

Mobile User Authentication with Deep Learning

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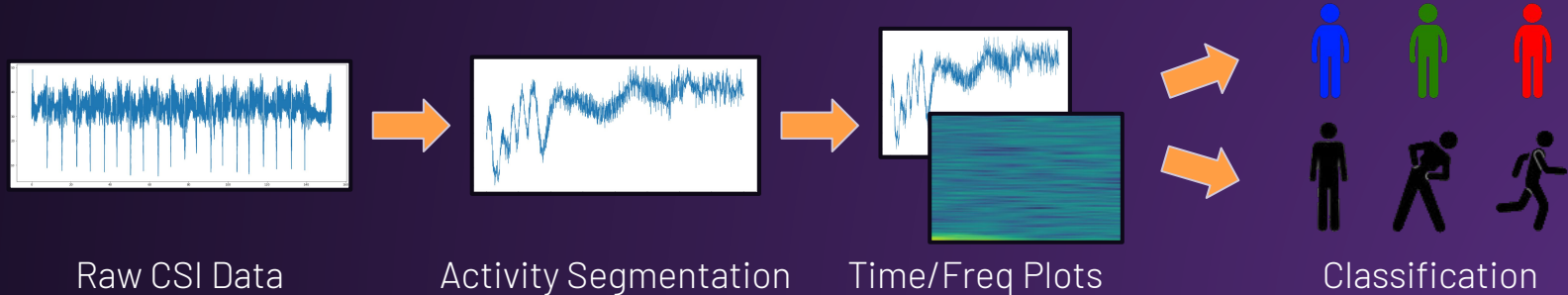
Emily Gao (HS)



David Man (HS)

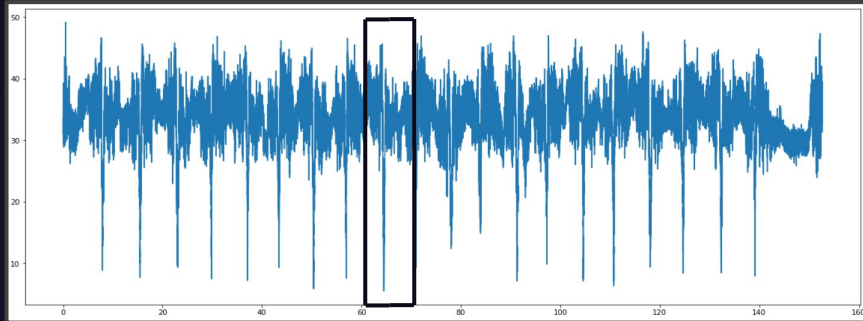
— Project Overview

- Achieve user authentication by analyzing Wifi channel state information (CSI)
 1. Segment CSI data into activities
 2. Generate time and frequency plots
 3. Create model to recognize user behavior and identity

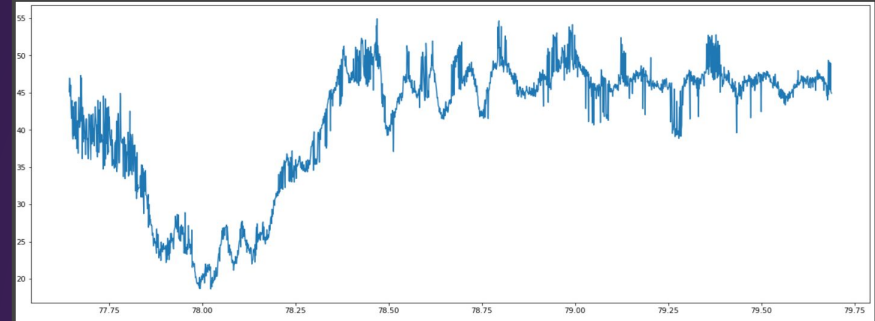


— Data Segmentation

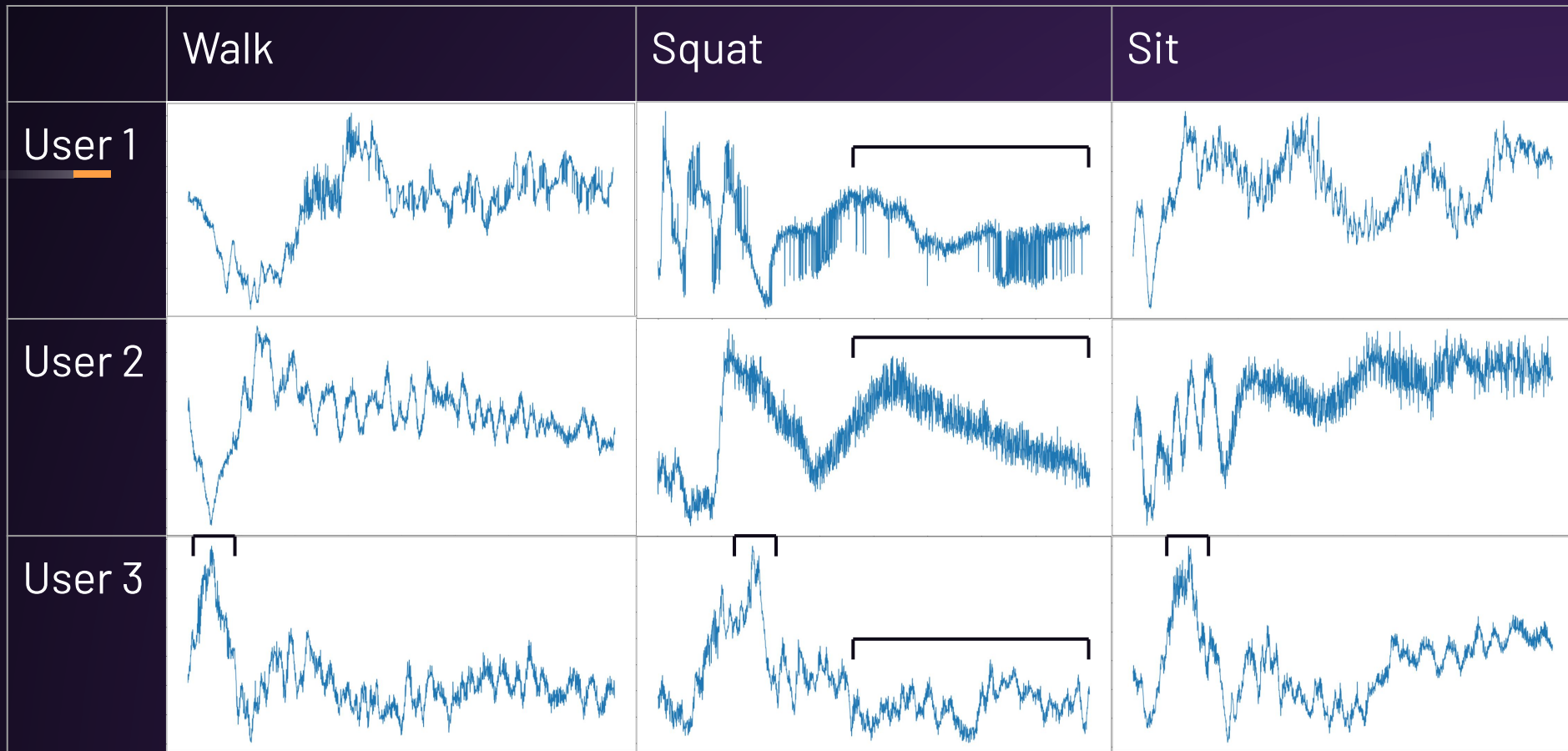
- Input: Wifi signals of users conducting an activity
- Variation in the data signifies human activity
- Rolling variance used to detect the start and end of activities
- Output: Two second time window of human activity



Unsegmented Raw Data



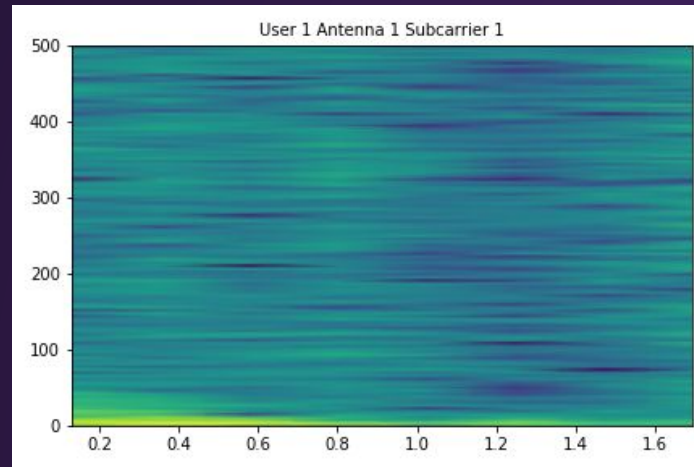
2-Second Activity Window



Different Users & Activities Produce Different Patterns for CNN to Identify

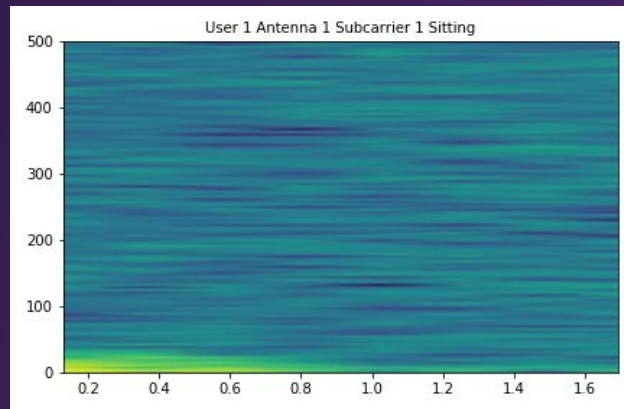
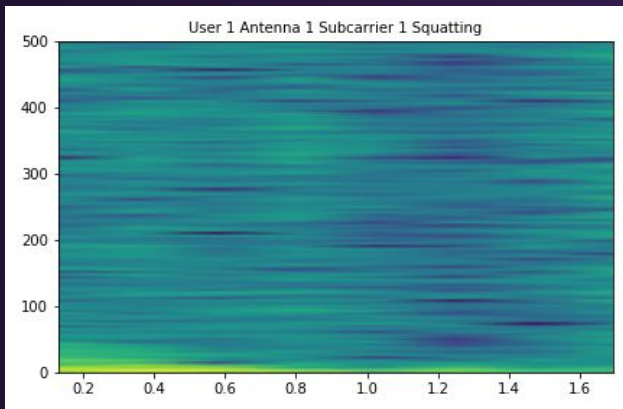
— Data Segmentation and Spectrograms

- Data differentiated through activity and user
- Displayed through spectrograms; displays of frequency spectrums in heat map format
- Example: Spectrogram of User 1 squatting, data from Antenna 1 Subcarrier 1



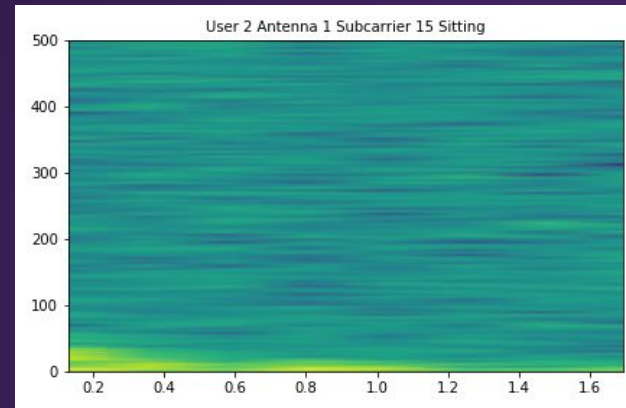
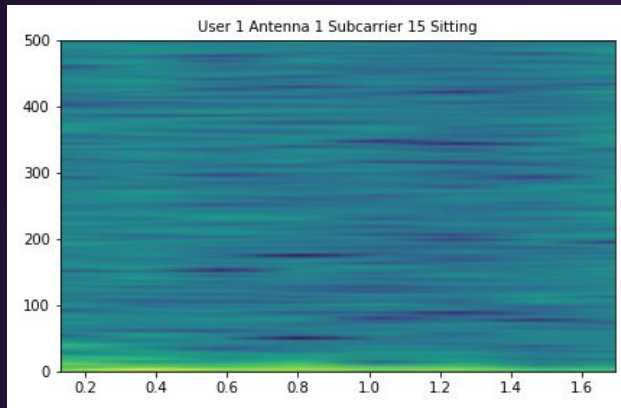
— Spectrogram Usefulness

- Spectrograms can help differentiate user actions
- Example: User 1 Squatting vs User 1 Sitting
 - Difference is subtle but the left part of the squatting spectrogram is notably different



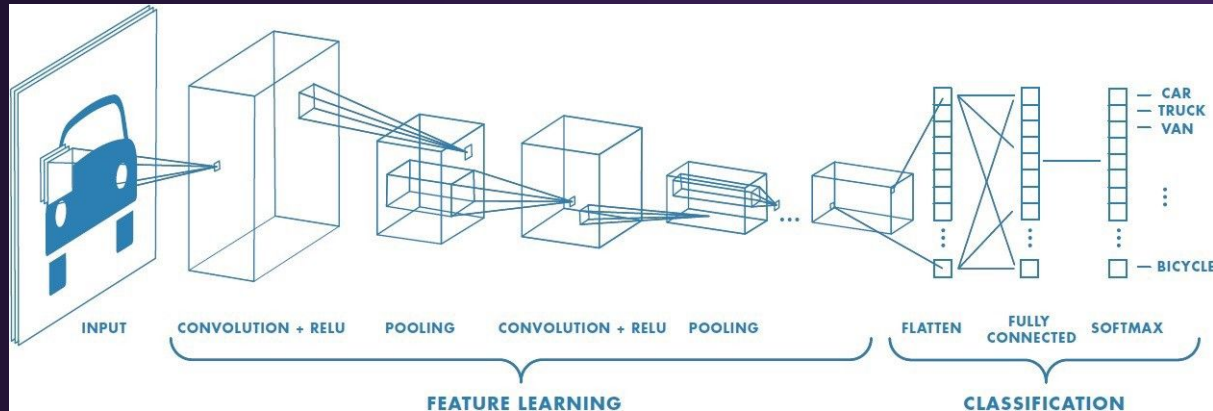
— Spectrogram Usefulness Part 2

- More importantly, it can differentiate between people
- Example: User 1 Sitting vs User 2 Sitting
 - Difference is the concentration of higher-energy frequencies



— Deep Learning Model

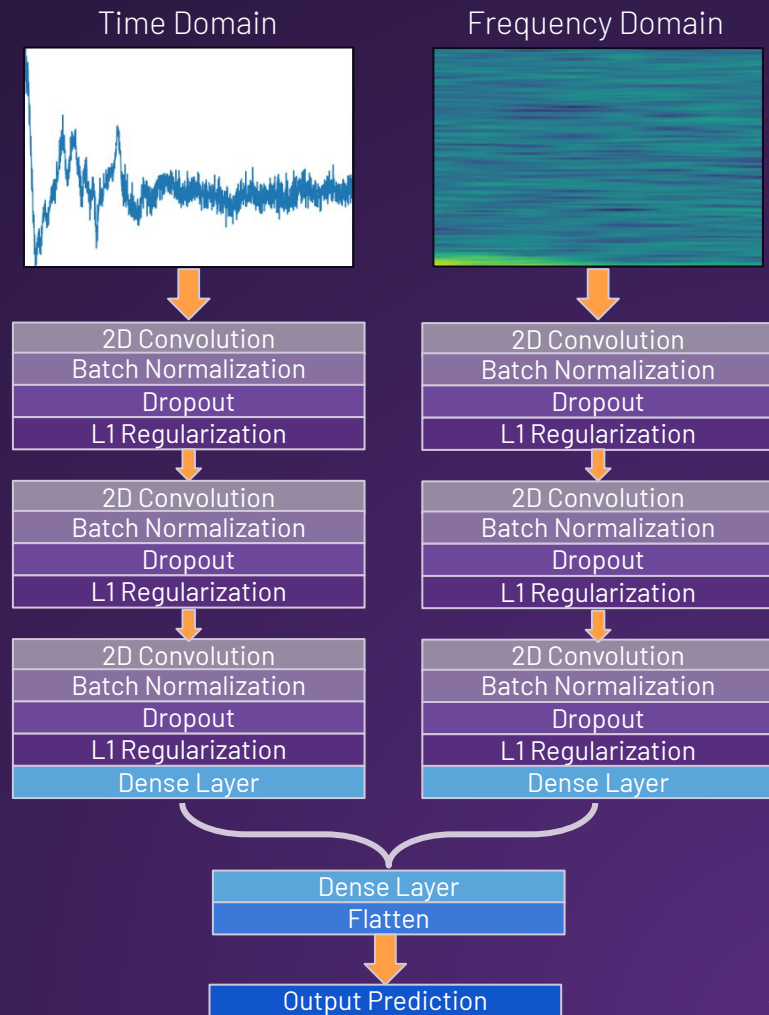
- Learns from time plots and spectrograms
- CNN model chosen for its effectiveness on image data
 - Extracts increasingly complex features from image



Overview of CNN Feature Extraction

Final Model Architecture

- Dual-input CNN model used to classify users/activities
 - 5 users
 - 3 activities
- Achieved 70% activity recognition and 60% user recognition accuracy



Device-Free User Authentication Using Wi-Fi.

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Research Mentors: Prof. Yingying Chen, Cong Shi, Wenjin Zhang

RUTGERS

WINLAB | Wireless Information
Network Laboratory

Introduction

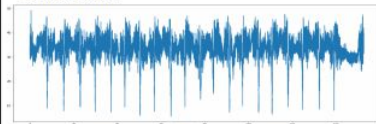
Achieve user authentication by analyzing variations in Wifi channel state information (CSI) caused by human activity

1. Segment CSI data into discrete activities
2. Generate time and frequency domain plots of activities
3. Create model to recognize user behavior and identity

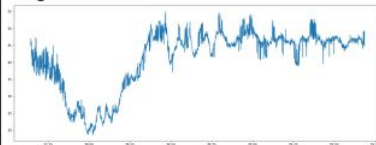
Data Segmentation

- Detect presence of human activities & precisely segment the corresponding CSI measurements.
- CSI data is segmented using moving variance in MATLAB.
- The size of the window for data segmentation was 2 seconds.

Raw CSI Data



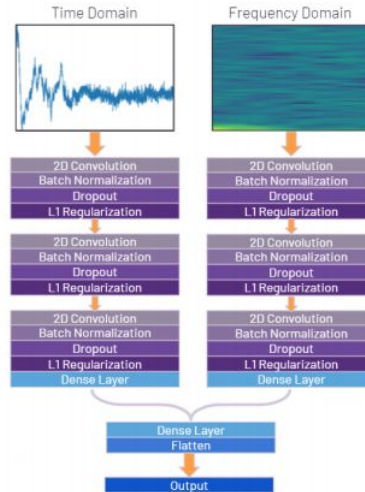
Segmented data



Methodology



CNN Model



Conclusions

- A device-free user authentication system by extracting unique behavioral characteristics captured by the CSI measurements in WiFi signals.
- An environment-independent system, was designed with the help of an unsupervised domain adaptation strategy to remove the location and environment-specific information entangled in CSI measurements to build an environment independent model for user identification and activity recognition.
- The system has the capability of authenticating users through daily behaviors under various scales of location variations and environmental changes

References

Shi, C., Liu, J., Borodinov, N., Leao, B., & Chen, Y. (2020). Towards environment-independent behavior-based user authentication using wifi. *2020 IEEE 17th International Conference on Mobile Ad Hoc and Sensor Systems (MASS)*. <https://doi.org/10.1109/mass50613.2020.00086>

Acknowledgments

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— References

- Shi, C., Liu, J., Borodinov, N., Leao, B., & Chen, Y. (2020). Towards environment-independent behavior-based user authentication using wifi. *2020 IEEE 17th International Conference on Mobile Ad Hoc and Sensor Systems (MASS)*.
<https://doi.org/10.1109/mass50613.2020.00086>