Datasets and Benchmarks for Densely Sampled 4D Light Fields

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Abstract
We present a new benchmark database to compare and evaluate existing and upcoming algorithms which are
tailored to light field processing. The data is characterised by a dense sampling of the light fields, which best fits
current plenoptic cameras and is a characteristic property not found in current multi-view stereo benchmarks. It
allows to treat the disparity space as a continuous space, and enables algorithms based on epipolar plane image
analysis without having to refocus first. All datasets provide ground truth depth for at least the center view, while
some have additional segmentation data available. Part of the light fields are computer graphics generated, the
rest are acquired with a gantry, with ground truth depth established by a previous scanning of the imaged objects
using a structured light scanner. In addition, we provide source code for an extensive evaluation of a number of
previously published stereo, epipolar plane image analysis and segmentation algorithms on the database.

1. Introduction
The concept of a light field was originally used mainly
in computer graphics as a powerful tool to describe scene
appearance [AB91, LH96], but recently it is also getting
more and more attention from the computer vision commu-
nity. One of the likely reasons is the availability of cheap
recording devices. While the first light field capturing tech-
niques used large camera arrays [WJV+05] which are ex-
pensive and not very practicable, hand-held light field cam-
eras [Ng06, PW10] are now available on the consumer mar-
ket.

However, the driving force for successful algorithm de-
velopment is the availability of suitable benchmark datasets
with ground truth data in order to compare results and initi-
ate competition. The current public light field databases we
are aware of are the following.

- Stanford Light Field Archive
  http://lightfield.stanford.edu/lfs.html
  The Stanford Archives provide more than 20 light fields
  sampled using a camera array [WJV+05], a gantry and a
  light field microscope [LNA+06], but none of the datasets
  includes ground truth disparities.

- UCSD/MERL Light Field Repository
  http://vision.ucsd.edu/datasets/lfarchive/
lfs.shtml
  This light field repository offers video as well as static
light fields, but there is also no ground truth depth avail-
able, and the light fields are sampled in a one-dimensional
domain of view points only.

- Synthetic Light Field Archive
  http://web.media.mit.edu/~gordonw/
  SyntheticLightFields/index.php
  The synthetic light field archive provides many interesting
  artificial light fields including some nice challenges like
  transparencies, occlusions and reflections. Unfortunately,
  there is also no ground truth depth data available for
  benchmarking.

- Middlebury Stereo Datasets
  http://vision.middlebury.edu/stereo/data/
  The Middlebury Stereo Dataset includes a single 4D light
  field which provides ground truth data for the center view,
  as well as some additional 3D light fields including depth
  information for two out of seven views. The main issue
  with the Middlebury light fields are that they are designed
  with stereo matching in mind, and thus the baselines are
  quite large and thus not representative for plenoptic cam-
eras and unsuitable for direct epipolar plane image analy-
sis.

While there is a lot of variety and the data is of high quality,
we observe that all of the available light field databases ei-
ther lack ground truth disparity information or exhibit large
camera baselines and disparities, which is not representative
for plenoptic camera data. Furthermore, we believe that a
large part of what distinguishes light fields from standard multi-view images is the ability to treat the view point space as a continuous domain. There is also emerging interest in light field segmentation [KSS12, SHH07, EM03, WSG13], so it would be highly useful to have ground truth segmentation data available to compare light field labeling schemes. The above datasets lack this information as well.

**Contributions.** To alleviate the above shortcomings, we present a new benchmark database which consists at the moment of 13 high quality densely sampled light fields. The database offers seven computer graphics generated datasets providing complete ground truth disparity for all views. Four of these datasets also come with ground truth segmentation information and pre-computed local labeling cost functions to compare global light field labeling schemes. Furthermore, there are six real world datasets captured using a single Nikon D800 camera mounted on a gantry. Using this device, we sampled objects which were pre-scanned with a structured light scanner to provide ground truth ranges for the center view, see figure 1. An interesting special dataset contains a transparent surface with ground truth disparity for both the surface as well as the object behind it - we believe it is the first real-world dataset of this kind with ground truth depth available.

We also contribute a CUDA C library with complete source code for several recently published algorithms to demonstrate a fully scripted evaluation on the benchmark database and find an initial ranking of a small subset of the available methods on disparity estimation. We hope that this will ease the entry into the interesting research area which is light field analysis, and are fully committed to increasing the scope of the library in the future.

The light field archive as well as the full version of this paper, which describes the archive structure and benchmarks in detail, can be downloaded on http://lightfield-analysis.net.

The CUDA library cocolib for continuous convex optimization and light field analysis is available on http://cocolib.net.

**References**

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