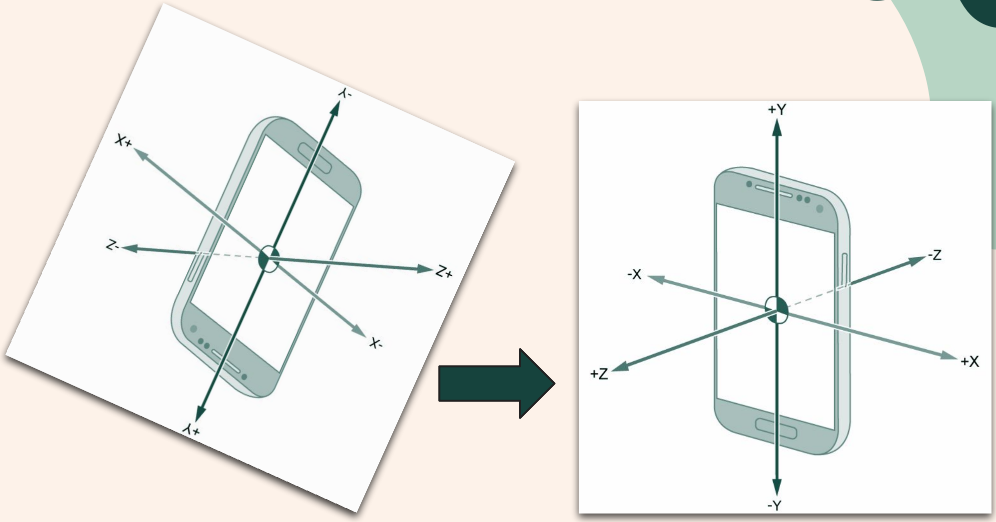


Photo Credit:
https://www.mathworks.com/help/supportpkg/android/ref/accelerometer.html

Defining our Neural Network Architecture

- Neural Network
  - No Feature Engineering Required
  - Fast Predictions
  - Not very interpretable

- Design inspired by previous work using a regression model for this type of problem

- Considered to be state-of-the-art time-series model architecture

Layer Normalization

Bi-LSTM (100 hidden units)

Layer Normalization

Soft Attention

Bi-LSTM (50 hidden units)

Layer Normalization

Soft Attention

Dense (Sigmoid)

TensorFlow

Keras

Source: tensorflow.org

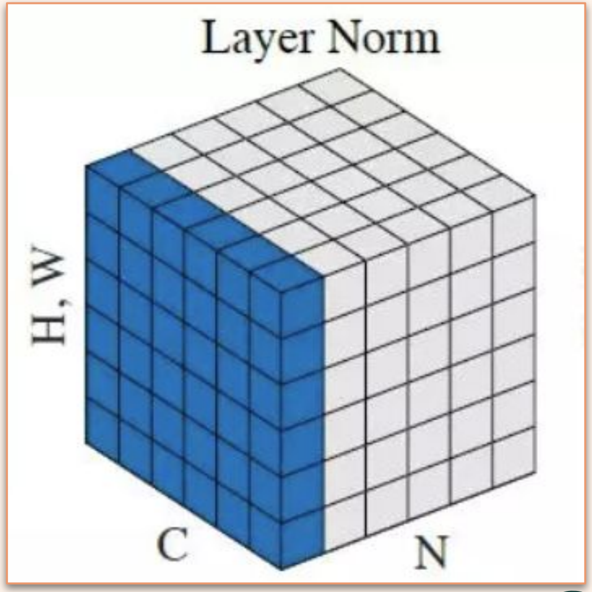
Improving Hidden State Dynamics with Layer Normalization

- Layer normalization normalizes activation by through each training point using mean and standard deviation

- Stabilizes training and hidden state dynamics

- Does not depend on batch size

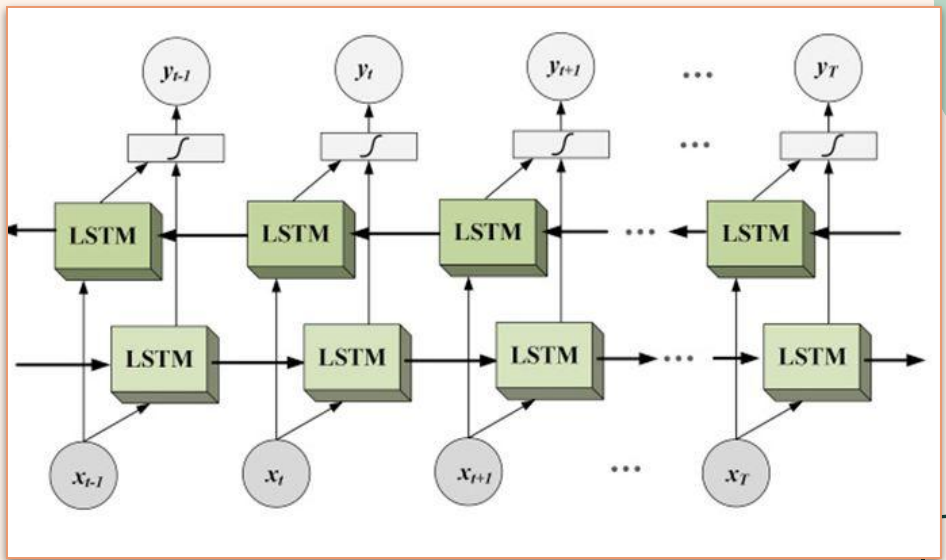
- Built as a custom layer to be ported to CoreML



Source: https://medium.com/syncedreview/facebook-ai-proposes-group-normalization-alternative-to-batch-normalization-fb0699bffae7

Learning Short and Long-Term Signals with Bi-Directional LSTMs

- Bi-Directional LSTMs
  - Learn short and long-term signals
  - Look at data in both directions in time
  - Elastic-Net Regularization
    - Kernel, Bias, Activation regularization

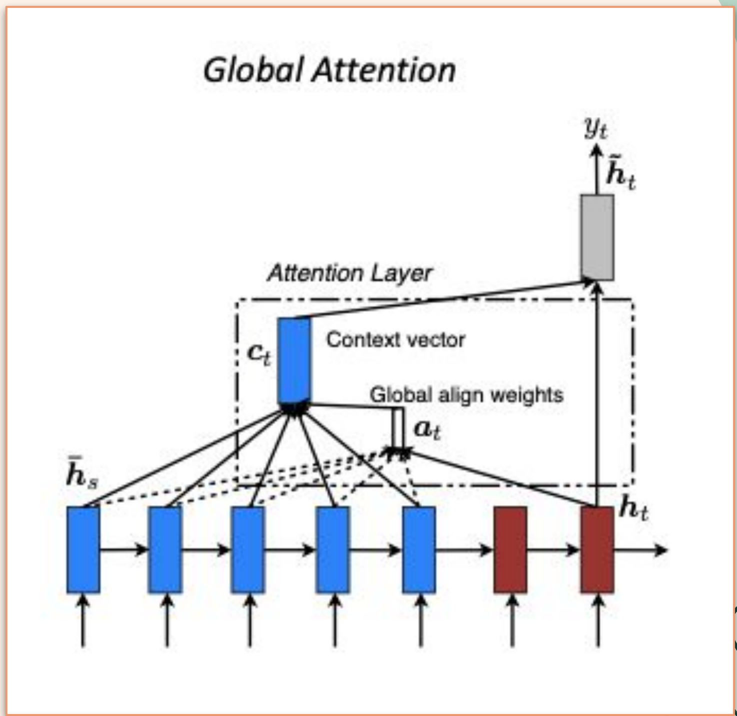


Source: https://www.i2tutorials.com/deep-dive-into-bidirectional-lstm/

Focus in a Global Context using Soft-Attention

- Soft Attention allows the model to focus on certain areas of the time window

- Signals that are far apart timewise can still influence the output of the model, which LSTMs fail to do



Source:
https://towardsdatascience.com/attention-in-neural-networks-e66920838742

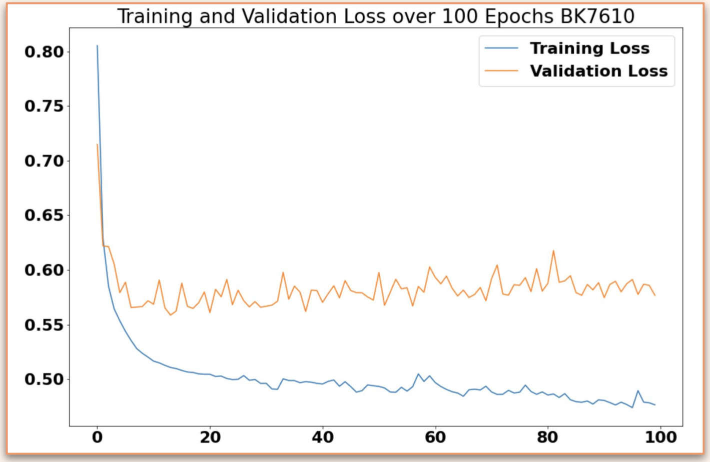
Implementing Leave One Subject Out CV

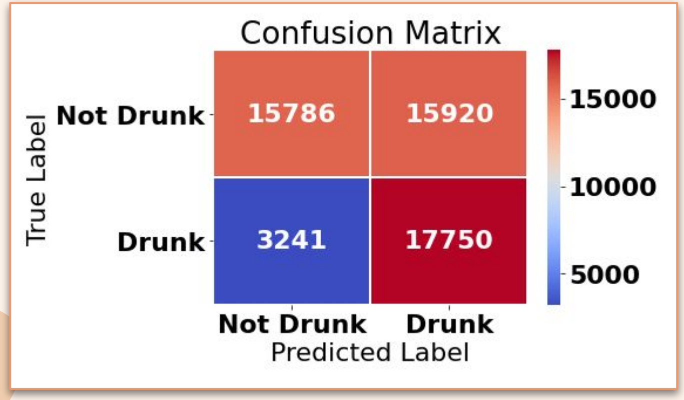
- Alternative to standard K-Fold CV
  - Each user used a validation fold
  - Train new model on each combination of n-1 folds

- Early Stopping (10 epochs)

- Measures performance on unseen users

(Validation Set from a single user fold)





- Average Accuracy: 63.6%

- True Positive Rate: 84.5%

- False Negative Rate: 15.4%

Modeling Takeaways

- Realignment of axes transforms the data to have consistent mean and standard deviation

- Noise filtering and Layer Normalization lead to training stabilization and convergence

- Use LOOCV testing that mirrors deployment environment, rather than standard methods
    - Attempt to validate model in deployment environment as well

Product Building Takeaways

- MVP features are heavily dependent on implementation constraints
- Know the constraints of your machine learning environment before beginning model development
- Begin app development early to better ideate on key features
- Leverage existing codebases to ease learning curve

Future Work

With more funding

1. Purchase an Apple Developer’s License to publish RUM on the app store
2. Run controlled trials to create more training and testing data
3. Build out app UI and develop background inebriation detection
4. Develop online learning techniques to tune model to user’s previous data over time

Summary

- Mission: Create an accessible way to assess your inebriation level
- Problem Statement: Billions around the globe have no affordable and accessible solution to inebriation detection
- Product Differentiation: Making inebriation prediction free and easy to use with an offline classification model
- Impact: Anyone with an Apple smartphone can now detect their inebriation level within 10 steps.

Closing Takeaways

- State of the art model, without requiring internet
- Zero-cost accessible inebriation measurement tool
- Accurate application for a billion dollar industry
- Billions of global drinkers can check their inebriation

Acknowledgements

- Github user @tylerhutcherson for app tutorial and skeleton code
    - https://github.com/skafos/ActivityClassifier
- USC and Ohio State researchers for modeling inspiration
    - http://ceur-ws.org/Vol-2429/paper6.pdf
- Estimation of Blood Alcohol Concentration From Smartphone Gait Data Using Neural Networks
    - https://ieeexplore.ieee.org/document/9335590
- Using gait symmetry to virtually align a triaxial accelerometer during running and walking
    - https://ietresearch.onlinelibrary.wiley.com/doi/pdf/10.1049/el.2012.3763

Acknowledgements (Continued)

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- https://developer.apple.com/documentation/coremotion/getting_raw_accelerometer_events

Visit rum-app.com to view our website!

Thanks!

Any Questions?

FAQ

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Group Contributions

- Zain - EDA, iOS app development, Lead Data Engineer, Model Support/ Debugging
- Joshua - Lead Data Scientist, Architecture design and testing, Porting model to CoreML
- Ben Chu - iOS wireframing, App testing, Website Design and Creation, Slide Theme and development