Differentiable Methods for Visual Computing

Dr Fangcheng Zhong
Inverse Problems in Machine Perception

Observation
(e.g. images, Lidar, etc.)

Causal factors
(camera and scene parameters,
e.g. geometry, lighting,
materials, motion, etc.)
Geometry Representations

Surface Representations
- Mesh
- Parametric surface
- Point clouds
- Signed distance function

Volume Representations
- Voxel grids
- Density fields
Material Representations

Textures

BRDFs
Light Representations

Lightmap Images

Spherical harmonics
Data-Driven Inference

Generative Methods

Traditional CV Methods

• Constrained optimization
  – SLAM, Structure from Motion
  – Light probes, structured light
Differentiable Rendering

Generalization of traditional CV methods

Materials
Lights
Cameras
Geometry

Scene Parameters

Render

Meta Image
RGB Image
Depth Image
Silhouette Image

Rendering Output

Objective Function

Ground Truth

Derive useful gradients in rendering
Differentiable Volume Rendering

Differentiable Volume Rendering

Differentiable Volume Rendering

Differentiable Volume Rendering

Differentiable Volume Rendering

Differentiable Volume Rendering

Differentiable Surface Rendering

Differentiable Surface Rendering

Which one is real?
Differentiable Surface Rendering

Reparameterizing Discontinuous Integrands for Differentiable Rendering

Guillaume Loubet (EPFL)  Nicolas Holzschuch (INRIA)  Wenzel Jakob (EPFL)

SIGGRAPH Asia 2019

Differentiable Surface Rendering

MipNeRF360 ($\sigma = 50$)  Plenoxels ($\sigma = 50$)  Ours

RGB  NeuS  HFS
Hybrid Representations for Differentiable Rendering

Sitzmann, Vincent, Semon Rezhikov, Bill Freeman, Josh Tenenbaum, and Fredo Durand. "Light field networks: Neural scene representations with single-evaluation rendering." NeurIPS 2021
Differentiable Rendering with Data-Driven Prior

Extended Differentiable Visual Computing

Everything differentiable can be integrated!

geometry  motion  rendering
Extended Differentiable Visual Computing

Differentiable displays and cameras
Differentiable Visual Computing for Generative AI

Differentiable Visual Computing for Generative AI

Differentiable Visual Computing for Generative AI

Differentiable Visual Computing for Generative AI

Constrained Neural Fields for Differentiable Visual Computing

Summary

- Differentiable visual computing for inverse problems
- Differentiable visual computing for machine learning
- Basics concepts, applications, research topics