UAV-based Light Field Sampling

Large Scale Collection and Light Field Video

- With the DARPA Swarm Challenge, visualization is difficult
- Light fields can allow for immersive, user-defined views of the field
- The goal of this project is to demonstrate proof of concept with quadcopters

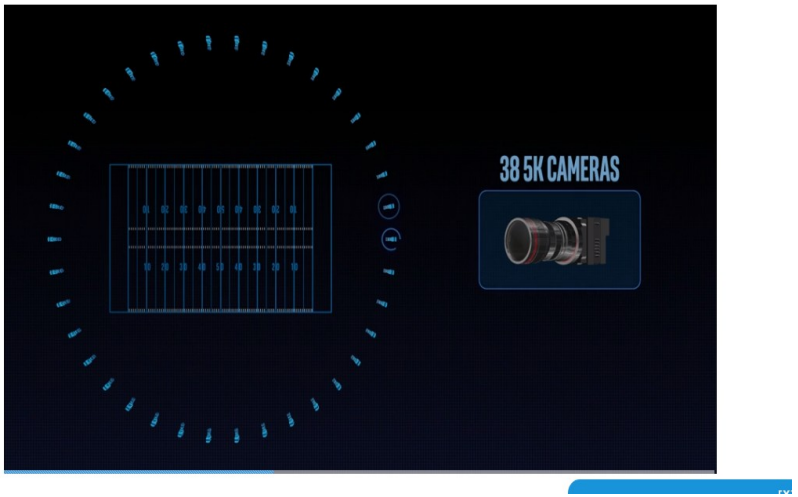
DARPA Swarm UAV challenge

What is a Light Field?

- **A collection of images taken from varying angles with a subject at the center**

- Light fields are not uncommon
- Are used to create holograms
- Now used in sports for immersive replays
- Not to be confused with panoramas

How Do They Do It?



Collect a Lot of Data

- 38 cameras pointed at the field
- High resolution, small field of view
- Recording at all times

Process that data quickly

- Find correct location and time on field or court
- Arrange images for replay

Basis of the Light Field

Purpose

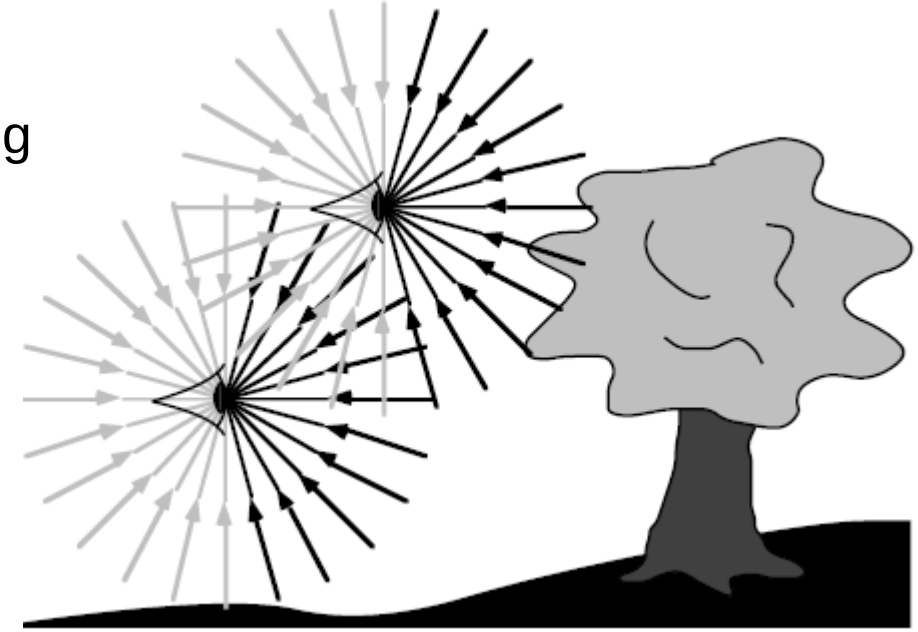
- An immersive rendering method for rendering
- Can reconstruct depth from scenes
- Interactive image processing post capture
- Of great interest in VR circles, gaining in robotics

Plenoptic Function

- Describes all of the light from every possible view

Light Field Parameterizations

- A 4D function that describes the direction of a ray

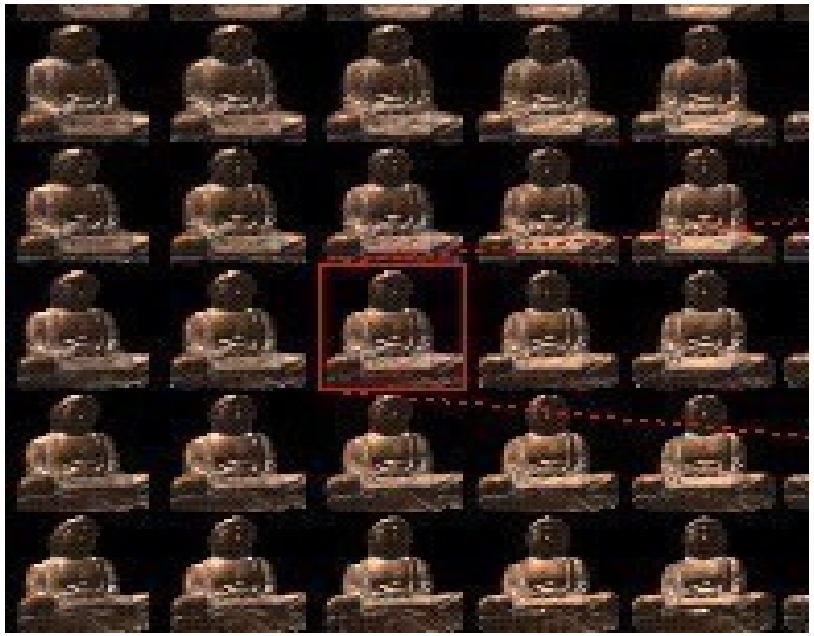


Visualization of the plenoptic function from Anderson et al

Example Light Slabs

Slab captured by Levoy et al

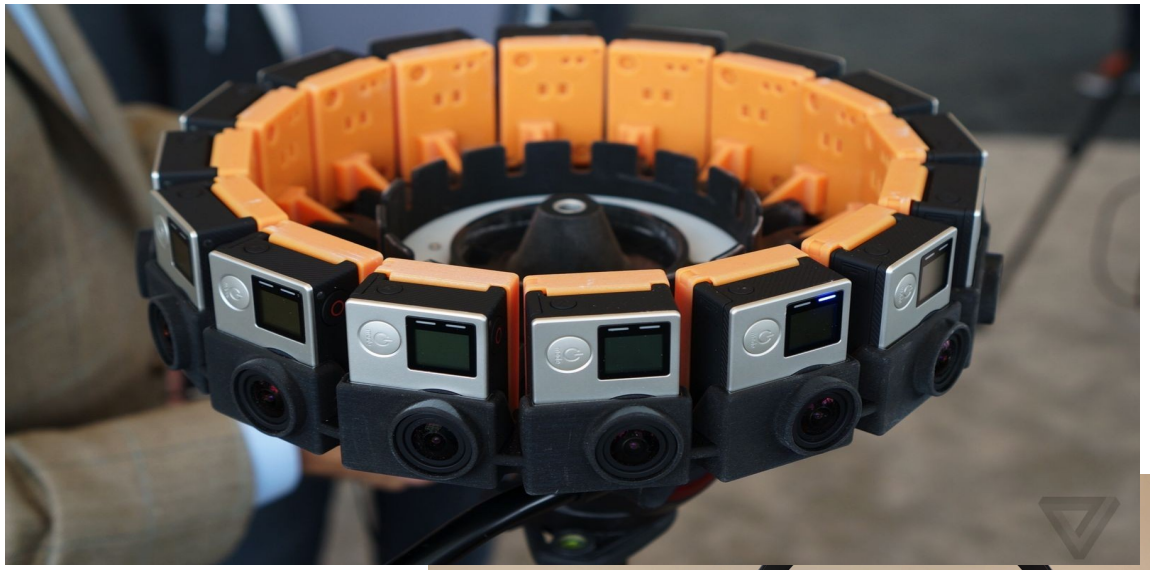
Slab captured by Baxter robot



Captured Light Field

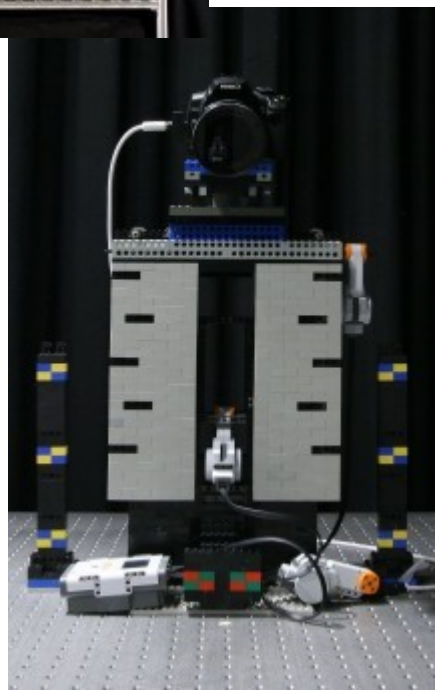
- The 4D representation of the plenoptic function
- Very dense data spatially and angularly
- Generally referred to as a slice or slab of the plenoptic function
- Examples shown with 2PP

Typical Collection Methods



Google Jump

Stanford array



Stanford Gantry

Lytro Immerge

Handheld Camera

Raytrix r5 and raw image

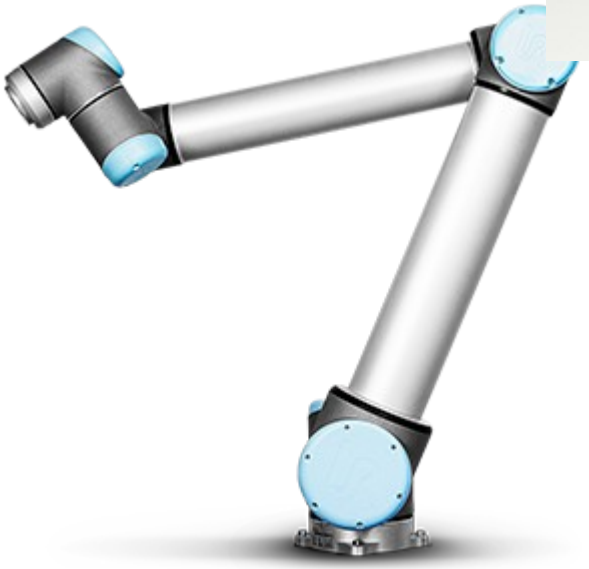
- Large image sensors preceded by microlens array
- Not hugely popular due currently limited applications
- Can be used for 3D capture

Robot Platforms Used

- New method for capturing light field
- Can capture for difficult locations
- Potential to adapt to subject and/or environment

PR2

UR10



Baxter

AR Drone

First Drone Light Field

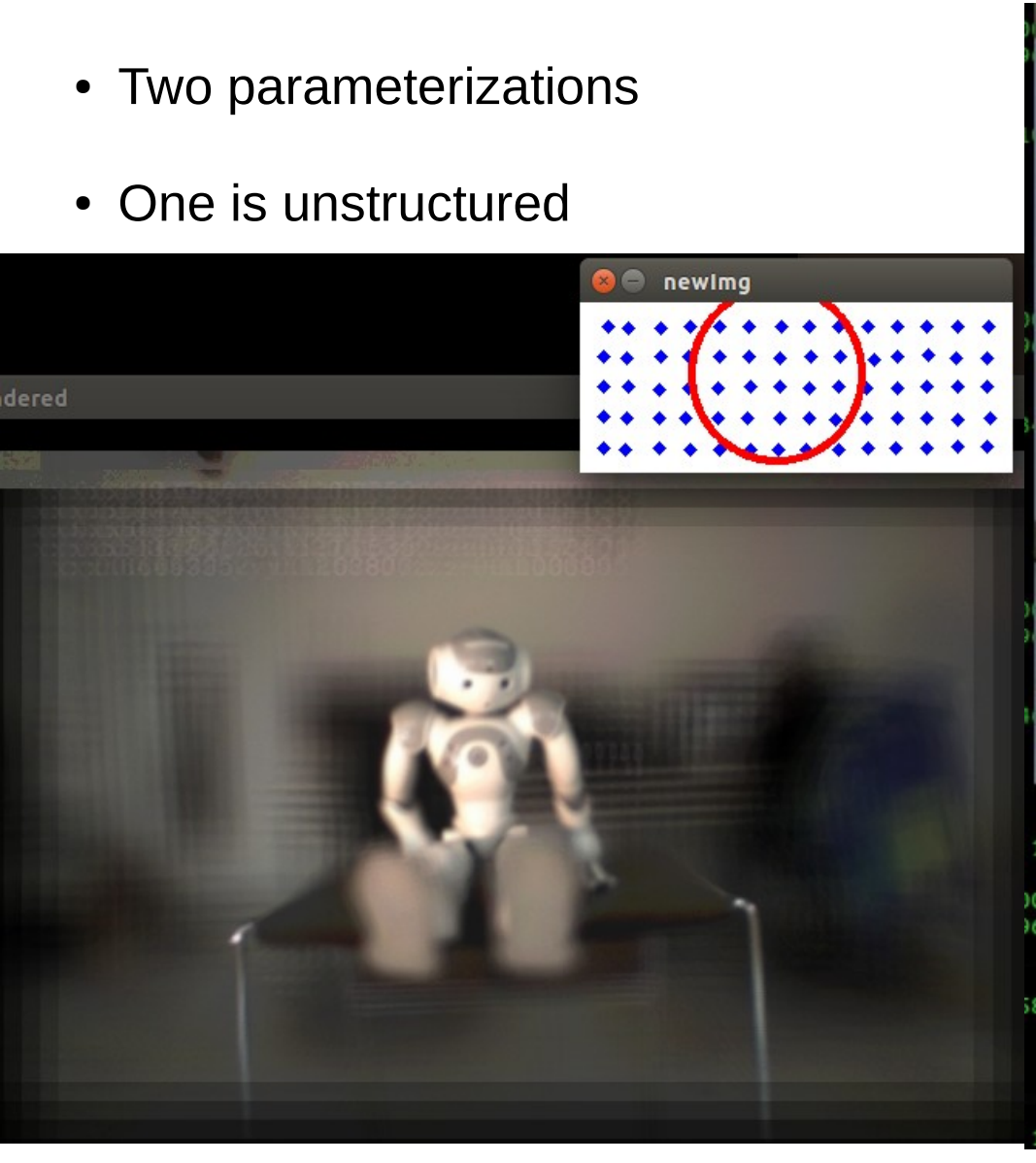
- Controlled ARDrone Parrot integrated with Vicon motion capture system
- PID control loop for position hold and control
- Integrated via ROS

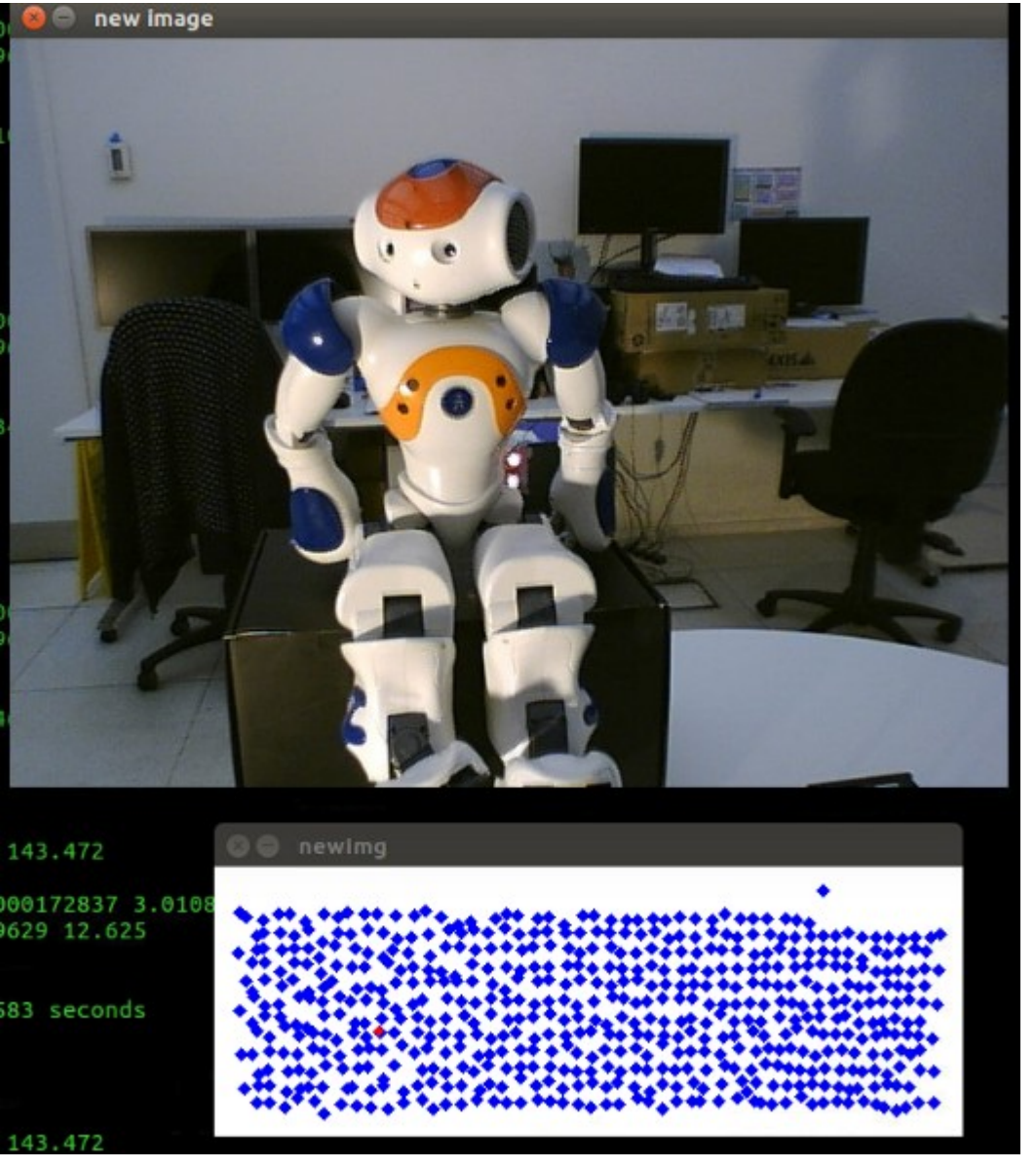
Vicon camera example

Andy Serkis image from Wired.com

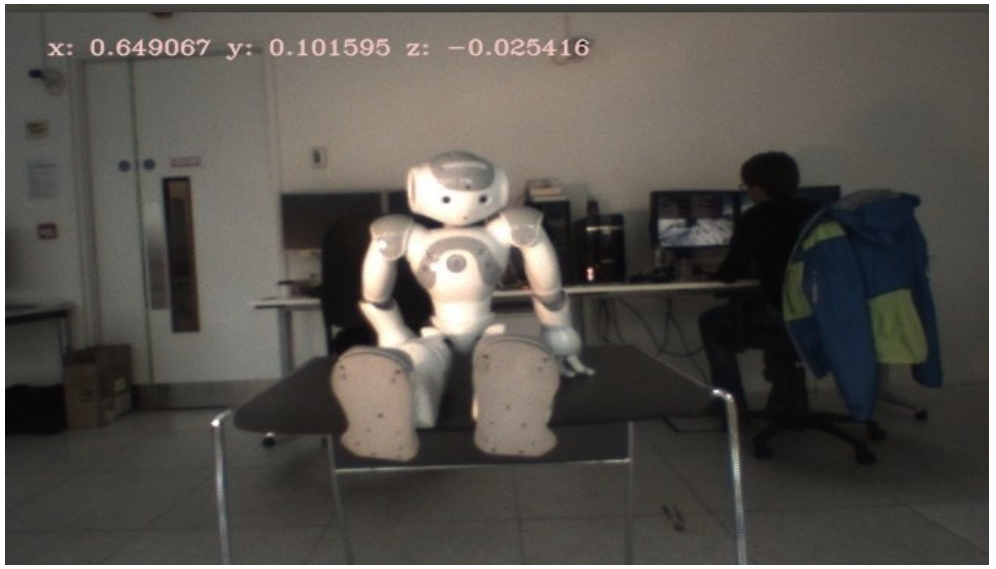
Systems In Place

- Two light fields collected with Baxter
- Two parameterizations
- One is unstructured





Successful Demonstration of Light Field Properties

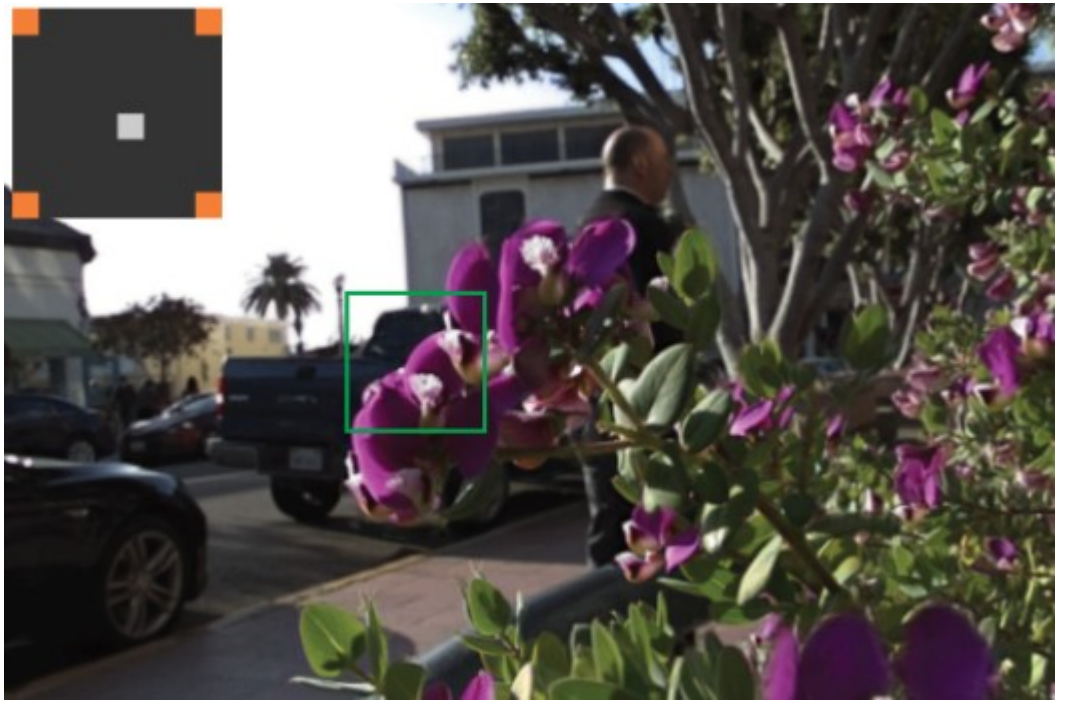


Lab collected images with large aperture

Isaksen et al, large aperture

Next Steps: Minimizing Images Required and Fitting Parameterization

- Explored by many researchers (Kalantari et al, Shi et al, Camahort et al, etc)
- Methods vary from geometric, to Fourier reconstruction, to convolution NNs
- All methods are tried with structured light fields
- Implement method by Kalantar et al.



Kalantari et al demonstrating learning image relationships