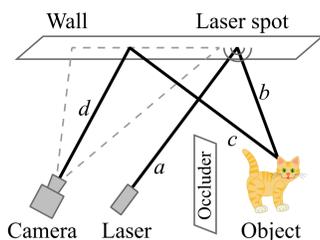


1. Introduction

Traditional cameras can only sense objects in the direct line of sight. Non-Line-of-Sight imaging overcomes this limitation:

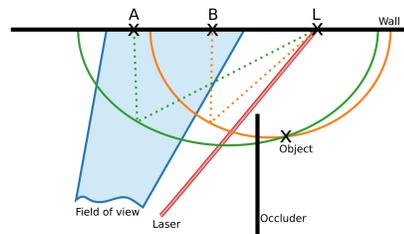


Using indirect reflections to see hidden objects:

- Diffuse reflector: Angular information is destroyed
- Reconstruction is a challenging problem

Transient imaging as established tool

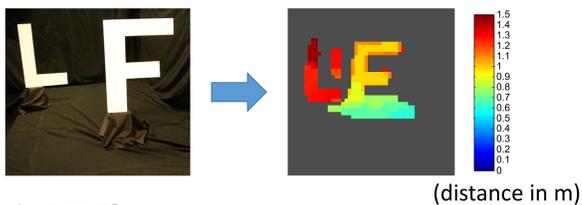
- Time-of-flight defines ellipsoids
- Object is at intersection point



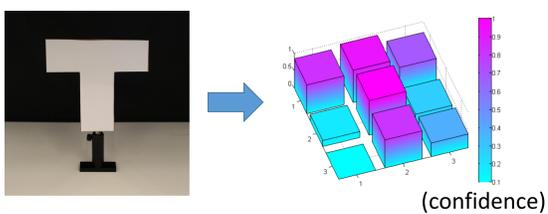
2. State-of-the-Art

Direct comparison impossible due to vastly different evaluation methods. Example:

- [Heide 2014]:
1.5 m distance / 1.5 x 1.5 x 2 m volume



- [Kadambi 2015]:
1 m away / 0.2 x 0.2 m object size



⇒ It is hard to say, which method performs better. A fair comparison requires a standardized evaluation method.

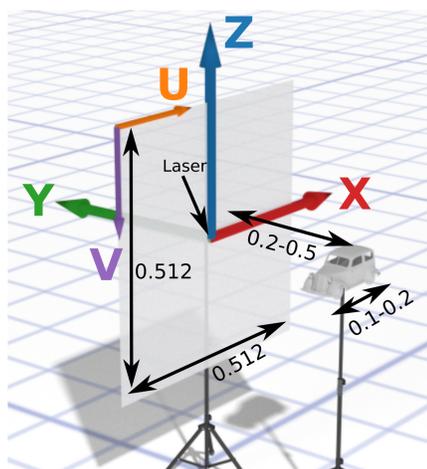
3. Unified Datasets

Standardized setup:

- Designed to generalize most existing setups
- Contains only the essential components
- Well-defined geometry

Data generation:

- Synthetic images do not exhibit hardware artifacts
- Distances are stored in unwarped mode (travel times from laser to reflector and reflector to camera are removed)



4. Challenges

Our benchmark contains a variety of challenges to test different capabilities of reconstruction algorithms. The challenges also contain tasks that are harder than what has previously been solved to encourage the development of new algorithms.

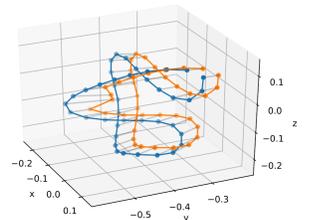
Geometry reconstruction

- 16 objects
- 5 difficulty categories



Object tracking

- Position and orientation tracking
- 3 objects
- 10 trajectories, 30-40 frame



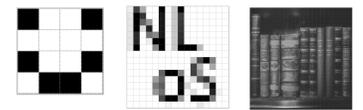
Object classification

- 11 objects
- Rendered at 88 random positions / orientations



Image reconstruction

- 12 images
- 4x4 to 128x128 pixels
- Varying dynamic range



Each challenge comes with its own set of error metrics tailored to the individual needs.

5. Evaluation

- Online submission system with leaderboard
- Transparent evaluation (scripts are available) but ground truth solutions remain secret
- Few, but meaningful metrics for each challenge
- Two step submission:
Contestants can see their results before publishing them (anonymous testing possible)

Rank	Score	Time	Size	Comments
1	0.88	0.01	0.01	Berend Carlsberg
2	0.46	0.06	1.00	Aditya Kulkarni
3	0.37	0.04	0.00	Chakraborty Heung II
4	0.30	0.03	0.00	Maximilian
5	0.12	0.01	0.00	Maximilian
6	0.01	0.00	0.00	Maximilian
7	0.00	0.00	0.00	Maximilian
8	0.00	0.00	0.00	Maximilian
9	0.00	0.00	0.00	Maximilian
10	0.00	0.00	0.00	Maximilian

<https://nlos.cs.uni-bonn.de>



6. Outlook

- We hope that the systematic evaluation of techniques on our benchmark datasets will direct the field towards better future algorithms.
- We plan to expand and adapt the benchmark to the future progress in the field.