This repository contains the codes and sample data files for extracting a 3D human mesh model performing some activity from a video, as well as the simulation of the RF signal that would have been measured if this person was performing the activity in an RF-covered area. Such 3D extraction and RF simulation can be useful for designing real-world RF sensing applications that involve human motion. For instance, in our papers listed below, we have utilized this simulation pipeline to successfully train an RF sensing system solely based on video data for human activity recognition (Ref. [1]). We have also utilized this simulation pipeline to enable a cross-modal gait-based person identification system across video and RF (Ref. [2]).

[1] H. Cai\*, B. Korany\*, C. R. Karanam\*, and Y. Mostofi, "Teaching RF to Sense without RF Training Measurements," in Proceedings of the ACM on Interactive, Mobile, Wearable, and Ubiquitous Technologies (IMWUT), Vol. 4, Issue 4, 2020.

[2] B. Korany\*, C. R. Karanam\*, H. Cai\*, and Y. Mostofi, "XModal-ID: Using WiFi for Through-Wall Person Identification from Candidate Video Footage," in Proceedings of the International Conference on Mobile Computing and Networking (MobiCom), 2019.

(\*indicates equal contribution)

In this repository, we provide sample usage of our simulation pipeline using three sample gym activities: lateral lunge, sit-up, and stiff-leg deadlift. There are two main stages in this simulation pipeline: 1) 3D human mesh extraction and 2) RF signal simulation using Born approximation.

1. **3D human mesh extraction**

This part is based on the Mask-RCNN system (Ref. [3]) and the Human Mesh Recovery (HMR) system (Ref. [4]). It runs on Ubuntu and requires a CUDA GPU.

To extract the meshes, run the script “*get\_mask\_mesh.sh*”. The Mask-RCNN implementation requires Tensorflow and Python 3, and the HMR implementation requires Tensorflow and Python 2. The script assumes that you have the corresponding Anaconda environments. Please refer to the original repositories of Mask-RCNN and HMR for detailed system requirements (see links below). The code will first go into the folder “*video\_frames*” to search for video frames to perform human mesh extraction. The extracted human masks and meshes are saved in the folder “*video\_meshes*”. Please refer to the corresponding Python scripts called in “*get\_mask\_mesh.sh*” for more details.

[3] K. He, G. Gkioxari, P. Dollár, and R. Girshick, "Mask R-CNN," in Proceedings of the IEEE International Conference on Computer Vision, 2017.

Codes used in our implementation: https://github.com/matterport/Mask\_RCNN

[4] A. Kanazawa, M. J. Black, D. W. Jacobs, J. Malik, “End-to-end recovery of human shape and pose,” in Proceedings of the International Conference on Computer Vision and Pattern Recognition, 2018.

Codes used in our implementation: https://github.com/akanazawa/hmr

1. **RF simulation for human activity**

The RF simulation is implemented using Matlab. The main script for simulating RF signals for a given human activity is “*generate\_wifi\_from\_video.m*”. Within the script, specify the ID of the gym activity that you want to simulate the RF signal for, in line 39. The IDs of the sample activities are as follows (see Fig. 4 of [1]):

|  |  |
| --- | --- |
| **Activity** | **ID** |
| Lateral lunge | 5 |
| Sit up | 9 |
| Stiff-leg deadlift | 10 |

Then, set whether you want to visualize the meshes (before and after alignment) in the binary variable “*show\_meshes*” in line 35. Please see the comments within the script for more clarifications.

Here is a list of the other related functions, scripts, and folders.

* Folder: “*Functions*”

This folder contains MATLAB scripts that are used for the simulation, such as a function “*mesh\_alignment\_algorithm*” that aligns the 3D human mesh (e.g., such that the human properly stands on the floor), or a function “*get\_local\_coordinate\_system*” that uses eigen analysis to calculate the local coordinate system (see Sec. 3.1 in [1] for details).

* Folder: “*MeshInfoMatfiles*”

This folder contains some .mat files used for simulation. These .mat files contain the indices of different body parts in an extracted mesh.

* Folder: “human mesh recovery”

This folder contains the codes and scripts that extract the meshes from the video frames, as described in part 1 of this document.

* Folder: “*Simulated\_spectrograms*”

This folder contains the output of the main Matlab script, i.e., the spectrograms of the simulated RF signals for different videos of different activities.

* Folder: “*Video\_frames*”

This folder contains the frames of all the videos of all activities.

* Folder: “*Video\_meshes*”

This folder contains the extracted meshes (the output of the human mesh recovery algorithm). It also contains the cropped images for the persons in the videos (the outputs of Mask-RCNN). These meshes and cropped images are used in the main Matlab script “*generate\_wifi\_from\_video.m*” to generate the WiFi signals.