

Non-Line-of-Sight 3D Object Reconstruction

via mmWave Surface Normal Estimation



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Motivation

Can we enable high-accuracy non-line-of-sight object reconstruction with mmWave signals?

Box



Hidden Object



Existing mmWave Reconstruction



mmNorm



Applications

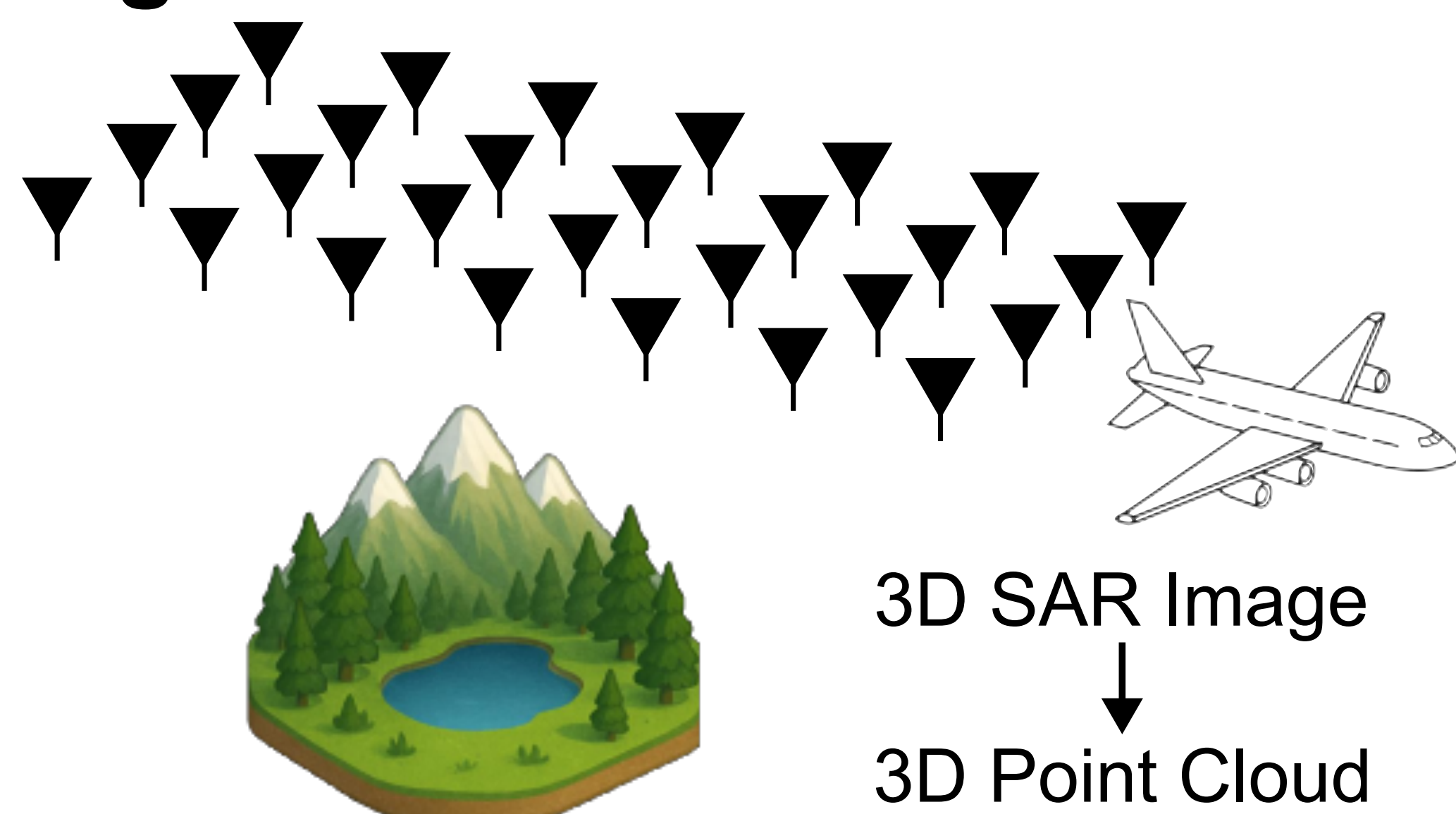


Robotic Manipulation,
Shipping & Logistics,
Augmented Reality

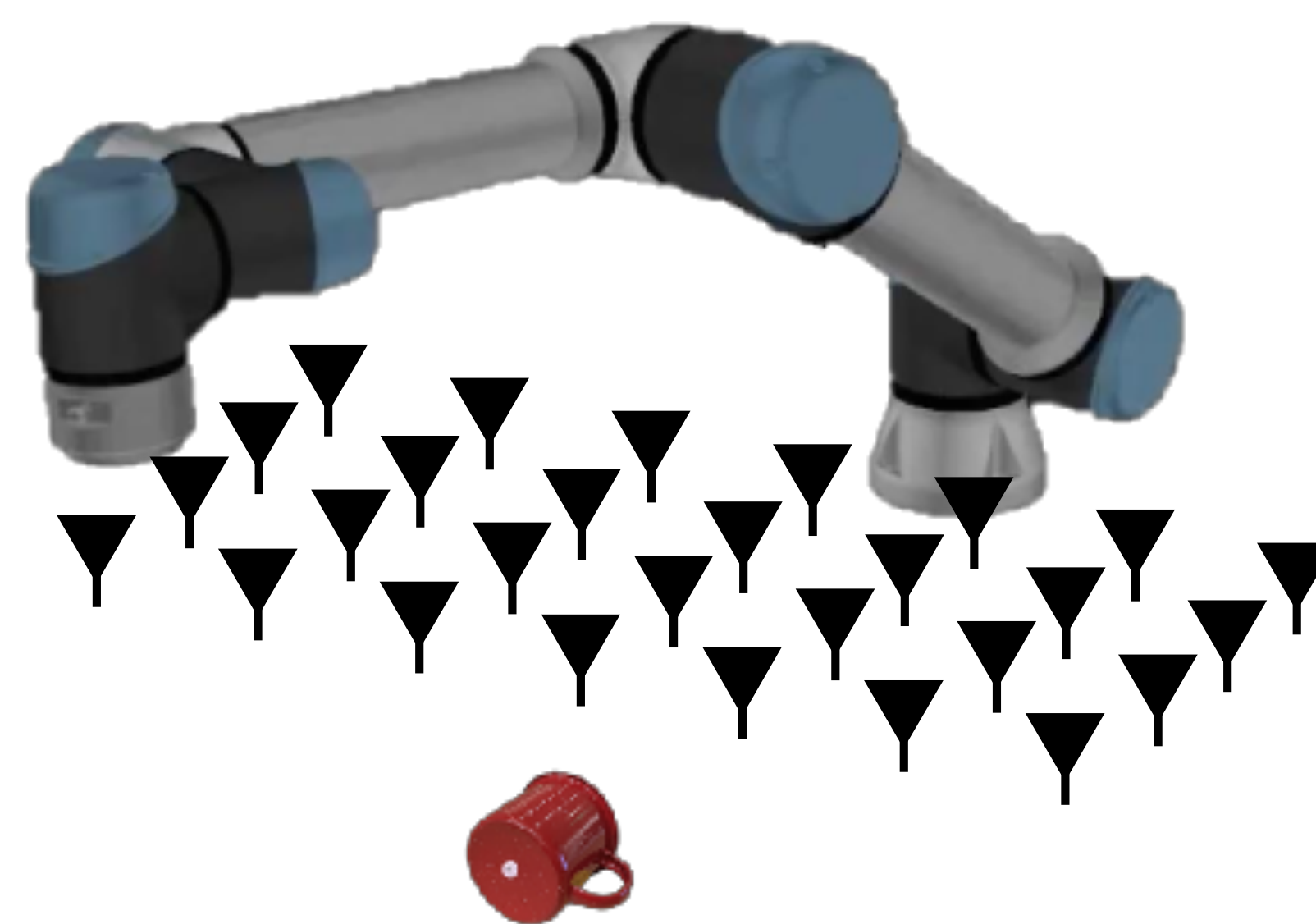
Prior Approaches

3D reconstruction methods have not drastically changed for several decades

Large Scale Reconstruction



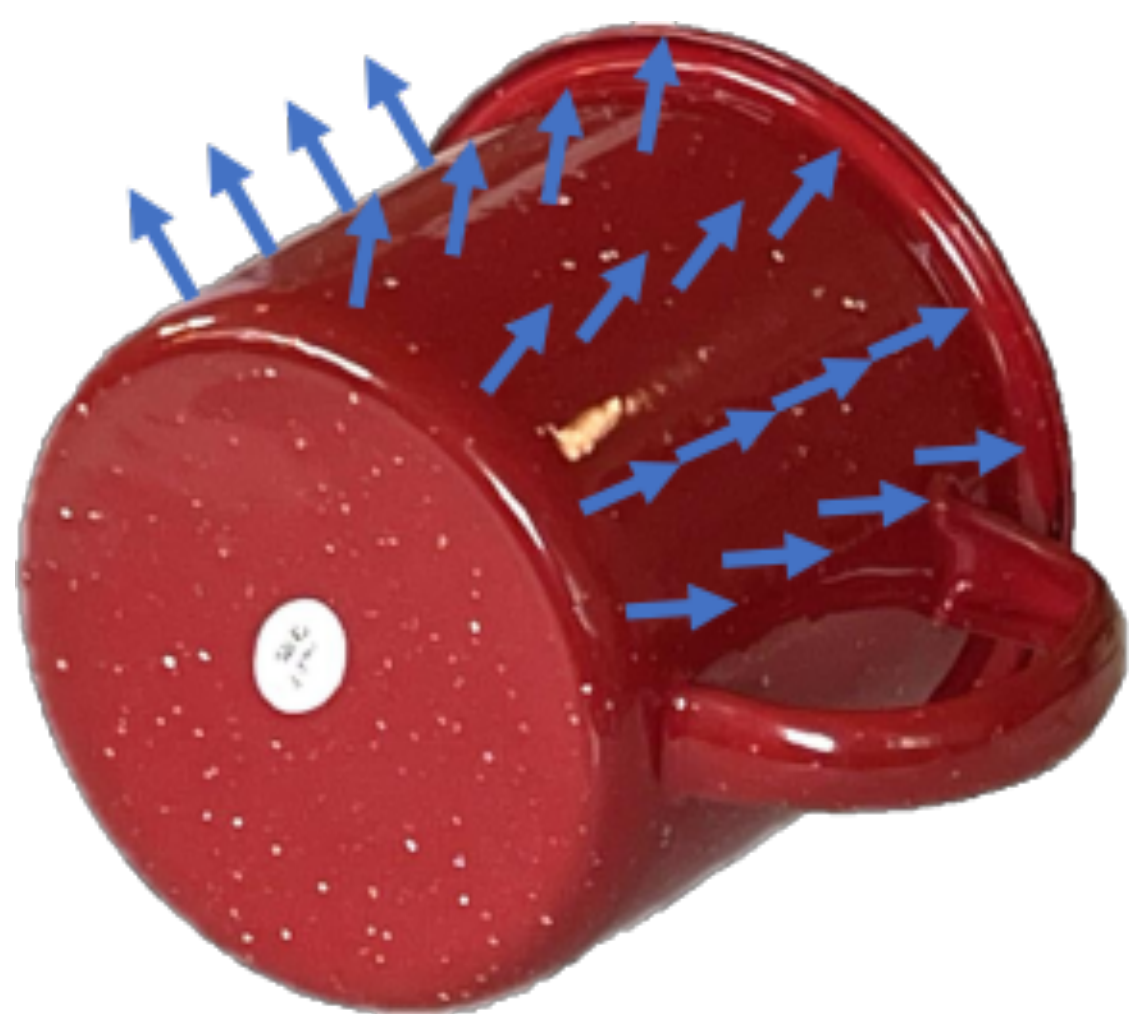
Small Scale Reconstruction



Reconstruction limited by
SAR Resolution (i.e., bandwidth)

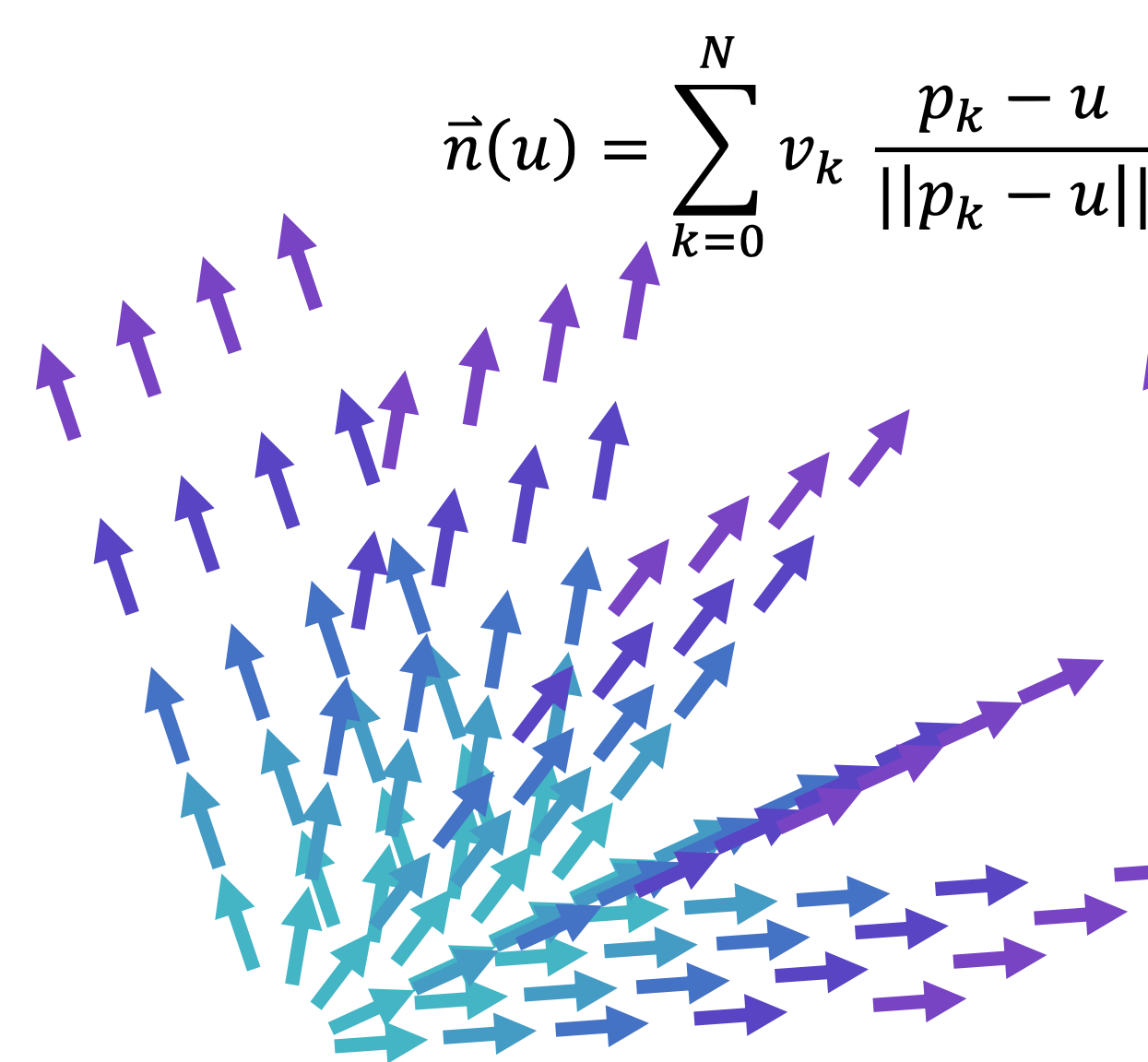
Our Idea

Reconstruct surface by
estimating normal vectors

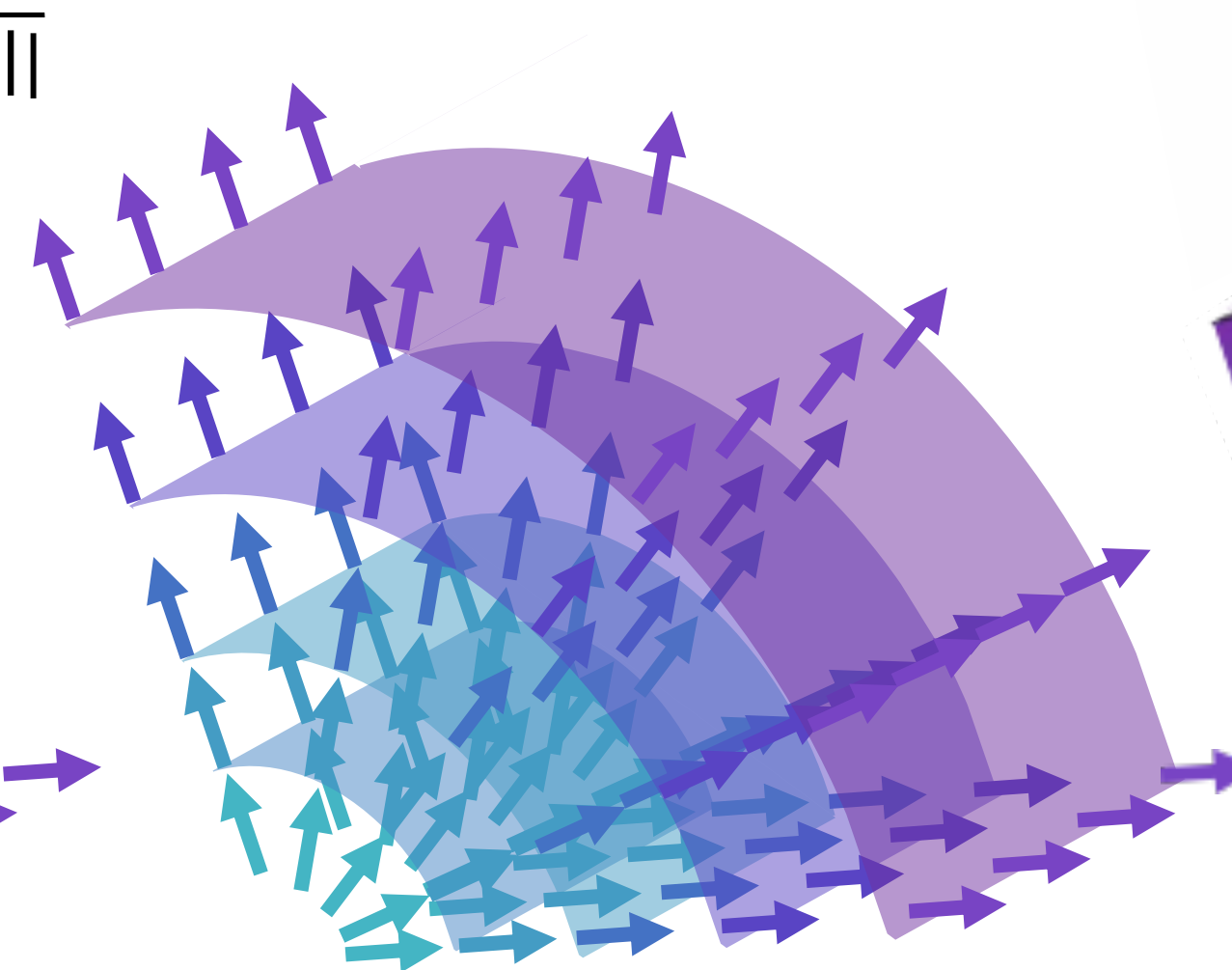


Our Approach

1. Normal Vector
Field Estimation



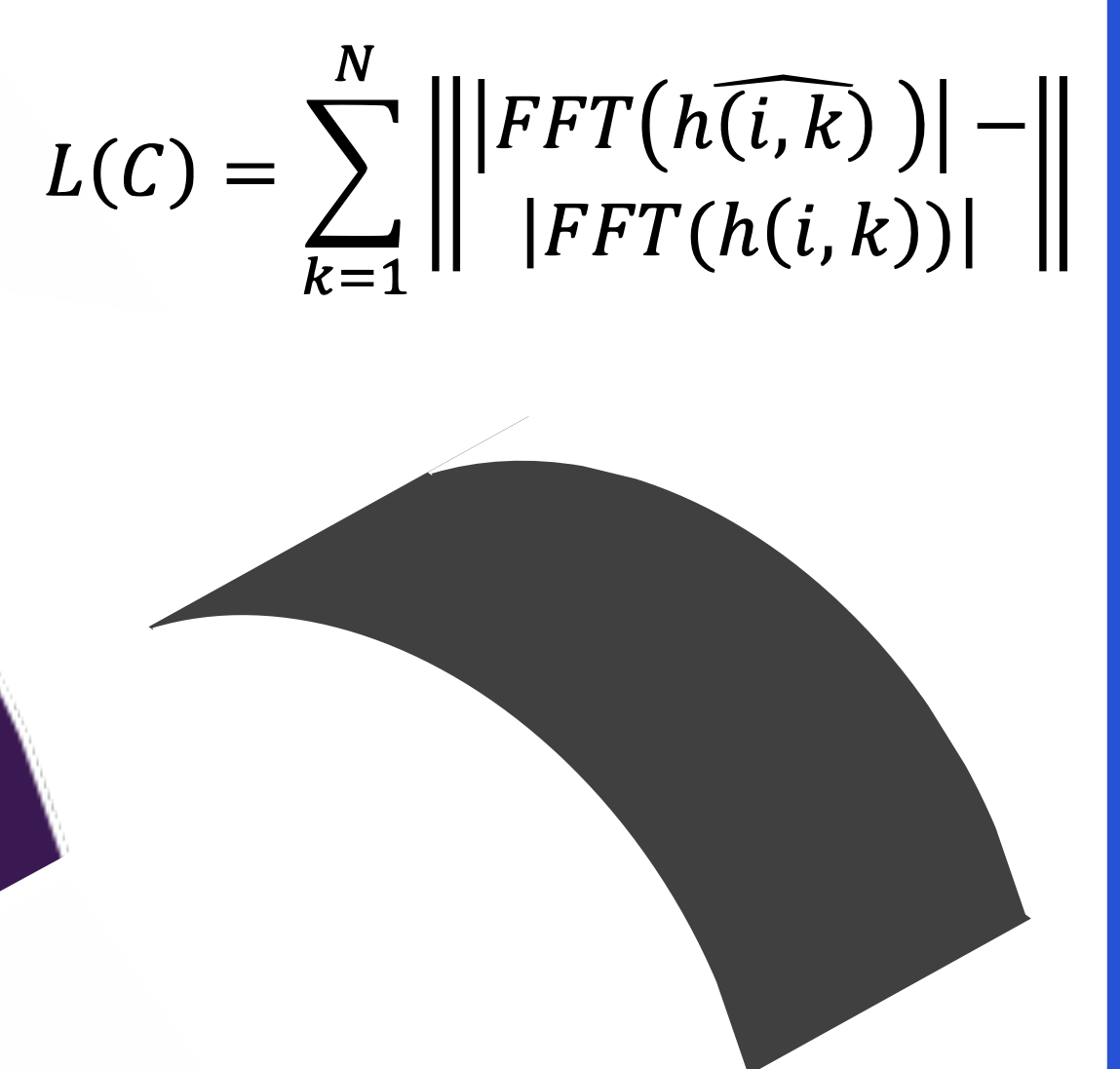
2. Multiple
Valid Surfaces



3. Single Unifying
Function



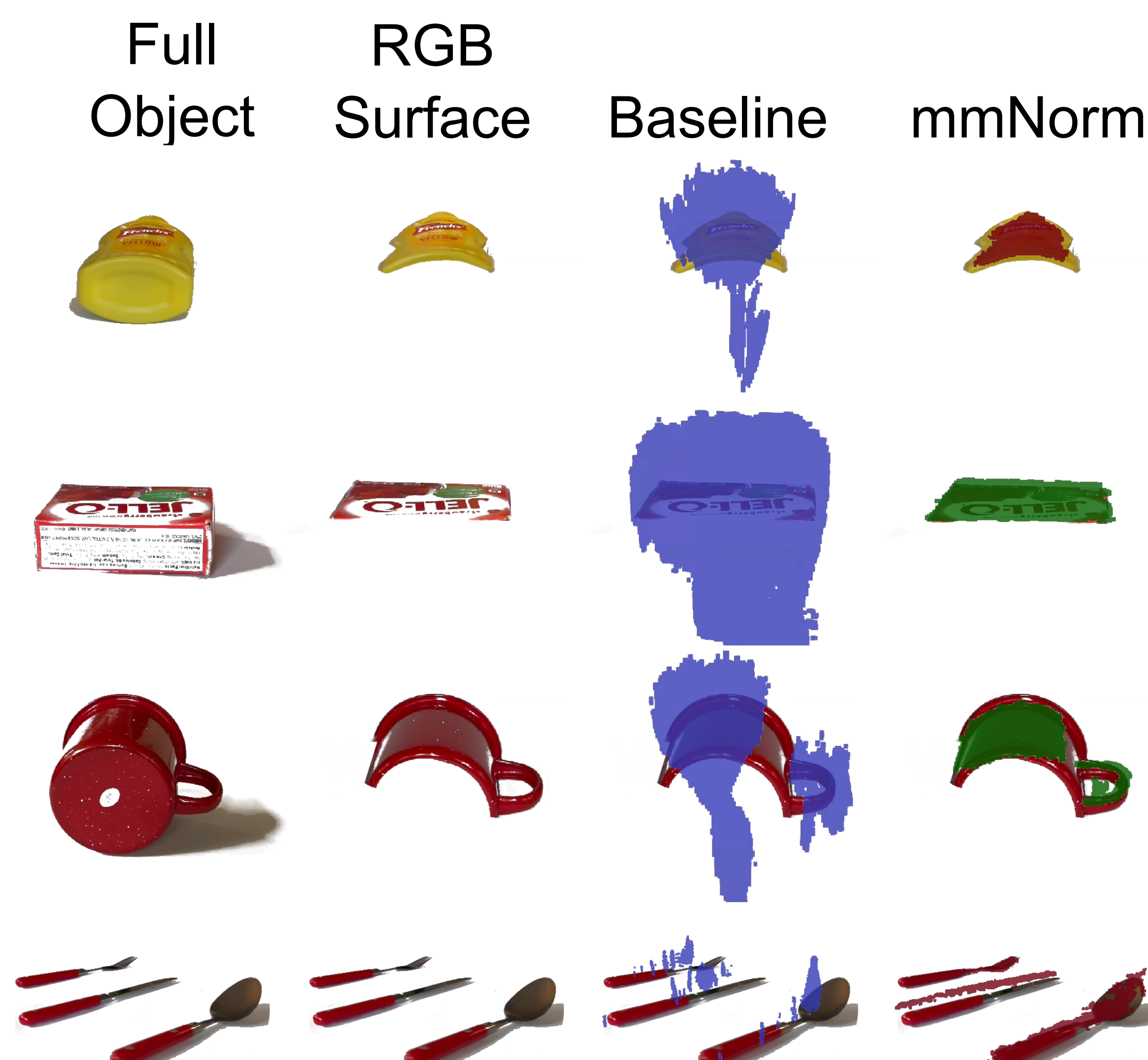
4. Isosurface
Optimization



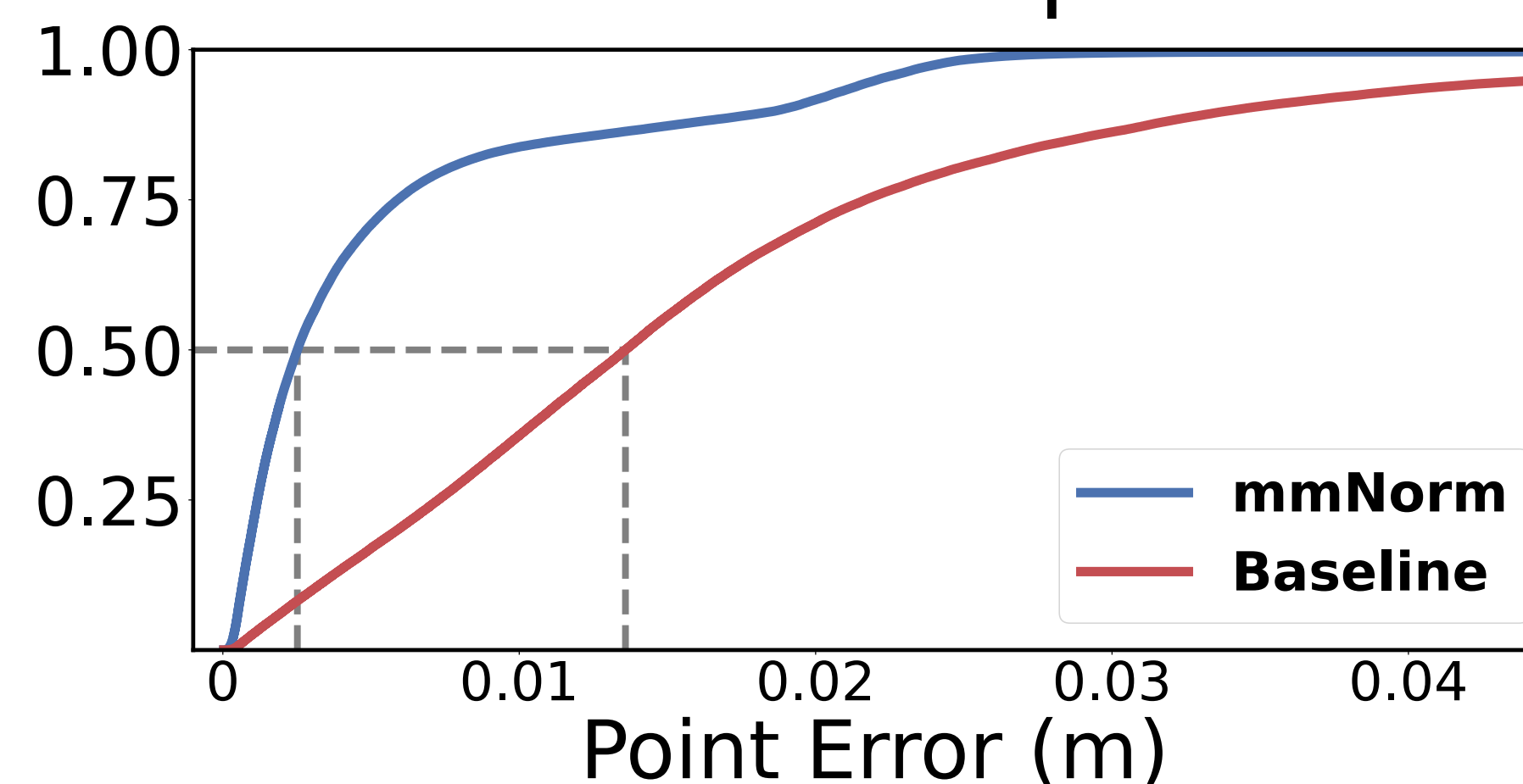
$$L(C) = \sum_{k=1}^N \left\| \frac{|FFT(h(i,k))|}{|FFT(h(i,k))|} - 1 \right\|$$

Results

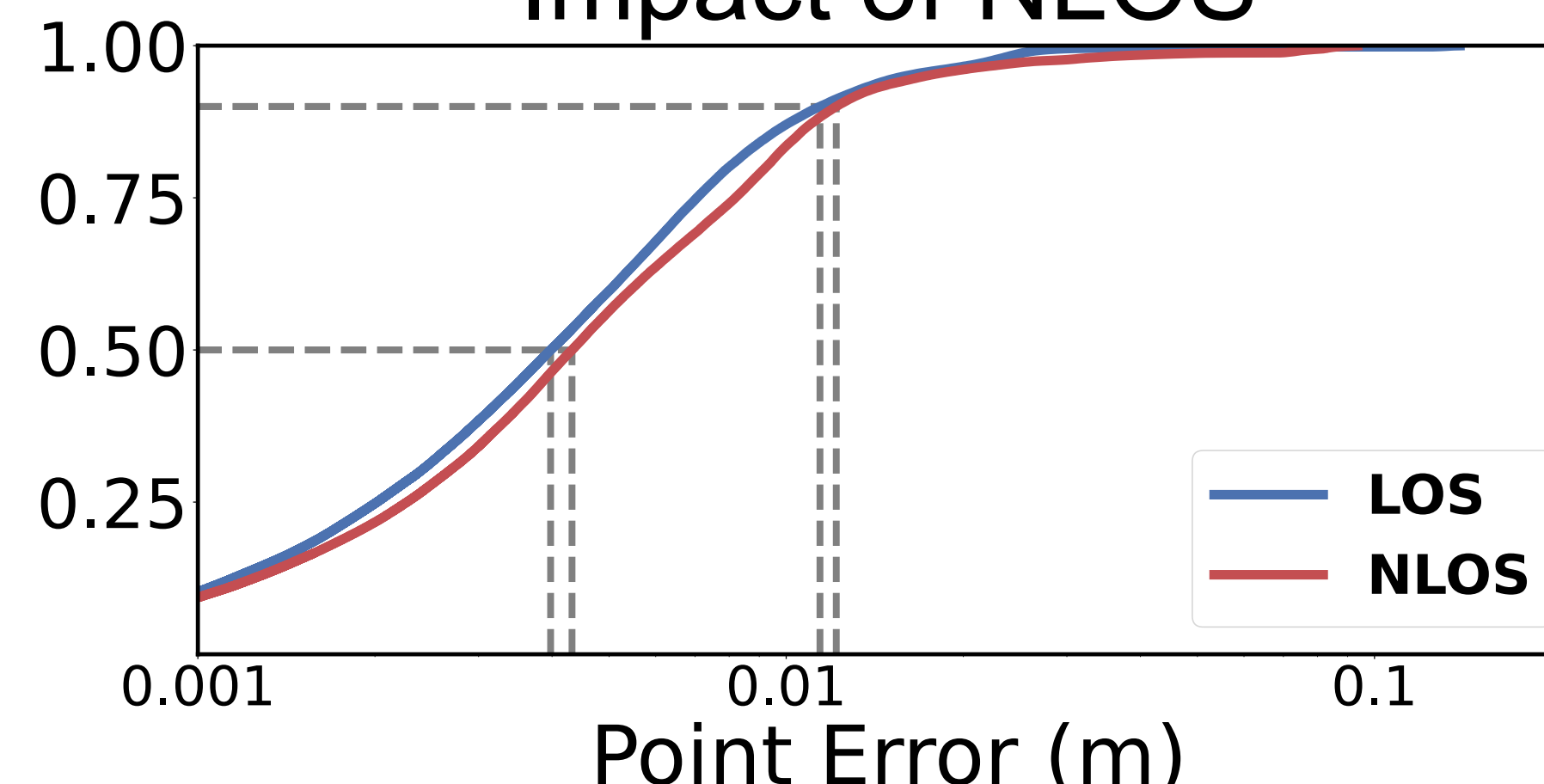
We evaluated mmNorm across 61 diverse everyday objects



Baseline Comparison

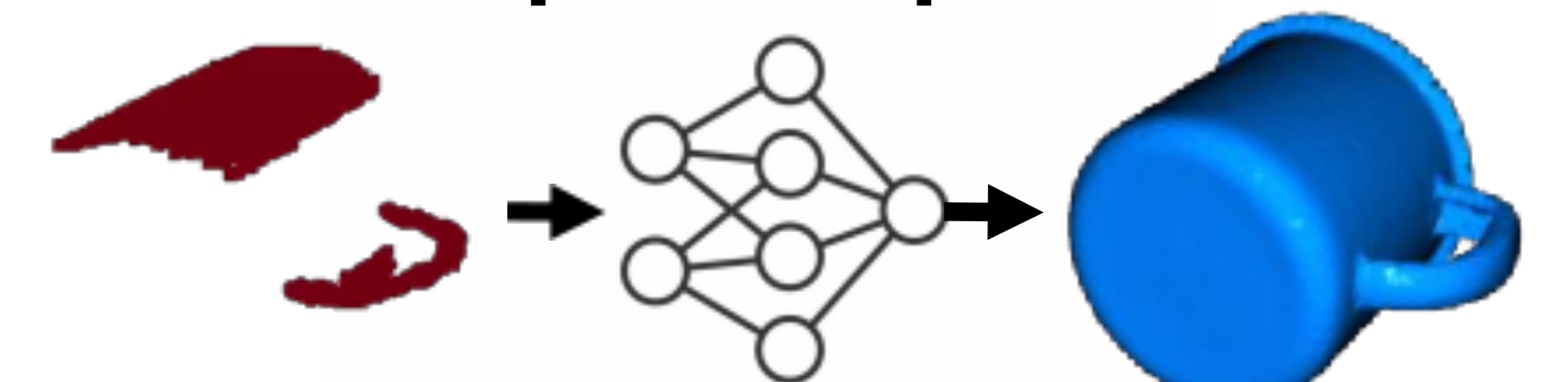


Impact of NLOS



Future Work

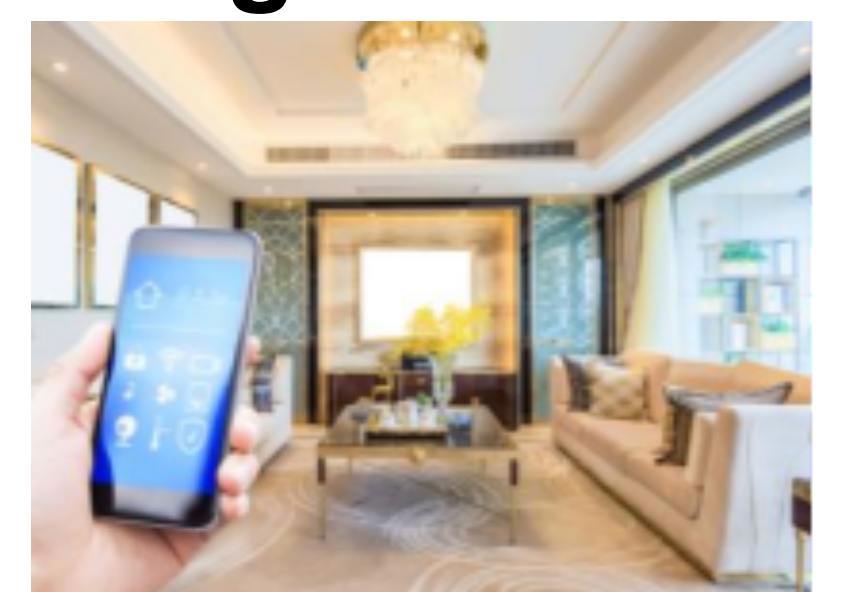
Shape Completion



Novel Tasks



Large Scenes



mmNorm Code

