Depth Imaging – Original Goals

- Face recognition
- Gait analysis
- Skeletonization

Uses for:
- Military
- Defense
- Security and surveillance
Additional Uses of Depth Imaging

- Gestural Interfaces
- Cheap 3D scanners
- Motion capture
- Bio-metrics
- Manipulating 3D models
Digital Geometry Capture

- Photographic methods
- Laser scanning
- Pattern projection methods
What is a Light Field?

- A light field is defined as the radiance at a position \((x, y)\), and a direction \((\theta, \varphi)\).
- The radiance is defined as the light energy coming from a specific direction.
- Thus, the light field is a 4-dimensional space.
A Light-Field of Michelangelo's Statue of Night
The Lytro Camera

LENS ASSEMBLY
Features an 8x optical zoom and a constant f/2 lens.

LIGHT FIELD SENSOR
Records the rays of light entering the camera as data.

USB POWER BOARD

LITHIUM-ION BATTERY

MAIN PROCESSOR BOARD

ZOOM CONTROL SENSOR

LCD DISPLAY
DISPLAY AND WIRELESS BOARD

4.41 Inches
1.61 Inches
Light Field Cameras

Cameras like the Lytro and the Raytrix use a microlens array to mimic a planar gantry.

In order to extend the depth-of-field of the camera, the Raytrix uses microlenses with different focal lengths.
Lytro Camera
Capturing Geometry from Photographs

How can we extract geometric information from a set of photographs when we only have image data?
Computer Vision

• The science and technology of machines that see
• Can the machine extract desired information from an image?

What did I see?
Simple case

Known camera positions \((x_e, y_e, z_e)\), camera optics, known corresponding points each image.
Early Work - 1975
Sagan House
Can we reconstruct the 3D geometry from a set of photographs from the same camera?
1 2 3 Catch
Can we reconstruct the 3D geometry from an arbitrary set of photographs?
Correspondence and 3D Structure from Different Camera Positions

*Note:* The pictures are in correspondence. 2D dots with same color correspond to the same 3D points.
3D Structure from Different Camera Positions
3D Structure from Different Camera Positions

Assuming the position of the red dot is known, there is reprojection error in Camera 3.
Motion Capture Markers
Motion Capture
Markerless Motion Capture
The Curious Case of Benjamin Button 2008
The Curious Case of Benjamin Button 2008
Digital Geometry Capture

- Photographic methods
- Laser scanning
- Pattern projection methods
Cyberware Scanner
Cyberware Scanner Diagram
Cyberware Scanner
Uncle Don
Digital Geometry Capture

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Microsoft’s Kinect

3D DEPTH SENSORS
RGB CAMERA
MULTI-ARRAY MIC
MOTORIZED TILT
Microsoft’s Kinect
Kinect speckle pattern

- Near region (0.8 – 1.2m)
  Small dots
- Middle region (1.2 – 2.0m)
- Far region (2.0 – 3.5 m)
  Large dots
Point Cloud Drawn from the Kinect’s 3D data
Depth Image

The gray scale indicates the depth of the object for each pixel. Black indicates no depth information because closer objects obscure those that are further away.
Kinect: Depth Image and Real Image
Step 1: Compute a Depth Map

31 fps
Step 2: Infer a Body Position
Skeleton Manipulation
Extracted Skeleton

Kinect
Kinect 2
Pulsed Modulation

- Measure distance to a 3D object by measuring the absolute time a light pulse needs to travel from a source into the 3D scene and back, after reflection
- Speed of light is constant and known, $c = 3 \cdot 10^8 \text{m/s}$
Matterport Camera
Floored

Mapping The Matterhorn using a Fleet of Drones

"Sensefly and Drone Adventures Toss UAVs Off the Summit of the Matterhorn"
Google’s Autonomous Driving Vehicle

Autonomous Driving

Google’s modified Toyota Prius uses an array of sensors to navigate public roads without a human driver. Other components, not shown, include a GPS receiver and an inertial motion sensor.

LIDAR
A rotating sensor on the roof scans more than 200 feet in all directions to generate a precise three-dimensional map of the car’s surroundings.

POSITION ESTIMATOR
A sensor mounted on the left rear wheel measures small movements made by the car and helps to accurately locate its position on the map.

VIDEO CAMERA
A camera mounted near the rear-view mirror detects traffic lights and helps the car’s onboard computers recognize moving obstacles like pedestrians and bicyclists.

Radar
Four standard automotive radar sensors, three in front and one in the rear, help determine the positions of distant objects.

Source: Google

End