mmWave-based Activity Recognition

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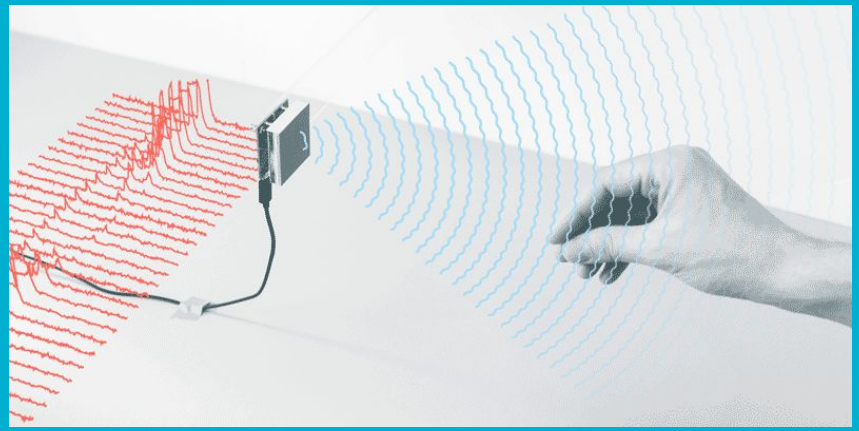
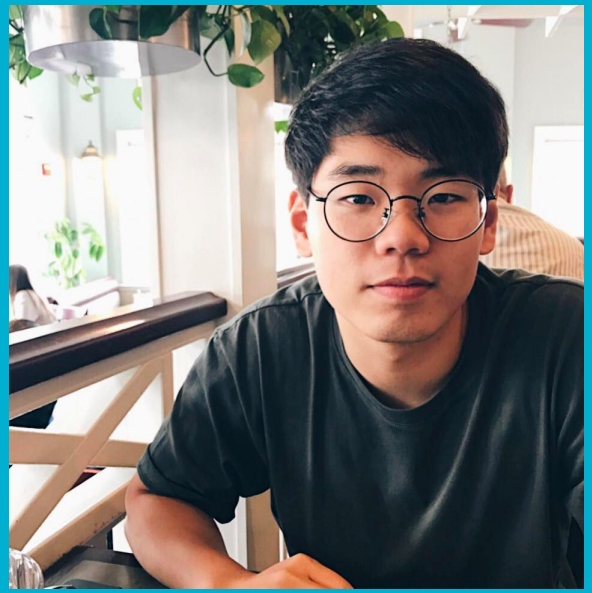


Advisors: Prof. Yingying Chen, Song Yang, Xin Yang

Undergraduate Interns



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Motivation

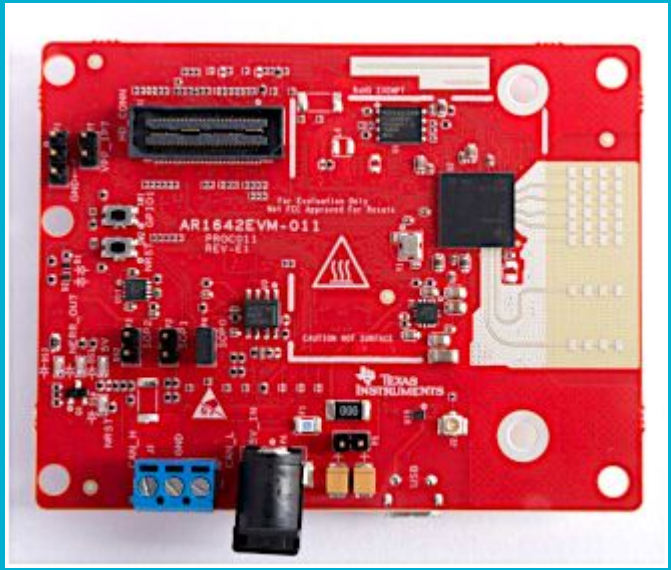
- Human Activity Recognition (HAR) has a wide-range of applications
  - Smart home, health care, fitness tracking
- Device-based approaches (e.g. smart watches) are inefficient
  - Uncomfortable, expensive
- Other sensor devices (e.g. cameras) have potential privacy issues

Objective

- Use mmWave sensors to achieve Human Activity Recognition
- mmWave sensors, based on movement, result in angle and amplitude changes
    - Use signal processing and deep-learning techniques to leverage these signals
- Can be just as accurate as other devices!

ACTIVITY: Dancing

WHAT ARE mmWAVE SENSORS?



mmWave Sensor

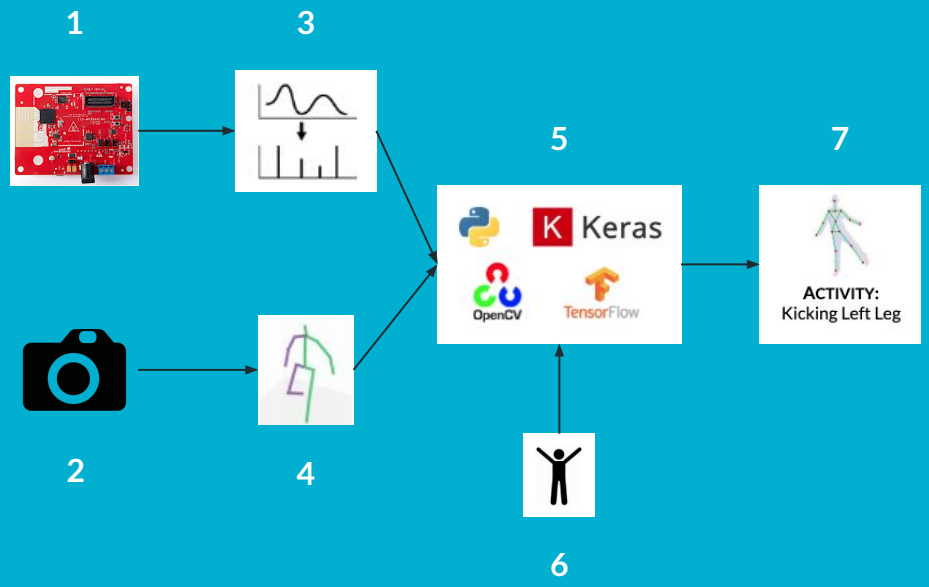
- Device manufactured by Texas Instruments
- Transmits electromagnetic waves and captures reflected signals from objects
- Transmits short wavelengths that are in the millimeter range
  - High frequencies

ADVANTAGES OF mmWAVE SENSORS

1. Size of mmWave sensor & components (e.g. antennas) are relatively small
2. High accuracy
    a. Ability to detect movement as small as a fraction of a millimeter
3. mmWave data has unique information pertaining to a certain activity
    a. Very helpful in classifying different activities

Approach

Our proposed network:

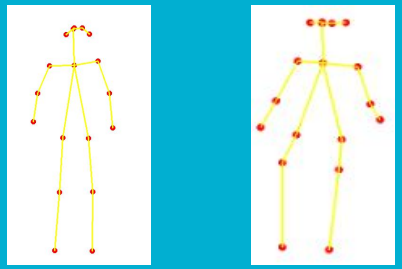


- Use OpenPose as labels for mmWave data (1, 2)
- Train our network composing of a Convolutional Neural Network, using built-in Python packages (5)
- Final results provide a pose estimation skeleton + activity classification (7)

How do we train/test the model?

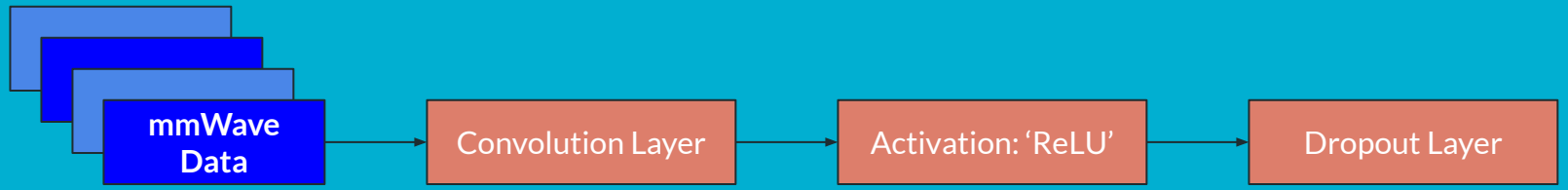
- Model is trained to classify three different activities: kicking, stretching, and sitting down
- Each activity is trained using static data, composed of a total of 1200 samples
  - Activities have 450, 450, and 300 samples respectively
- Model is tested using dynamic data

Example of Static Data



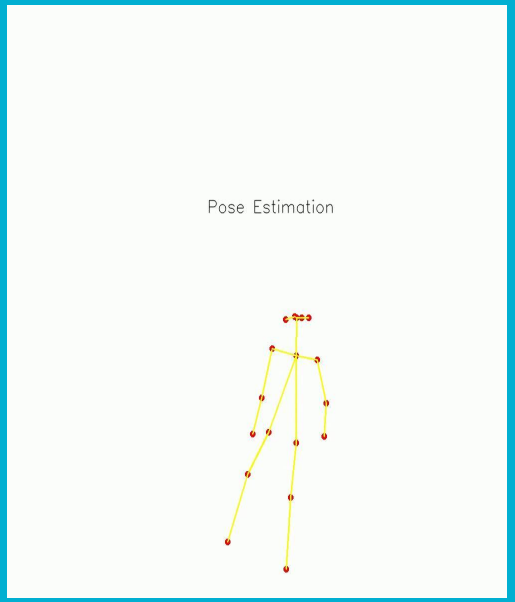
Example of Dynamic Data

Our Model Architecture

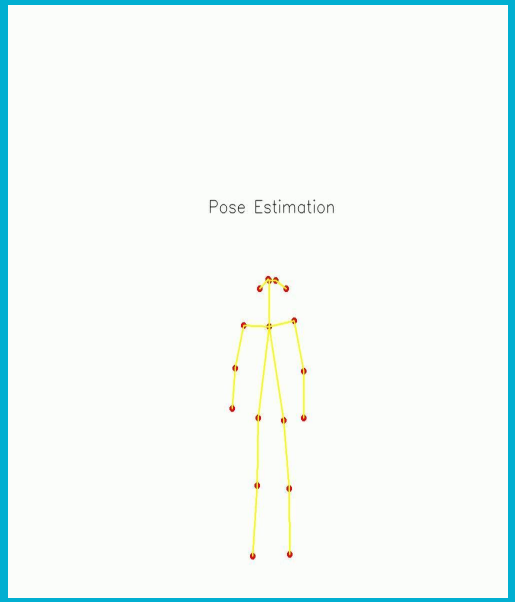


- 4 convolution layers, each followed by an activation & dropout layer, and 2 dense layers
- mmWave data is a 3-D matrix
- After making pose estimated human skeleton, another layer makes activity classification based on labels

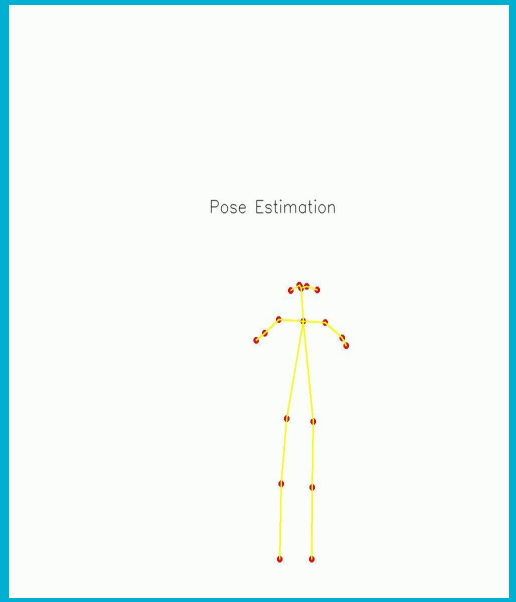
Results



Kicking Outward



Sitting Down



Stretching

Conclusion & Future Work

- We explored a method of hands-free HAR with mmWave sensors using signal processing and deep-learning techniques
- This model can classify amongst three different activities
  - Kicking outward, stretching, sitting down
- Future work consists of gathering more data and optimizing our model for better clarity and accuracy
  - Explore other parameters for a better architecture

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Thank You!
Questions?