MilliPose: Facilitating Full Body Silhouette Imaging from Millimeter-Wave Device

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MilliPose: Objective and Challenges

Objective

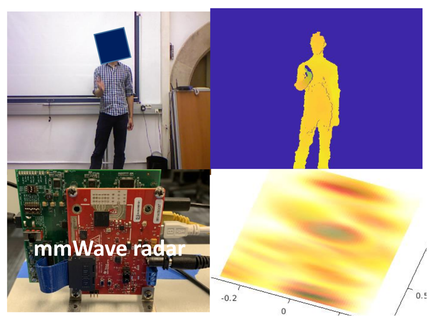
- To facilitate **full human body silhouette imaging** and 3D pose estimation from **5G millimeter-wave (mmWave) devices.**

Motivation

- How to enable through-occlusion imaging that is not privacy-invasive and can perform well under low visibility and the low light condition?

Challenges

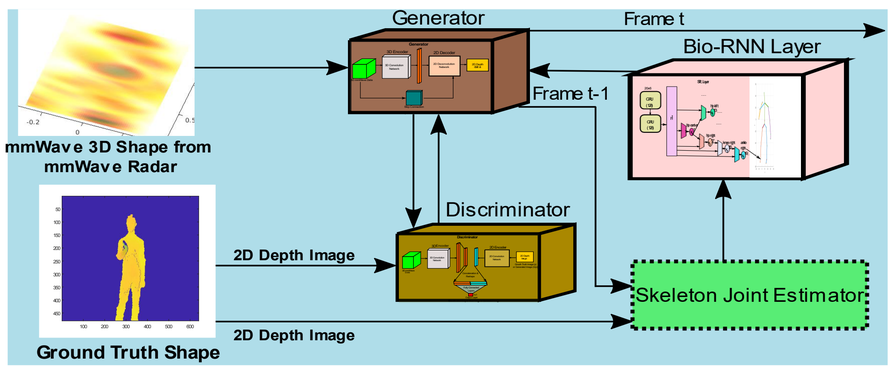
- The **image resolution is extremely poor** due to the mmWave frequency and limited bandwidth.
- **Specular reflectivity** and nature of human body create an imperceptible output image.



cGAN for Silhouette Generation

Improving image resolution using cGAN

- Conditional Generative Adversarial Network (**cGAN**) learns the association between 3D mmWave images to the 2D ground truth (Kinect Depth) images.

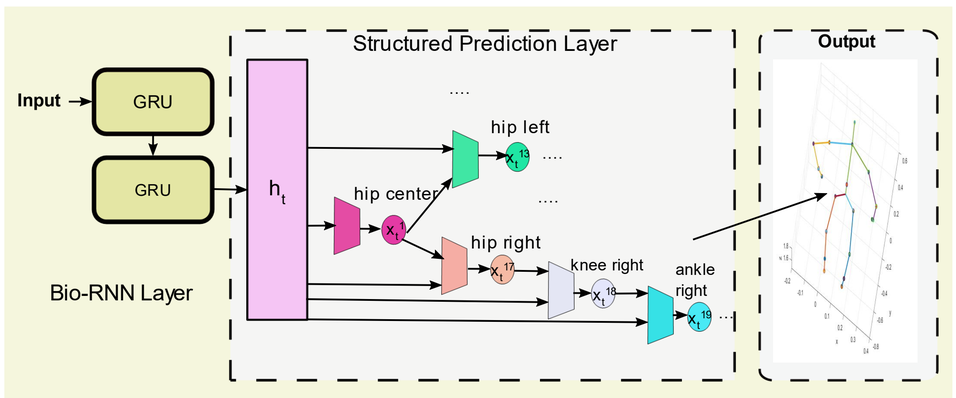


- cGAN trains **Generator** and **Discriminator** with **custom loss function.**

Bio-RNN for Silhouette Quality Improvement

Predicting pose by incorporating rules of human biomechanics

- Bio-RNN predicts the **next pose** from the pose estimated by cGAN and skeleton joint estimator in the previous frame.
- Bio-RNN uses **Gated Recurrent Unit (GRU)** and **Structured Prediction Layer (SPL)** with **custom loss function** to train the network.



- Bio-RNN **feedbacks cGAN** to recover missing parts and high spatial frequency information and assists cGAN during the training process.

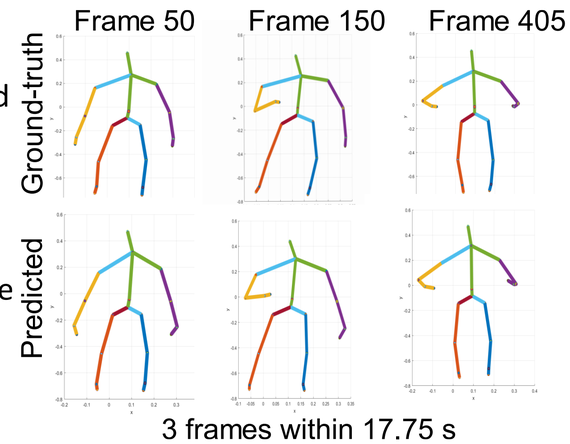
Preliminary Results and Conclusion

Pose prediction

- Bio-RNN predicts 3D joint location with a **median error of 2.1 cm** for diverse poses.

Conclusion

- *Millipose* combines machine-learning and knowledge about human bio-mechanics.
- Bio-RNN module in *Millipose* can predict joint location accurately.
- Post training, cGAN can take 3D mmWave images and generates 2D silhouette.



Future works

- Design and prototype cGAN network and jointly train it with Bio-RNN.
- Experiment with multiple volunteers in both home and office settings to evaluate *Millipose* end-to-end.