Shape As Points: A Differentiable Poisson Solver

Songyou Peng   Chiyu "Max" Jiang   Yiyi Liao   Michael Niemeyer   Marc Pollefeys   Andreas Geiger

ETH *zürich*
MAX PLANCK INSTITUTE FOR INTELLIGENT SYSTEMS

EBERHARD KARLS UNIVERSITÄT TÜBINGEN

Motivation

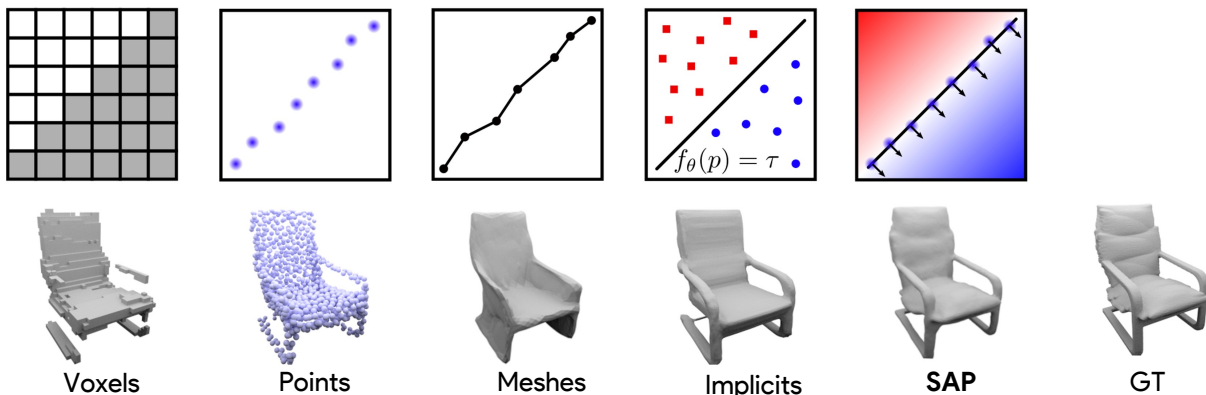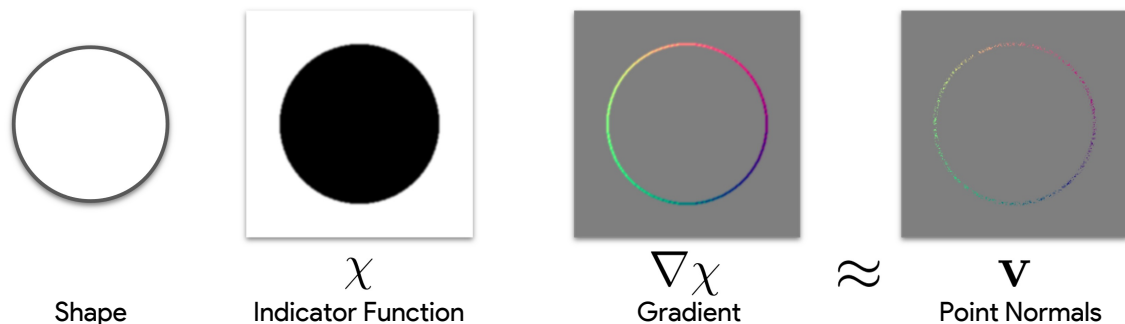Voxels   Points   Meshes   Implicits   **SAP**   GT

SAP **efficiently** and **differentiably** bridge oriented point clouds and meshes.

Differentiable Poisson Solver

$$\nabla^2 \chi := \nabla \cdot \nabla \chi = \nabla \cdot \mathbf{v}$$

Shape   Indicator Function χ Gradient $\nabla\chi$ $\approx$ Point Normals $\mathbf{v}$

We solve the Poisson equation with **GPU-accelerated spectral methods**.
(12 ms for computing a 128^2 indicator grid, 140 ms for 256^2)

Paper, code, and video are available:
https://pengsongyou.github.io/sap

Application: 3D Reconstruction from Point Clouds

Shape-As-Points

Optimize Points and Normals → DPSR → Marching Cubes → $\mathcal{L}_{\mathrm{CD}}$ → Target

Optimization-based Setting

Target PCL   IGR   Point2Mesh   SPSR   **SAP**   GT Mesh

Noisy Input → Features ϕ_θ / Offsets $\mathbf{f}_\theta$ / Normals $\mathbf{g}_\theta$ (Optimize Parameters) → DPSR → $\mathcal{L}_{\mathrm{DPSR}}$ → Marching Cubes → Mesh Output

Indicator Function ← PSR ← Sample ← Ground Truth

Learning-based Setting

PCL w/ **Large Noise**   ConvONet   **SAP**   PCL w/ **50% Outliers**   ConvONet   **SAP**