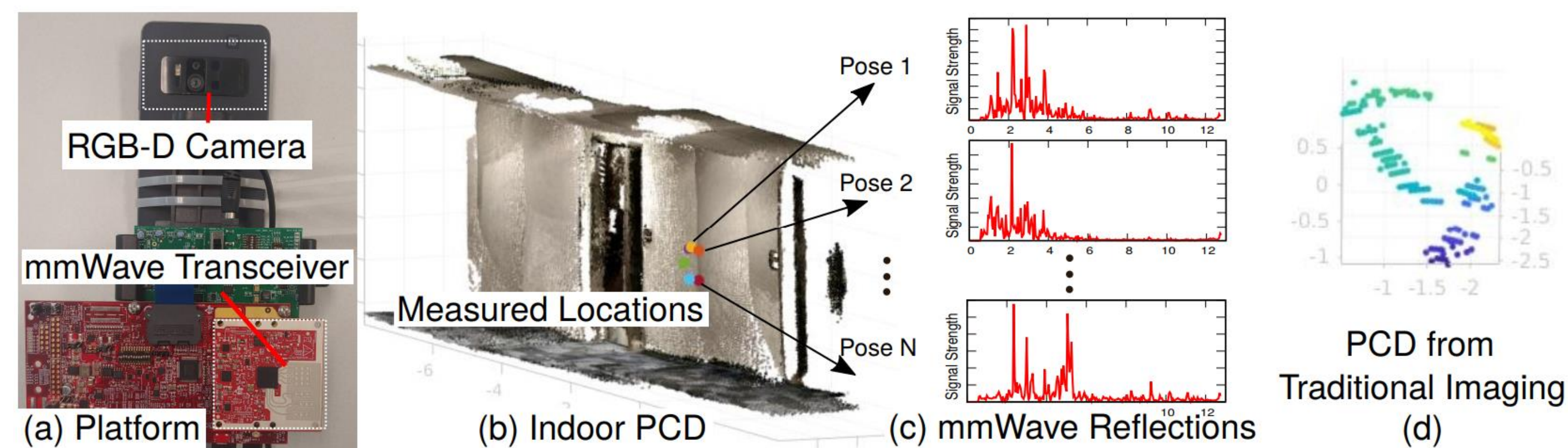




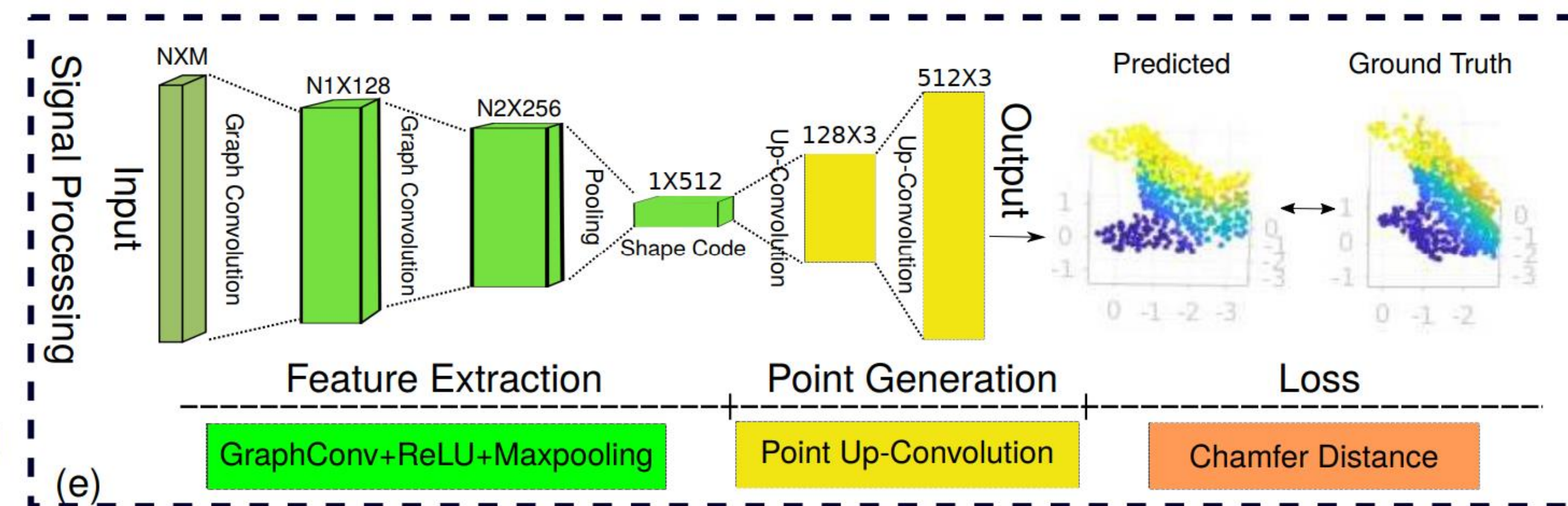
Objective and Motivation

- **Objective**
 - Generating millimeter-wave (mmWave) Point Cloud Data (PCD) with **denser points and better shapes** for different environments.
- **Motivation**
 - RGB-D cameras require good ambient lighting and unobstructed views, but **mmWave works under poor or zero visibility**.
 - **Traditional** mmWave imaging can only produce **sparse/ambiguous PCD**.
 - Deep learning could improve the quality by modeling the relationship between mmWave reflections and true 3D structure from data samples.



Intuition and Challenges

- **Intuition behind MilliCloud**
 - Since a mmWave transceiver can estimate correct depths, we can identify a **coarse structure** by combining measurements from **multiple viewpoints**.
 - A deep learning model can then identify the unordered position of different viewpoints, extract geometric features, and learn to generate better PCD.
- **Challenges with MilliCloud**
 - Collecting and generating the training dataset.
 - **Extracting relevant geometric features** from mmWave signals of multiple viewpoints and generating high-quality PCD.



MilliCloud System Design

- **Data Collection**
 - No existing device can produce mmWave and visual PCD simultaneously.
 - We design a system with a **co-located RGB-D camera and mmWave transceiver** to measure the visual PCD and mmWave reflections.
- **PCD Generation**
 - Use a **Graph Neural Network** with poses and reflected signals as input to generate a **shape-code** representing an abstract environmental structure.
 - Use two up-convolution networks to **convert the shape-code to 3D PCD**.

Result and Future Works

- **Result and Conclusion**
 - It is possible to generate high-quality PCD with *MilliCloud*.
 - *MilliCloud* achieves a **mean Chamfer Distance of 0.309 sq. m.** and outperforms the traditional method (0.608) in several unseen environments.
- **Future Works**
 - Explore different network structures & settings to improve quality further.
 - Train and evaluate *MilliCloud* under various environmental conditions.
 - Combine mmWave PCD with RGB-D PCD to facilitate ubiquitous sensing.