RF Genesis:
Zero-Shot Generalization of mmWave Sensing through Simulation-Based Data Synthesis and Generative Diffusion Models

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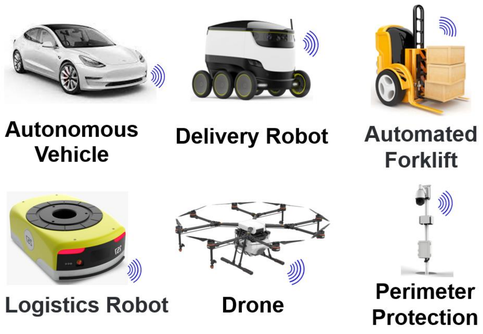
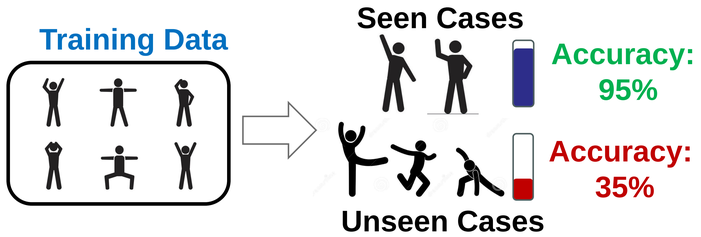
Generalization of mmWave Sensing

mmWave Sensing:

- Widely used in various applications



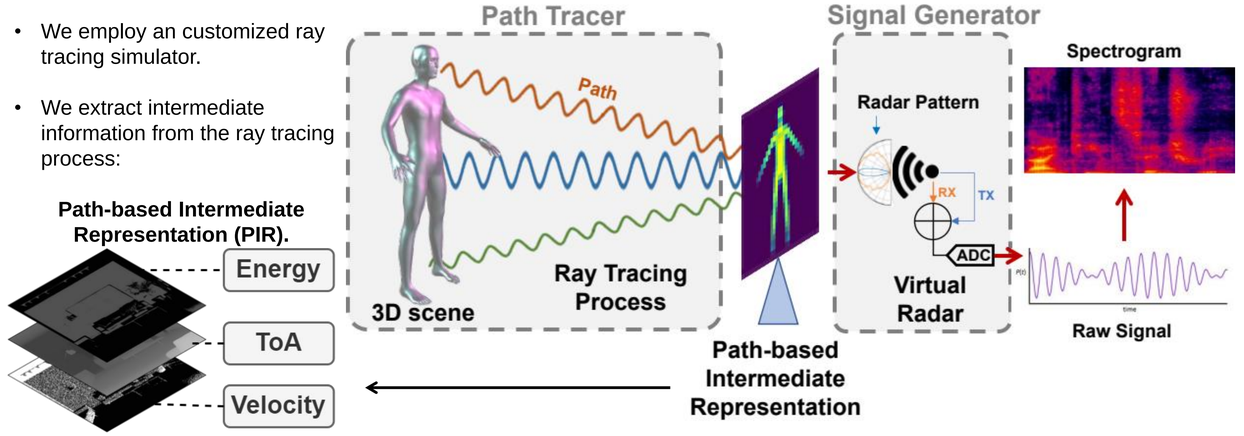
Generalization of mmWave Sensing:



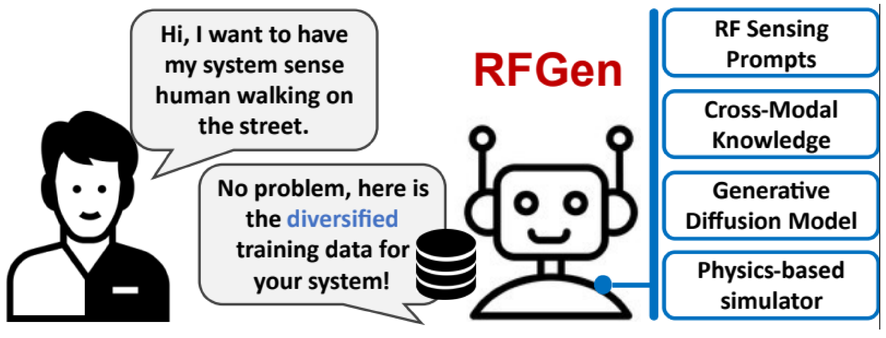
- The data driven methods performs poorly with data it has not seen before.
- Increase the size and diversity of the training dataset is costly and often impractical.

Physical Model and Intermediate Representation

- We employ an customized ray tracing simulator.
- We extract intermediate information from the ray tracing process:

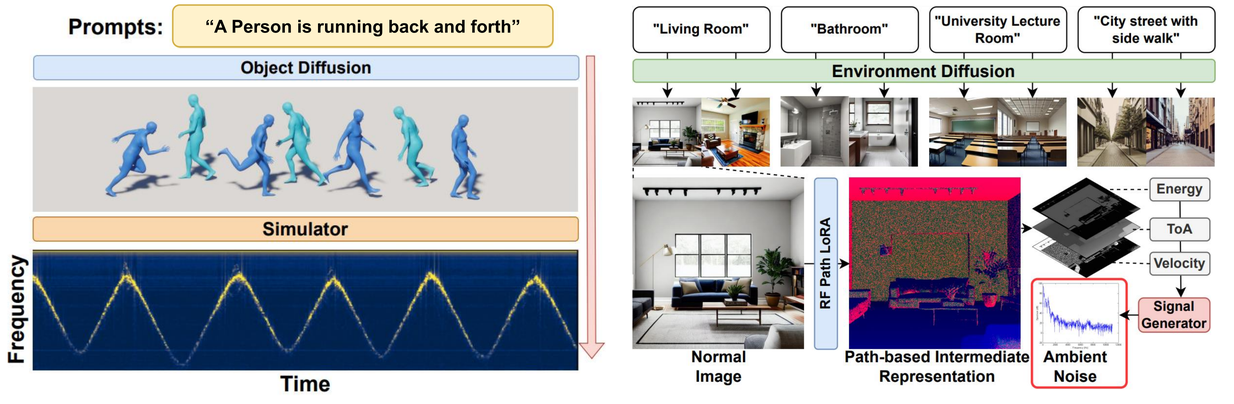


Zero-Shot Generalization through Generative Diffusion Model

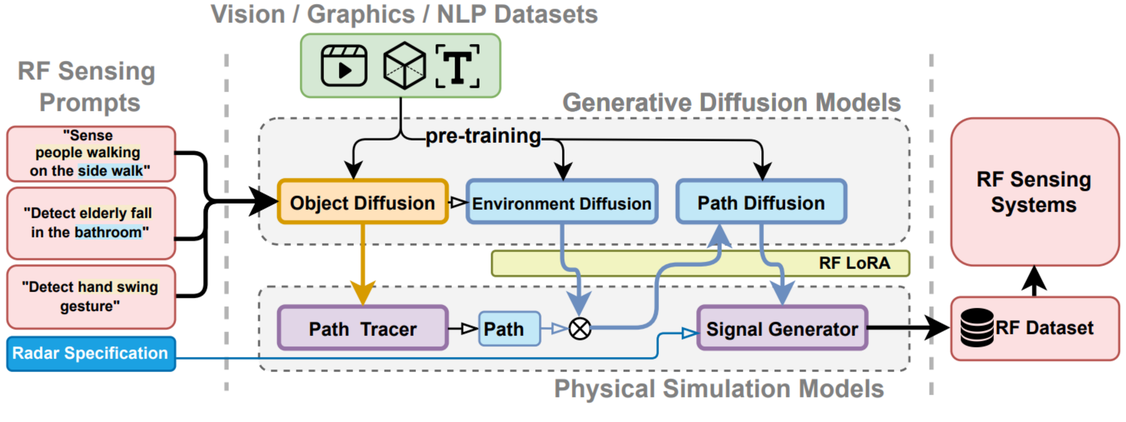


- **RF Genesis can generate diverse training data for RF sensing applications to improve generalization, based on the description of the target sensing application and its large cross-modal knowledge**

Object and Environment Diffusion Model

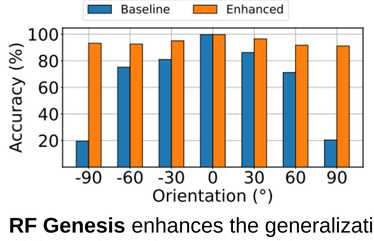


RF Genesis System Design

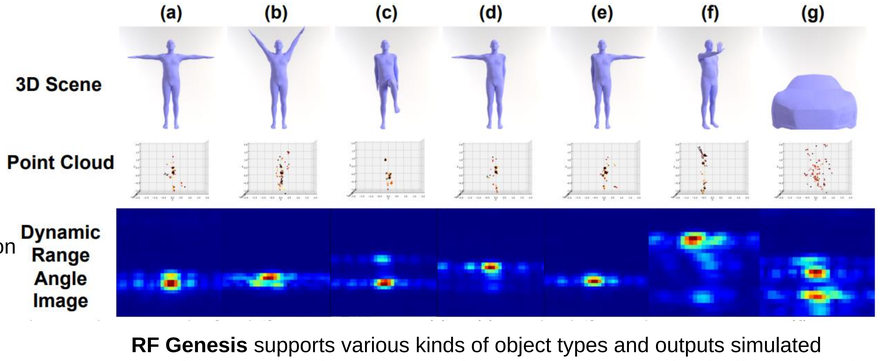


- **RF Genesis operates on a hybrid model that merges white-box physical law models with black-box deep learning models.**

Results and Conclusion



RF Genesis enhances the generalization of the real sensing system without collecting additional radar data.



RF Genesis supports various kinds of object types and outputs simulated signals in the same format as a real radar, which is capable of different signal processing methods.

Conclusion:

RF Genesis

- A mmWave sensing data synthesis framework.
- High-precision ray tracing simulator + cross modal generative diffusion model.
- Demonstrates a remarkable enhancement in sensing and generalization.