Utilizing Millimeter-Wave Sensors for Human Activity Recognition

Soo Min Kwon*, Christine Mathews*, Shreya Patel*, Song Yang**, Xin Yang**

Advisors: Prof. Yingying Chen & Jian Liu

Motivations & Objectives

- ❑ Human Activity Recognition (HAR) has a wide range of real-world applications, such as health care and fitness tracking
- ❑ Device-based approaches for HAR (e.g. smart watches) have limitations due to cost and discomfort
- ❑ Many significant efforts have recently been made to explore device-free HAR that utilizes the information collected from wireless infrastructures (e.g. WiFi signals)
- ❑ Other existing wireless devices, such as cameras, can potentially leak and lead to privacy issues
- ❑ We propose a network, utilizing mmWave data that can accurately classify amongst different human activities, that is cheaper and user-friendly
- ❑ mmWave radar systems transmit short wavelength waves that are in the millimeter range, and thus have high frequencies

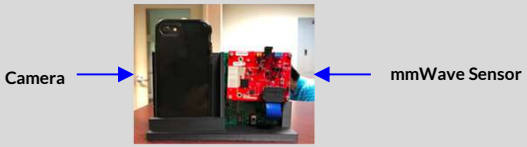


FIGURE 1

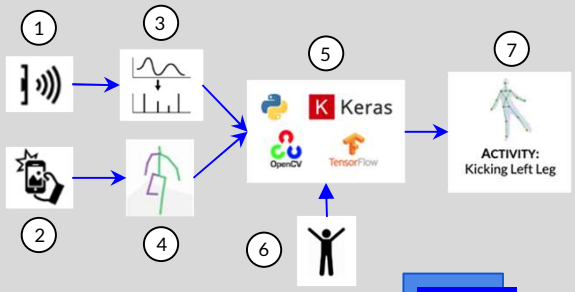
Figure 1 shows camera and mmWave sensor setup

References

[1] Cao, Zhe & Hidalgo, Gines & Simon, Tomas & Wei, Shih-En & Sheikh, Yaser. (2018). "OpenPose: Realtime Multi-Person 2D Pose Estimation using Part Affinity Fields".

[2] Wang, Fei & Panev, Stanislav & Dai, Ziyi & Han, Jinsong & Huang, Dong. (2019). "Can WiFi Estimate Person Pose?".

Methodology



1. mmWave sensor triggers 150 frames and captures data
2. Camera takes picture synchronous to mmWave sensor
3. Process mmWave data to perform 2-D Fast Fourier Transform (FFT)
4. Images are further processed using open-source project OpenPose [1] to be used as labels
5. Classification model is a teacher-student network similar to [2] that is composed of a Convolutional Neural Network (see Figure 2), using built-in Python packages
6. Model is further tested using dynamic data
7. Provides a human pose estimated figure performing activity and classification of activity

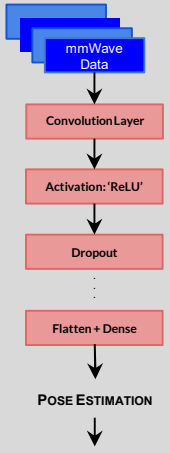
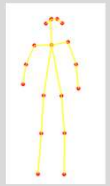


FIGURE 2

Results

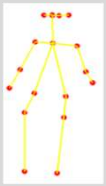
We trained our classification model for 200 epochs with an Adam optimizer and a total of 1200 data samples. Our current model can classify amongst three different activities: stretching, kicking right leg, and sitting down. The experiments for these activities have 450, 450, and 300 samples respectively.

EXAMPLE RESULTS FOR SITTING



ACTIVITY: Sitting

FIGURE 3



ACTIVITY: Sitting

FIGURE 4

Figure 3 and Figure 4 lead up to a person sitting down respectively

Conclusion & Future Direction

- ❑ We explored a method of hands-free HAR with mmWave sensors by using signal processing and deep-learning techniques
- ❑ Future work consists of gathering more data and optimizing our model for better clarity and accuracy

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* Undergraduate Student ** PhD Candidate