mmPoint: Dense Human Point Cloud Generation from mmWave

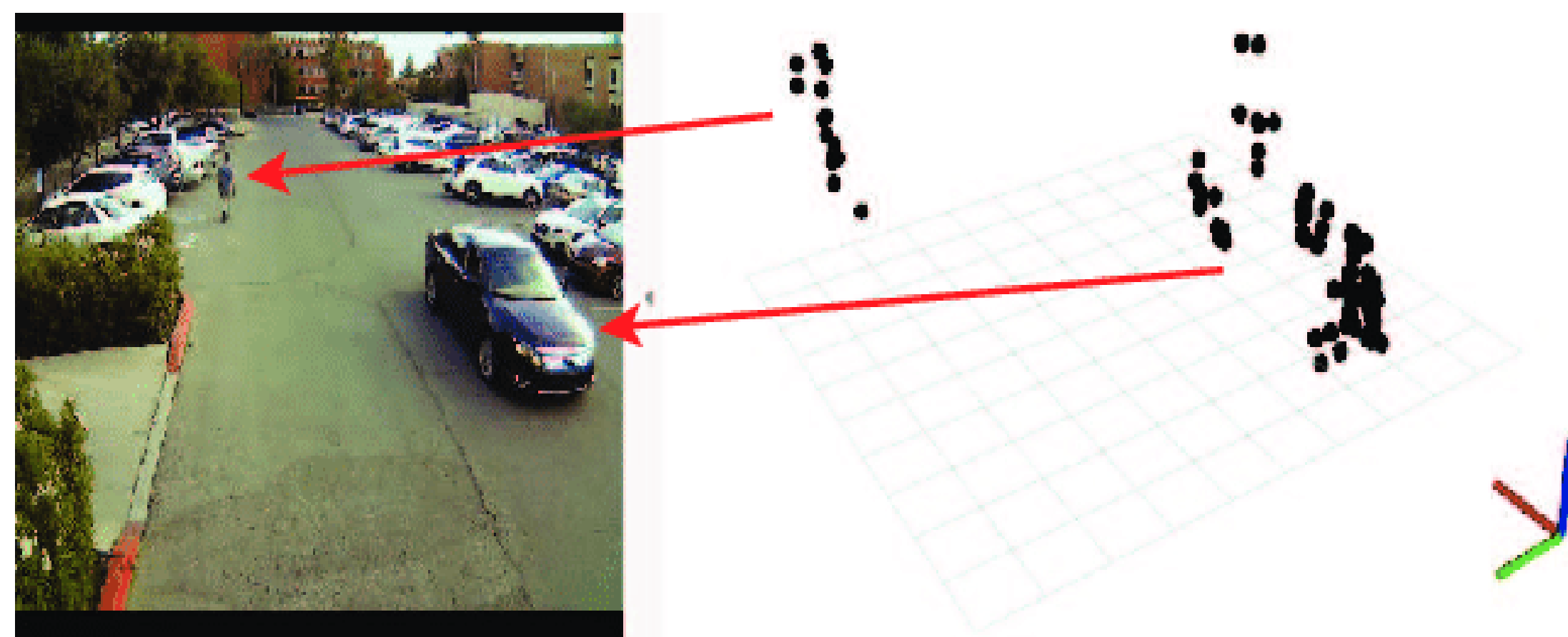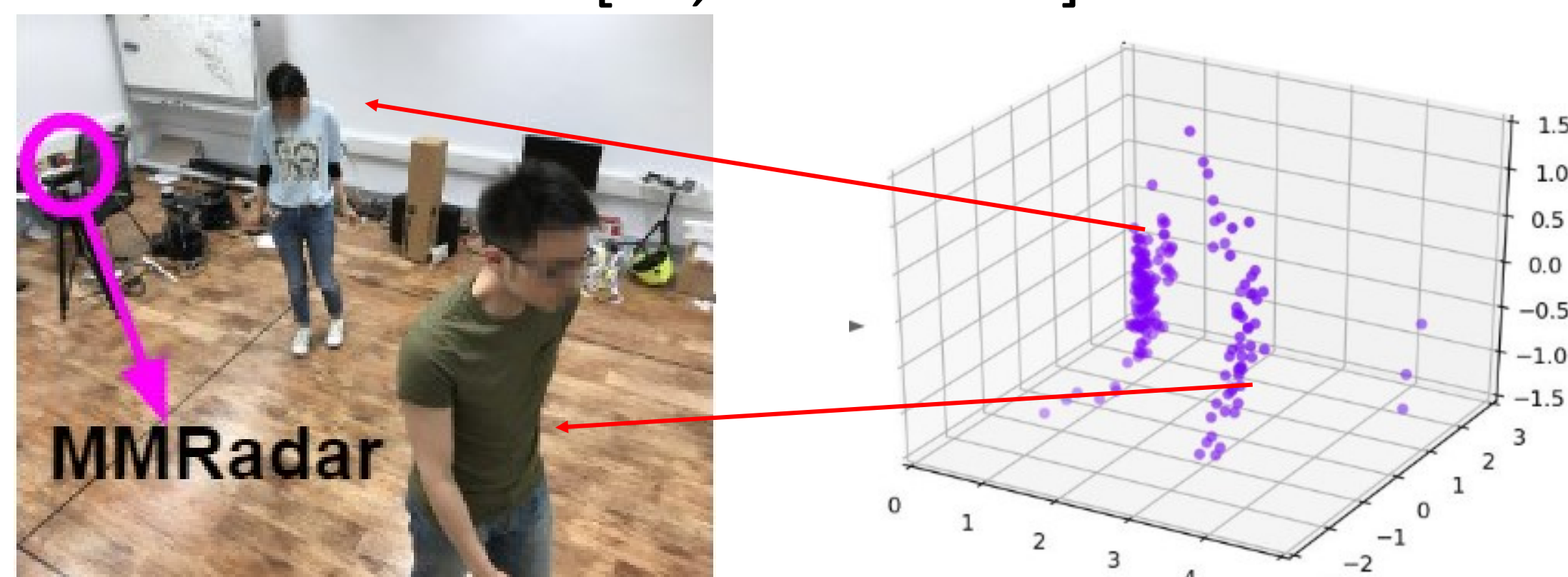Qian Xie, Qianyi Deng, Ta-Ying Cheng, Peijun Zhao, Amir Patel, Niki Trigoni, Andrew Markham

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Motivation:

➤ **The main disadvantage of mmWave radar is that it produces rather sparse data, because the radio waves emitted by radar have weak straightness. In addition to wavelength problems, inherent noise is also a cause of the sparsity in radar data. [Lee, et al. 2022]**

➤ **This causes inaccurate results because the quality of the generated point cloud has a significant effect on the accuracy and effectiveness of the subsequent data process. [Zhang, et al. 2022]**
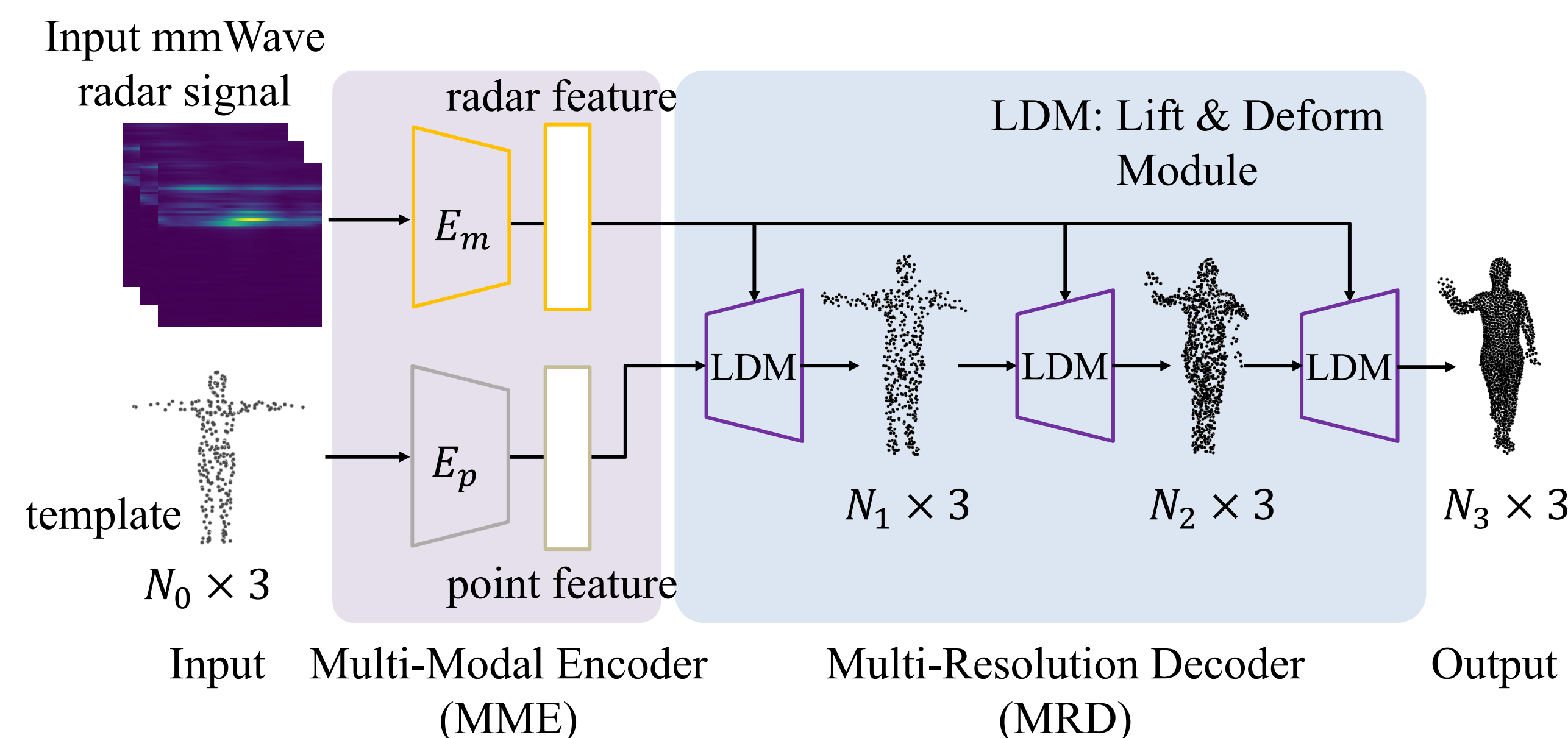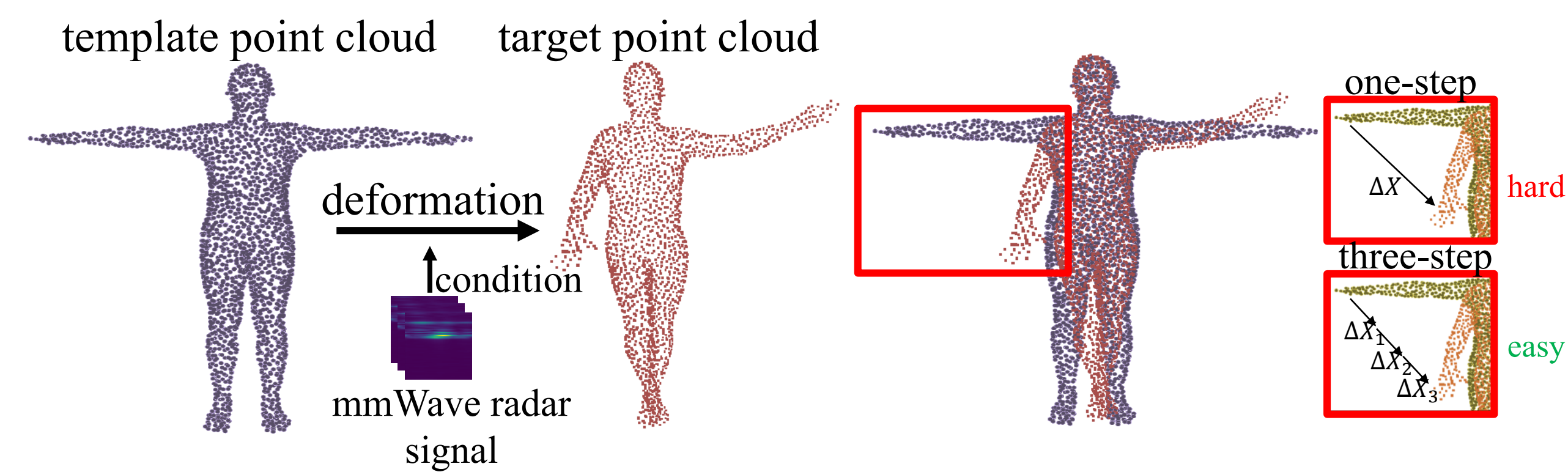
mmWave point clouds are sparse and noisy!!!
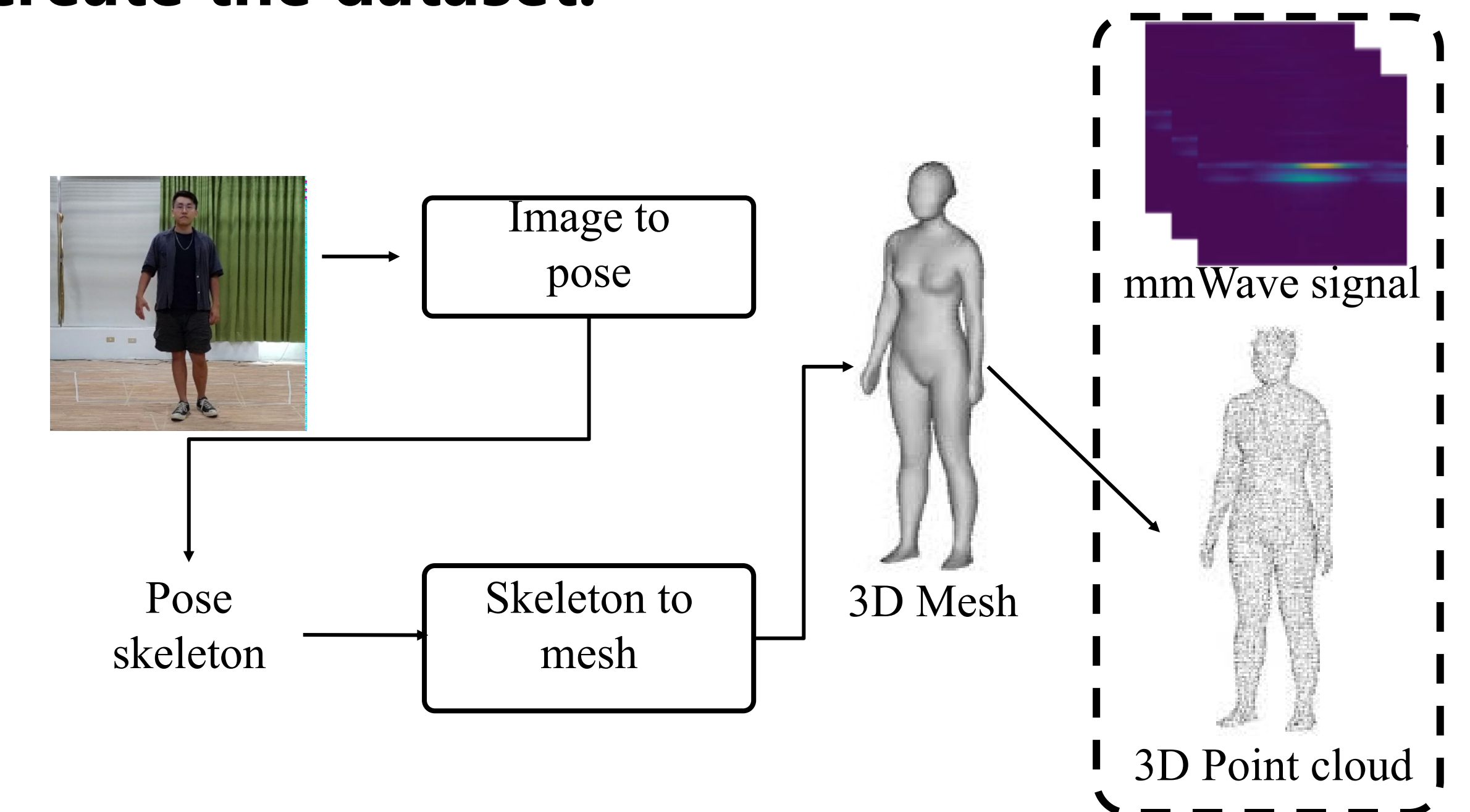

[*Jin, et al. 2019*]

MMRadar

[*Zhao, et al. 2021*]

Method:

➤ *(contribution #1)* **A reformulation of the difficult point cloud generation task to a simpler point cloud deformation problem. We reformulate the point cloud generation problem from mmWave signals as a mmWave-conditioned point cloud. deformation task.**

➤ *(contribution #2)* **A novel three-step point cloud deformation framework to further reduce learning difficulty.**

template point cloud → target point cloud

deformation

condition

mmWave radar signal

one-step ΔX hard

three-step $\Delta \hat{X}_1$ $\Delta \hat{X}_2$ $\Delta \hat{X}_3$ easy

Input mmWave radar signal

radar feature

LDM: Lift & Deform Module

E_m

E_p

template $N_0 \times 3$

point feature

LDM → $N_1 \times 3$ → LDM → $N_2 \times 3$ → LDM → $N_3 \times 3$

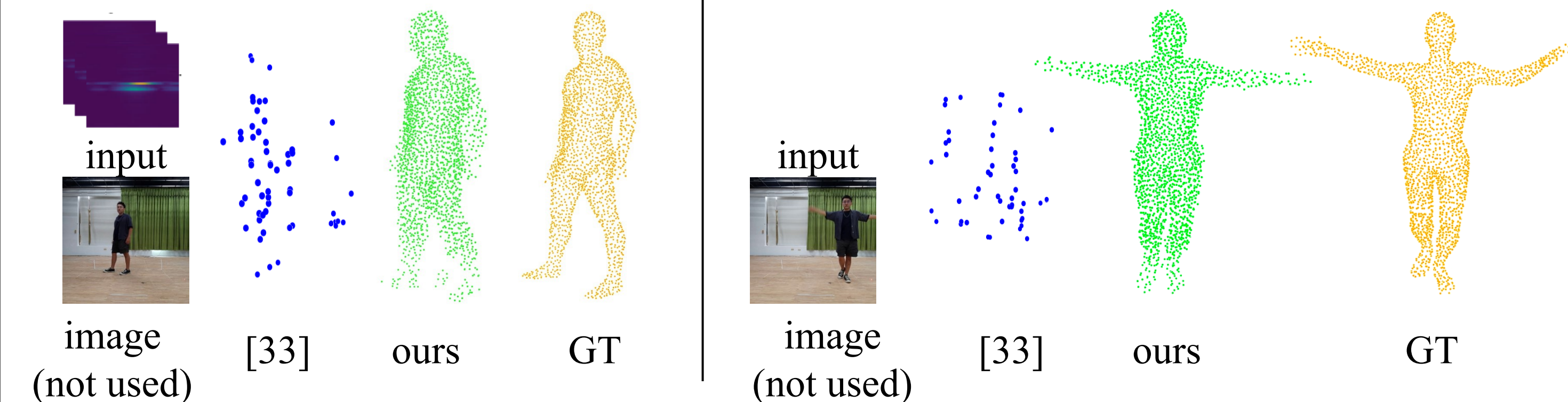Input | Multi-Modal Encoder (MME) | Multi-Resolution Decoder (MRD) | Output

Dataset:

➤ **There is no existing dataset containing both mmWave signal and 3D human point clouds since capturing dynamic human point clouds is expensive and complicated.**

➤ *(contribution #3)* **We propose a pseudo point cloud ground-truth generation framework to create the dataset.**

Image to pose → mmWave signal

Pose skeleton → Skeleton to mesh → 3D Mesh

3D Point cloud

Results:

input | image (not used) | [33] | ours | GT | input | image (not used) | [33] | ours | GT

Metric: Distances to the ground point clouds	Methods	Average	Scene #1	Scene #2	Scene #3	Scene #4	Scene #5
	mmMesh [33]	10.65	9.68	13.21	11.39	10.26	8.73
	mmPoint(Ours)	2.92	2.78	3.06	3.25	2.88	2.61