

Visual Imaging in the Electronic Age

Advanced Digital Photography Geometry and Motion Capture

Lecture #11
September 29, 2015
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Google Street View Car Fleet



October 15, 2012

Google's Autonomous Driving Vehicle

2010

Autonomous Driving

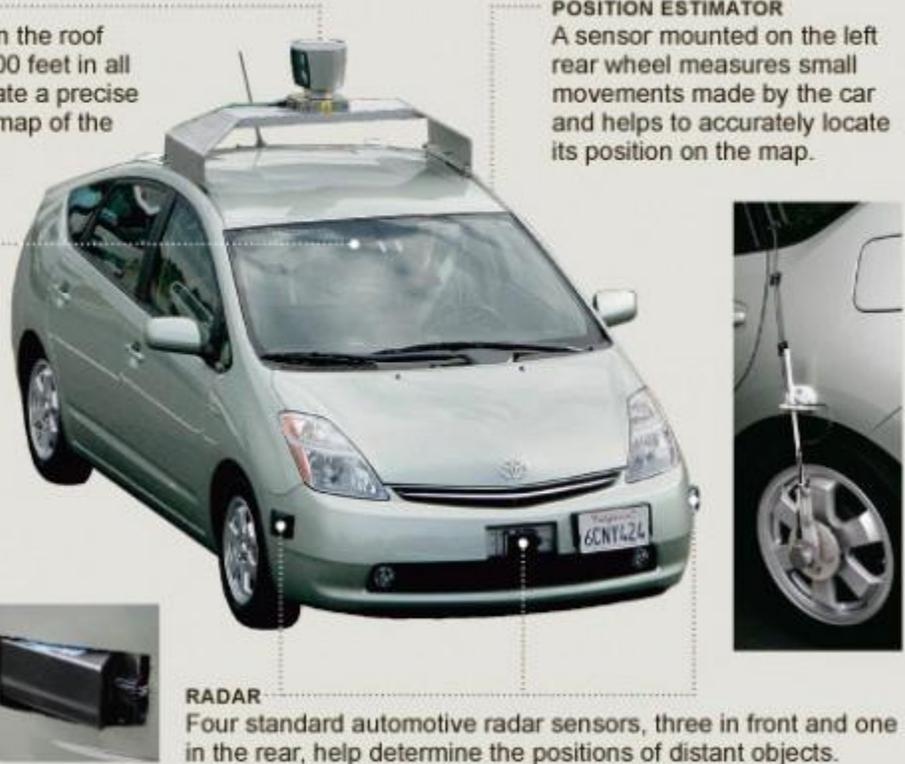
Google's modified Toyota Prius uses an array of sensors to navigate public roads without a human driver. Other components, not shown, include a GPS receiver and an inertial motion sensor.

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

THE NEW YORK TIMES, PHOTOGRAPHS BY RAMIN BAHMIAN FOR THE NEW YORK TIMES

Google Street View



- The world contains roughly 50 million miles of roads, paved and unpaved, across 219 countries (ref.)
- This is equivalent to circumnavigating the globe 1250 times.
- To date, hundreds of cities in many countries across four continents have been captured.
- Google has developed several vehicular platforms and texture information in the project's seven year history.

Google Street View

2012

- 2011 Google announced it would start charging (large) commercial sites
- 2012 Google allows users to post photos and reviews of locations

By October 2012, Google will have updated 250,000 miles of U.S. roads

Note: They have also added Google Moon and Google Mars

Google Street View Acquisition Map

2012



Lombard Street, San Francisco



Street View Vehicular Platforms



Modified Snowmobile

Using Street View data to enhance user walk-through experiences in Google Earth.

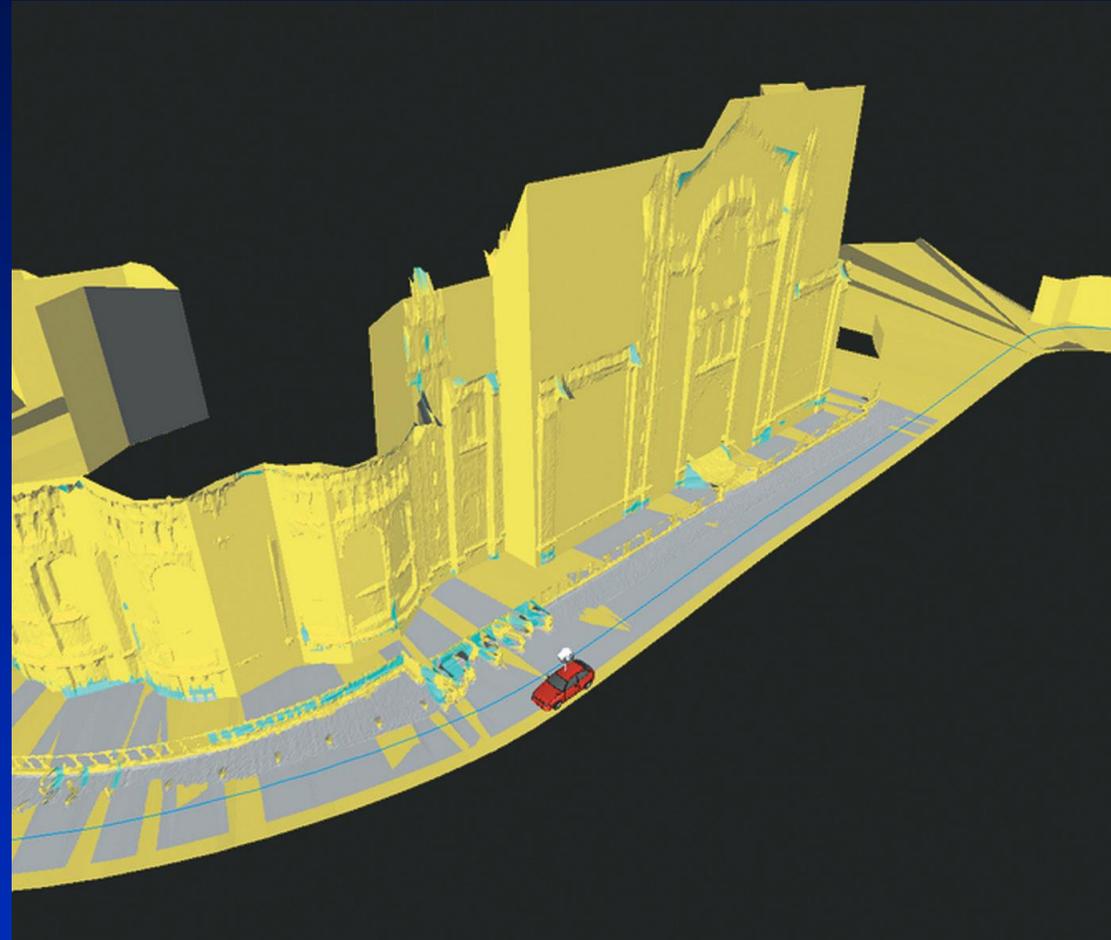


Original 3D models of a New York City scene from airborne data only.



Fused 3D model with high-resolution facades. The visual quality is considerably higher, and many storefronts and signs can now be easily identified and recognized.

Imagery from new Street View Vehicle is accompanied by laser range data



- which is aggregated and simplified by robustly fitting it in a coarse mesh that models the dominant scene surfaces.

Digital Geometry Capture

- Photographic methods
- Time of Flight
- Radar
- Sonar
- *All of the Above*

Sensors on Google's ADV

VIDEO CAMERA

Mounted near the rear-view mirror, the camera detects traffic lights and any moving objects.

LIDAR

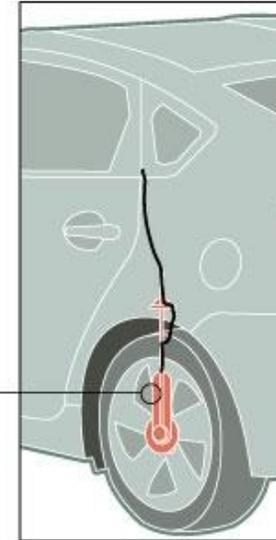
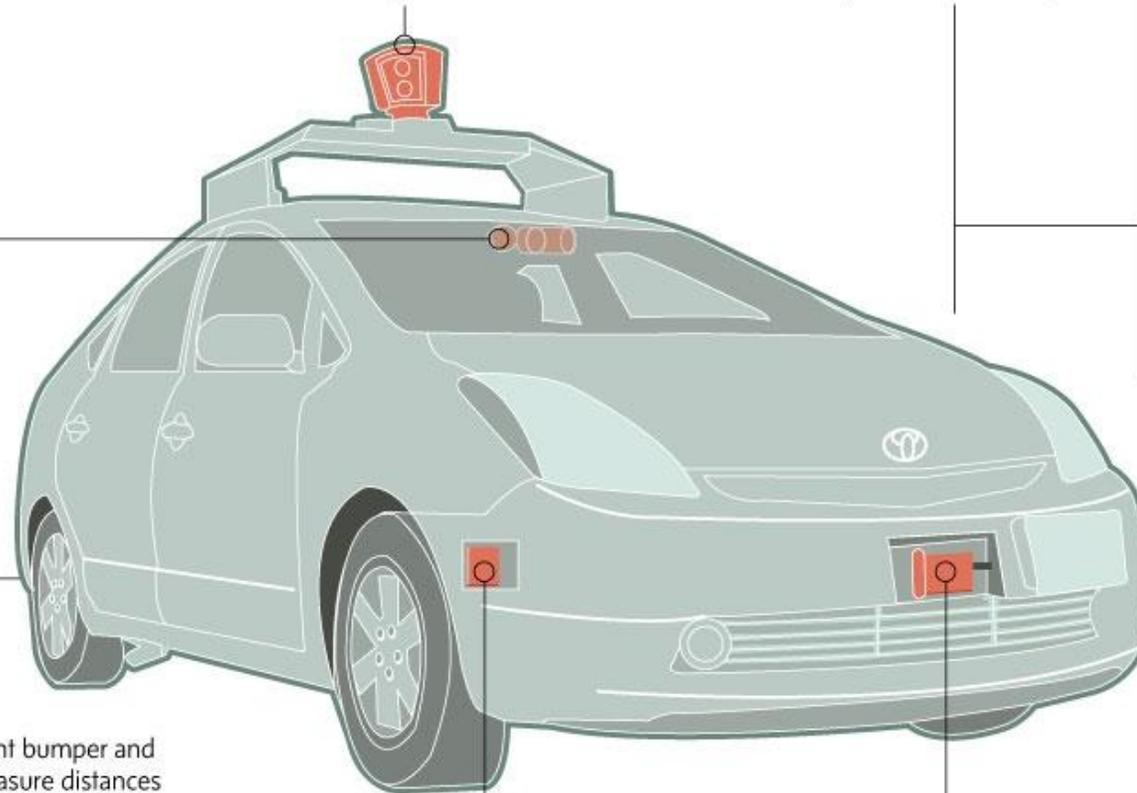
A rotating sensor on the roof scans the area in a radius of 60 metres for creation of a dynamic, three-dimensional map of the environment.

POSITION ESTIMATOR

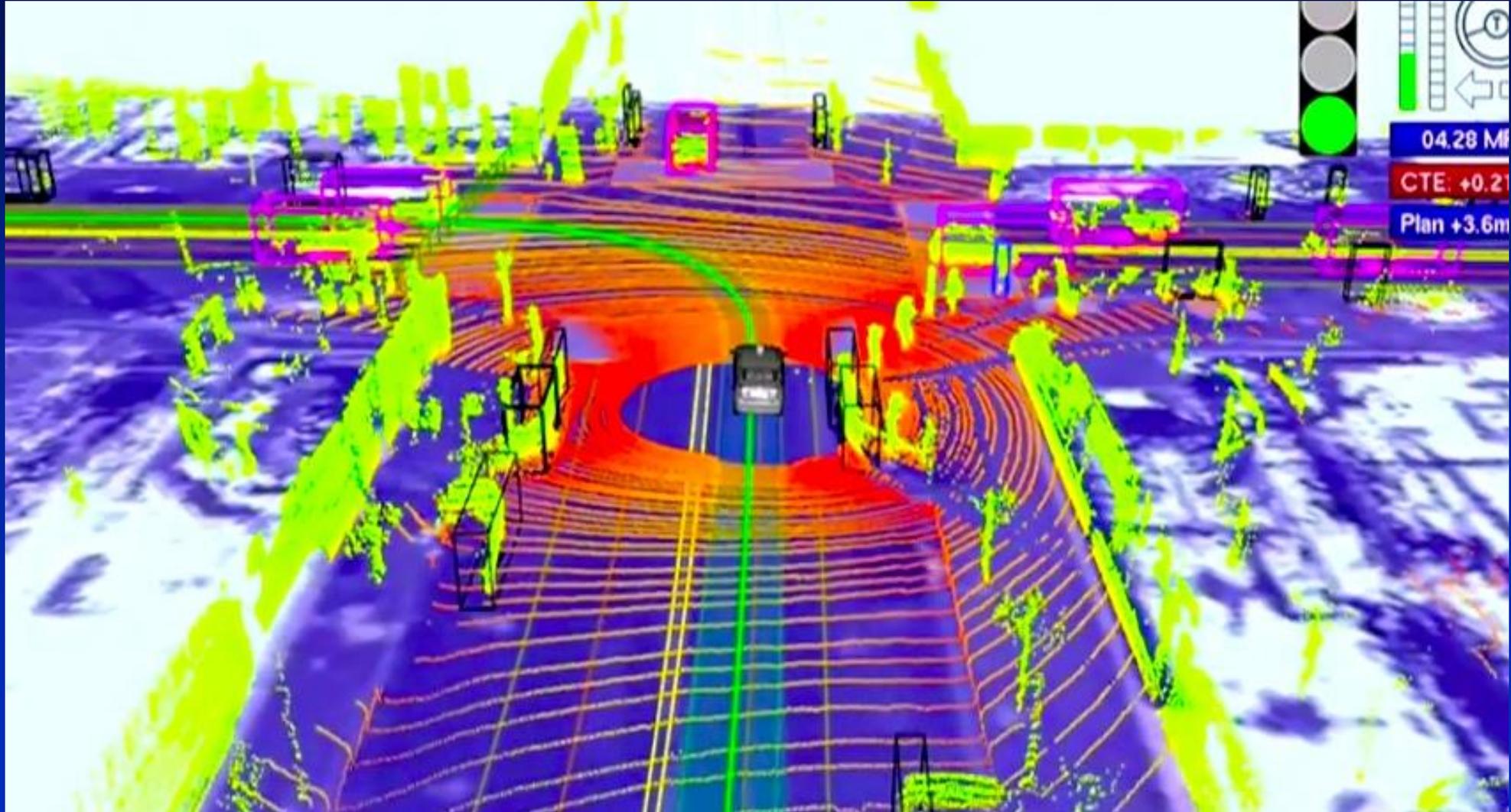
A sensor mounted on the left rear wheel measures lateral movements and determines the car's position on the map.

DISTANCE SENSORS

Four radars, three in the front bumper and one in the rear bumper, measure distances to various obstacles and allow the system to reduce the speed of the car.



Sensors on Google's ADV



Google's Autonomous Driving Vehicle

2013

- Uses multiple sensors, each with a different view of the world
- Laser
 - 64 beams @ 10 revolutions/second scanning 1.3 million points in concentric waves starting 8 feet from the car
 - It can spot a 14" object at a distance of 160 feet
- Radar
 - Has twice the range of the Laser, but much less precision
- Photography
 - Excellent at identifying road signs, turn signals, colors and lights

Google's Autonomous Driving Vehicle

2014-2015

- New laser sensors
 - 2 X range
 - 30 X resolution
 - @ 300' can spot a metal plate <2" thick
 - Size of a coffee mug
 - Cost \approx \$10,000 (less than current model @ \$80,000)

Autonomous Driving Vehicles

Pre-2000

- “There was no way, before 2000, to make something interesting”
- “The sensors weren’t there
- The computers weren’t there
- The mapping wasn’t there”
- “Radar was a device on a hilltop that cost \$200M”

Sebastian Thrun

Founder of the Google Car Project

Will We Have Autonomous Driving Vehicles?

- Every decade another bit of automation is introduced:
 - 1950s Power steering
 - 1970s Cruise control
 - 1980s Anti-lock brakes
 - 1990s Electronic stability control
 - 2000s The first self-parking cars

- Now
 - Detection of lane lines
 - Distance from car ahead
 - Night vision
 - Blind spot detection
 - Stereo cameras to identify pedestrians





The Game of Drones



Capturing Motion

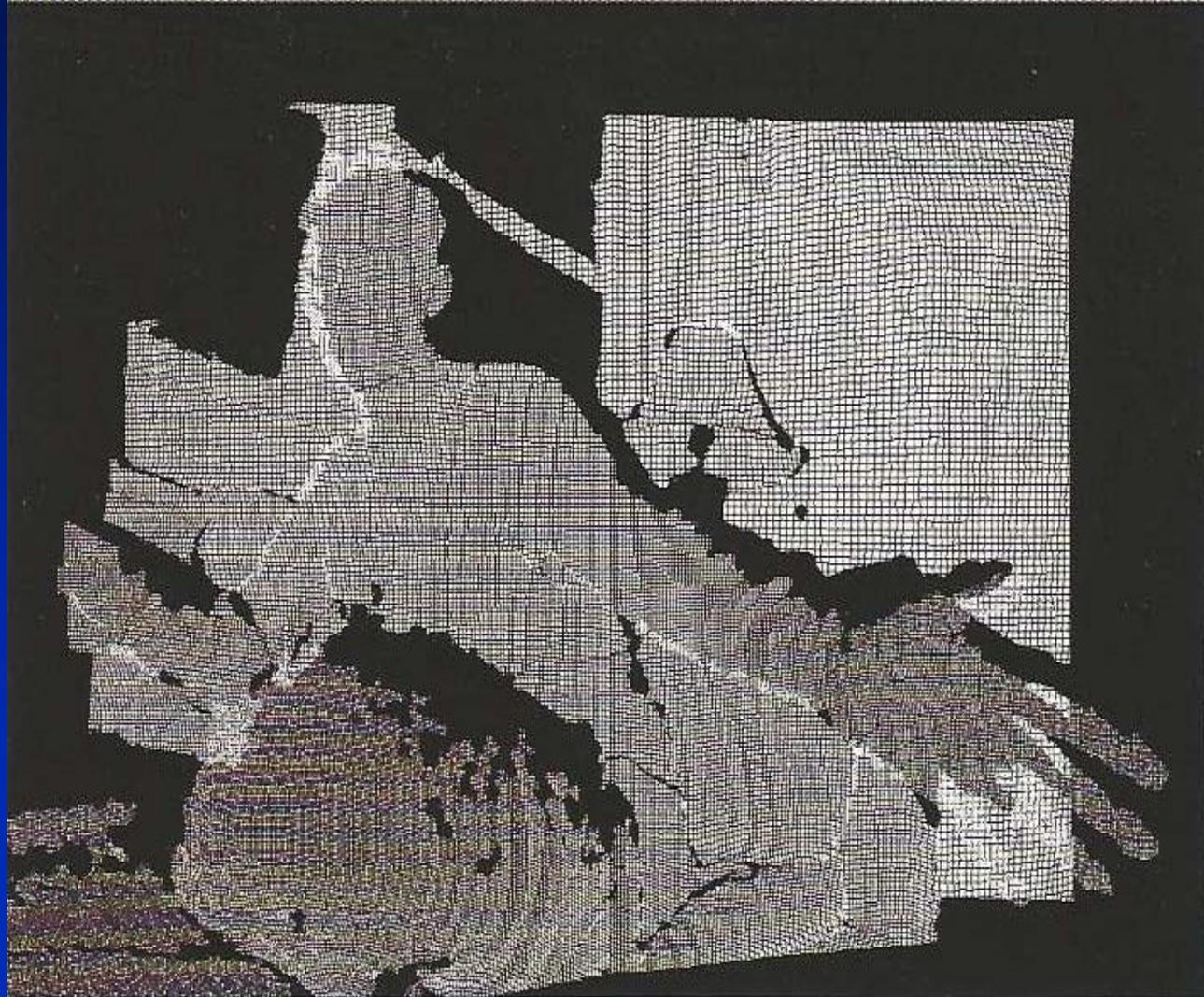
Kinect 2



The Kinect uses a pattern projection and machine learning

- Inferring body position is a two-stage process: First Compute a depth map (using projected pattern), then infer body position (using machine learning)

Point Cloud Drawn from the Kinect's 3D data

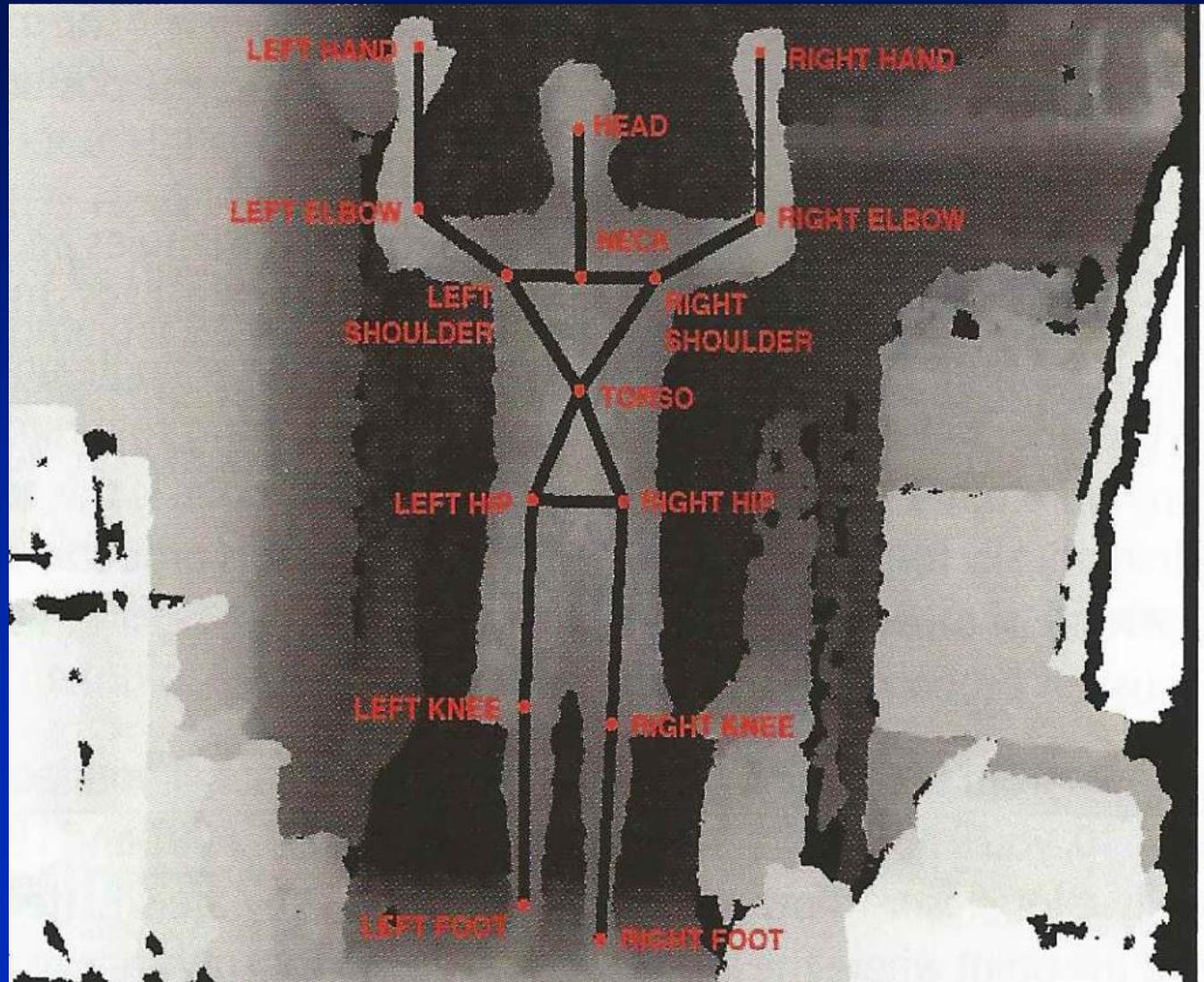


Step 1: Compute a Depth Map

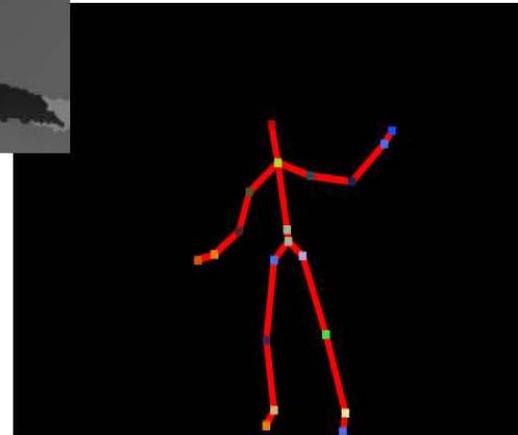


Extracted Skeleton

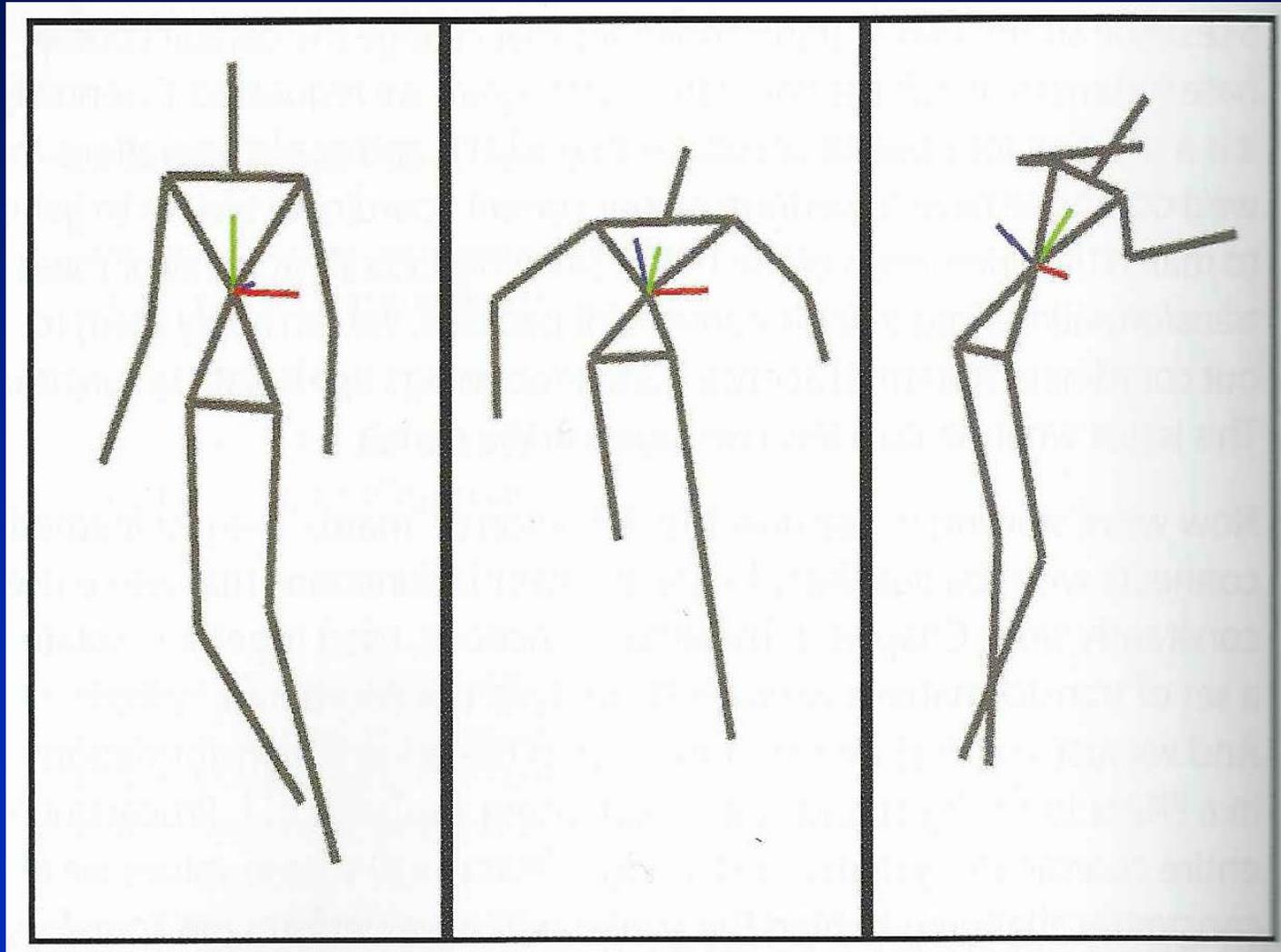
Kinect



Step 2: Infer a Body Position



Skeleton Manipulation



Tracking



Motion Capture Markers



Motion Capture



Seven Universal Expressions of Emotion

- Paul Ekman

anger

- 1 eyebrows down and together
- 2 eyes glare
- 3 narrowing of the lips

disgust

- 1 nose wrinkling
- 2 upper lip raised

fear

- 1 eyebrows raised and pulled together
- 2 raised upper eyelids
- 3 tensed lower eyelids
- 4 lips slightly stretched horizontally back to ears

happiness

A real smile always includes:

- 1 crow's feet wrinkles
- 2 pushed up cheeks
- 3 movement from muscle that orbits the eye

sadness

- 1 drooping upper eyelids
- 2 losing focus in eyes
- 3 slight pulling down of lip corners

surprise

Lasts for only one second:

- 1 eyebrows raised
- 2 eyes widened
- 3 mouth open

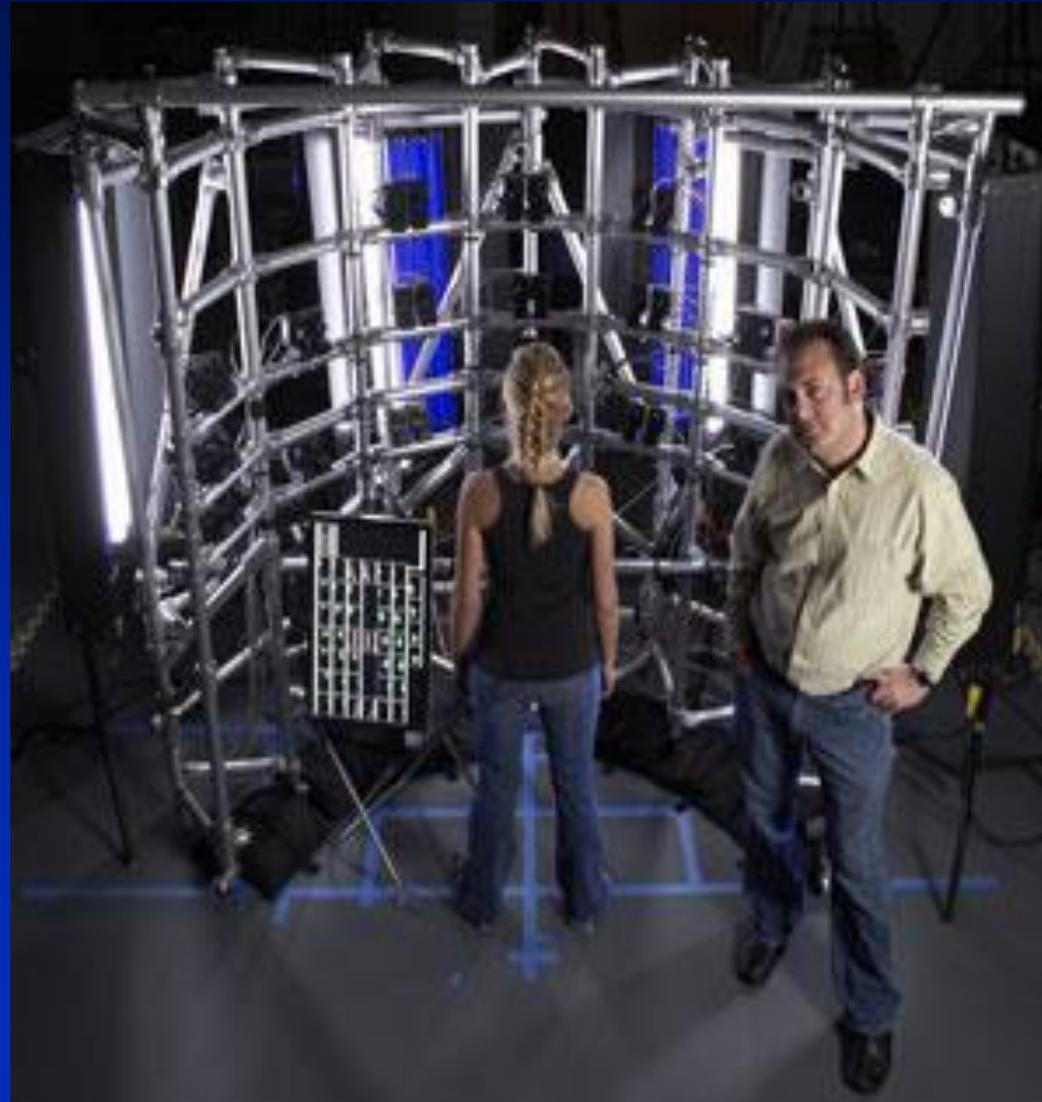
contempt

- 1 lip corner tightened and raised on only one side of face

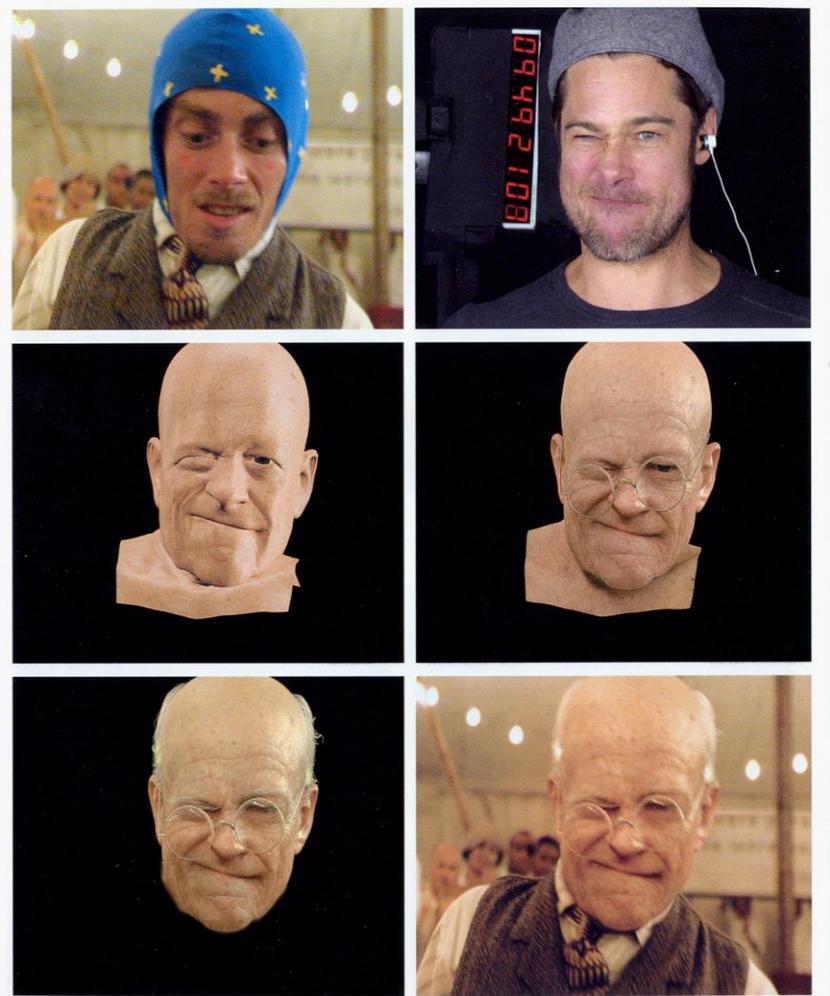
Inside Out



Markerless Motion Capture



The Curious Case of Benjamin Button 2008



82 □ CINEFEX 116

The Curious Case of Benjamin Button 2008



Cinefex 116, January 2009

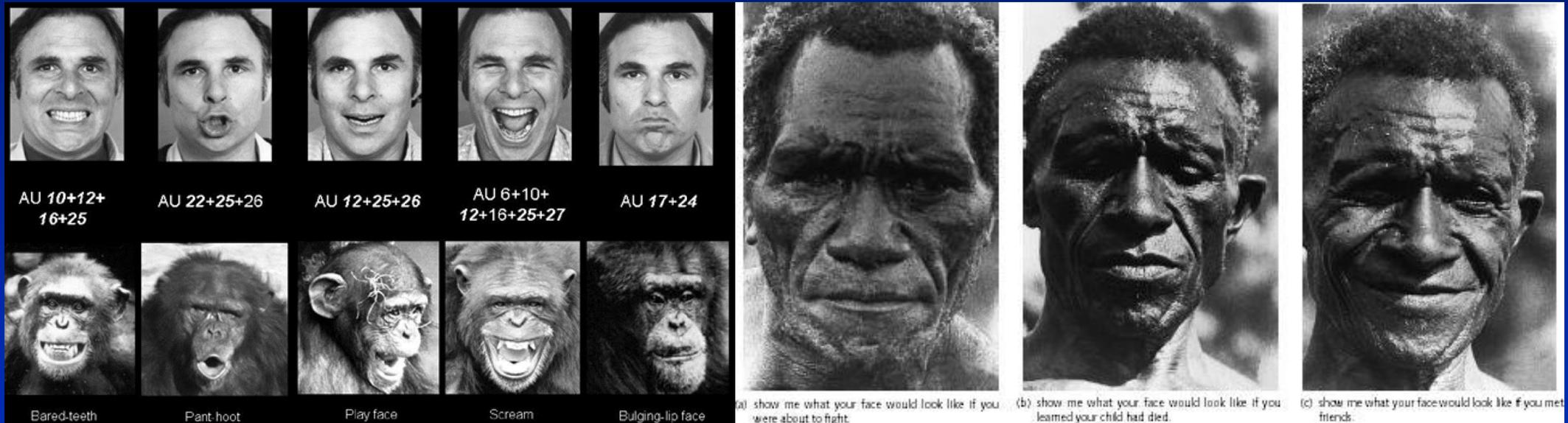
The Curious Case of Benjamin Button 2008



Cinefex 116, January 2009

Seven Universal Expressions of Emotion

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Affective Computing

Affidex Software

- Scan the image for a face(s) and isolates one.
- Using feature detection algorithms, identify the face's main regions (mouth, nose, eyes, eyebrows, etc.) and ascribe dots to each.
- Separate the dots into “deformable” and “non-deformable” points.
- Deformable points serve as anchors to estimate the magnitude of movement.

Affective Computing

- “I think that, ten years down the line, we won’t remember what it was like when we couldn’t just frown at our device, and our device would say, “Oh, you didn’t like that, did you?””
 - Rana el Kaliouby
Affectiva



End
