A Theory of Fermat Paths for Non-Line-of-Sight Shape Reconstruction

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Fermat paths: specular or boundary

Fermat’s principle: paths of stationary lengths

Why Fermat?
- Fermat pathlength: spherical constraint
  \[ x_F \in \text{sphere} (\nu, \tau_F) \]
- Fermat flow: ray constraint
  \[ n_{x_F} = -\nabla \cdot F_F (\nu) \]

Reconstructing a point and its normal

NLOS Reconstruction Pipeline

transient imaging using single-photon avalanche diode

non-line-of-sight (NLOS) Imaging

80cm x 80cm, 64 x 64 spots

80cm

transient imaging using optical coherence tomography

NLOS reconstructions

NLOS object

source & sensor

occluder

scan point

camera

relay wall

US quarter

80cm x 80cm

4cm x 4cm

4cm

1000 x 1000 spots

64 x 64 spots

1cm

NLOS reconstruction

LOS reconstruction

depth (10µm)

horizontal location

height profiles comparison

transient imaging using optical coherence tomography

dense scan wall

locally fit polynomials

reconstruct shape

imaging.cs.cmu.edu