mmSleep: Monitoring Sleep Posture from Commodity Millimeter-Wave Devices

Aakriti Adhikari
Siri Avula
Sanjib Sur

Objective and Challenges

Objective

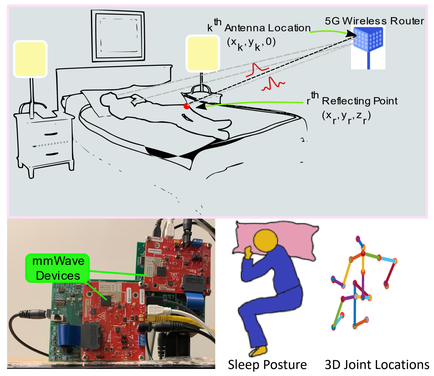
- To enable **continuous fine-grained sleep posture monitoring** throughout the night from **5G millimeter-wave (mmWave) devices**.

Motivation

- At-home sleep monitoring system that acts as a sleep diary to track users' sleep behavior **without being intrusive and privacy-invasive** is desirable.

Challenges

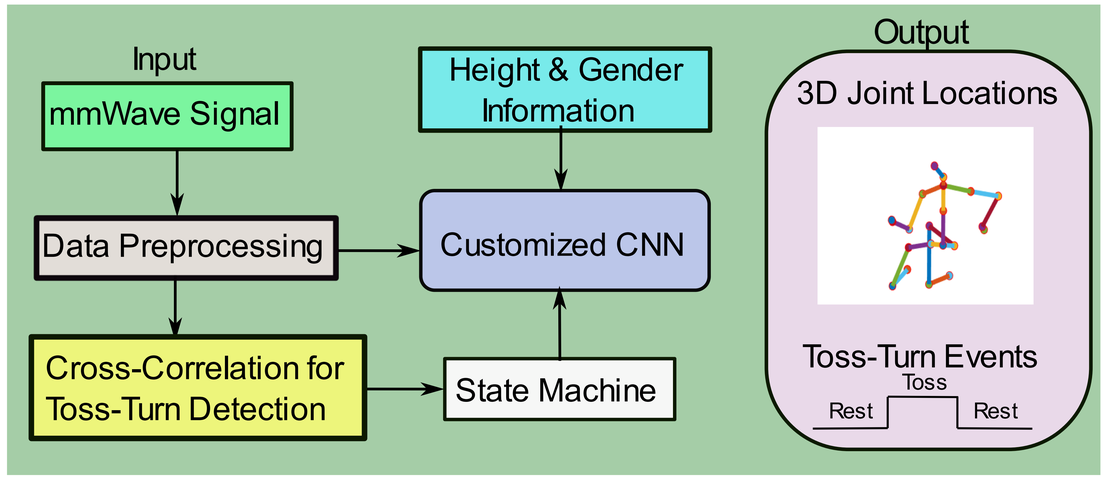
- MmWave devices have extremely **low resolution** compared to vision-based systems.
- **Signal specularity causes** inadequate information about body parts to reflect in the receiver.



Toss-Turn Event Detection

Predicting toss-turn during sleep

- Sleeping period can be classified as either rest or toss-turn states.
- *mmSleep* first identifies toss-turn events using a cross-correlation method.

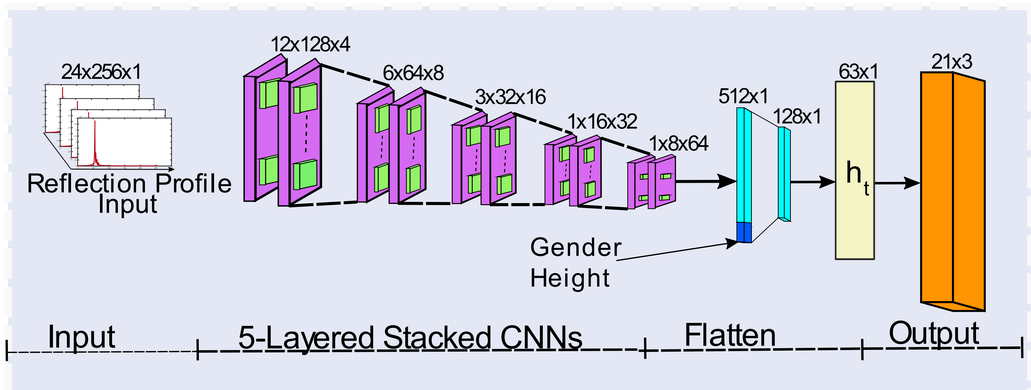


- State machine then switches to rest state to predict 3D locations of body joints.

CNN for 3D Joint Location Estimation

Predicting sleep postures by incorporating height and gender information

- **5-layered stacked CNN** predicts the 3D joint locations of a person exhibiting variations of sleep postures throughout the night in the rest state.
- CNN incorporates the known height and gender of a person to generalize well.

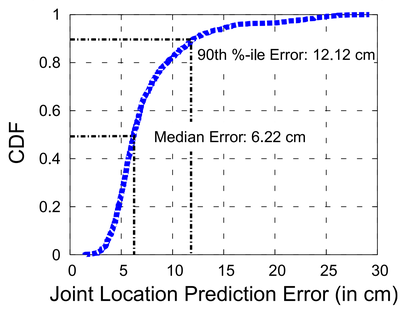


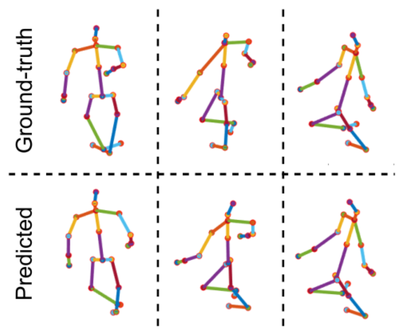
- During deployment, *mmSleep* predicts skeletons using only the reflected signals.

Preliminary Results and Conclusion

Sleep posture prediction

- *mmSleep* predicts 3D joint location with a **median error of 6.22 cm** for diverse sleep postures with 2000 samples.





Conclusion

- *mmSleep* combines deep learning and signal processing to monitor sleep postures.

Future works

- Conduct end-to-end field-trial with multiple diverse sets of volunteers.