Lesson 101 in Digital Image Processing, Computer Vision

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Outline

- **Basic Introduction**
- **Image Processing**
- **Computer Vision**
- **Applications**

Image Processing Fields

- **Computer Graphics:** The creation of images, Models to Images.
- **Image Processing:** Enhancement or other manipulation of the image, Image to Images.
- **Computer Vision:** Analysis of the image content, Images to Models.

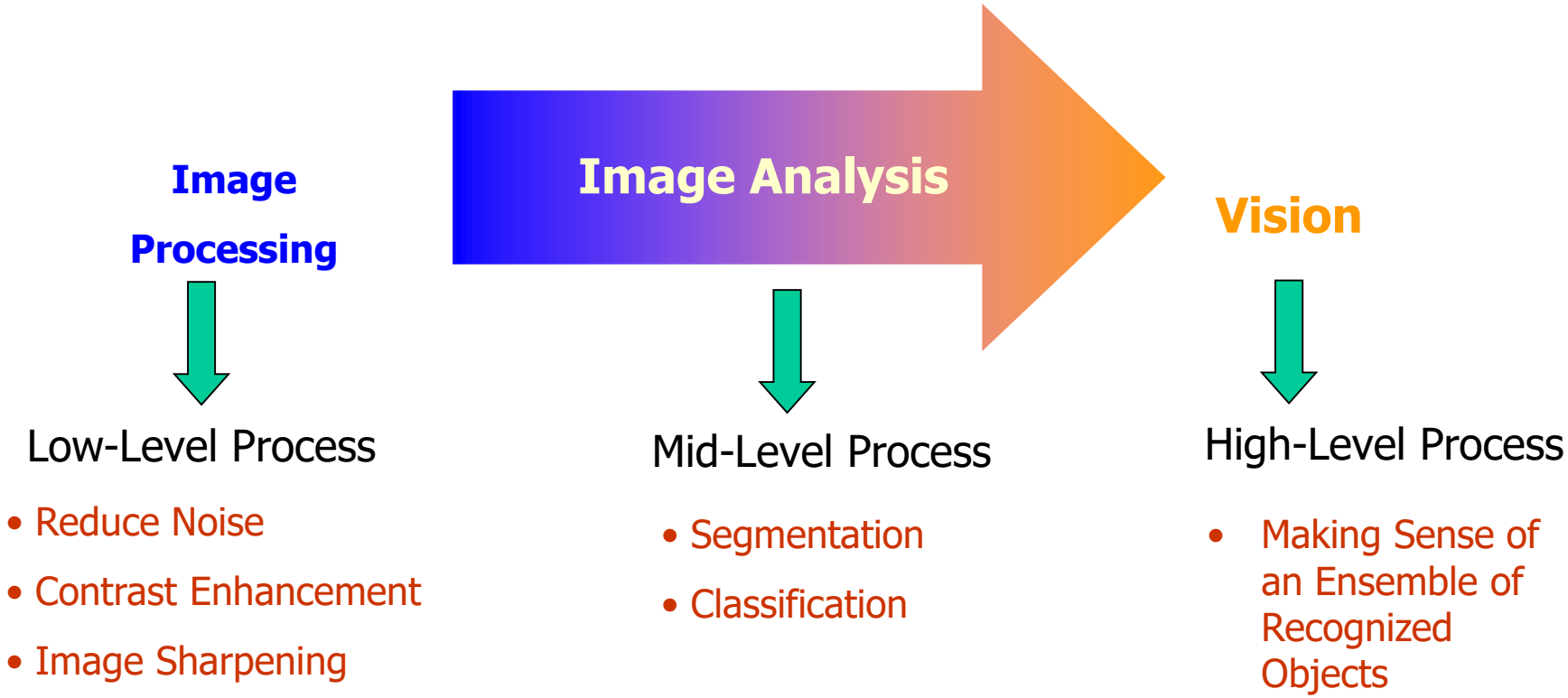


Image Processing Fields

Input / Output	Image	Description
Image	Image Processing	Computer Vision
Description	Computer Graphics	AI

Sometimes, Image Processing is defined as "a discipline in which both the input and output of a process are images

But, according to this classification, trivial tasks of computing the average intensity of an image would not be considered an image processing operation

Computerized Processes Types

- **Low-Level Processes:**
  - **Input** and **output** are images
  - **Tasks:** Primitive operations, such as, image processing to reduce noise, contrast enhancement and image sharpening

Computerized Processes Types

- **Mid-Level Processes:**
  - **Inputs**, generally, are images. **Outputs** are attributes extracted from those images (edges, contours, identity of individual objects)
  - **Tasks:**
    - Segmentation (partitioning an image into regions or objects)
    - Description of those objects to reduce them to a form suitable for computer processing
    - Classifications (recognition) of objects

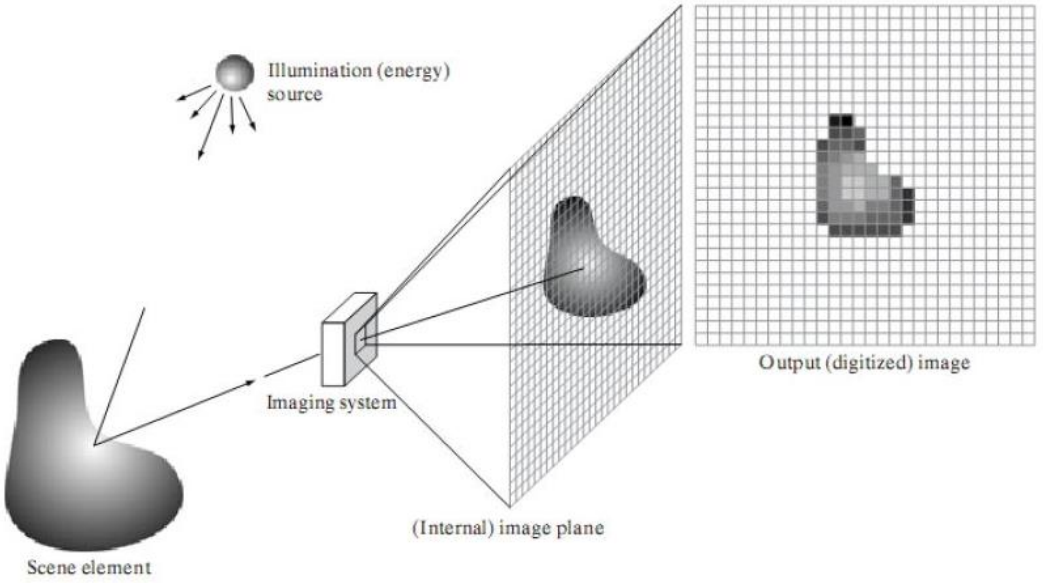
Computerized Processes Types

- **High-Level Processes:**
  - Image analysis and computer vision

Fundamental Steps Image Processing & Computer Vision

Image Acquisition:

- The image is captured by a sensor (eg. Camera), and digitized if the output of the camera or sensor is not already in digital form, using analogue-to-digital convertor



Fundamental Steps Image Processing & Computer Vision

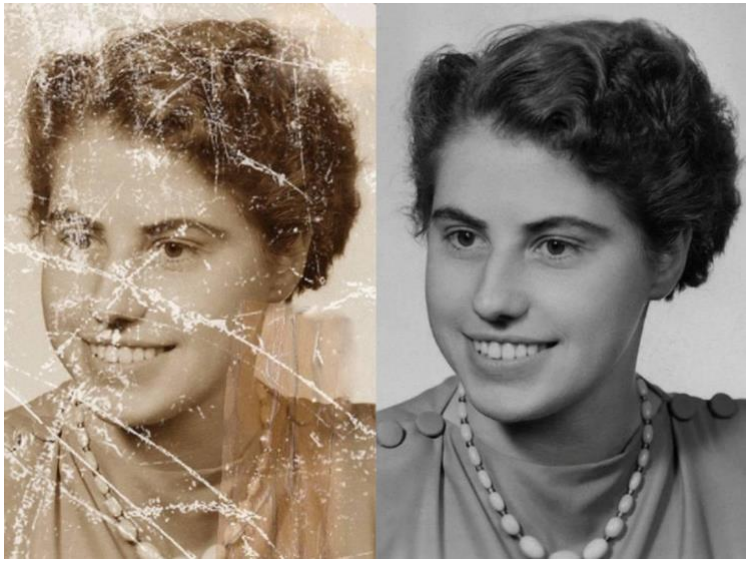
Image Enhancement:

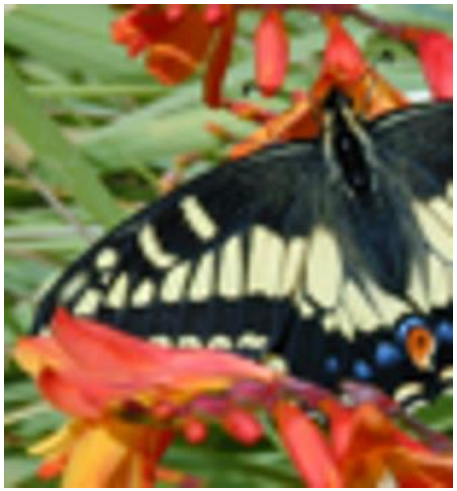
- The process of manipulating an image so that the result is more suitable than the original for specific applications.
- The idea behind enhancement techniques is to bring out details that are hidden, or simple to highlight certain features of interest in an image.

Fundamental Steps Image Processing & Computer Vision

Image Restoration:

- Improving the appearance of an image
- Tend to be mathematical or probabilistic models. Enhancement, on the other hand, is based on human subjective preferences regarding what constitutes a "good" enhancement result.





Fundamental Steps Image Processing & Computer Vision

Compression:

- Techniques for reducing the storage required to save an image or the bandwidth required to transmit it.

Fundamental Steps Image Processing & Computer Vision

Morphological Processing:

- Tools for extracting image components that are useful in the representation and description of shape.

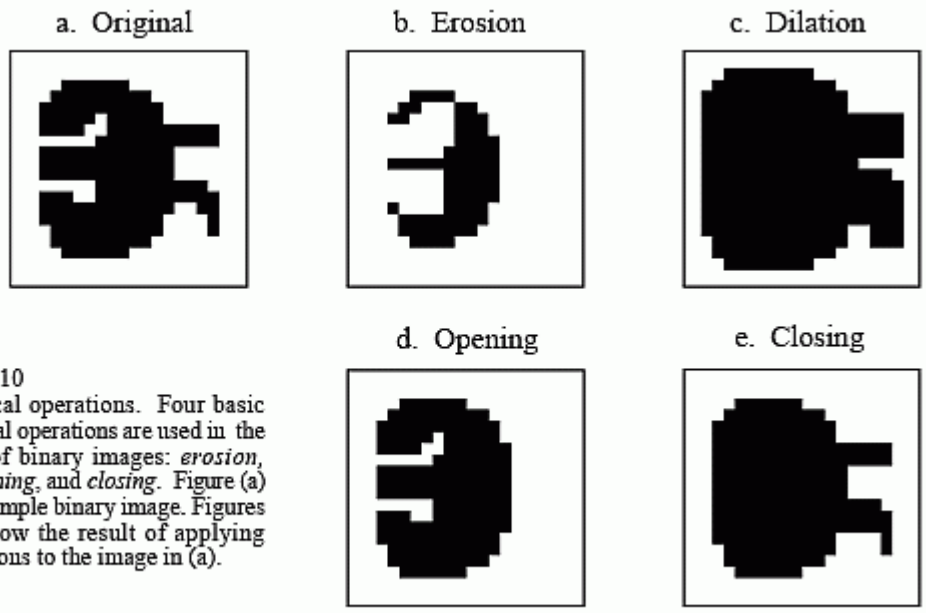


FIGURE 25-10
Morphological operations. Four basic morphological operations are used in the processing of binary images: *erosion*, *dilation*, *opening*, and *closing*. Figure (a) shows an example binary image. Figures (b) to (e) show the result of applying these operations to the image in (a).

Fundamental Steps Image Processing & Computer Vision

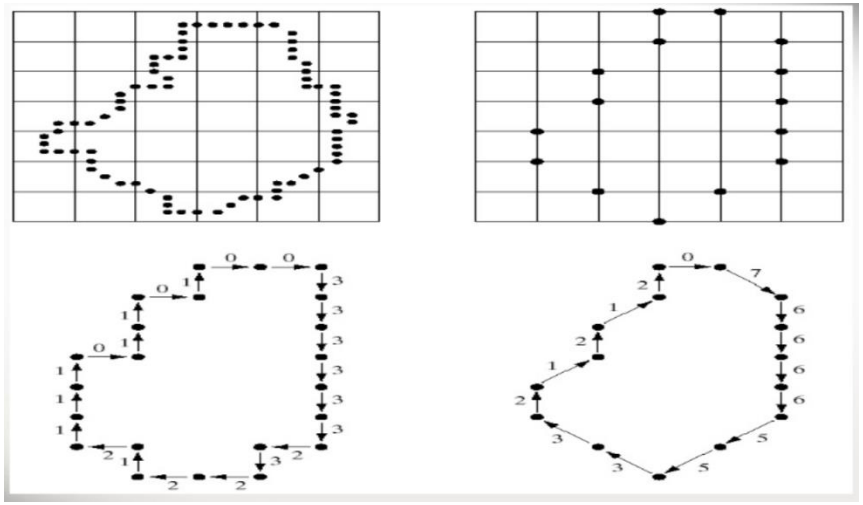
Image Segmentation:

- Segmentation procedures partition an image into its constituent parts or objects.
- Important Tip: The more accurate the segmentation, the more likely recognition is to succeed.

Fundamental Steps Image Processing & Computer Vision

Representation and Description:

- **Representation:** Make a decision whether the data should be represented as a boundary or as a complete region. It is almost always follows the output of a segmentation stage.
  - **Boundary Representation:** Focus on external shape characteristics, such as corners and inflections
  - **Region Representation:** Focus on internal properties, such as texture or skeleton shape

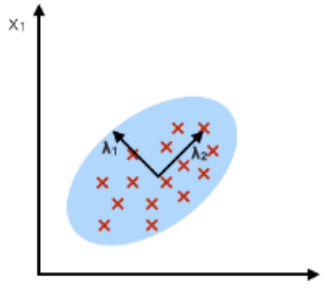


Fundamental Steps Image Processing & Computer Vision

Representation and Description:

- Choosing a representation is only part of the solution for transforming raw data into a form suitable for subsequent computer processing (mainly recognition)
  - **Description:** also called, ***feature selection***, deals with extracting attributes that result in some information of interest.

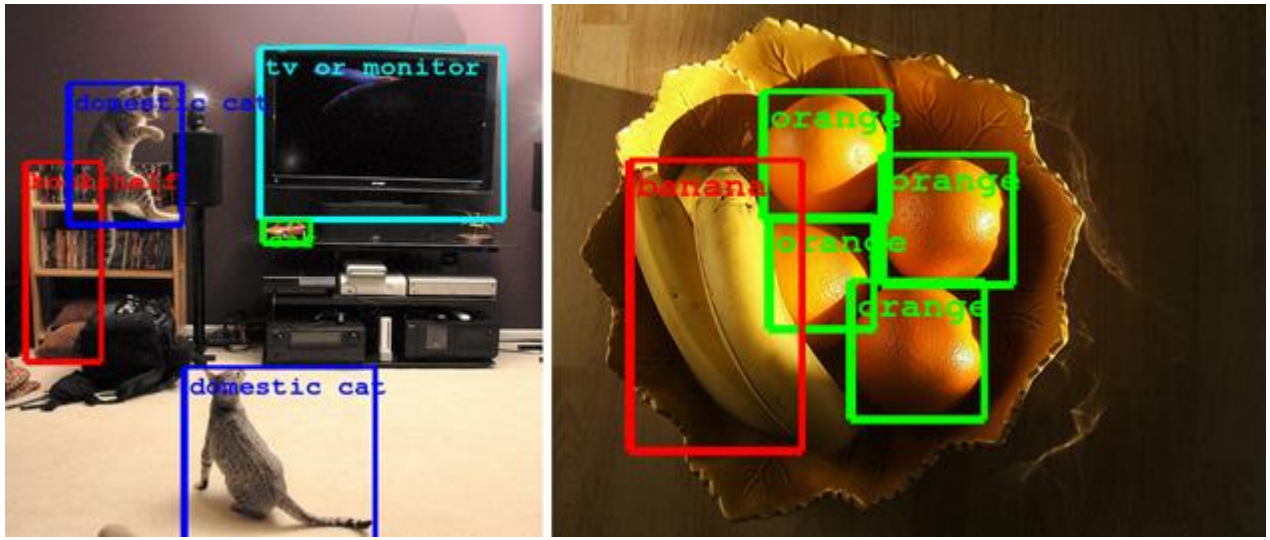
PCA:
component axes that
maximize the variance



Fundamental Steps Image Processing & Computer Vision

Recognition and Interpretation:

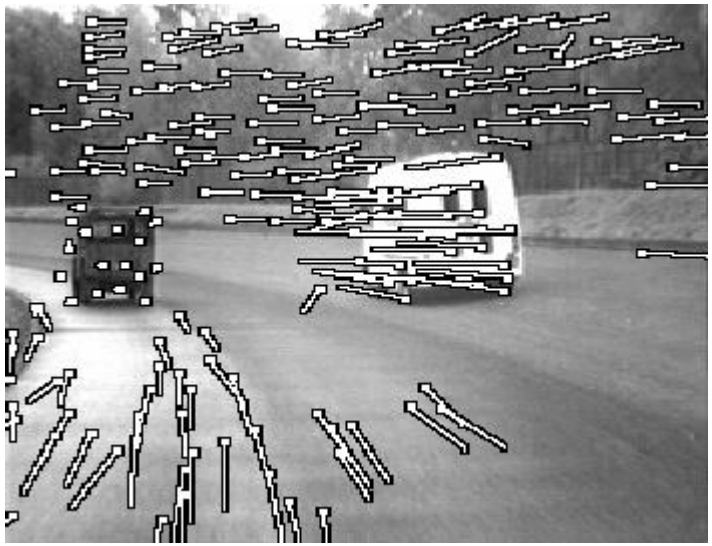
Recognition: the process that assigns label to an object based on the information provided by its description.



Fundamental Steps Image Processing & Computer Vision

Motion Analysis:

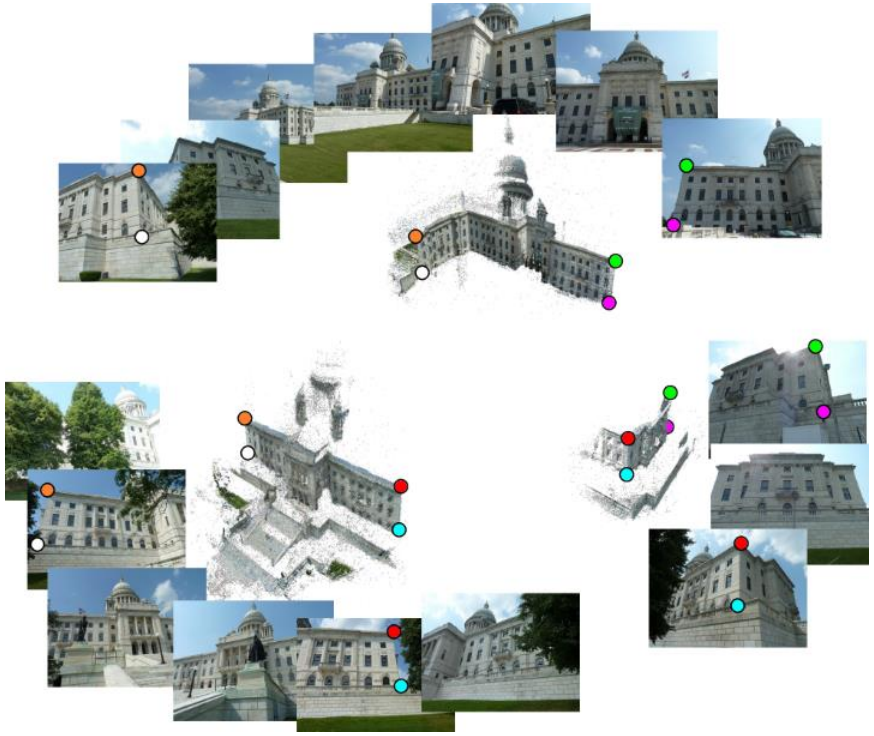
Several tasks relate to motion estimation where an image sequence is processed to produce an estimate of the velocity either at each points in the image or in the 3D scene, or even of the camera that produces the images.



Fundamental Steps Image Processing & Computer Vision

Scene reconstruction:

Given one or (typically) more images of a scene, or a video, scene reconstruction aims at computing a 3D model of the scene.



To understand visually

- Based on the above techniques, how could we make computers understand images and video?

What kind of scene?

Where are the cars?

How far is the building?

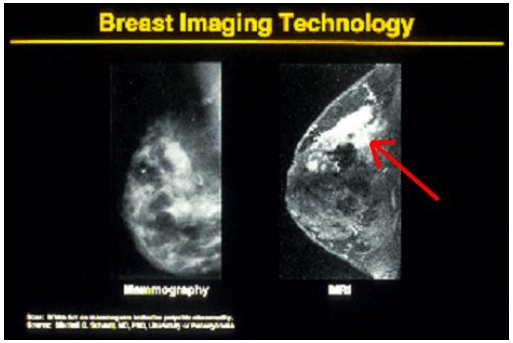
…

Vision is really hard

- Vision is an amazing feat of natural intelligence
  - Visual cortex occupies about 50% of Macaque brain
  - More human brain devoted to vision than anything else

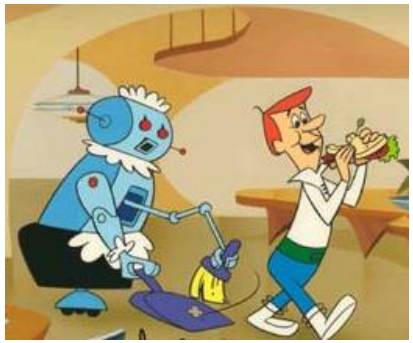
Why computer vision matters

Safety



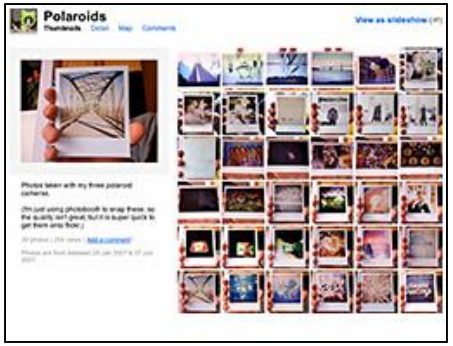
Health

Security



Comfort

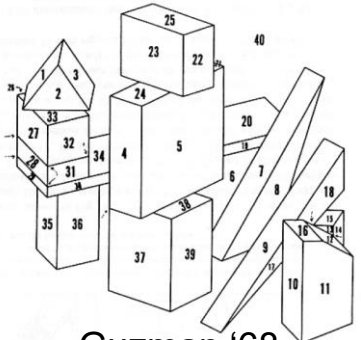
Fun



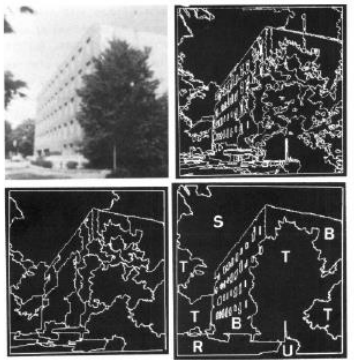
Access

Ridiculously brief history of computer vision

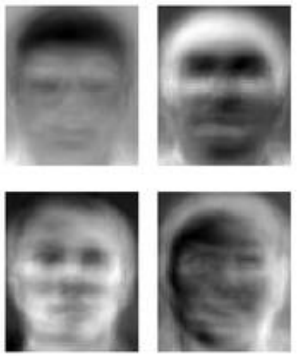
- 1966: Minsky assigns computer vision as an undergrad summer project
- 1960's: interpretation of synthetic worlds
- 1970's: some progress on interpreting selected images
- 1980's: ANNs come and go; shift toward geometry and increased mathematical rigor
- 1990's: face recognition; statistical analysis in vogue
- 2000's: broader recognition; large annotated datasets available; video processing starts
- 2030's: robot uprising?



Guzman '68



Ohta Kanade '78

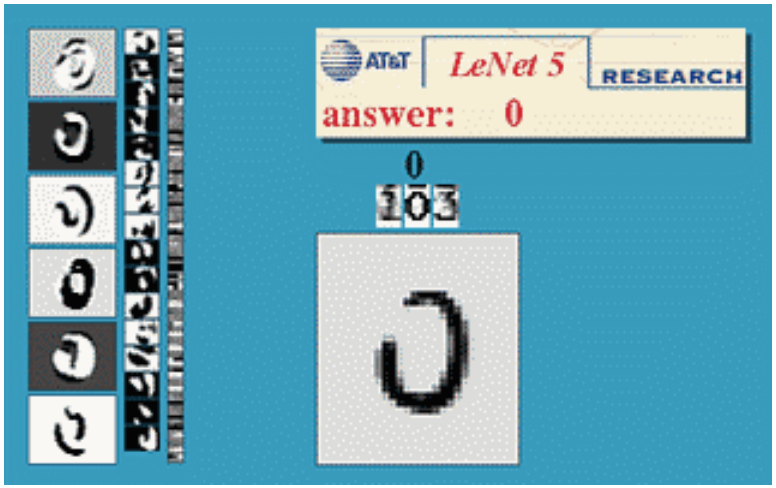


Turk and Pentland '91

Optical character recognition (OCR)

Technology to convert scanned docs to text

- If you have a scanner, it probably came with OCR software



Digit recognition, AT&T labs
http://www.research.att.com/~yann/

License plate readers
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

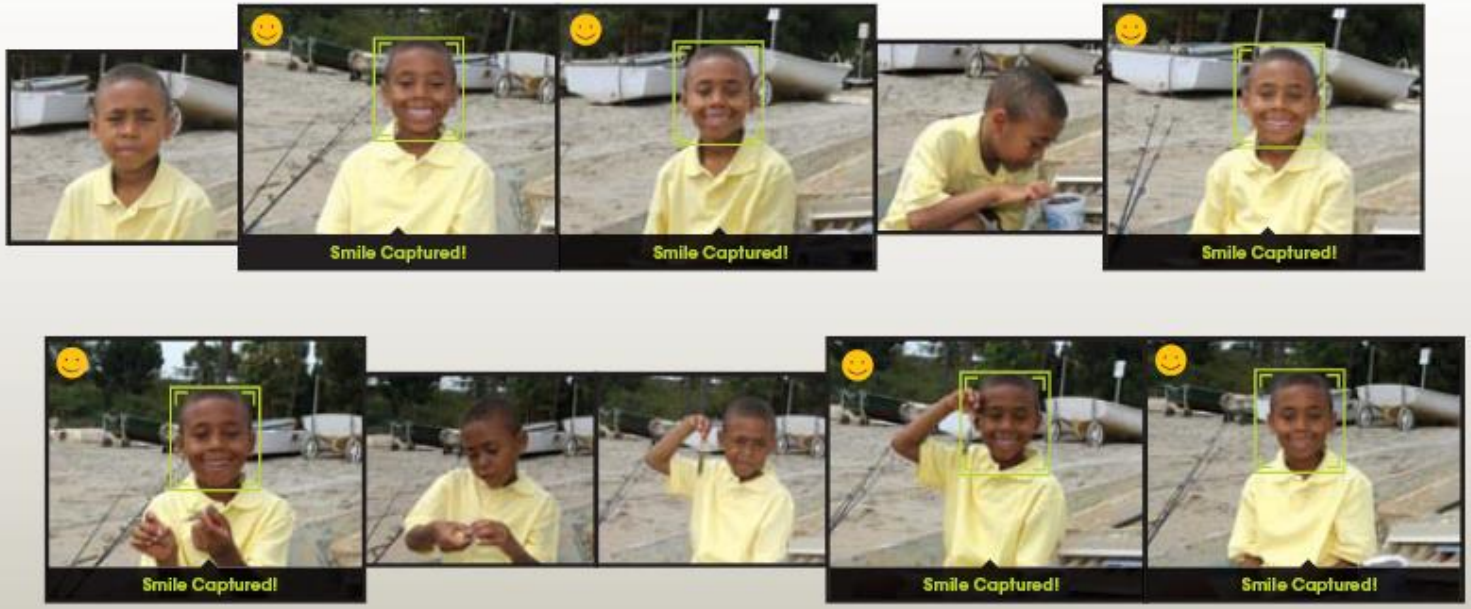
Face detection

- Many new digital cameras now detect faces
  - Canon, Sony, Fuji, …

Smile detection

The Smile Shutter flow

Imagine a camera smart enough to catch every smile! In Smile Shutter Mode, your Cyber-shot® camera can automatically trip the shutter at just the right instant to catch the perfect expression.

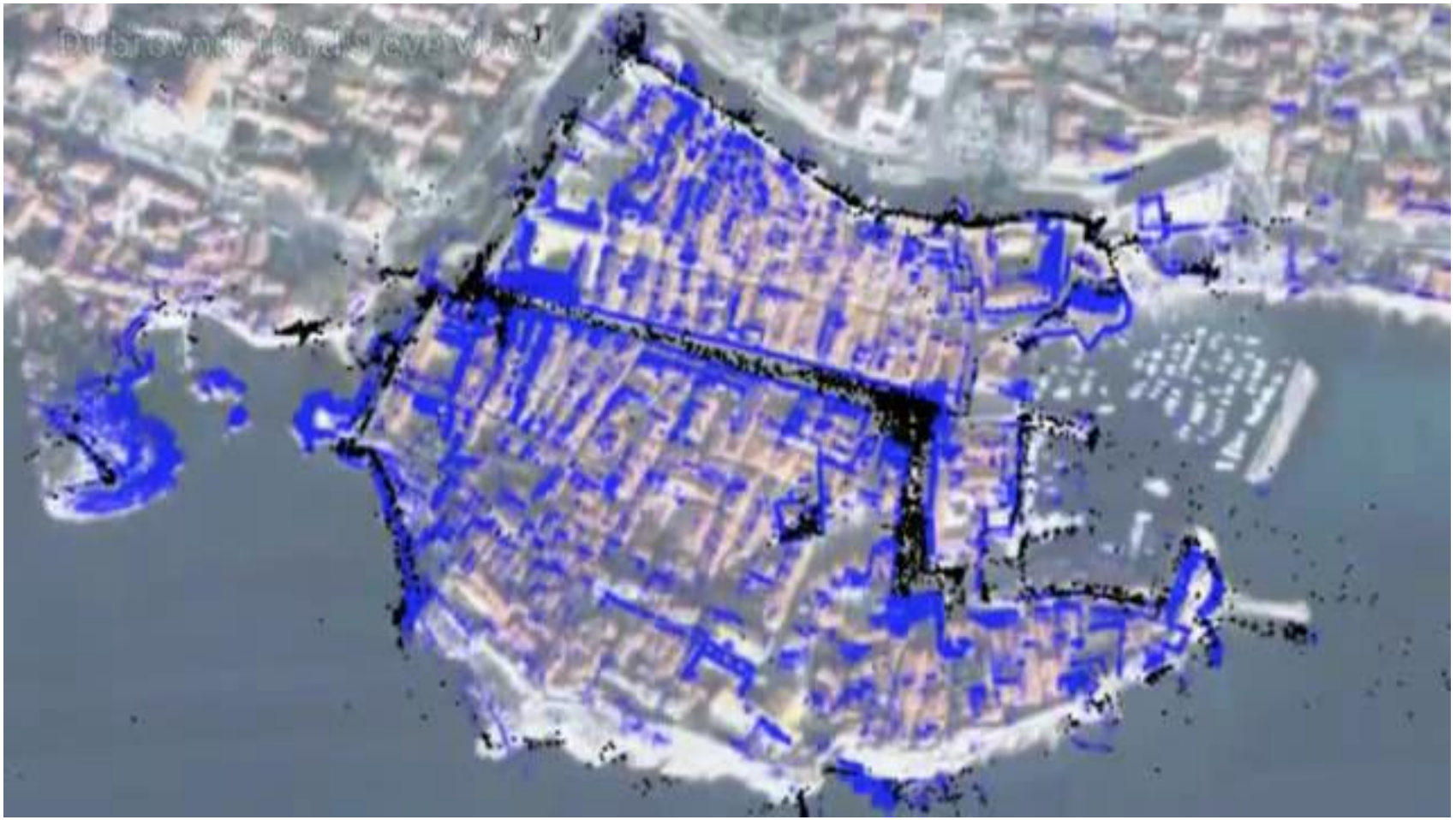


Sony Cyber-shot® T70 Digital Still Camera

3D from thousands of images

BigSFM: Reconstructing the World from Internet Photos
http://www.cs.cornell.edu/projects/bigsfm/

SfM demo video



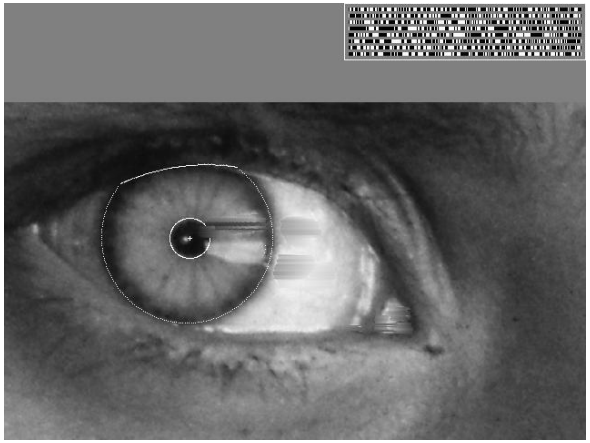
Object recognition (in supermarkets)

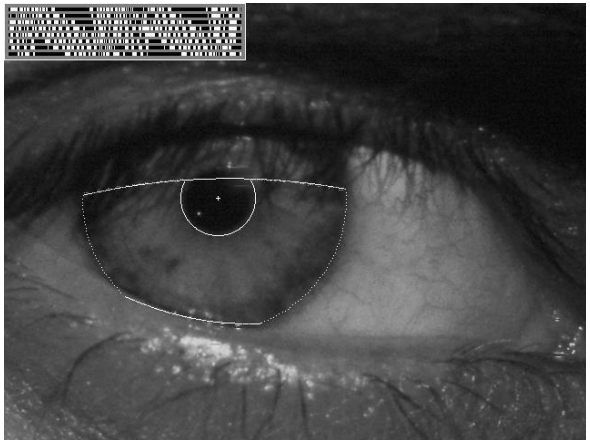
LaneHawk by EvolutionRobotics

“A smart camera is flush-mounted in the checkout lane, continuously watching for items. When an item is detected and recognized, the cashier verifies the quantity of items that were found under the basket, and continues to close the transaction. The item can remain under the basket, and with LaneHawk,you are assured to get paid for it… “

Vision-based biometrics

"*How the Afghan Girl was Identified by Her Iris Patterns*" ?
http://www.cl.cam.ac.uk/~jgd1000/afghan.html





Login without a password…

Fingerprint scanners on many new laptops, other devices

Face recognition systems now beginning to appear more widely
http://www.sensiblevision.com/

Object recognition (in mobile phones)

Point & Find, Nokia

Google Goggles

Google Images:

圖片大小：
256 × 256

尋找這個圖片的其他尺寸版本：
所有大小 - 中型 - 大型

可能的相關搜尋： ***lena png windows 93***

圖片大小：
812 × 1200

尋找這個圖片的其他尺寸版本：
所有大小 - 大型

可能的相關搜尋： ***超人 海報***

圖片大小：
483 × 547

找不到這個圖片的其他大小版本。

可能的相關搜尋： ***notre dame de paris***

圖片大小：
1200 × 630

尋找這個圖片的其他尺寸版本：
所有大小 - 中型

可能的相關搜尋： ***奇美 博物館***

圖片大小：
960 × 958

找不到這個圖片的其他大小版本。

可能的相關搜尋： ***gentleman***

https://images.google.com/

Special effects: shape capture

The Matrix movies, ESC Entertainment, XYZRGB, NRC

Special effects: motion capture

Pirates of the Carribean, Industrial Light and Magic

Sports

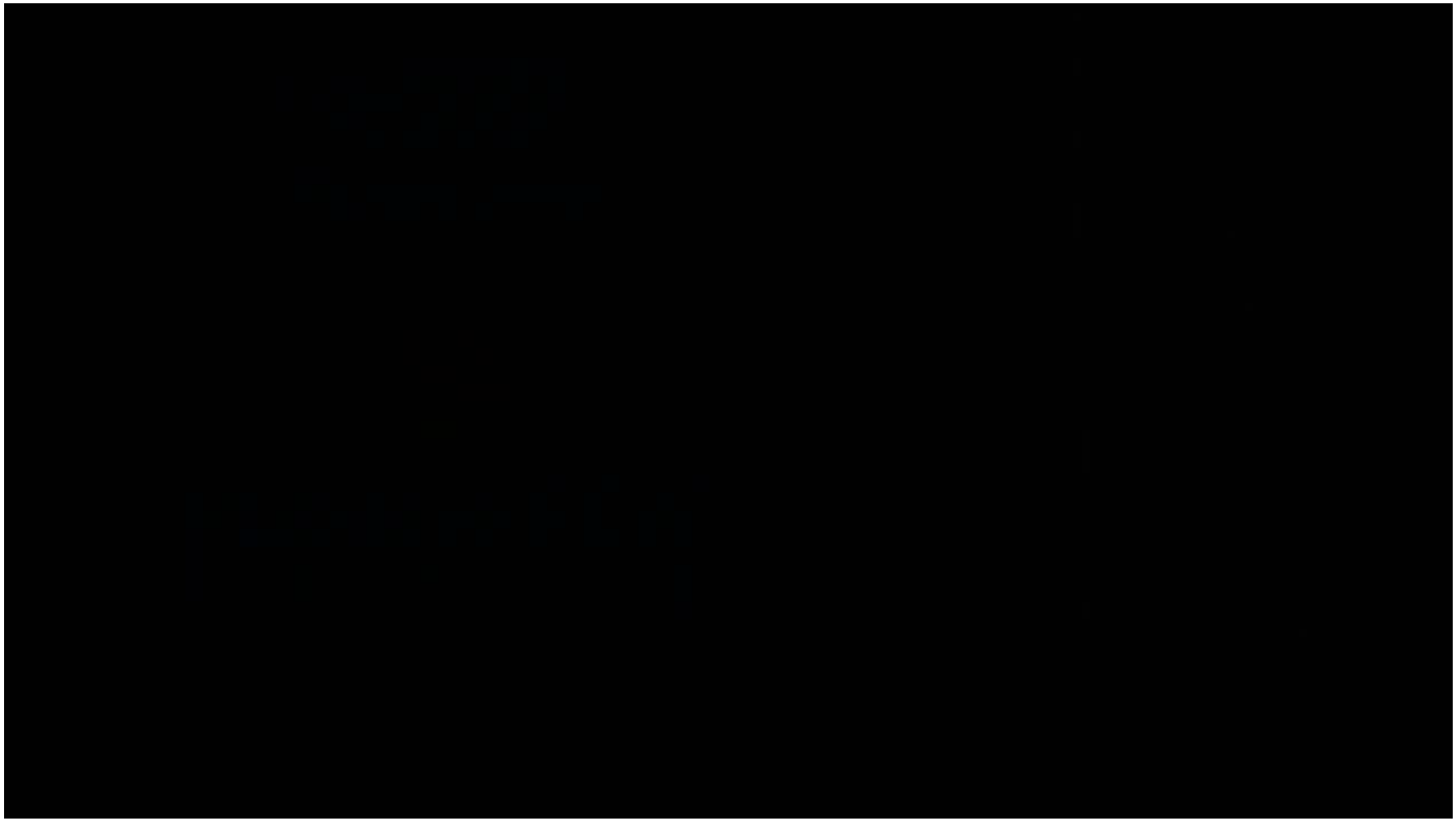
Sportvision first down line
Nice explanation on www.howstuffworks.com

http://www.sportvision.com/video.html

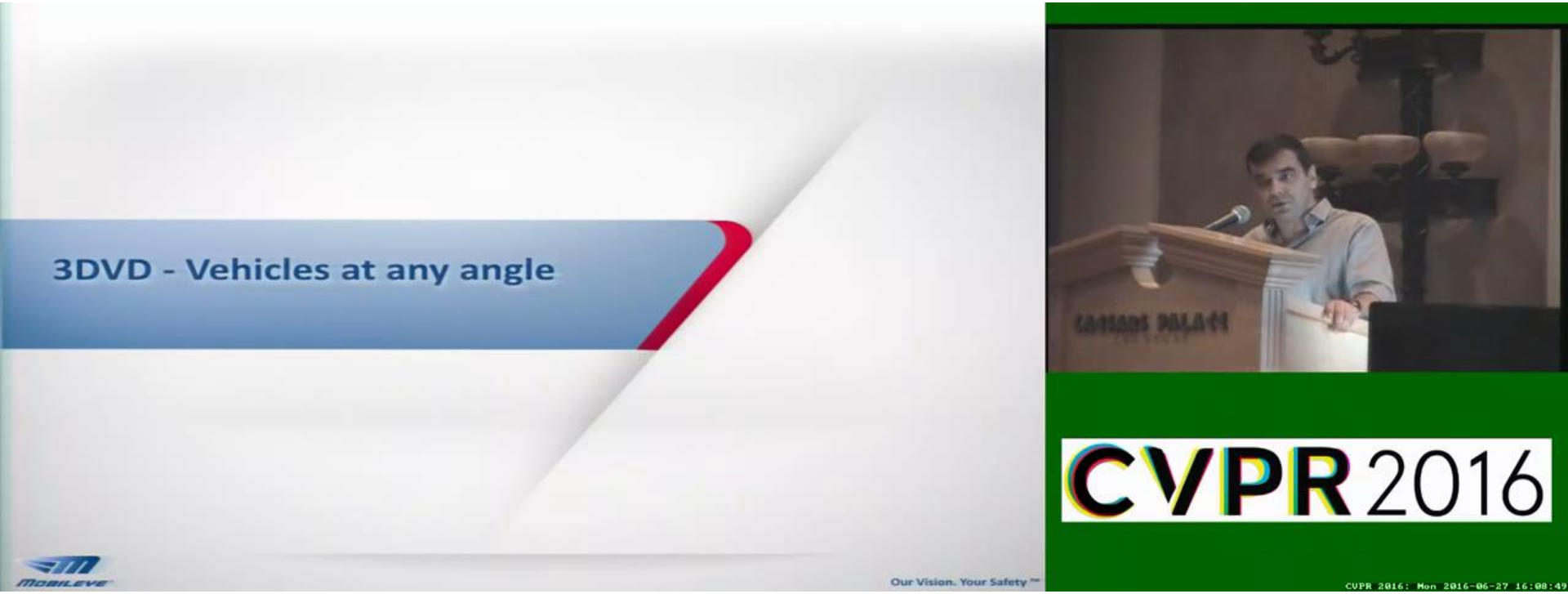
Smart cars

- Mobileye
  - Vision systems currently in high-end BMW, GM, Volvo models

Demo of Mobileye

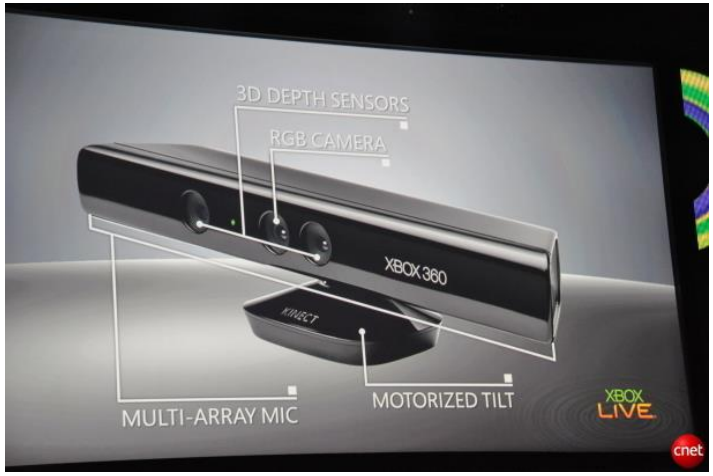


3D-vehicle detection



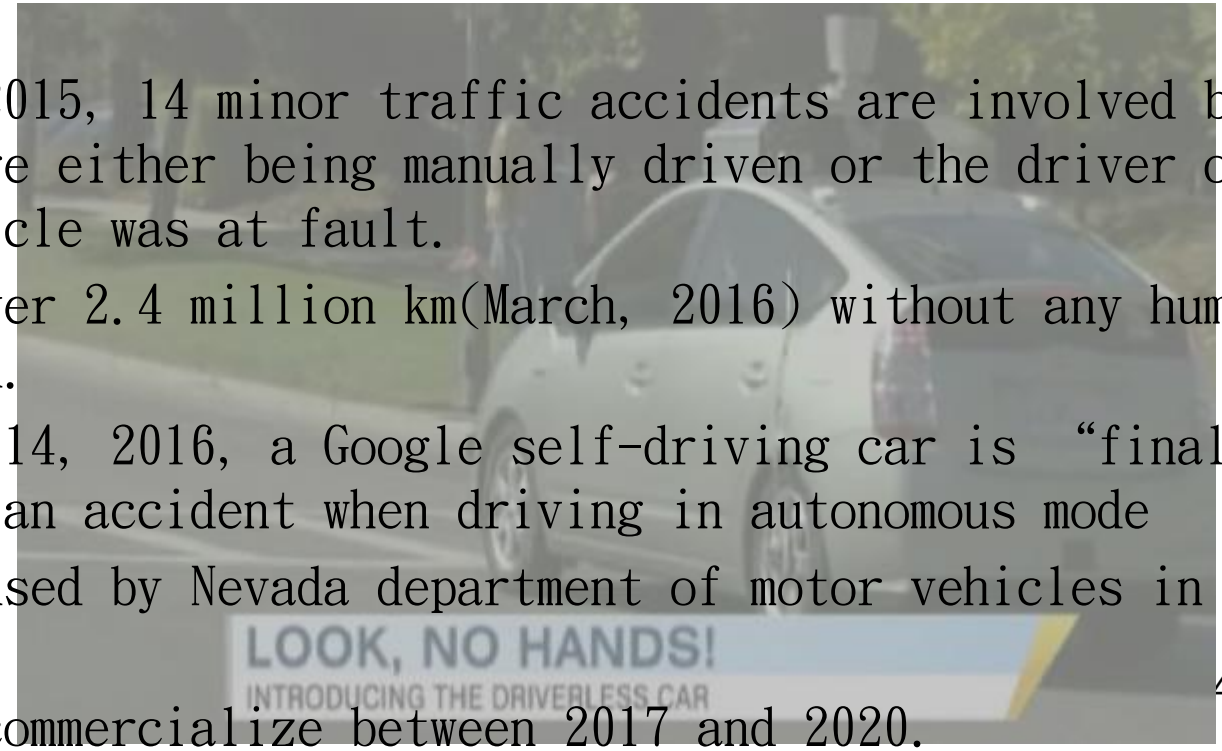
Interactive Games: Kinect

- Object Recognition: http://www.youtube.com/watch?feature=iv&v=fQ59dX0o63o
- Mario: http://www.youtube.com/watch?v=8CTJL51UjHg
- 3D: http://www.youtube.com/watch?v=7Qrnwo01-8A
- Robot: http://www.youtube.com/watch?v=w8BmgtMKFbY



Google's Driverless Car

- The project leader is Sebastian Thrun who won the 2005 Grand Challenge.
- Worth $150000 USD including a $70000 LIDAR system which is a Velodyne 64-beam laser for generating detailed 3D map of its environment.
- As of July 2015, 14 minor traffic accidents are involved but the cars were either being manually driven or the driver of another vehicle was at fault.
- It drives over 2.4 million km(March, 2016) without any human intervention.
- On February 14, 2016, a Google self-driving car is "finally" involved in an accident when driving in autonomous mode
- It was licensed by Nevada department of motor vehicles in May 2012.
- Planned to commercialize between 2017 and 2020.



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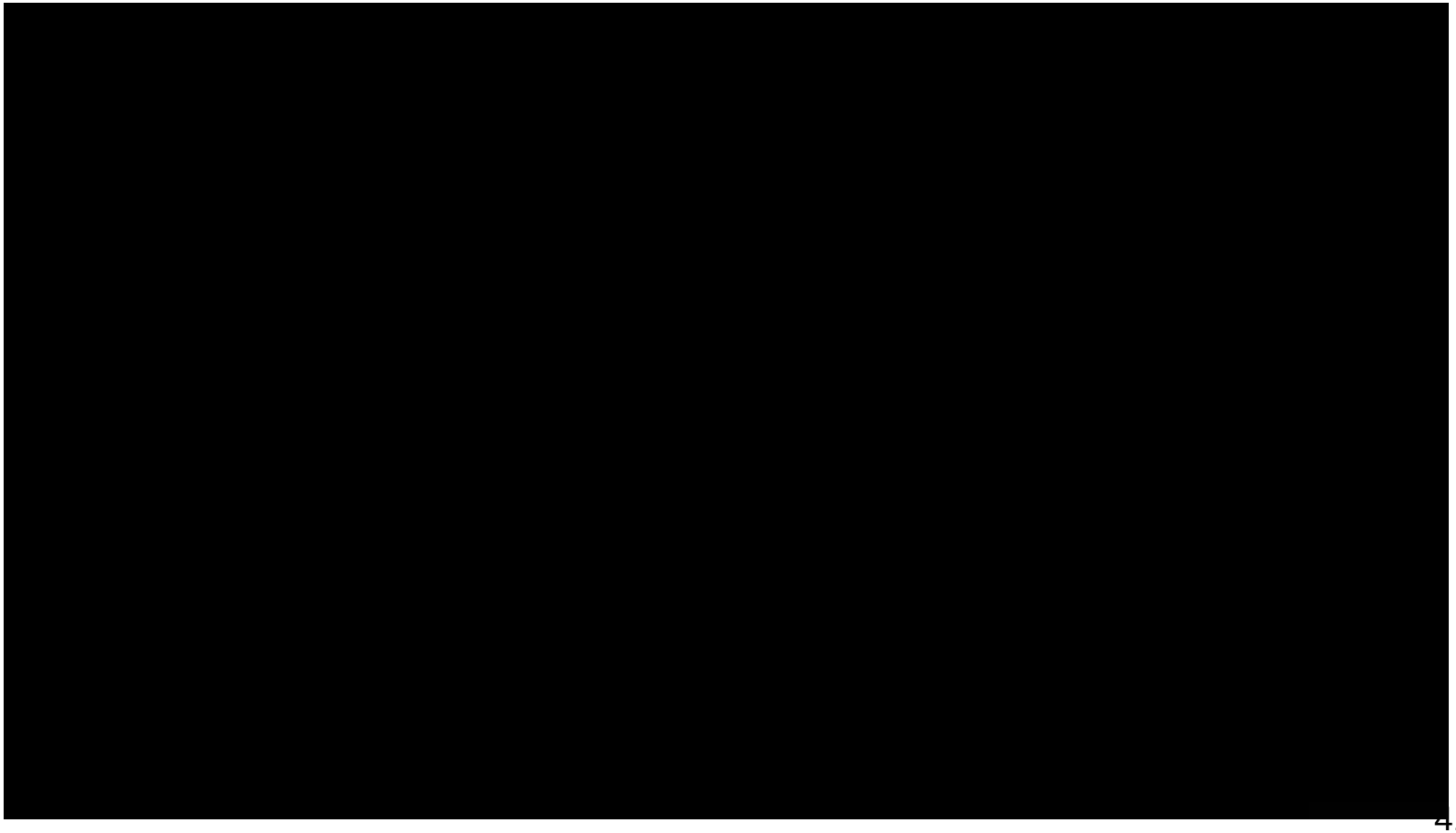
Google’s Driverless Car



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Vision in space

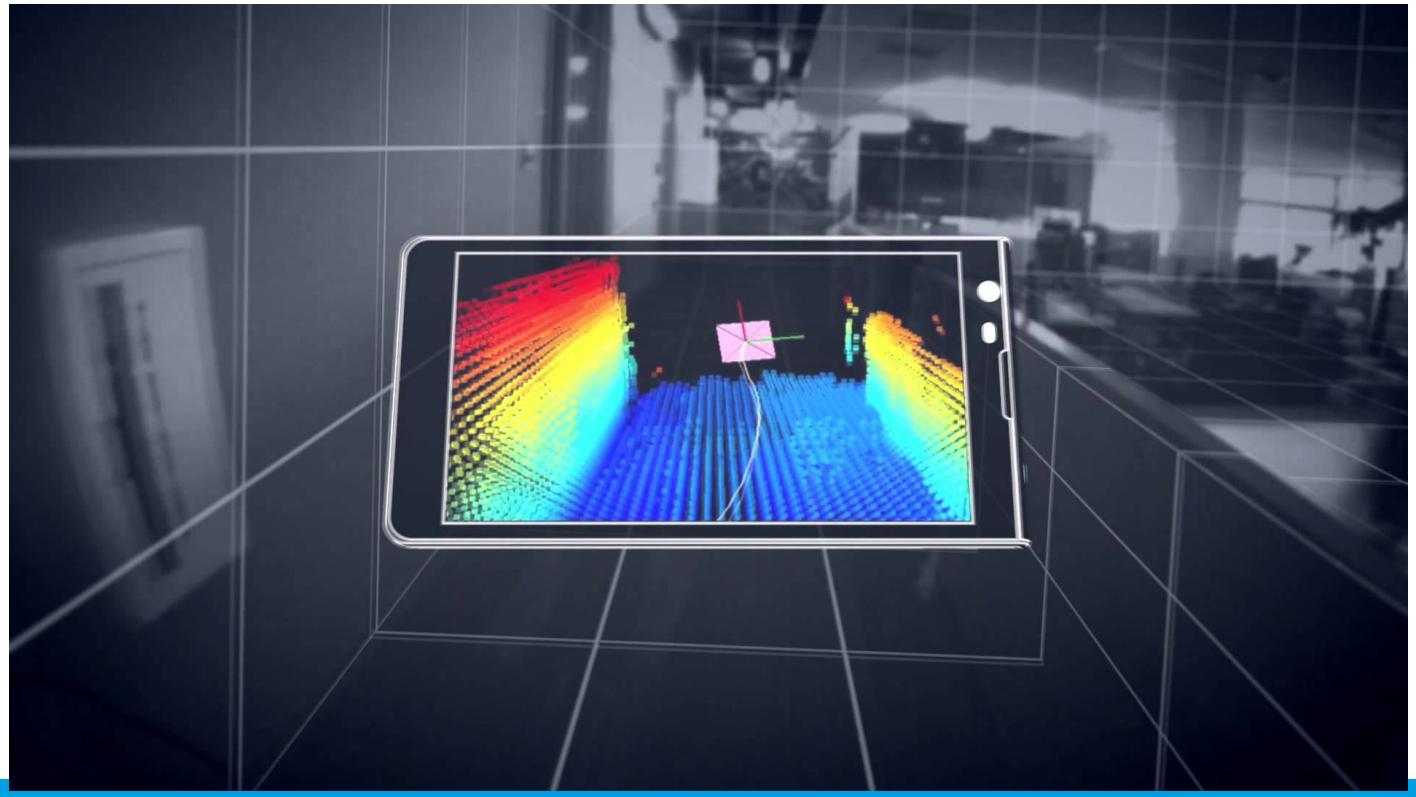
NASA'S Mars Exploration Rover Spirit captured this westward view from atop a low plateau where Spirit spent the closing months of 2007.

Vision systems (JPL) used for several tasks

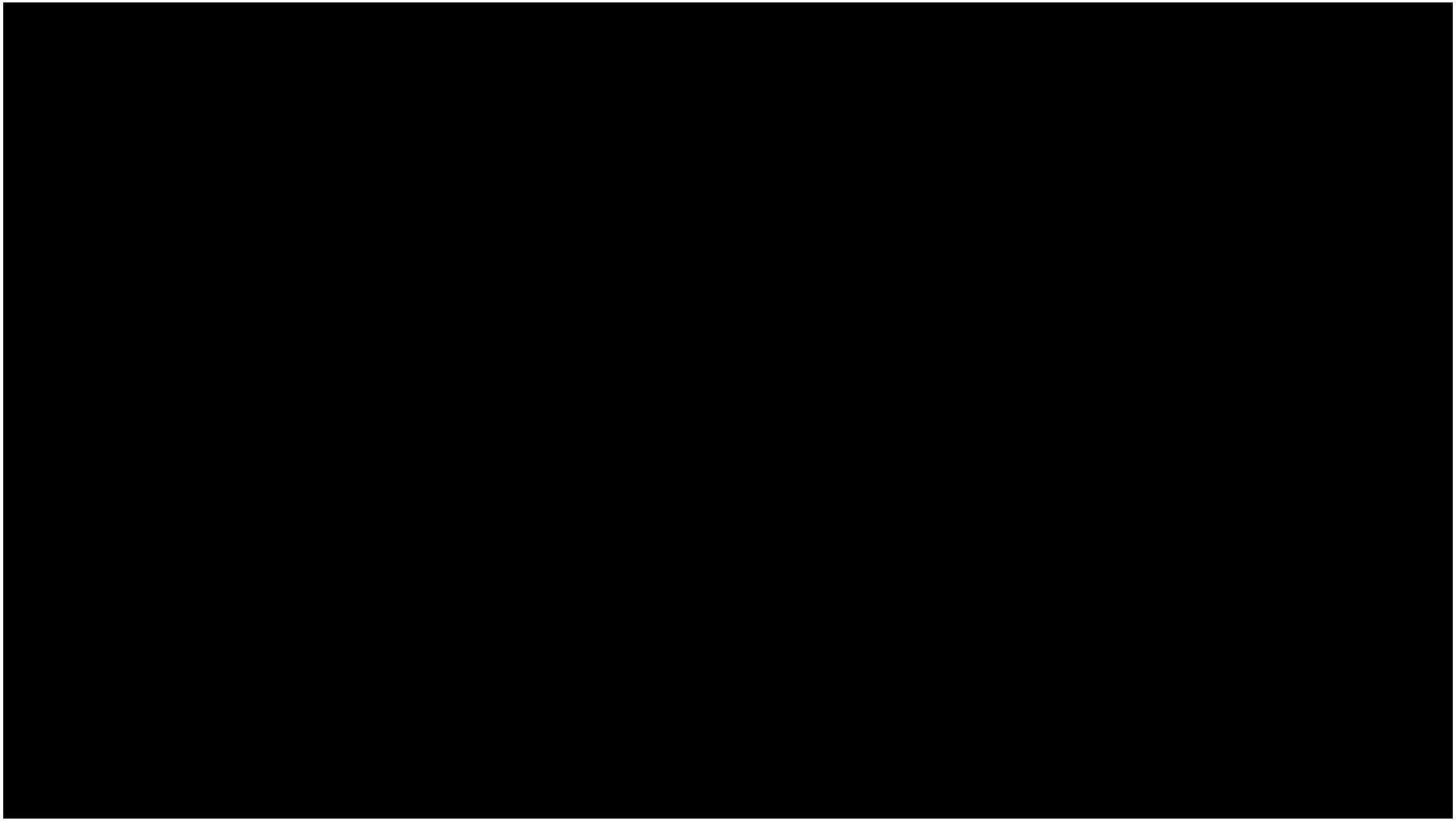
- Panorama stitching
- 3D terrain modeling
- Obstacle detection, position tracking
- For more, read “Computer Vision on Mars” by Matthies et al.

Project Tango

- Motion Tracking Camera+4MP camera + Integrated Depth Sensing = A device knowing the environment and how it moves through space.
- The result of technology partners and the developer community working hand in-hand to build something open and impactful.

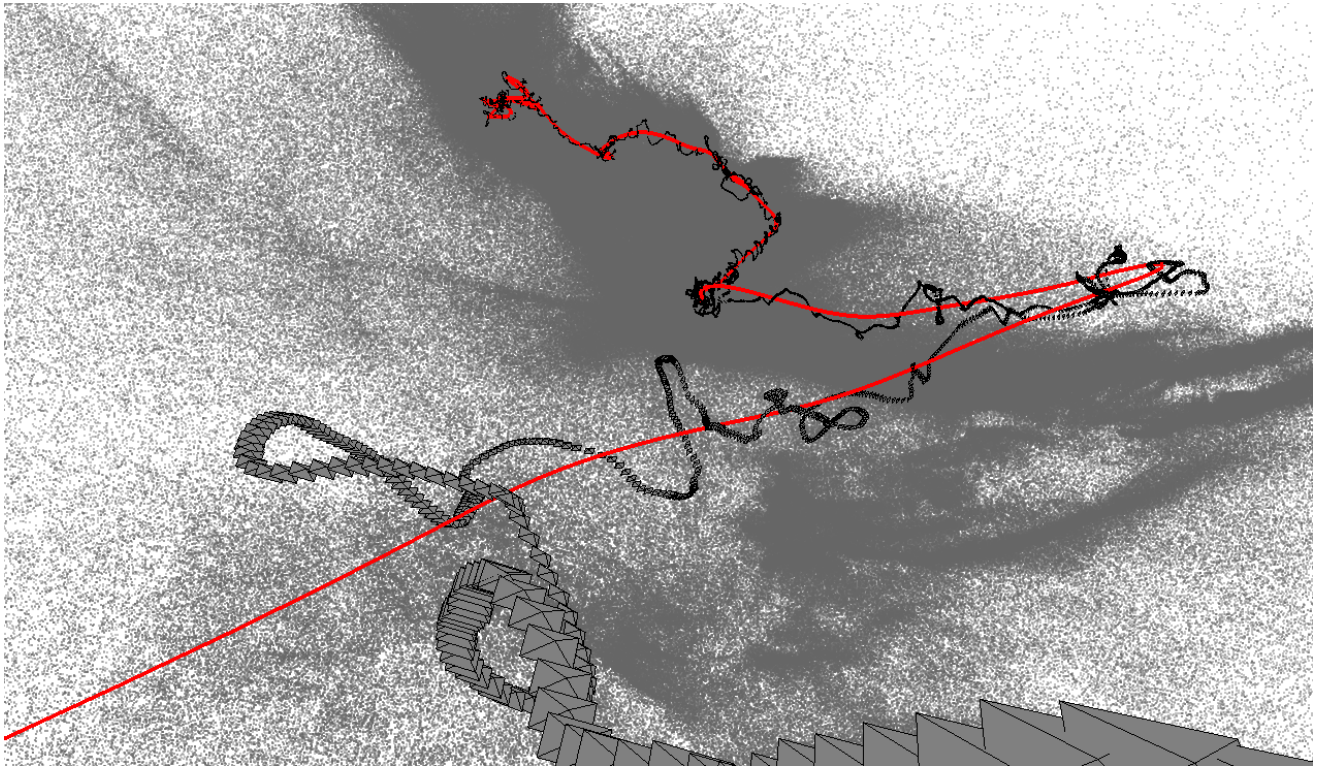


Demo Video



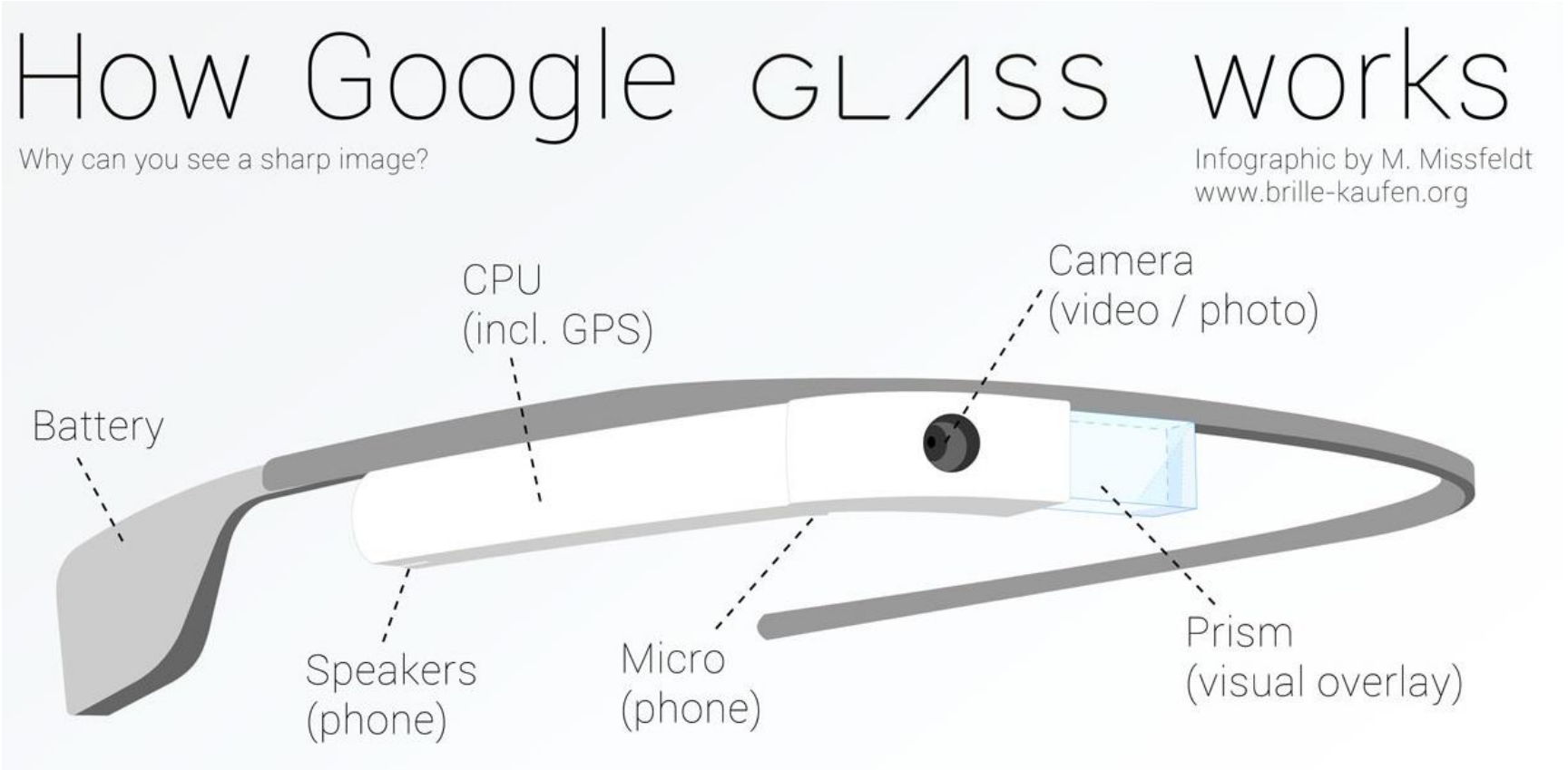
Microsoft Hyperlapse

- Image stabilization performed on video with high speed-up rate



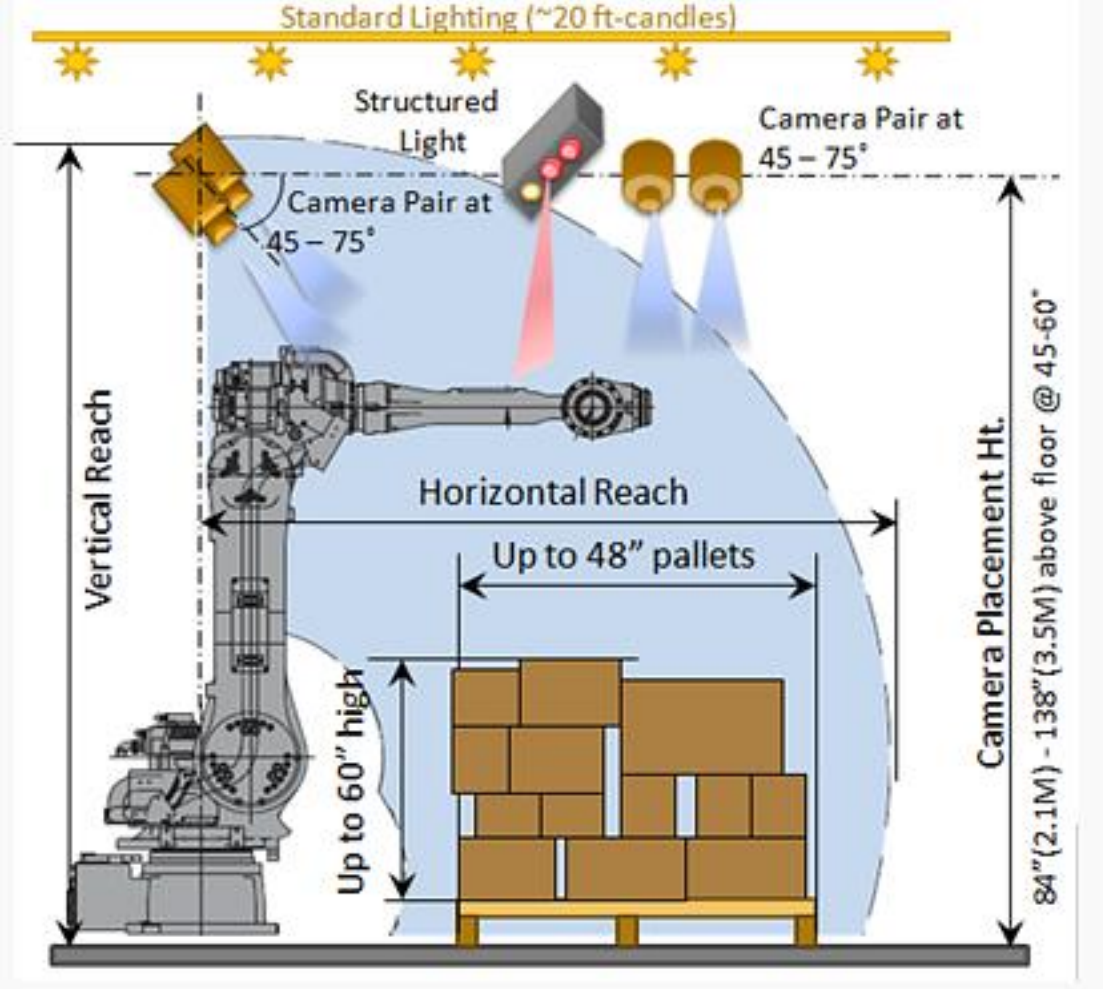
Demo Video

Wearable technology expected to integrate AR

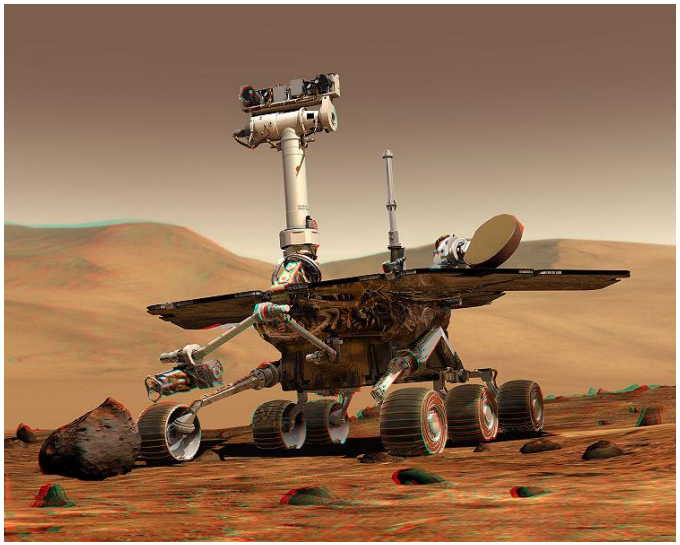


Demo Video

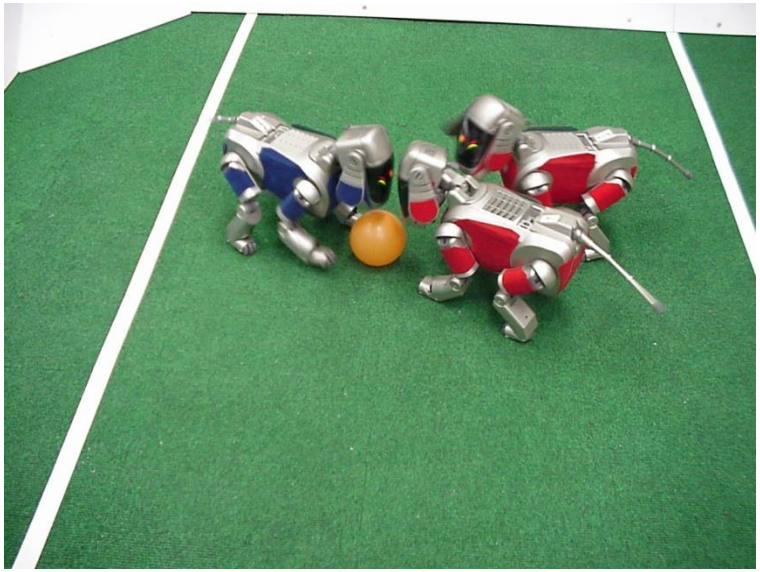
Industrial robots



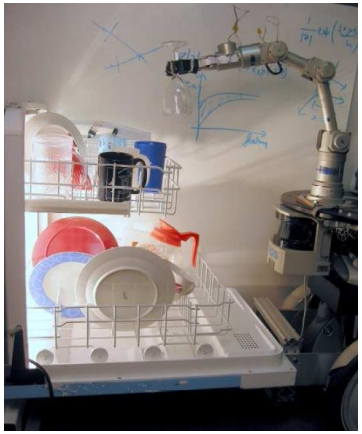
Mobile robots



NASA's Mars Spirit Rover
http://en.wikipedia.org/wiki/Spirit_rover

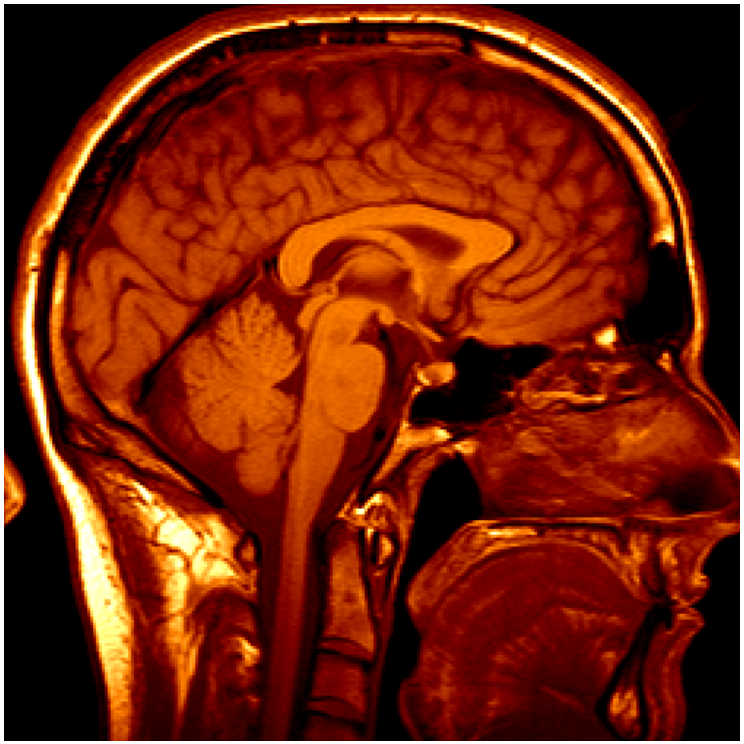


http://www.robocup.org/



Saxena et al. 2008
STAIR at Stanford

Medical imaging



3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT