Artificial Vision

Petia Ivanova Radeva

petia.ivanova@ub.edu

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You can find these slides in Campus Virtual

Theory teaching professor:

Petia Ivanova Radeva
(petia.ivanova@ub.edu)

Laboratory teaching professors:

Beatriz Remeseiro – grup a, Wednesday, 17-19:00h, ID
(bremeseiro@udc.es)

Petia Ivanova Radeva – grup f, Wednesday, 17-19:00h, IA
(petia.ivanova@ub.edu)

Mariella Dimiccoli – grup c, Thursday, 19-21:00h, IB
(mariella.dimiccoli@ub.edu)
Web page:

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Slides, laboratories, deliveries, forum and announcements

23:41

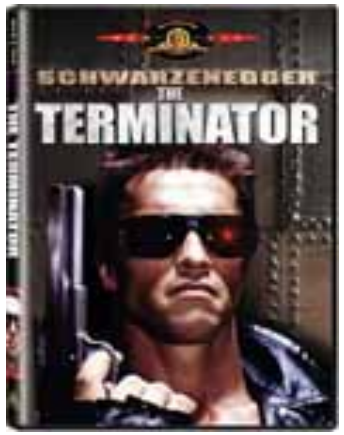
Today:

1. What is Artificial Vision?
2. A little bit of history
3. Main problems of Artificial Vision
4. Difficulties of the Artificial Vision
5. Applications
6. Subject organization

- Bibliography:
  - Szeliski, CV: A&A, Ch 1.0 (Introduction)

Computer Vision and the movies industry

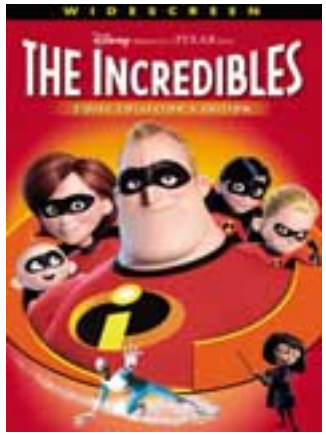
The Terminator (1984, USA)



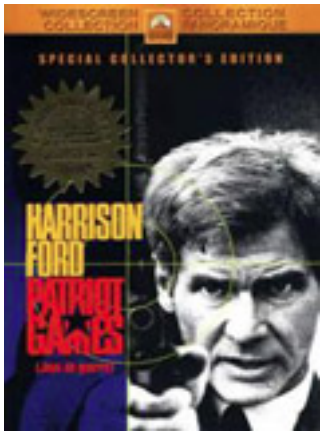
Minority report (2002, USA)

Charlie's Angels (2000, USA)

The Incredibles (2004, USA)



Patriot Games (1992, USA)



Person of interest (2007-2013, USA)

Robot and Franc(2012, USA)

OCR object recognition, tracking and improving vision.

Gesture recognition

Iris and fingerprint recognition

Satellite images of very high resolution are used for

recovering people and vehicles.

Face recognition

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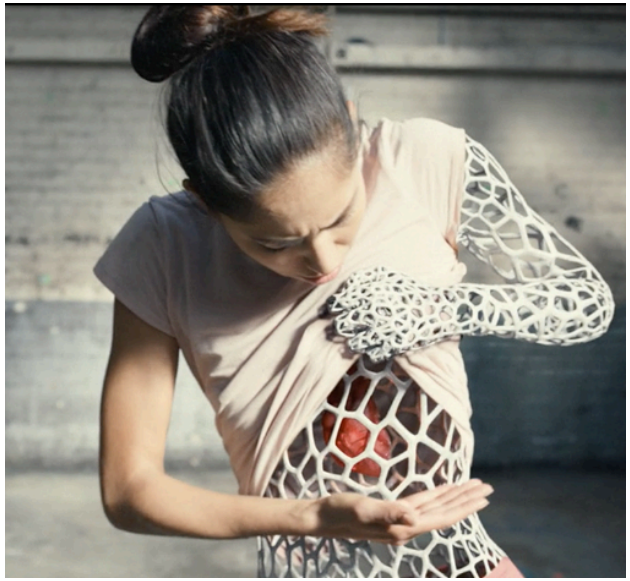
Computer Vision and Visual Effects



THE CHEMICAL BROTHERS
Wide Open

"Avatar"'2009

23:41

What is Artificial vision?

Computer vision is part of Artificial Intelligence.

It concerns with modeling and replicating human vision using computer software and hardware.

Formally, computer vision is a discipline that studies:

- how to perceive i.e. analyze, reconstruct and understand
- a 3D/4D scene from its 2D images or videos
- in terms of the properties of the structures and phenomena present in scene.

Terminator 2

Computer Vision

Make computers understand images and video.

- What kind of scene?
- Where are the cars?
- How far is the building?
- …

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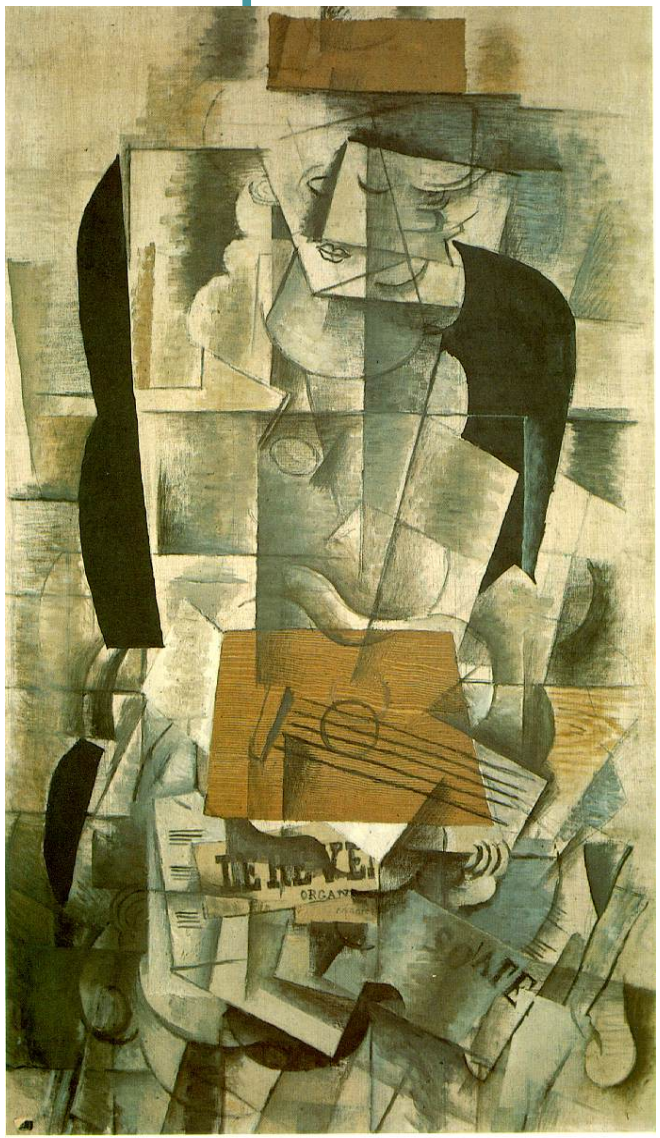
Vision is really hard

- Vision is an amazing feature of natural intelligence
  - More human brain devoted to vision than anything else

Measurement vs. Perception



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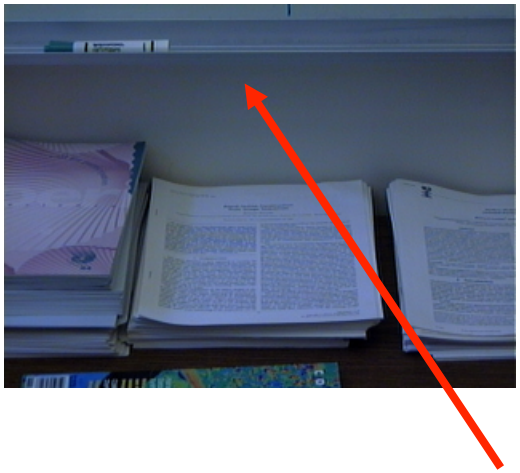
Vision: a split personality

- What does it mean, to see? The plain man's answer (and Aristotle's, too), would be, to know what is where by looking.
- "Vision is the process of discovering from images <u>what</u> is present in the world, and <u>where</u> it is." Marr



depth map

- Answer #1: *pixel of brightness 243 at position (124,54)*

  …and depth .7 meters
- Answer #2: *looks like bottom edge of whiteboard showing at the top of the image*

- **Which do we want?**

23:41– **Is the difference just a matter of scale?**

What is Computer Vision?

- *Vision* is about discovering from images what is present in the scene and where it is.

- In *Computer Vision* a camera (or several cameras) is linked to a computer.

  – The computer interprets images of a real scene to obtain information useful for tasks such as navigation, manipulation and recognition.

The problem

- Want to make a computer understand images
- We know it is possible – we do it effortlessly!

- Real world scene

- Sensing device

- Interpreting device

- Interpretation
  - Nature
  - A butterfly on rocks
  - Strange color painted stones
  - An artistic image

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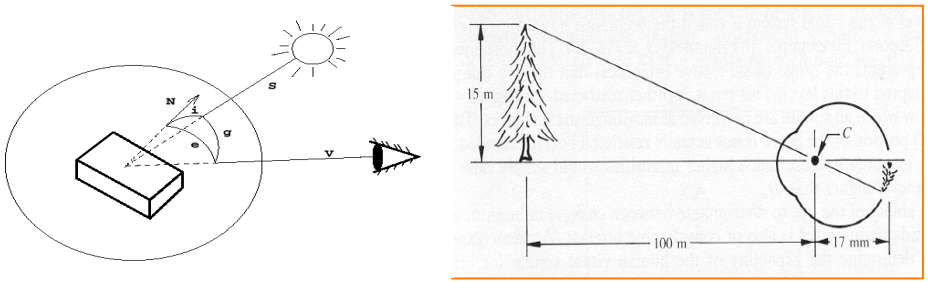
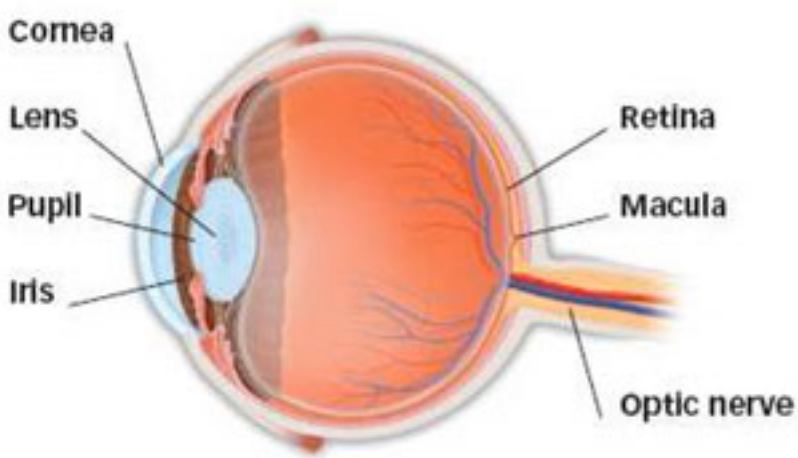
The Human Eye

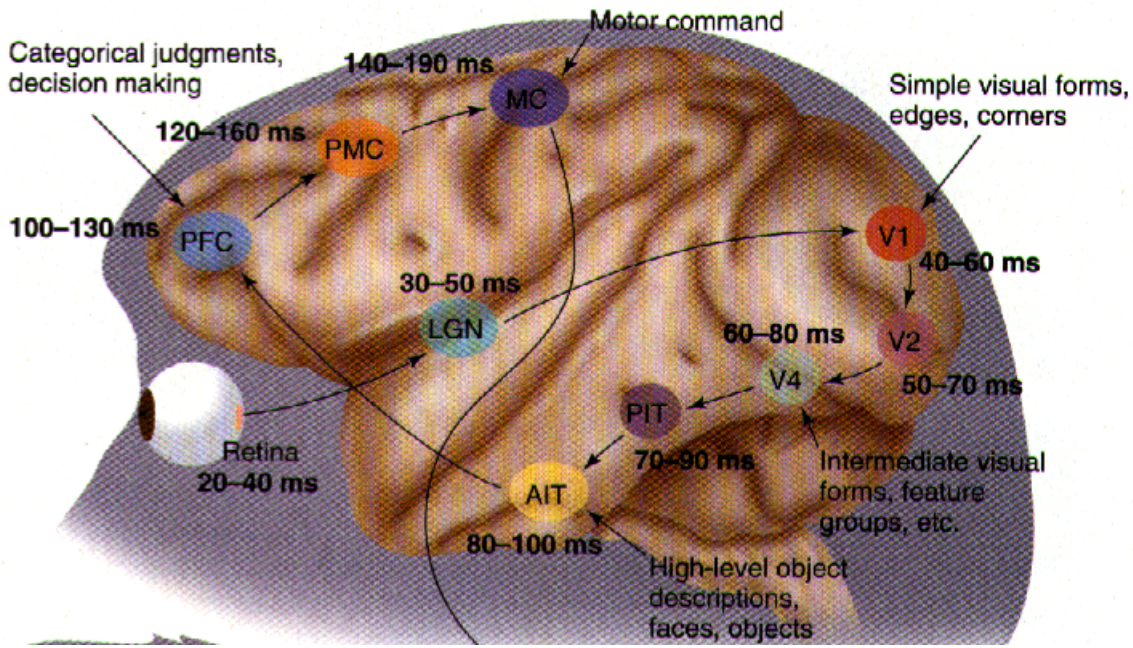
- Retina measures about 5 × 5 cm and contains 10^8 sampling elements (rods and cones).
- The eye's spatial resolution is about 0.01° over a 150° field of view.
- Intensity resolution is about 11 bits/element, spectral range is 400–700nm.
- Temporal resolution is about 100 ms (10 Hz).
- Two eyes give a data rate of about 3 GBytes!





Human visual system

- Vision is the most powerful of our own senses.



•[Thorpe et. al.]

- Around 1/3 of our brain is devoted to processing the signals from our eyes.

- The visual cortex has around O(10^{11}) neurons.

Why don't we just copy the human visual system?

- People try to but we don't yet have a sufficient understanding of how our visual system works.

- $O(10^{11})$ neurons used in vision

- By contrast, latest CPUs have $O(10^{9})$ transistors (most are cache memory).

- Very different architectures:
  - Brain is slow, but parallel.
  - Computer is fast, but mainly serial.

- Bird vs Airplane
  - Same underlying principles.
  - Very different hardware.

Why to study it?

- Gain insight into how we see
  - Vision is explored extensively by neuroscientists to gain an understanding of how the brain operates

- Replicate human vision to allow a machine to see:
  - Central to that problem of Artificial Intelligence
  - Many industrial and real life human-centric applications

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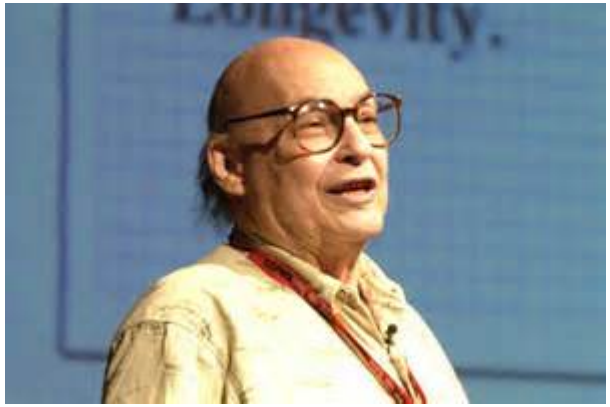
The Vision Story Begins…

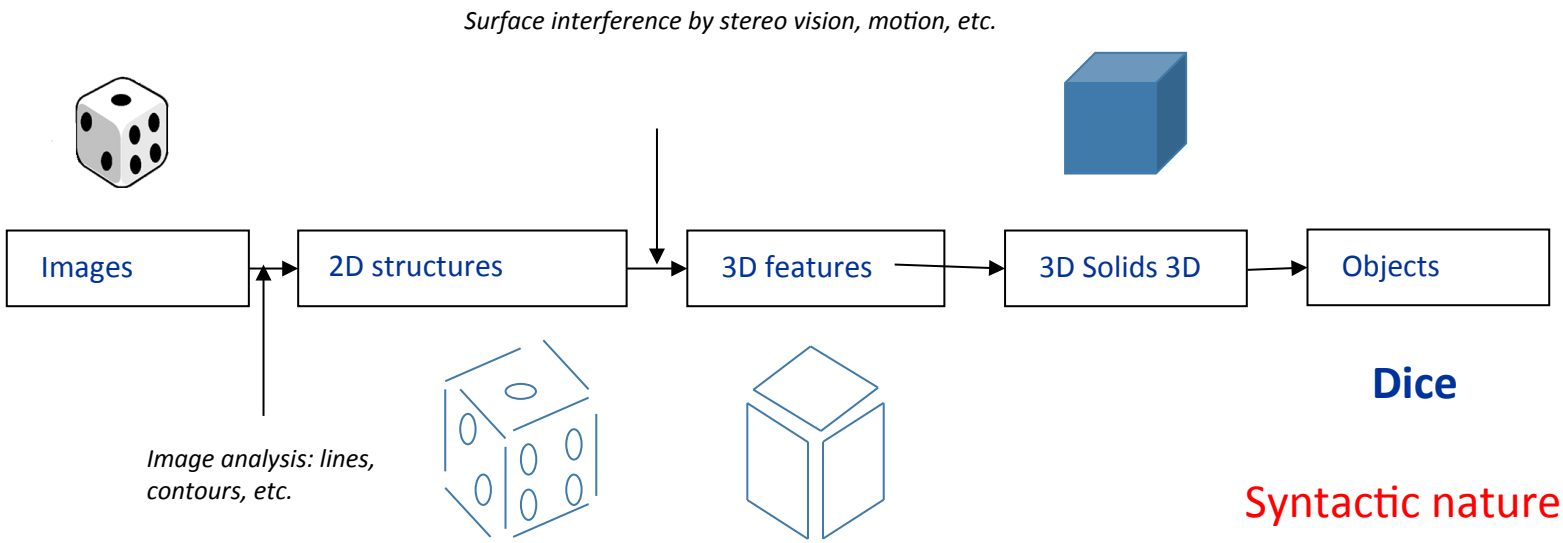
•In 1966, Marvin Minsky at MIT asked his undergraduate student Gerald Jay Sussman to "spend the summer linking a camera to a computer and getting the computer to describe what it saw".



•We now know that the problem is slightly more difficult than that. (Szeliski 2009, Computer Vision)

Mar's Historical definition

Q: How to answer:
What is this?
R: By a sequence of data transformations.



Dice

Syntactic nature

Historical definitions...

The mechanism that allows visual perception is the OPTICAL INVERSE ENGINEERING!

"Processing visual information is syntactic in nature (and consists of a set of modules that reconstruct general descriptions of the scene)."

"The semantics should be treated in a purely symbolic way as a result of the syntactic analysis."

David Marr, Vision, Freeman, 1982.

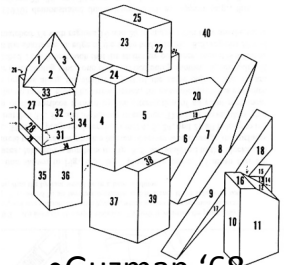
Vision...

But the environment is complex...

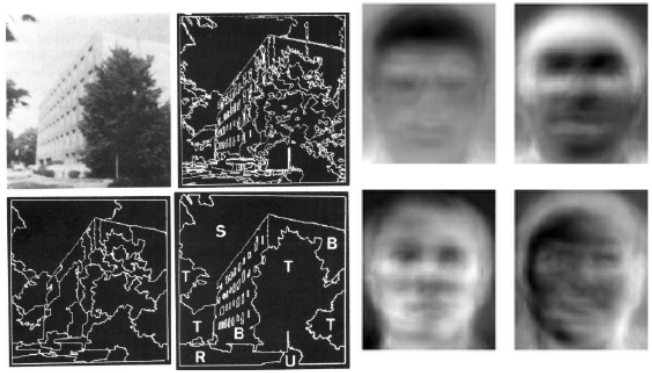
...not accessible, continuous, dynamic and non determinist. And this is a BASIC component of the problem...

Ridiculously brief history of computer vision

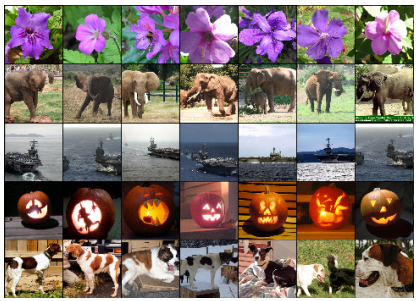
- 1966: Minsky assigns computer vision as an undergrad summer project
- 1960's: interpretation of synthetic worlds
- 1970's: some progress on interpreting selected images
- 1980's: ANNs come and go; shift toward geometry and increased mathematical rigor
- 1990's: face recognition; statistical analysis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



•Guzman '68



•Ohta Kanade '78 •Turk and Pentland '91



Imagenet: 15 mlln of images

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Each image tells a story…

- The aim of the Artificial vision is to write programs to interpret images, and perceive the story behind the image
  - Get the properties of the real world as 3D, names of persons or objects, etc.?!

Can computers beat the men?

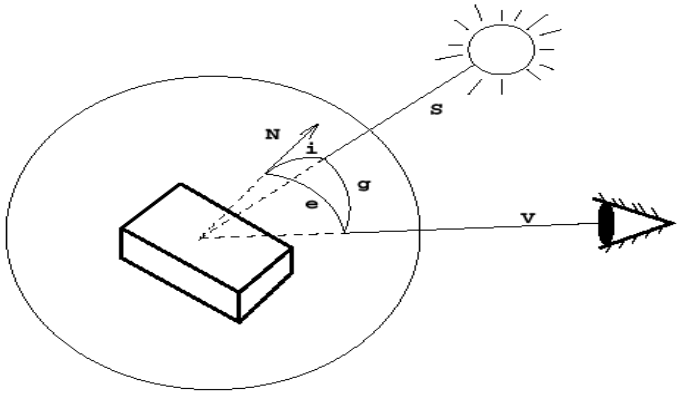
Yes and no (mostly not!)

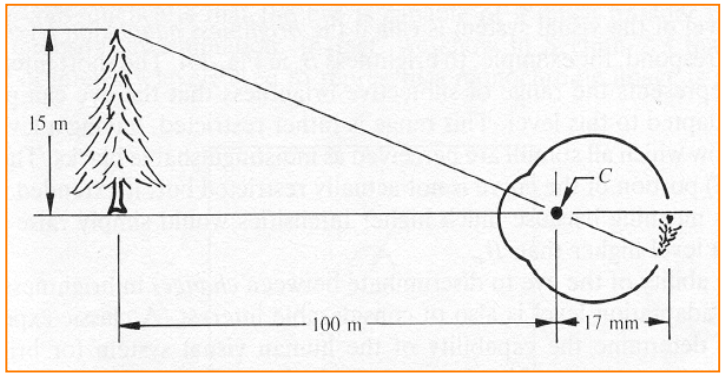
- Humans are better at "hard" things
- Computers are better at "easy" things

Computer Vision: A whole series of problems

- What is in the image ?
  - •- Object recognition problem
- Where is it ?
  - •- 3D spatial layout
  - - Shape
- How is the camera moving ?
- What is the action ?

Image is a projection of the world

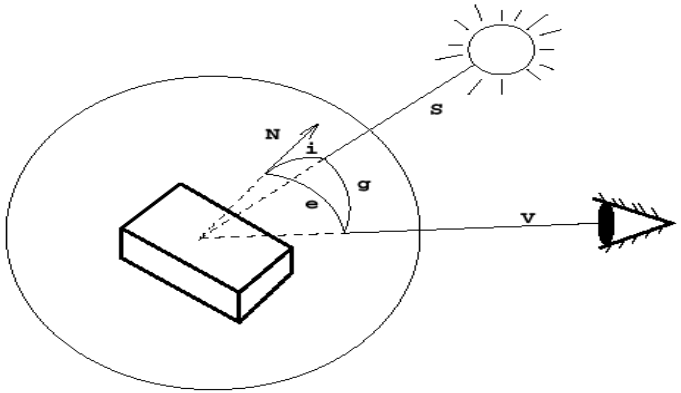


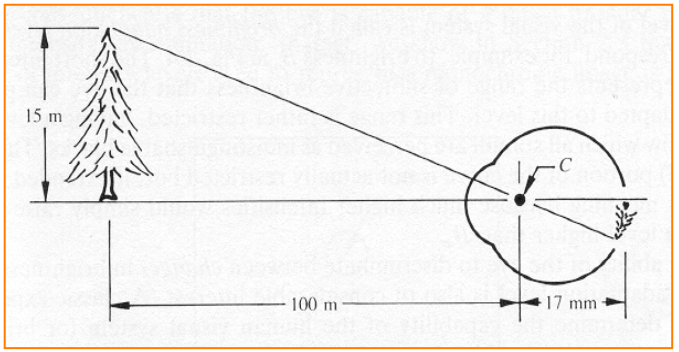


A point of the scene corresponds to one and only one point in the image,

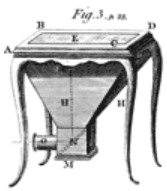
but a point of the image may correspond to infinite points of the scene (3D world).

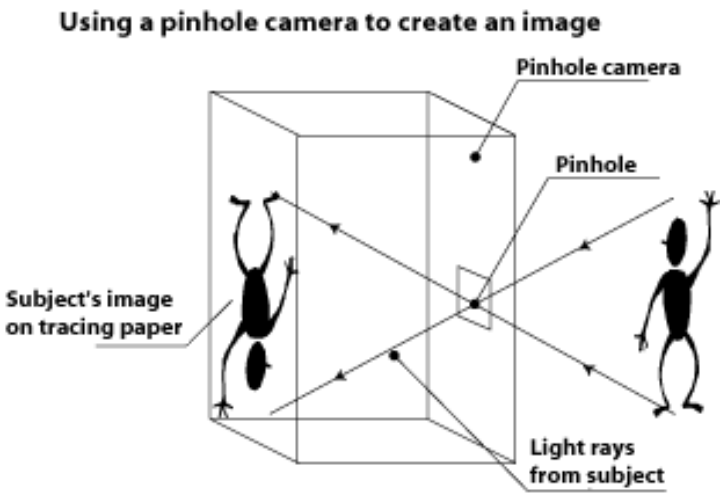
Image is a projection of the world





Pinhole camera





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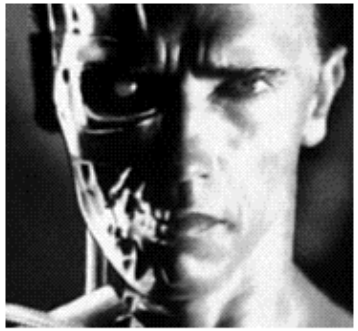
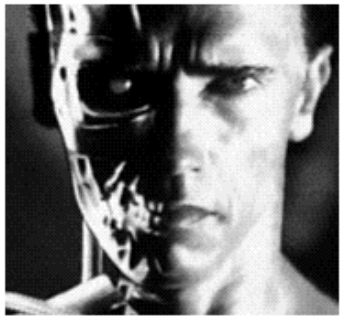
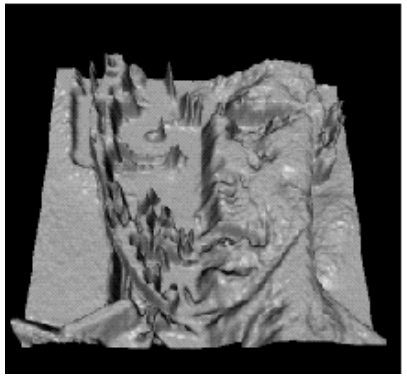
Computer Vision bridges the gap between pixels and "meaning"





- What we see

0	3	2	5	4	7	6	9	8
3	0	1	2	3	4	5	6	7
2	1	0	3	2	5	4	7	6
5	2	3	0	1	2	3	4	5
4	3	2	1	0	3	2	5	4
7	4	5	2	3	0	1	2	3
6	5	4	3	2	1	0	3	2
9	6	7	4	5	2	3	0	1
8	7	6	5	4	3	2	1	0

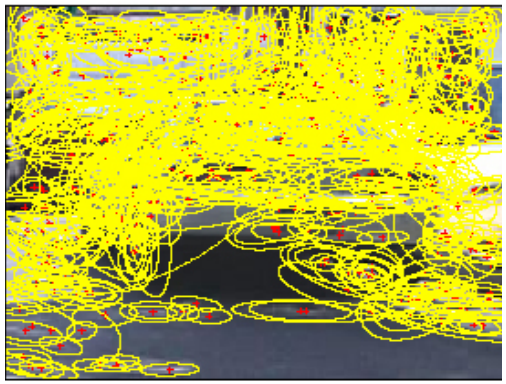


- What a computer sees

CV problems: Low-Level Feature extraction

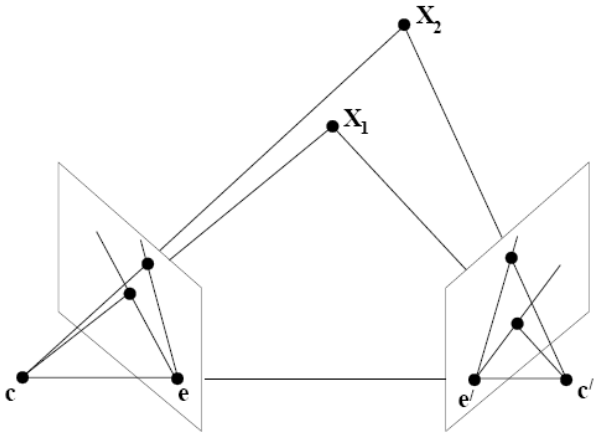
- Edges, corners

- Local regions

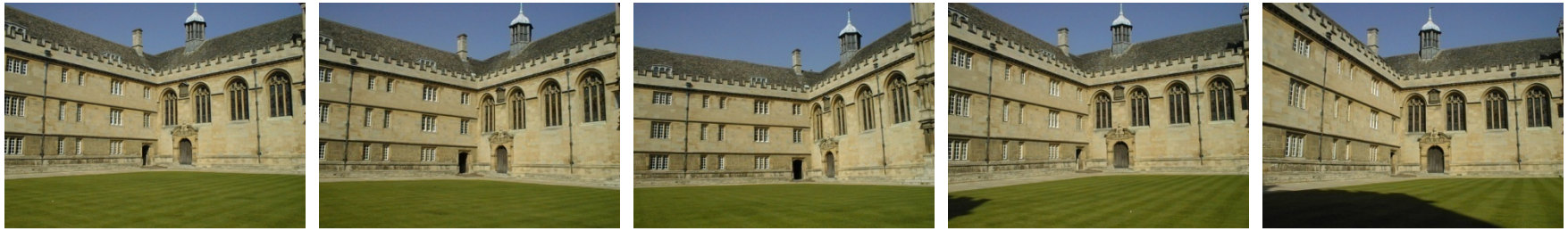


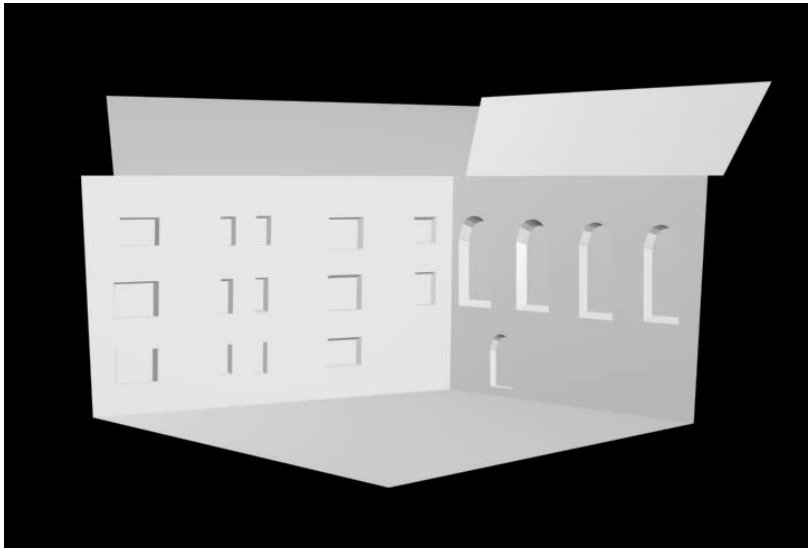
CV problems: Stereo Vision

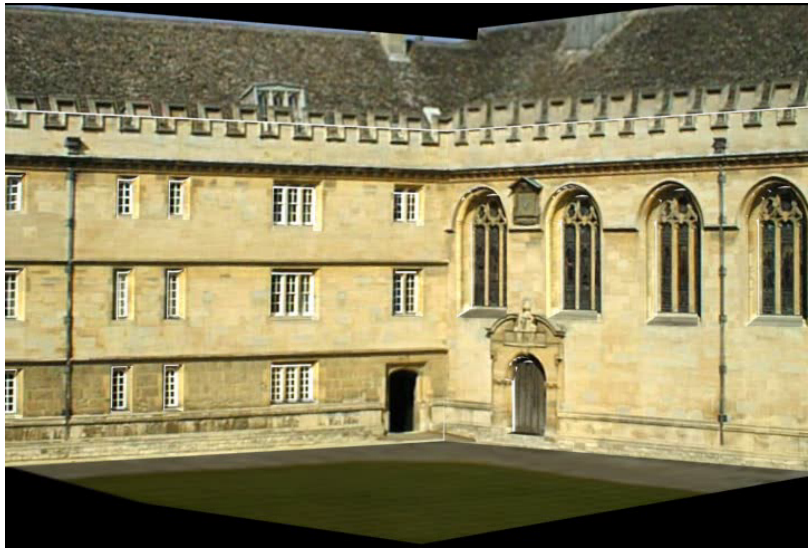
- By having two cameras, we can triangulate features in the left and right images to obtain the depth to the 3D point.
- Need to match features between the two images:
  - Correspondence Problem



CV problems: Geometry:
•3D models of planar objects







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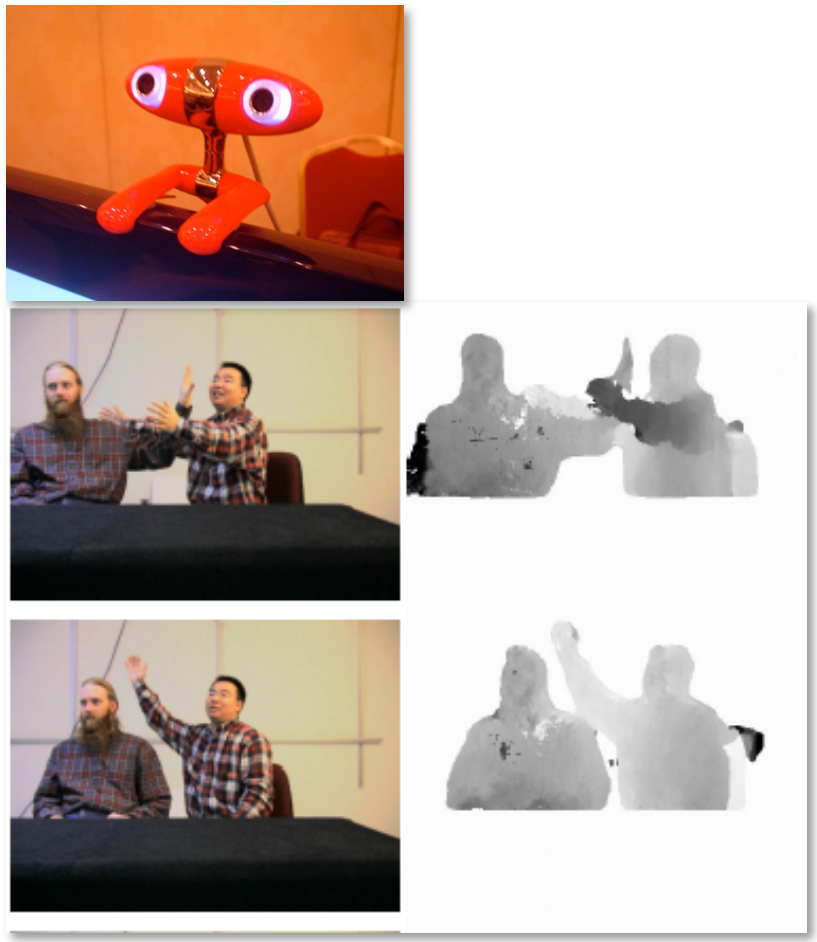
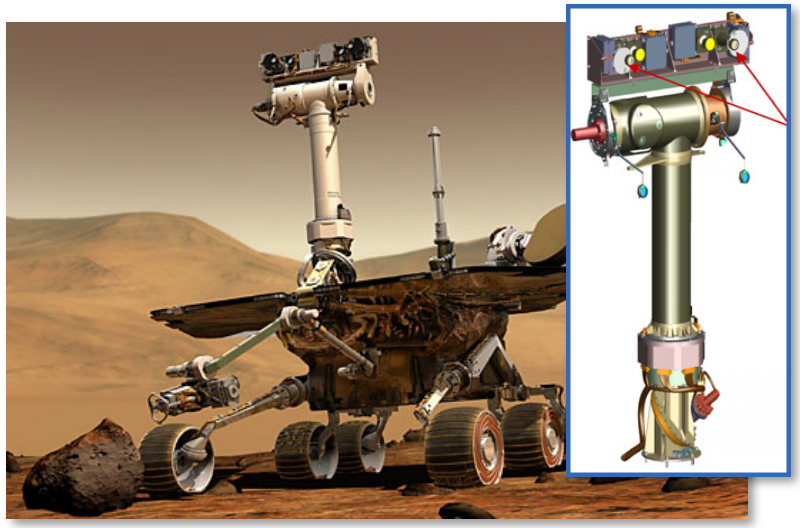
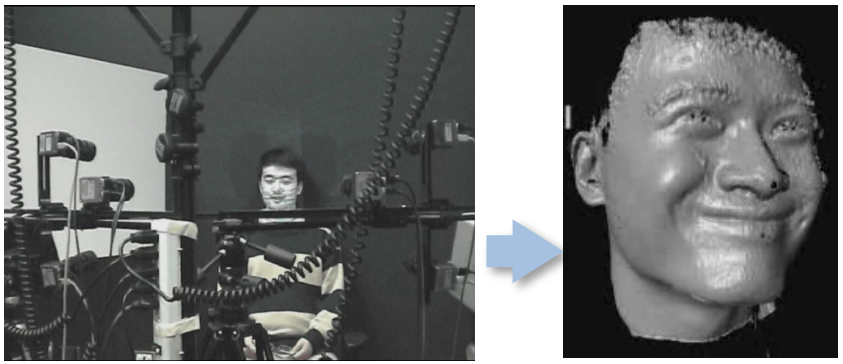
- [Fitzgibbon et. al]
- [Zisserman et. al.]

CV problems: 3D reconstruction by a Kinect







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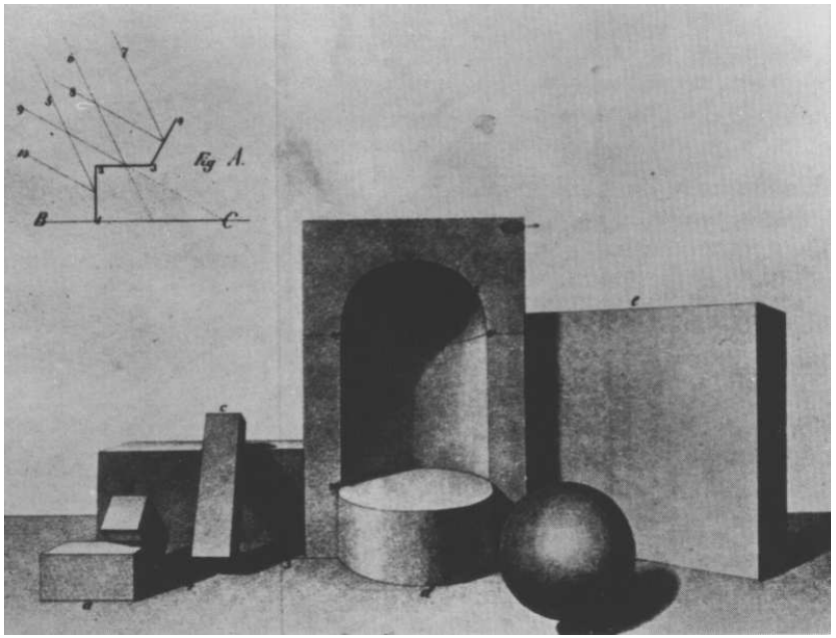
Get the 3D shape of the objects

CV problems: Shape from Shading

- Recover scene structure from shading in the image



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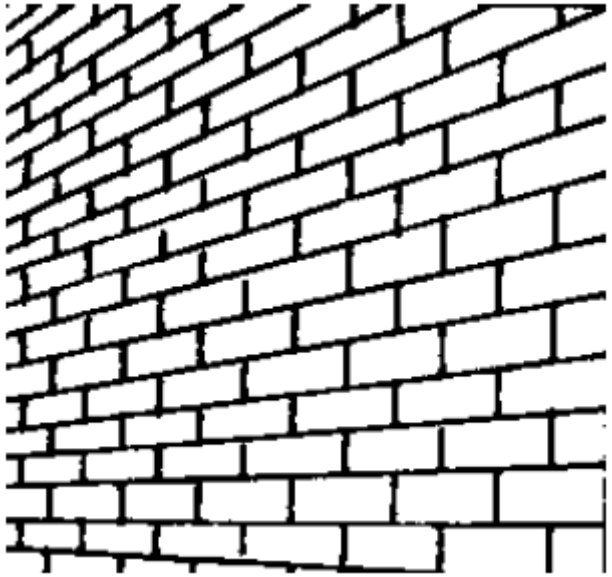
CV problems: Shape from Texture

- Texture provides a very strong cue for inferring surface orientation in a single image.
  - Necessary to assume homogeneous or isotropic texture.
  - Then, it is possible to infer the orientation of surfaces by analyzing how the texture statistics vary over the image.



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CV problems: Augmented reality

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CV problems: Segmentation

- Image

- Segmentation

23:41

CV problems: Scene interpretation from limited cues

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CV problems: Human motion detection

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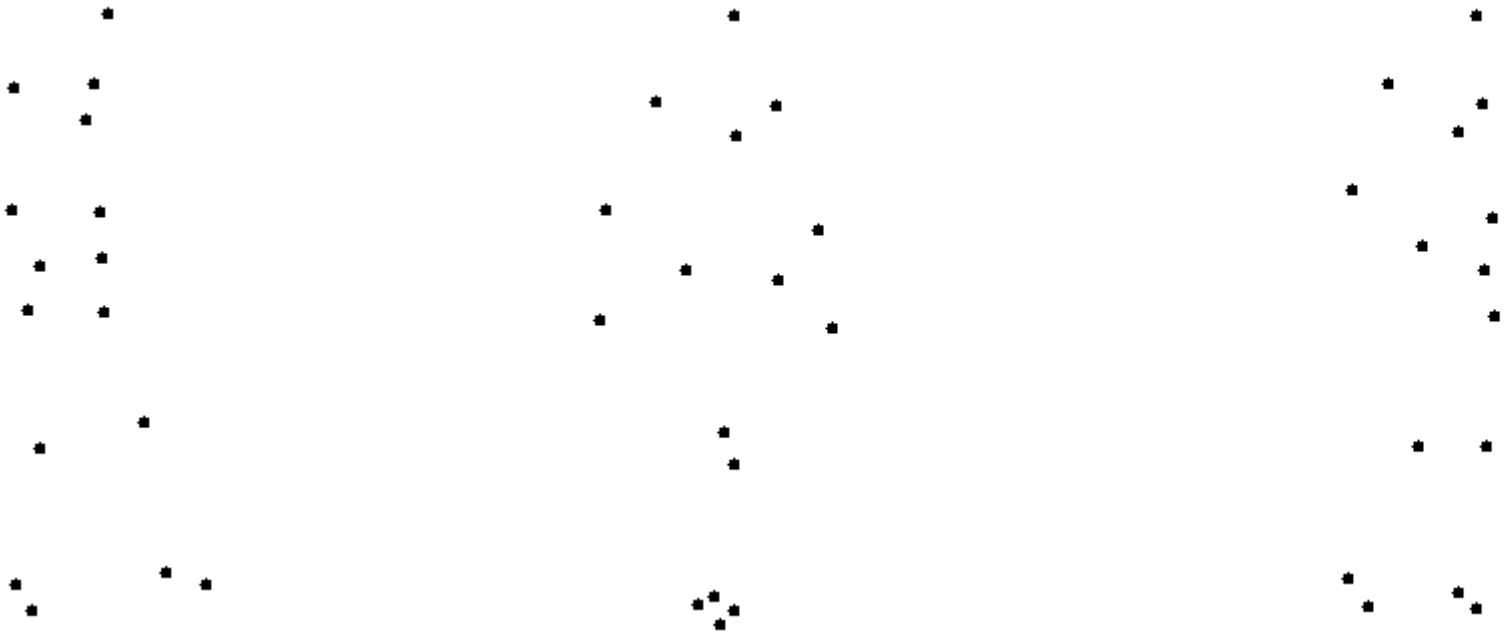
Johansson's experiments ['70s]



https://www.youtube.com/watch?v=1F5ICP9SYLU

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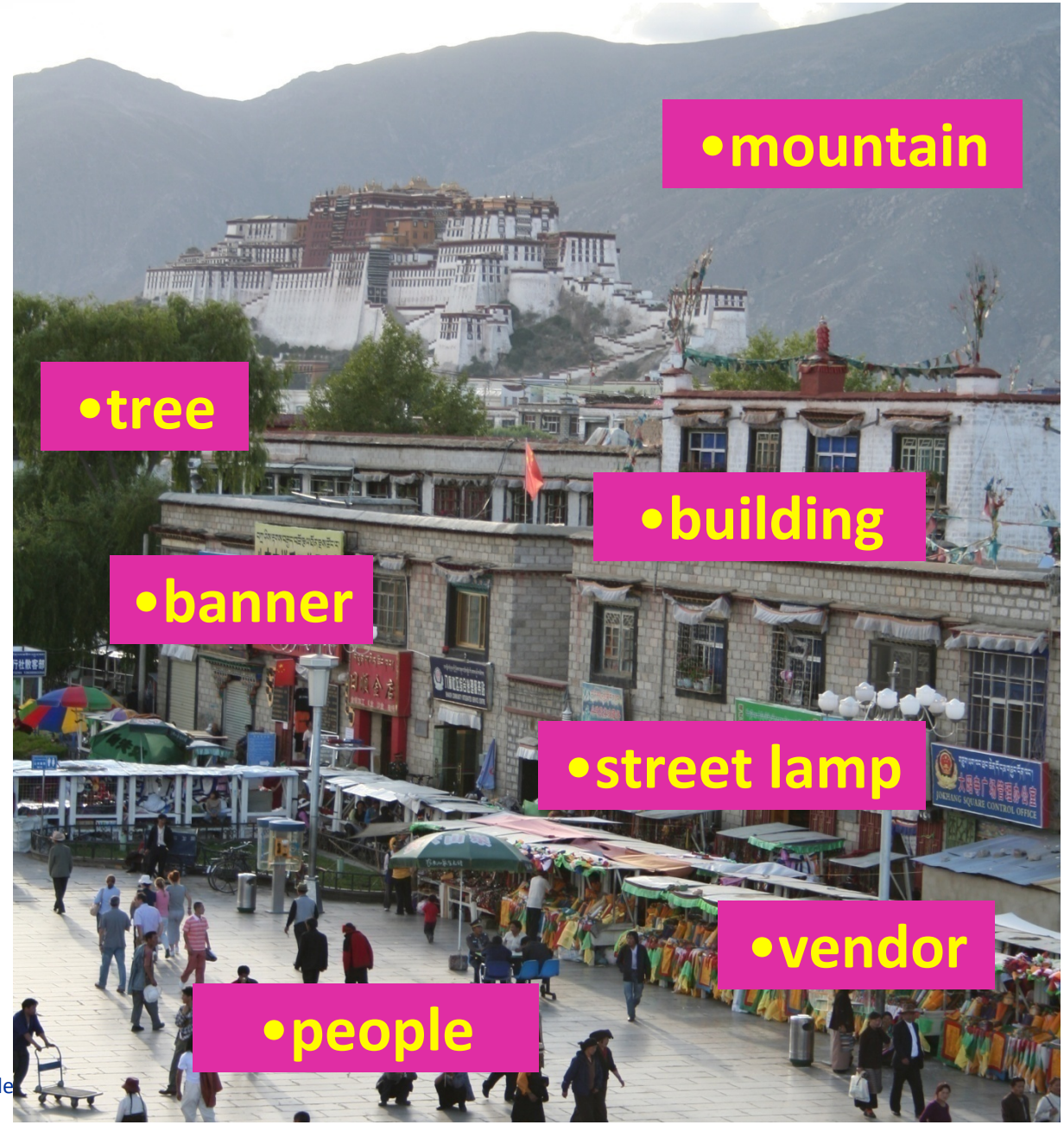
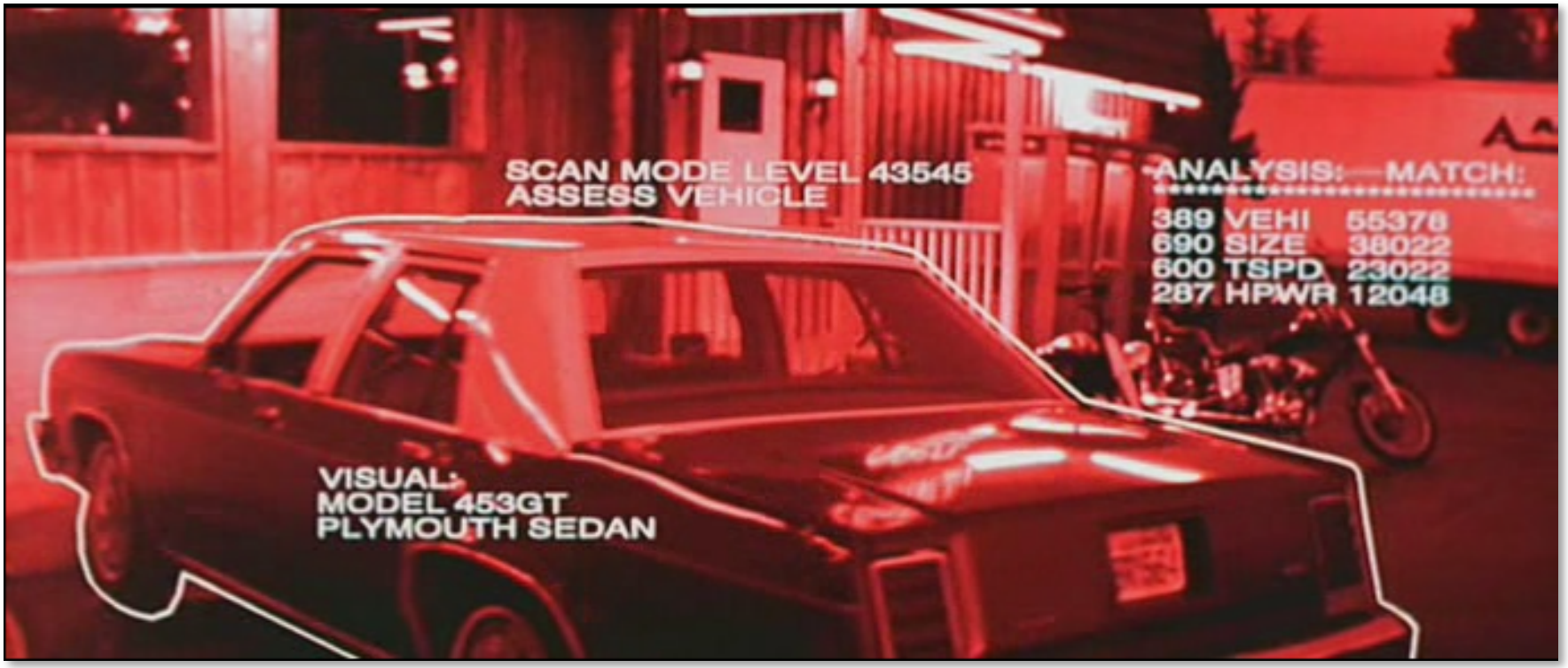
CV problems: Object detection

Object categorization



Object and person recognition



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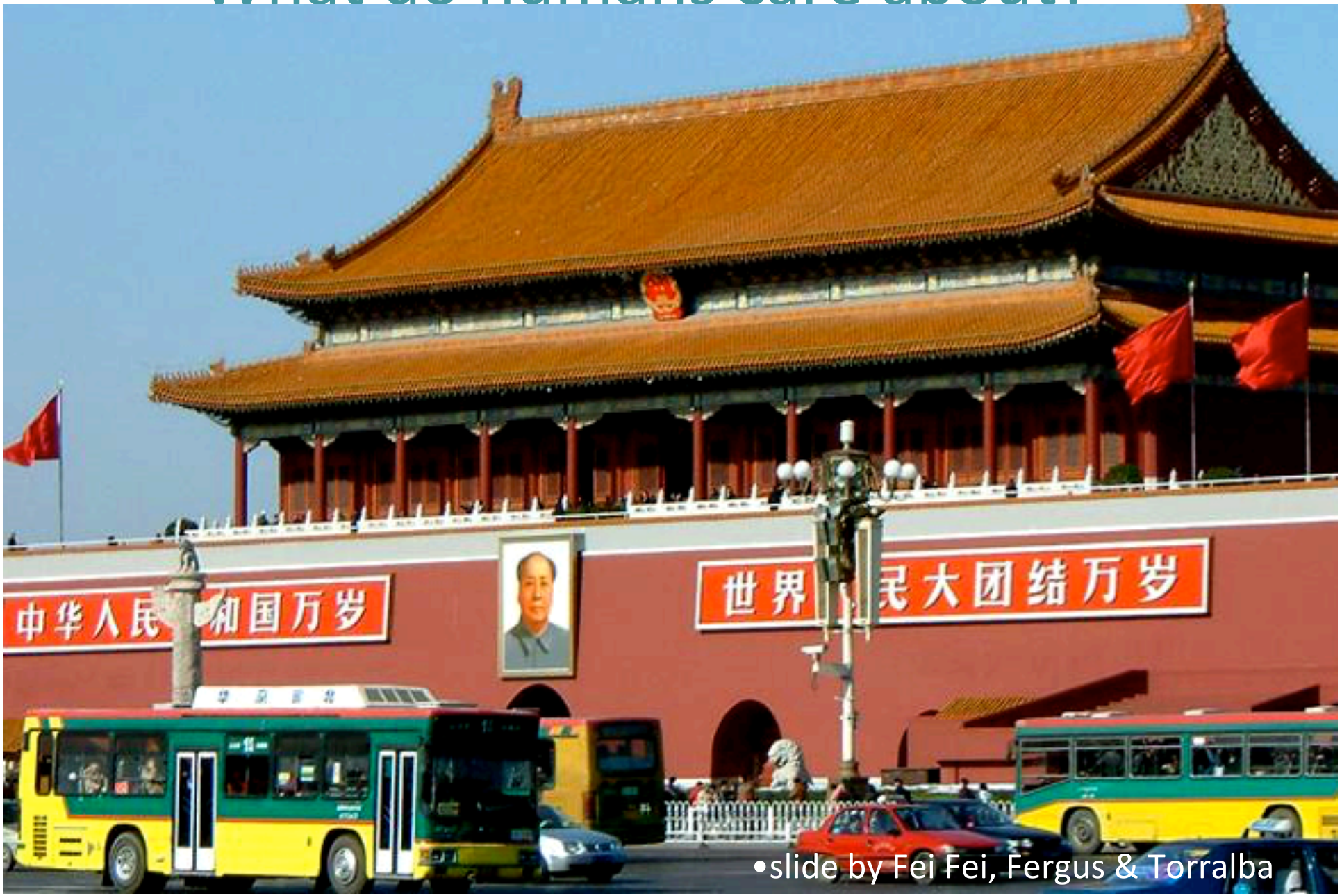
What do humans care about?



•slide by Fei Fei, Fergus & Torralba

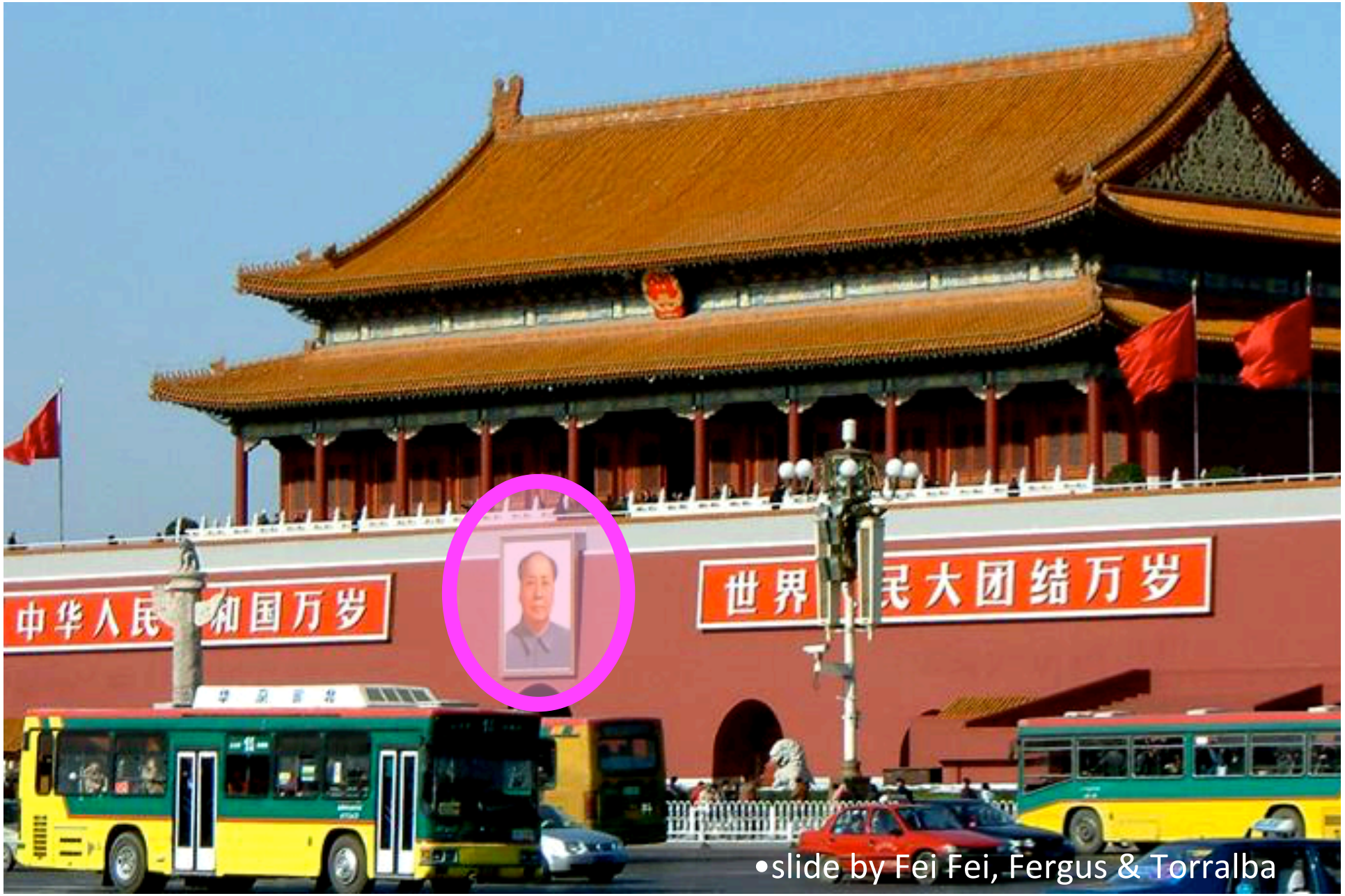
Verification: is that a bus?

•slide by Fei Fei, Fergus & Torralba

Detection: are there cars?

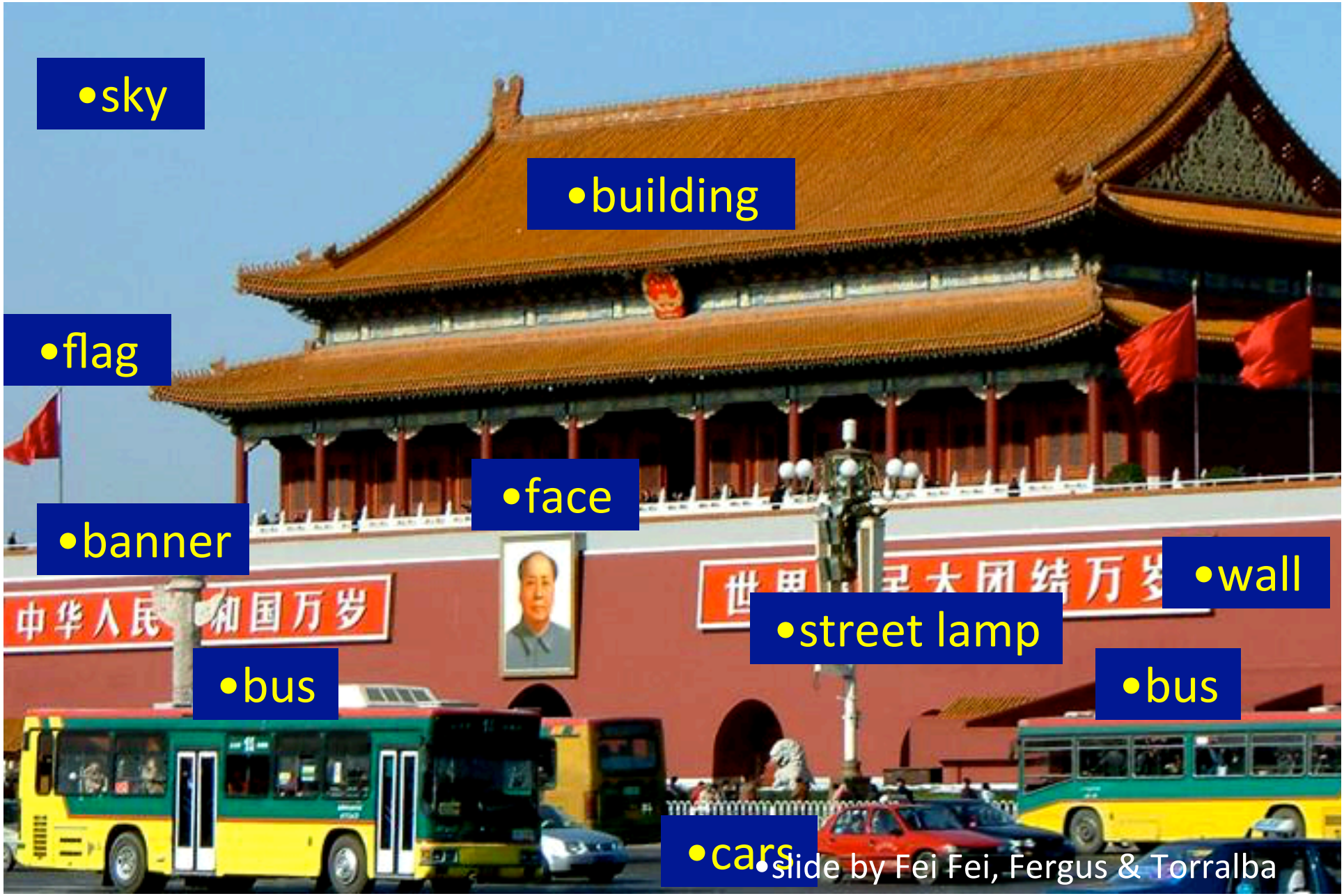
•slide by Fei Fei, Fergus & Torralba

Identification: is that a picture of Mao?



•slide by Fei Fei, Fergus & Torralba

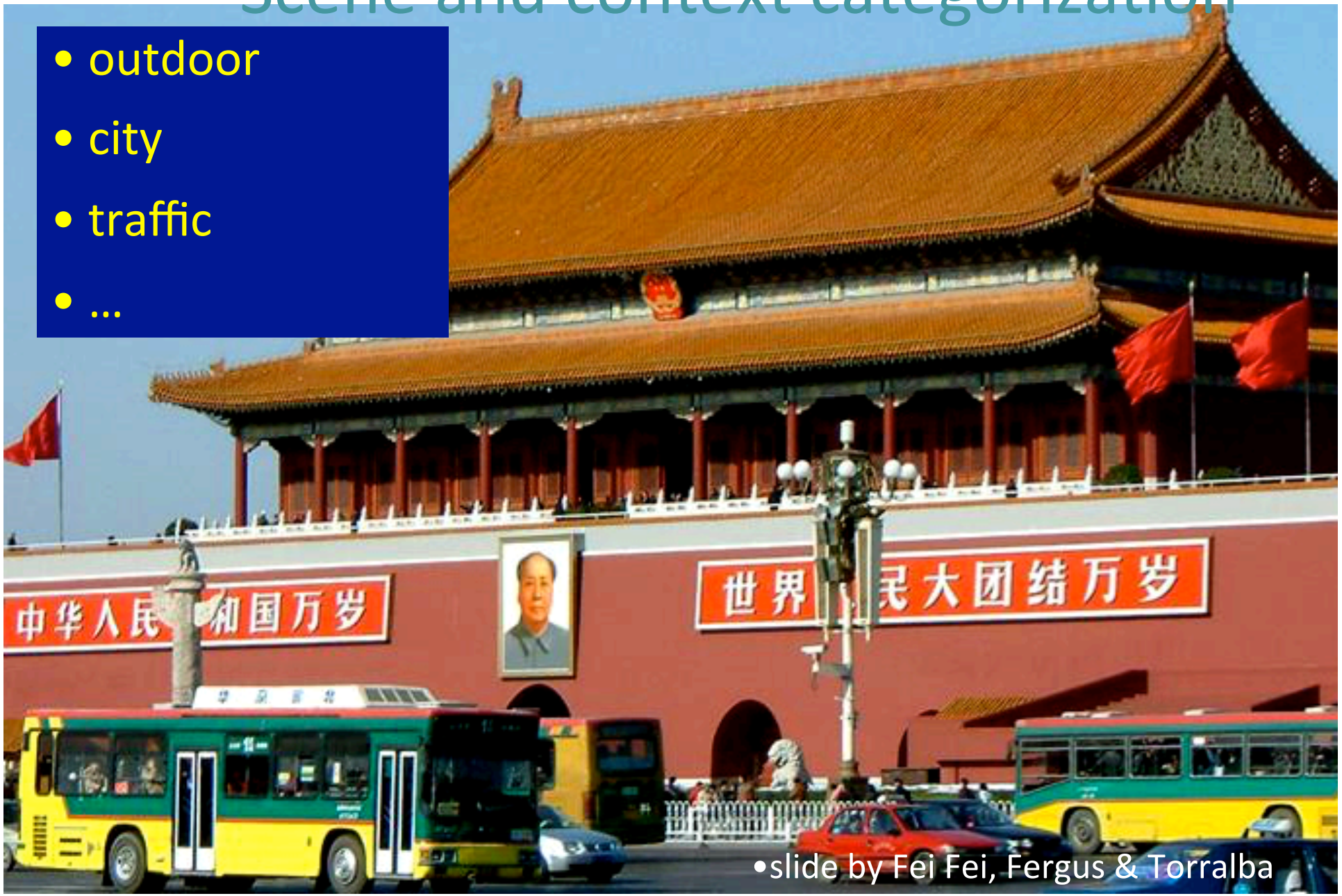
Object categorization



•slide by Fei Fei, Fergus & Torralba

Scene and context categorization

- outdoor
- city
- traffic
- …



•slide by Fei Fei, Fergus & Torralba

Rough 3D layout, depth ordering

•slide by Fei Fei, Fergus & Torralba

Today:

1. What is Artificial Vision?
2. A little bit of history
3. Main problems of Artificial Vision
4. Difficulties of the Artificial Vision
5. Applications
6. Subject organization

- Bibliography:
  - Szeliski, CV: A&A, Ch 1.0 (Introduction)

Why is it hard?

- Variation of point of view

- Illumination

- Scale

Why is it hard?

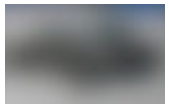
•Intra-class variation

•Movement(Font: S. Lazebnik)

•Cluttered background

•Occlusion

Why is it hard?



- Local ambiguity

- slide credit: Fei-Fei, Fergus & Torralba

Some things know that you have eyes

- Brady, M. J., & Kersten, D. (2003). Bootstrapped learning of novel objects. J Vis, 3(6), 413-422

Bottom-up data analysis

- The problem is the ambiguity of the implicit perception
  - Many 3D scenes can give the same 2D scene

We need information about the World in order to unambiguate the images.

Image source: F. Durand

Is the human perception perfect?

Sinha and Poggio, *Nature*, 1996

- We still don't understand completely the perception in order to simulate/model/copy it

23:41

Why is the Artificial vision hard?

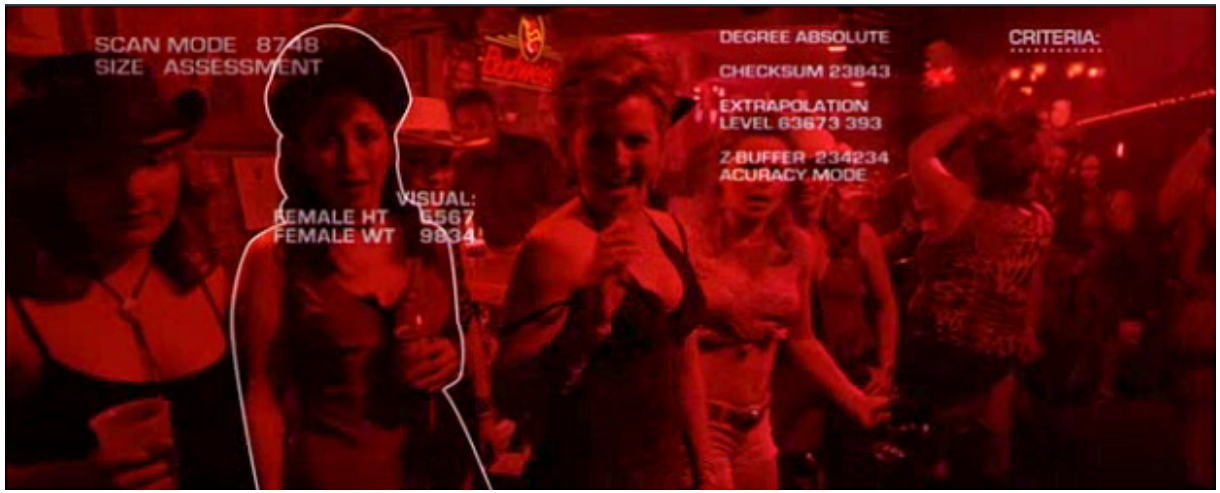
What is this imatge representing?

Why do we easily read the sentences?

Sgenos un etsdui d'una uivenrstiat agnlsea, no ipmotra l'odre en el que les ltleers etsan ersciets, l'uicna csoa ipormtnat es que la pmrirea i l'utlima lterla etisiugn ecsrites en la psiocio cocrrtea. La rstea pdeon eatsr ttaolmnet deesrodneads i tot i axio pordas leligr-ho snsee pobrleems.

What does it mean: "to be able to see"?

The problem is complex and we should avoid oversimplifications...



Visual illusions

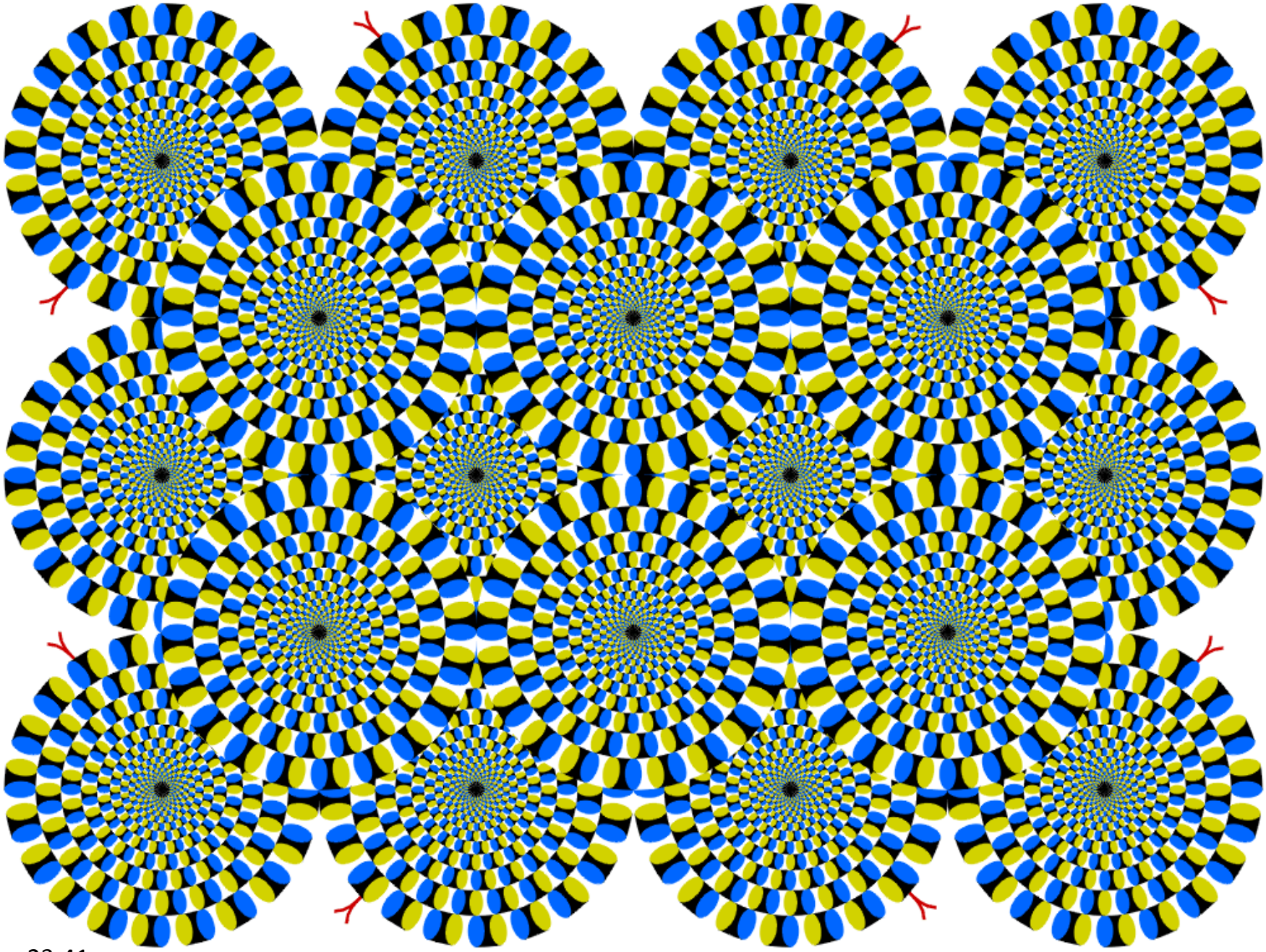
In the visual percepcion different factors intervene associated with aspects of the observer and his/her environment.

The knowledge acquired culturally.

Assumptions about the world acquired for evolution.

Visual memory and past experiences.

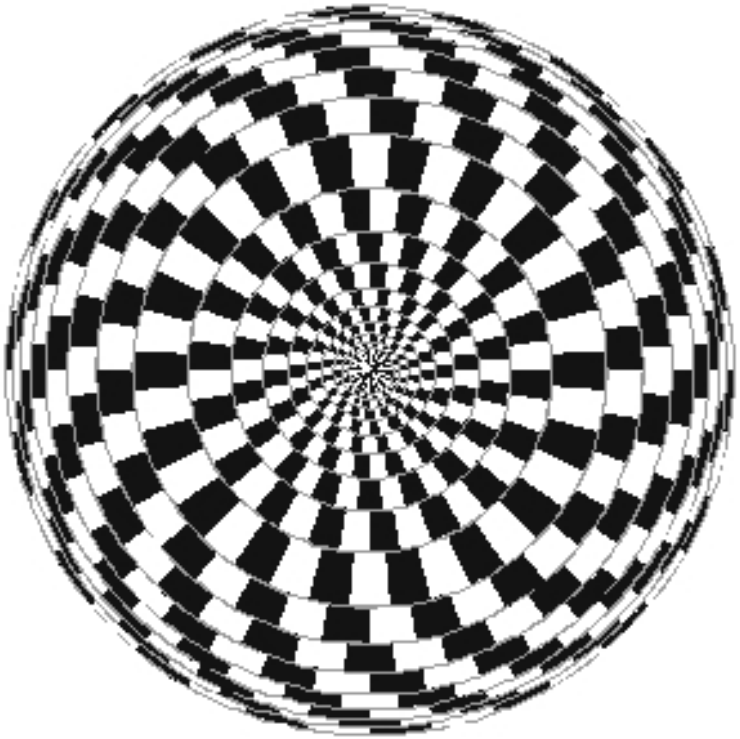
The architecture of the human visual system.



23:41

Copyright A.Kitaoka 2003

Visual illusions



So you think you see spirals? Well, your brain may construct a spiral but nowhere in these graphics do spirals exist. The curves form independent concentric circles! Trace the lines with your finger and discover it for yourself.

Visual illusions

VERMELL BLAU BLANC

GROC BLAU VERD

VERMELL ROSA NEGRE

BLAU TARONJA VERMELL

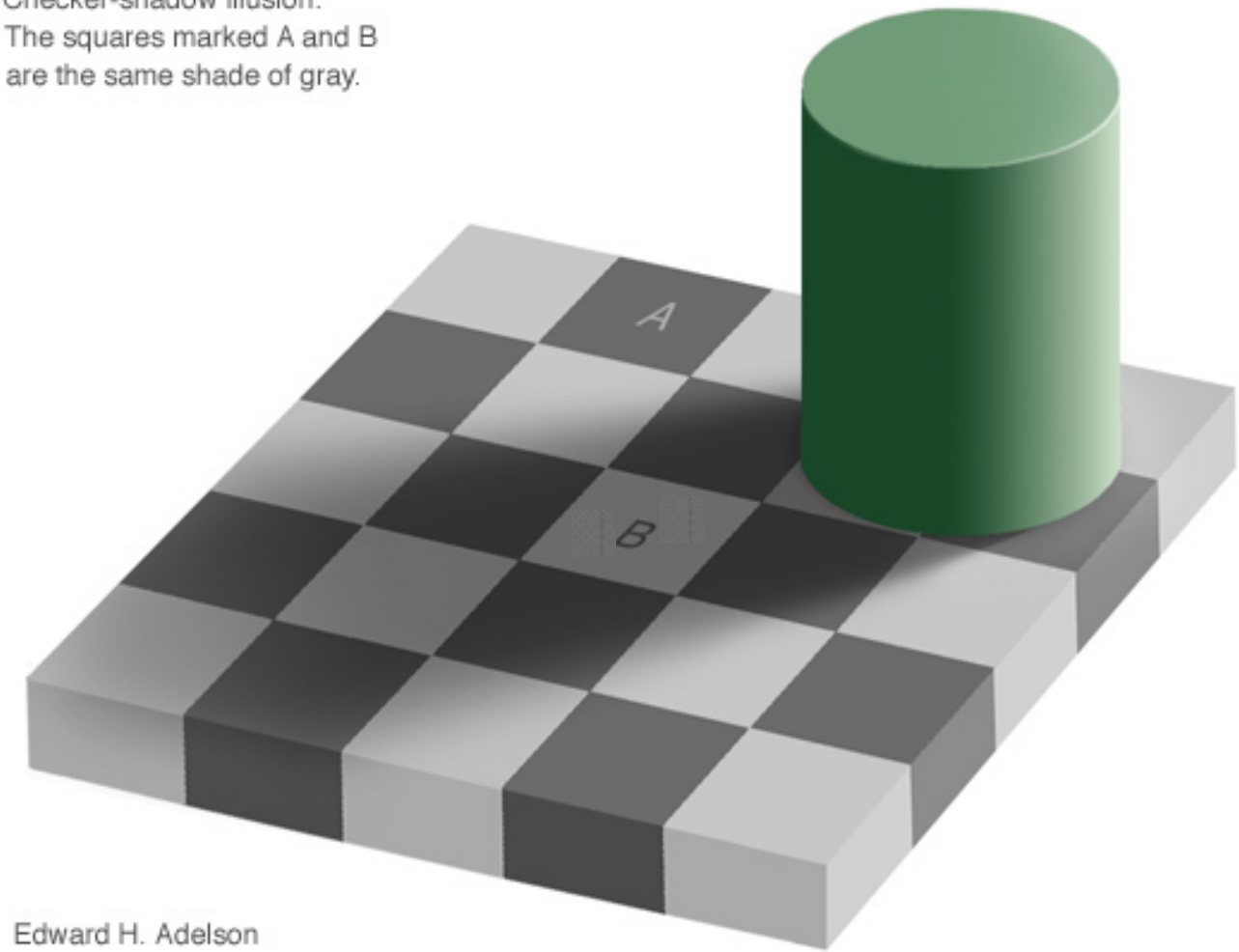
ROSA VERMELL MARRÓ

BLAU GROC VERD

See each word and tell the color (not the word).

Visual illusions

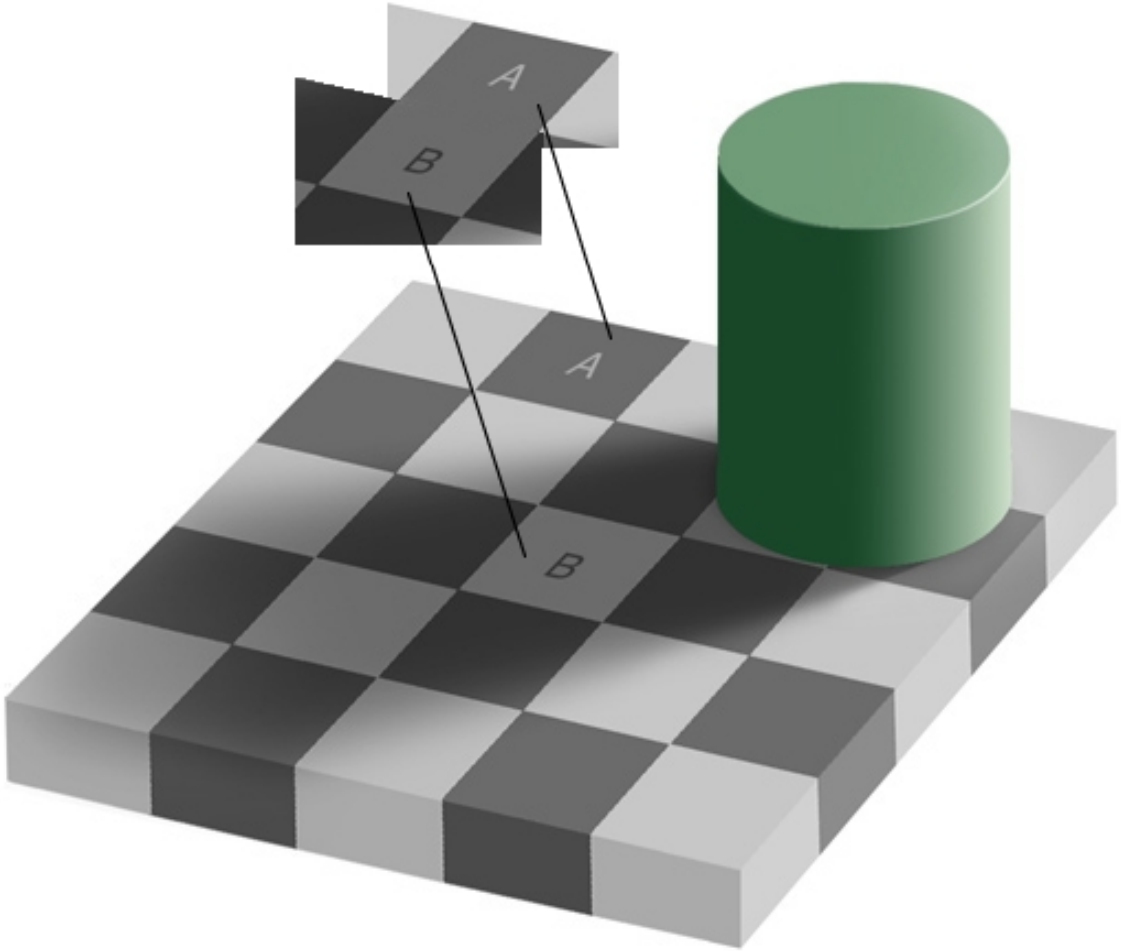
Checker-shadow illusion:
The squares marked A and B
are the same shade of gray.



Edward H. Adelson

http://www-bcs.mit.edu/gallery

Visual illusions



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- Bibliography:
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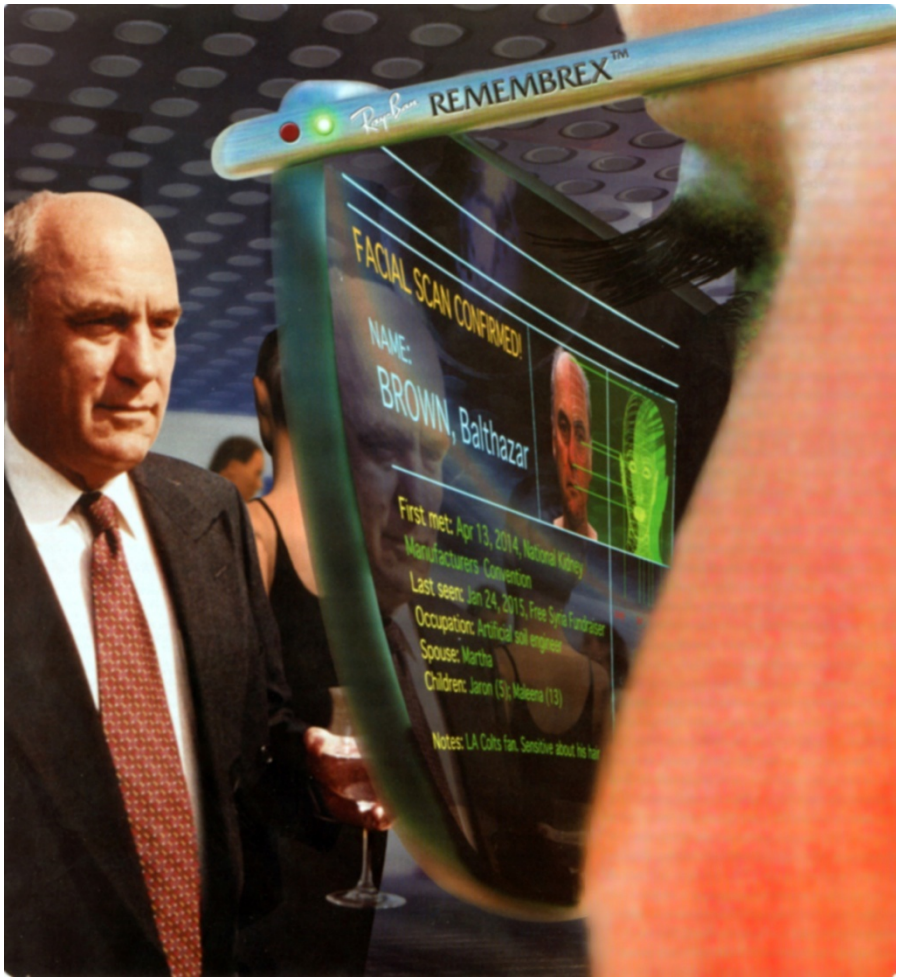
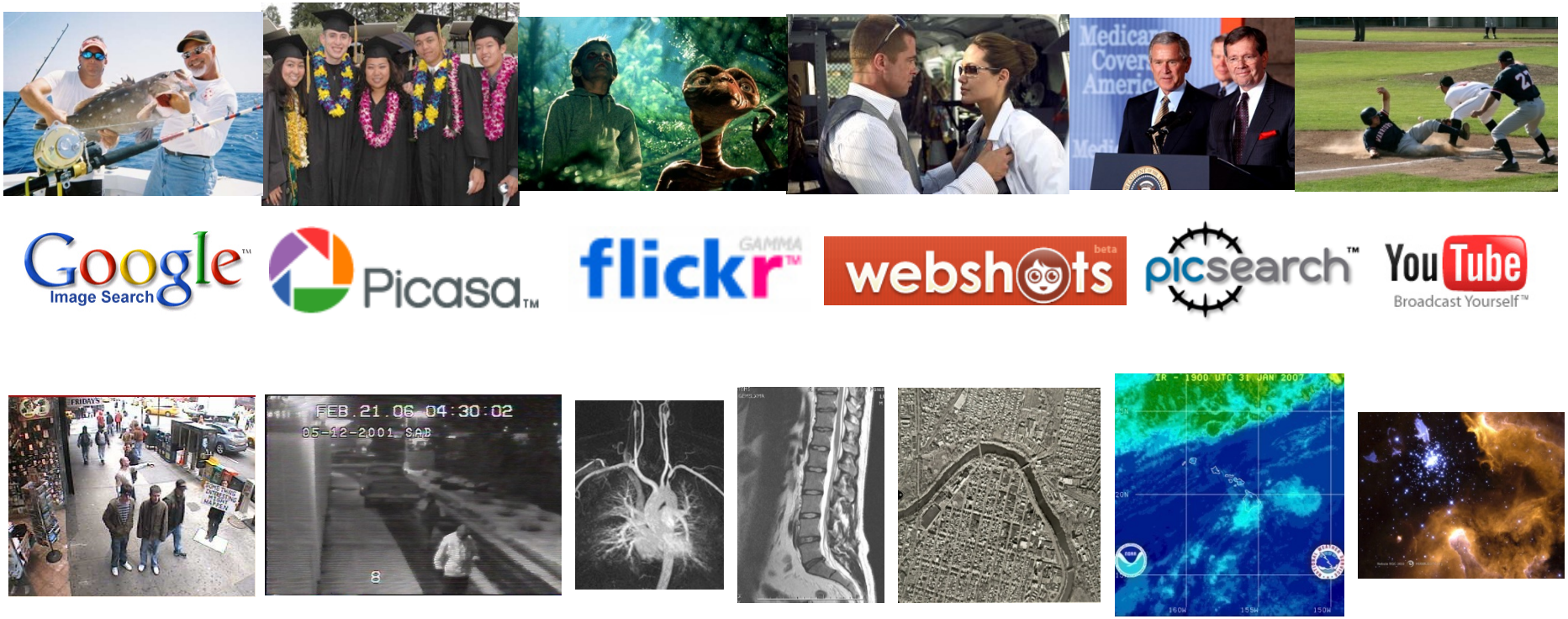
Is Artificial vision useful?



Why to study Computer Vision?

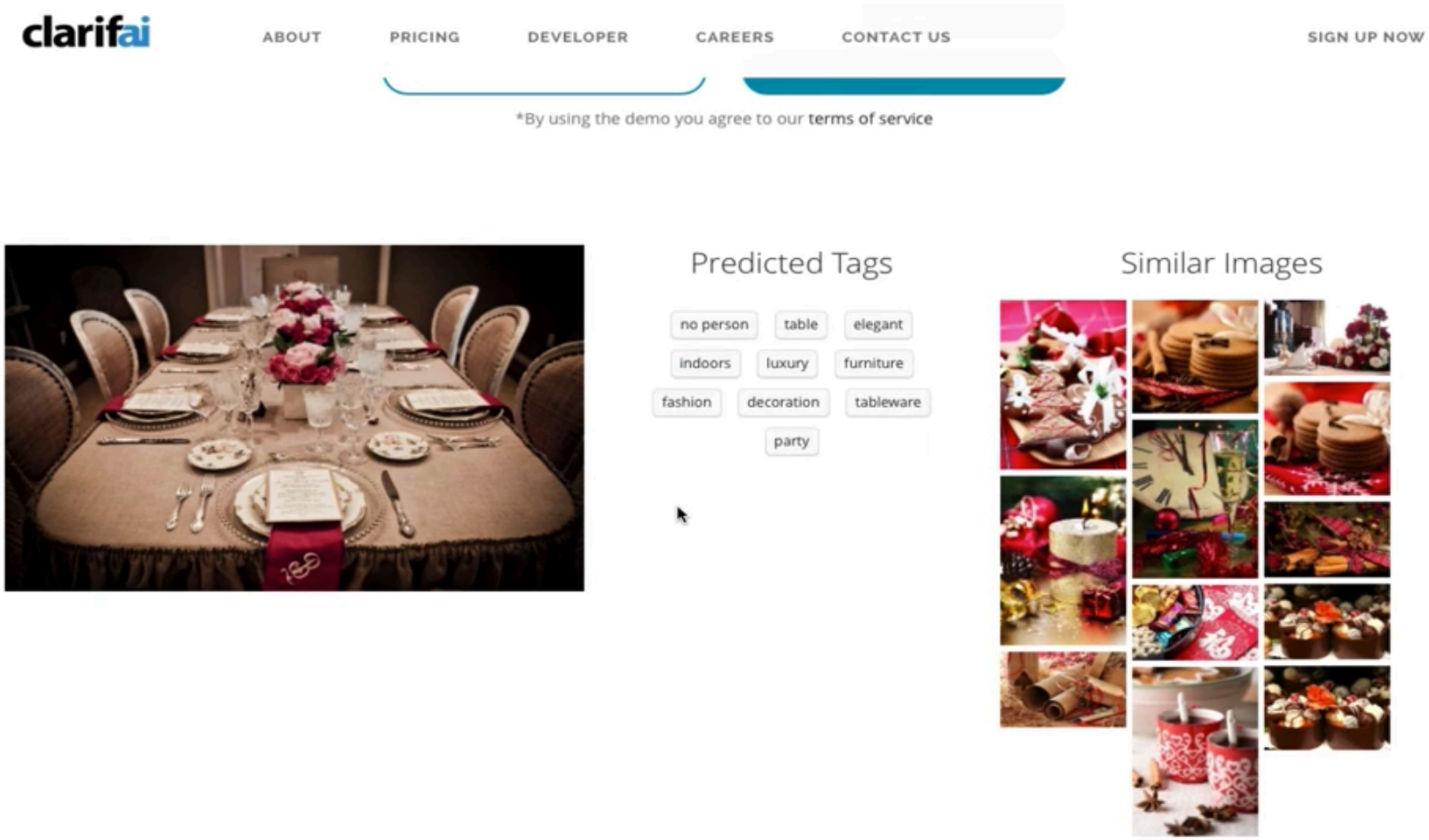
- Each second million of images are captured and stored



- Numerous real applications

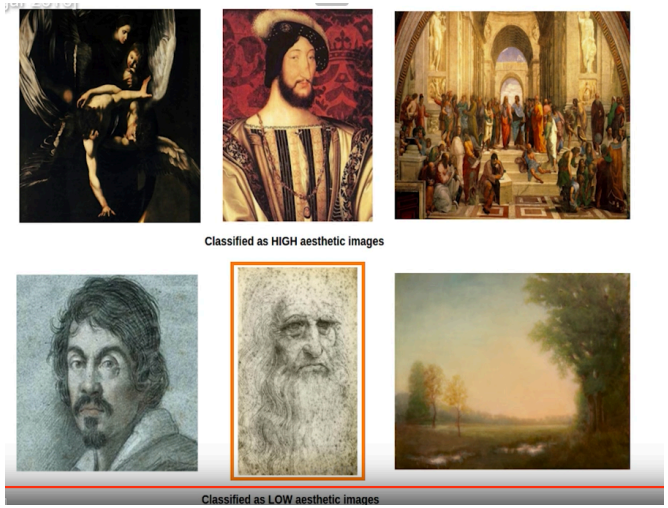
•Source: S. Lazebnik

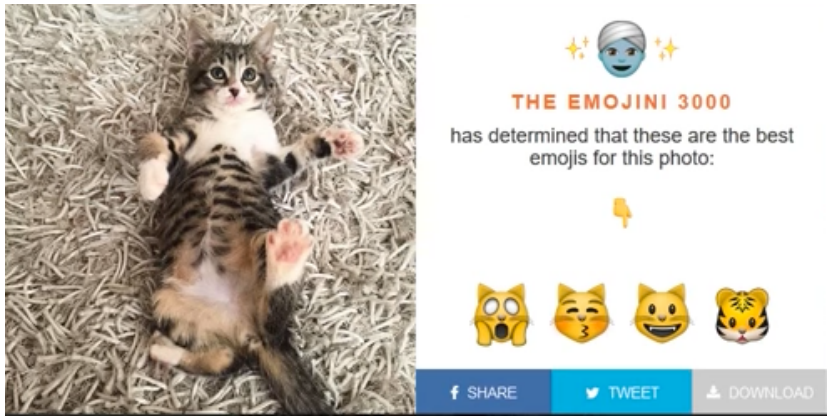
Deep learning

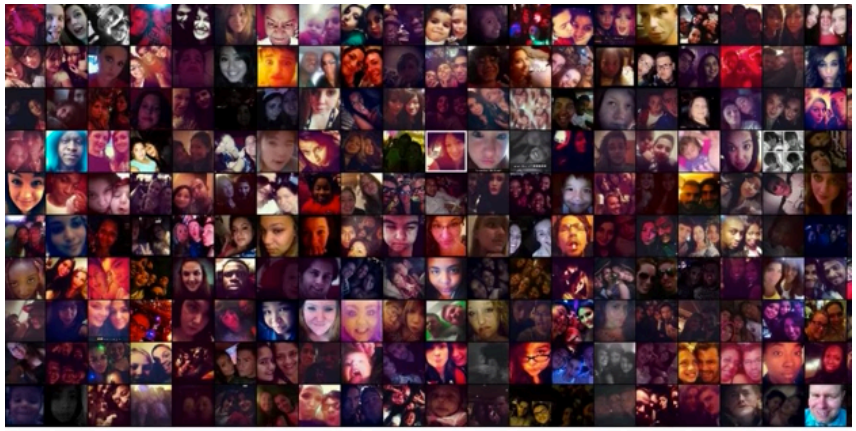


23:41

Deep learning







Worst 300 out of 50,000 selfies, as judged by the Convolutional Neural Network.

23:41

Computer vision today

Only a few examples.

- Most have less than 5 years!

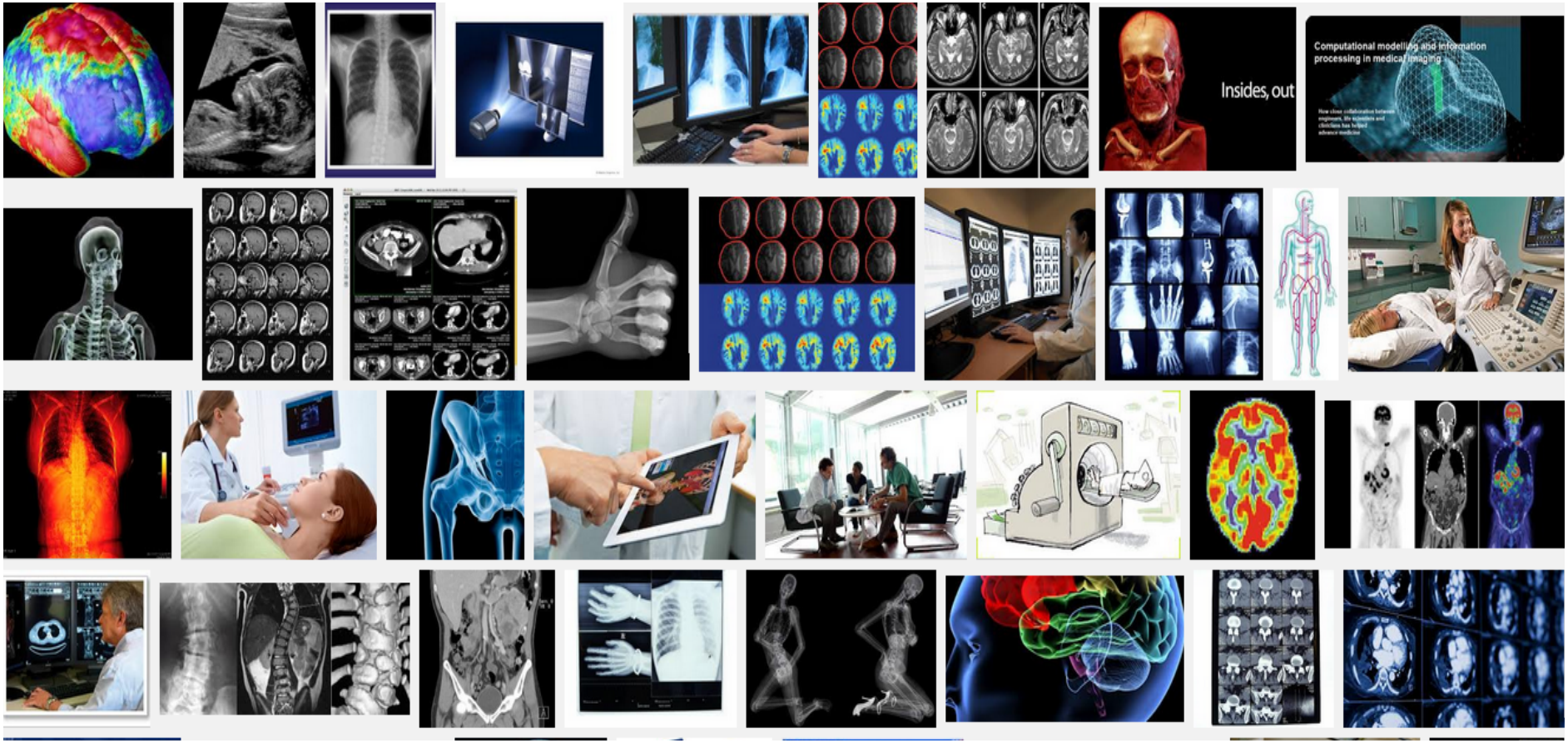
A very active and changing area

- Expected numerous applications the next 5 years!
  - https://angel.co/computer-vision (284 Computer Vision companies)

If you want to learn more about applications and Companies:

- David Lowe maintains an excellent page on Companies vision
  - http://www.cs.ubc.ca/spider/lowe/vision.html

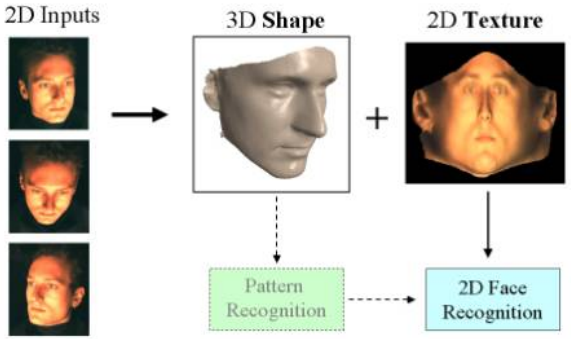
Medical images and health

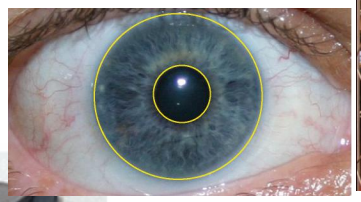


23:41

Surveillance and security: biometric systems

•Fingerprint identification, facial recognition, iris and retinal scan, hand geometry, geometry of the ear, signature recognition, voice identification, identification of the DNS, the smell of human characteristics or recognition of typing motion (not a privilege of science fiction any more).





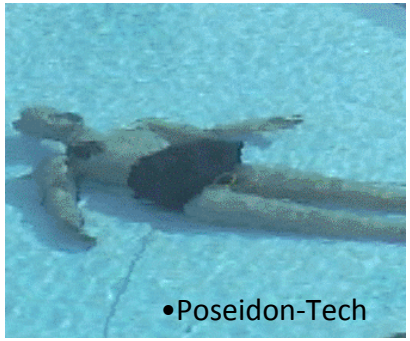
23:41

Surveillance and security: biometric systems

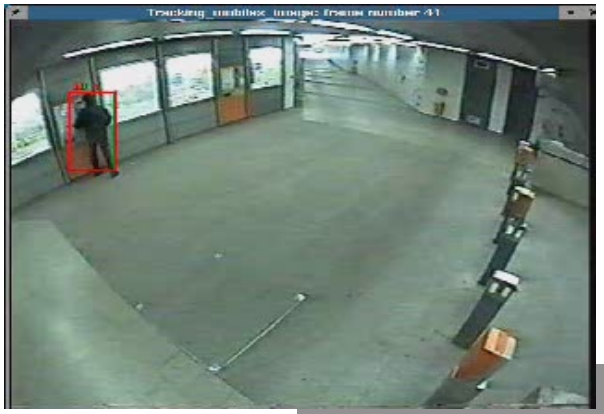
•Viisage

•US-VISIT

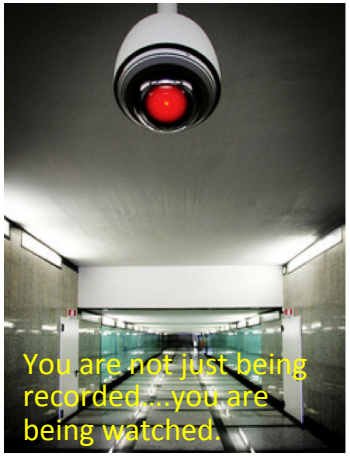
•3M



•Poseidon-Tech



> A Person is forcing a Ticket Machine!!”



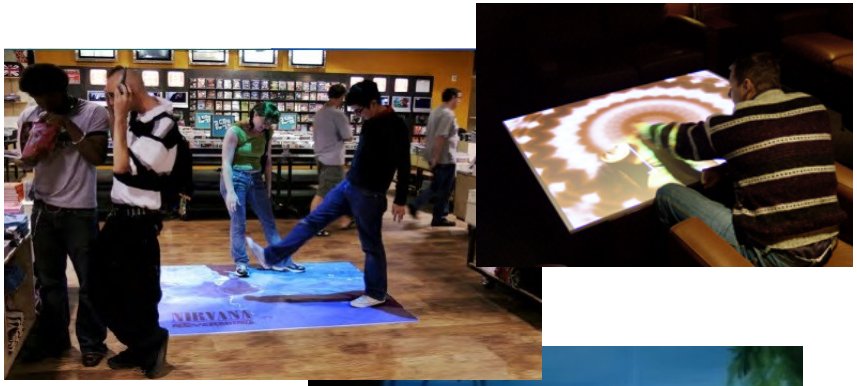
Media and Entertainment

•Gaming interfaces

•Sony EyeToy (for PlayStation .) Allows players to interact with games using motion, color detection and sound.

• Augmented Reality

•ARmusement



•GestureFX. Gesture Interfaces ground, wall or table.

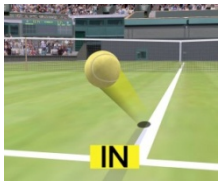
•Digital Fotography

•Photosynth (Microsoft LiveLabs)

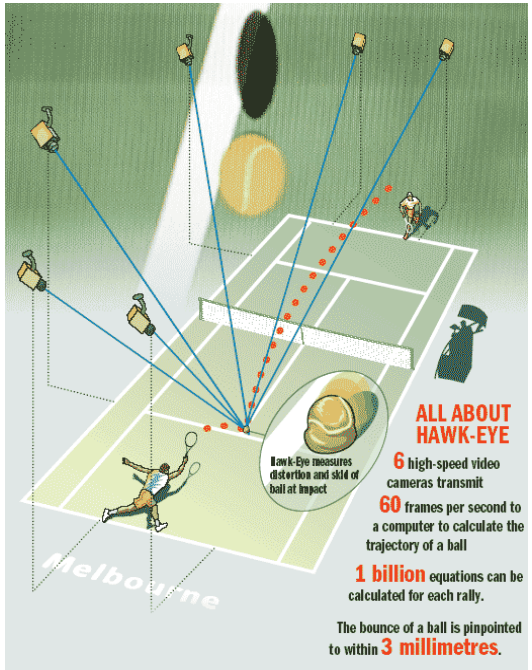
23:41

Media and Entertainment

- Augmented TV



- Hawk Eye: tracking the ball in game sports.



- PVI: Virtual publicity in real television pictures.

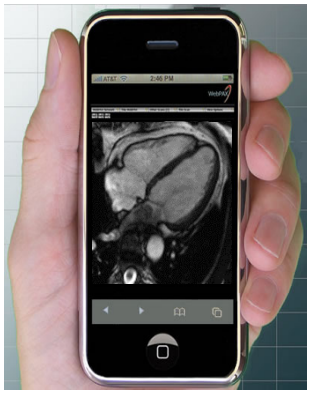
23:41

Mobile Computer Vision

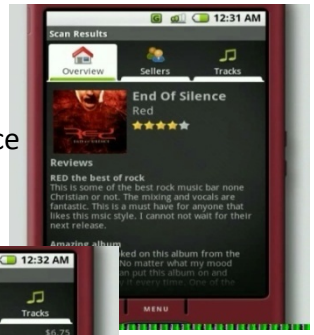
- Client services

- For visually impaired

- Health services



- Android Developer Challenge (Google): Barcode Reader for price list and product information



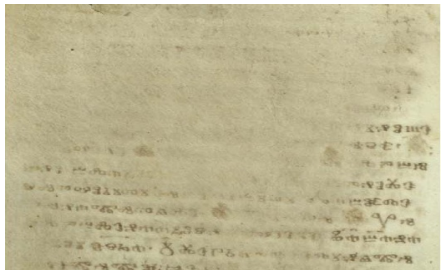
- Tourism

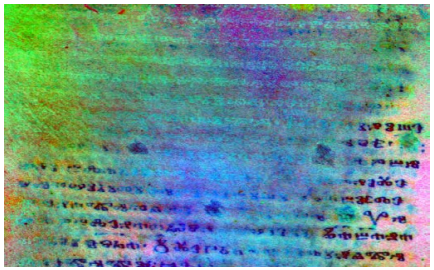
23:41

Cultural inheritance

- Arqueology

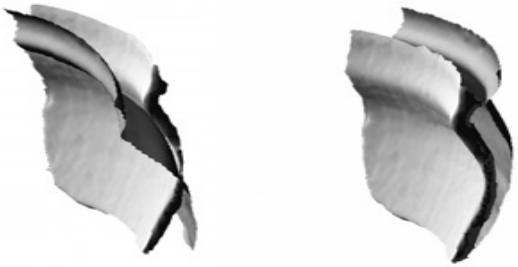
- Old documents

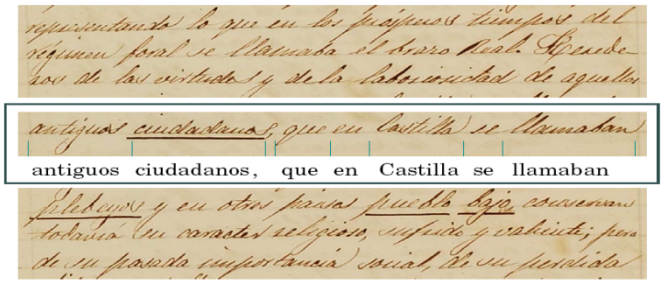




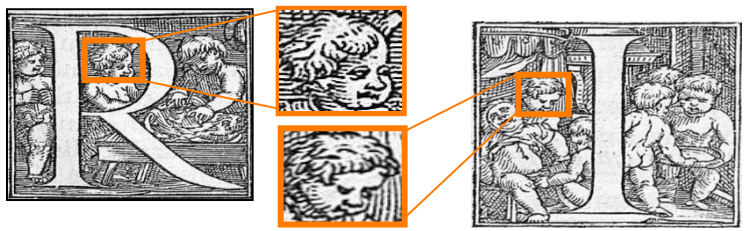
- Manuscript recognition

- 3D reconstruction of ceramics





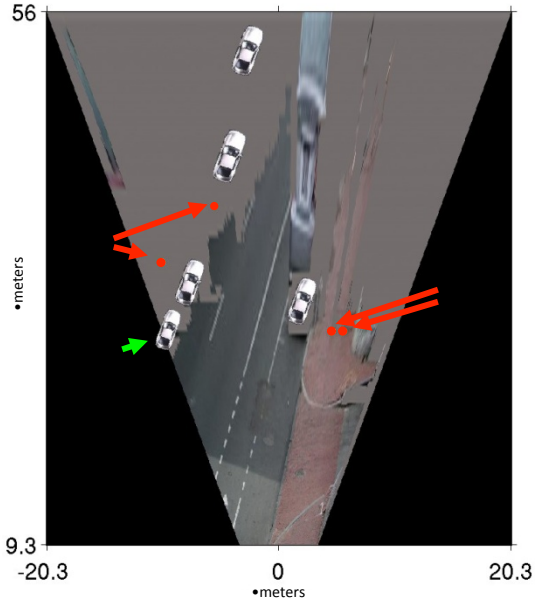
- Restauration

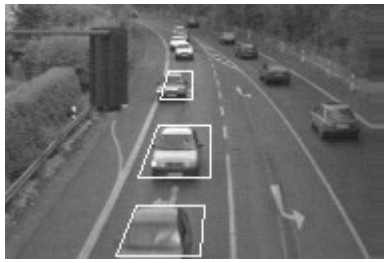


- Engravings analysis

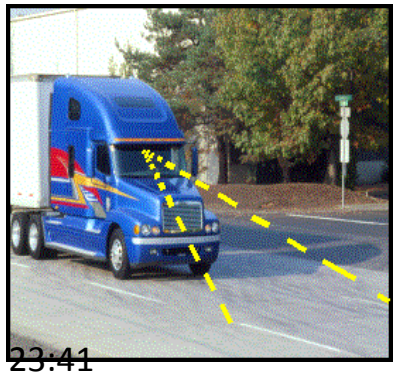
Assisted driving

- Pedestrian and car detection





- Lane detection



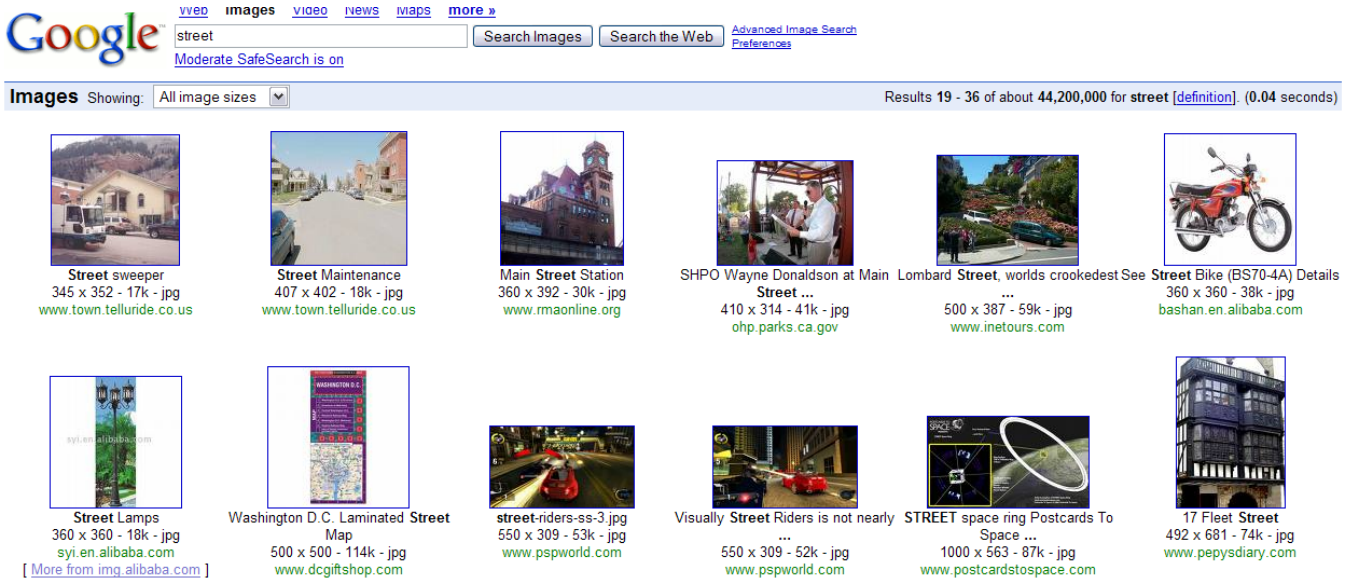
- Collision warning systems with adaptive cruise control,
- Lane departure warning systems,
- Rear object detection systems,

•Slide credit Fei-Fei, Fergus, Torralba CVPR07 Short Course

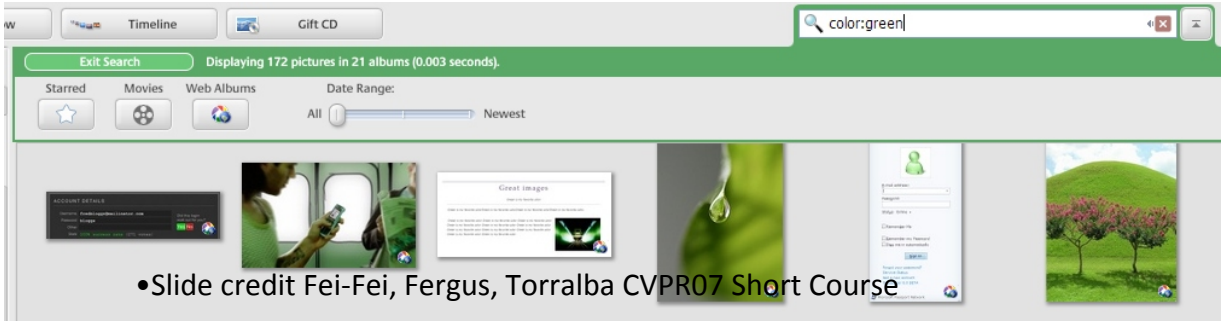
Improving online search

flickr
webshots
Ask Images
Cydral Image & Site Search
picsearch
Google Image Search
altavista

- Query:
- STREET

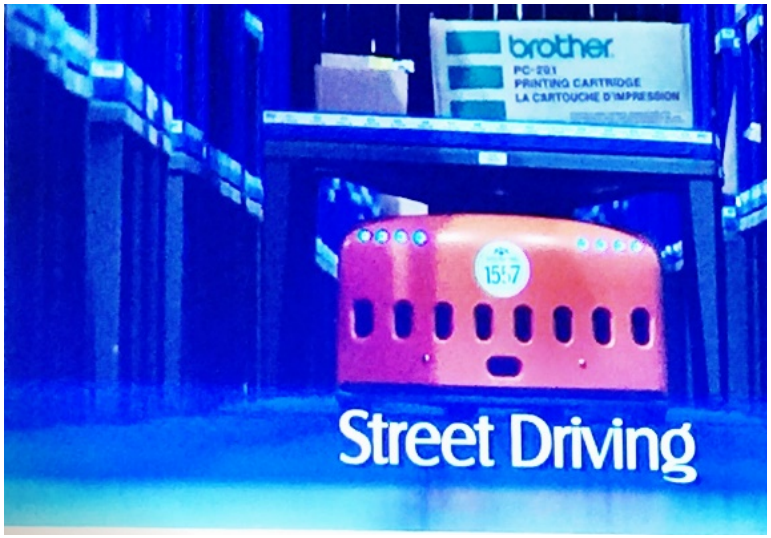


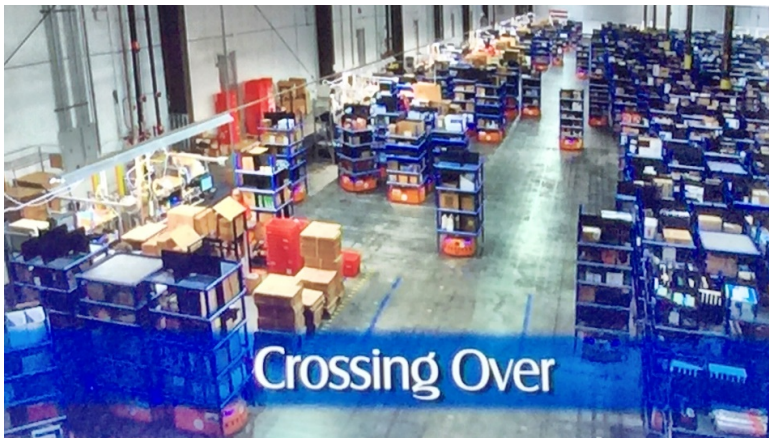
- **Organizing photo collections**



- Slide credit Fei-Fei, Fergus, Torralba CVPR07 Short Course

Amazon farm



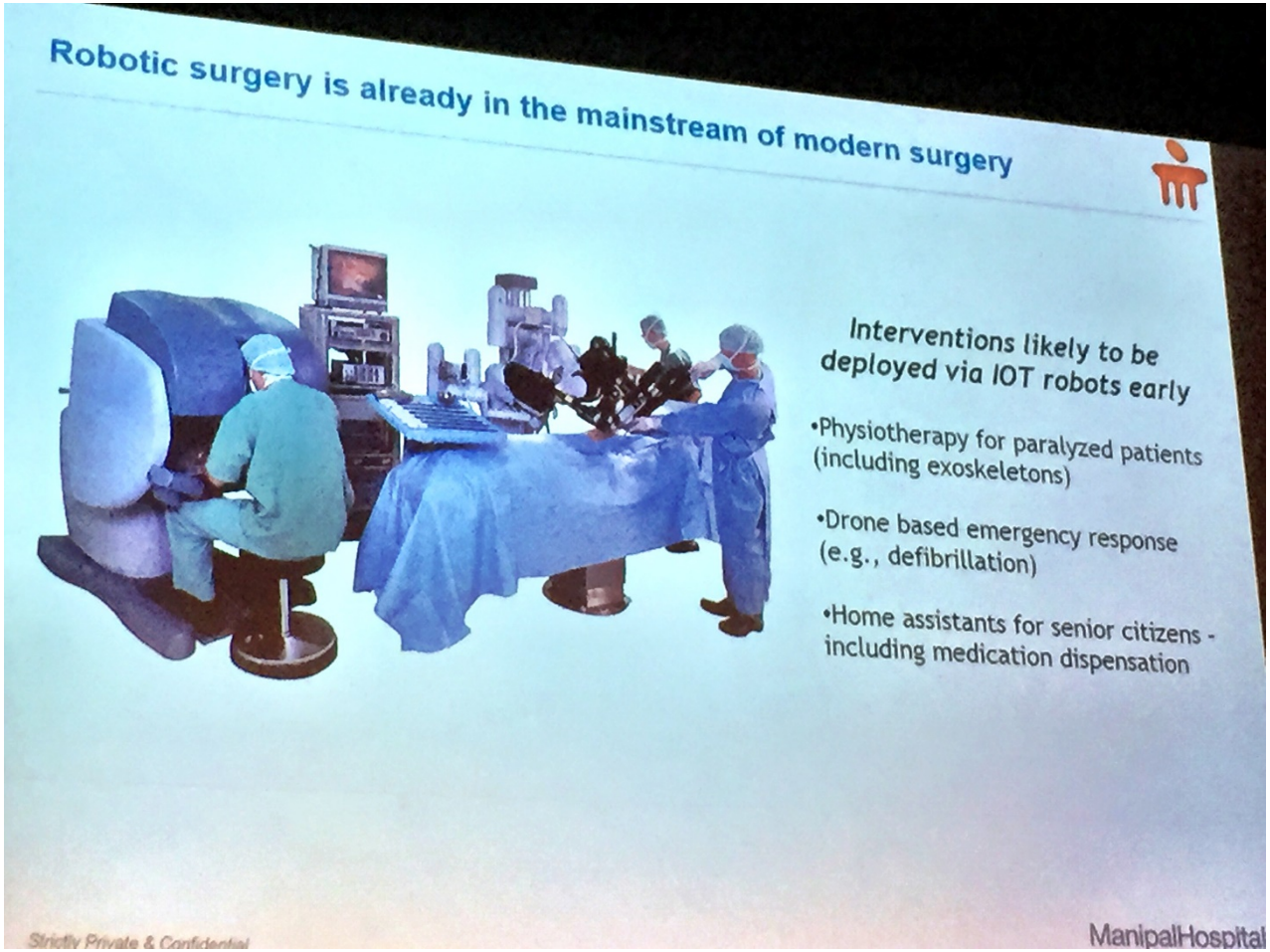


23:45

Robots in hospitals

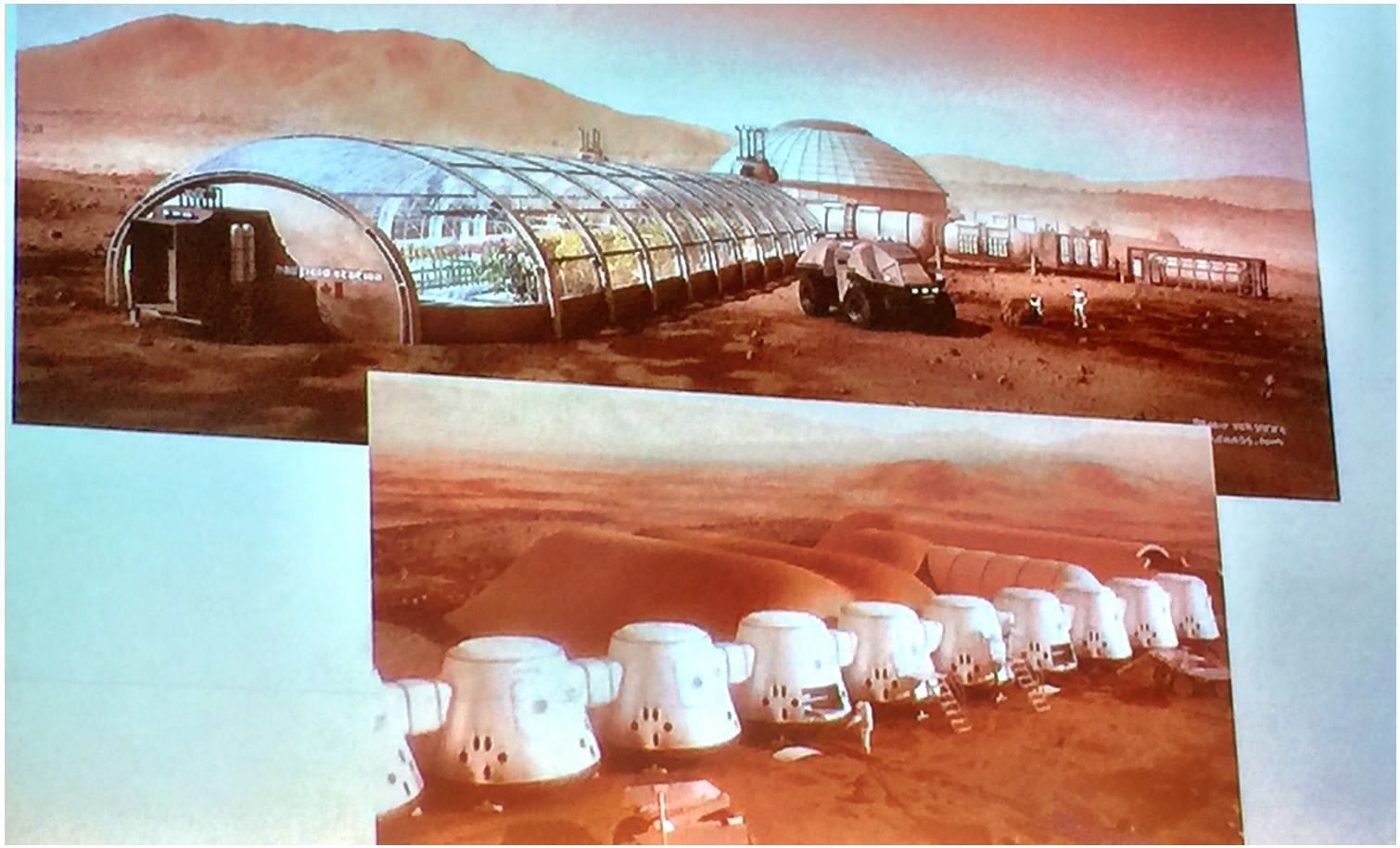
23:41

InternetofThings' 2015



23:41

Visiting Mars



23:41

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1. What is Artificial Vision?
2. A little bit of history
3. Main problems of Artificial Vision
4. Difficulties of the Artificial Vision
5. Applications
6. Subject organization

In this subject we will:

Subject content

Presentation and introduction

•The subject. What is artificial Vision?

Features detection

•Edge detection. Differential operators. Discrete approximations. Discontinuities.

•Detection and localization of contours. Differential operators. Structure of the image.

•Visual characteristics (HOG, Harris, SIFT), etc.

Shape

• Contours and Segmentation

•Texture analysis and image retrieval.

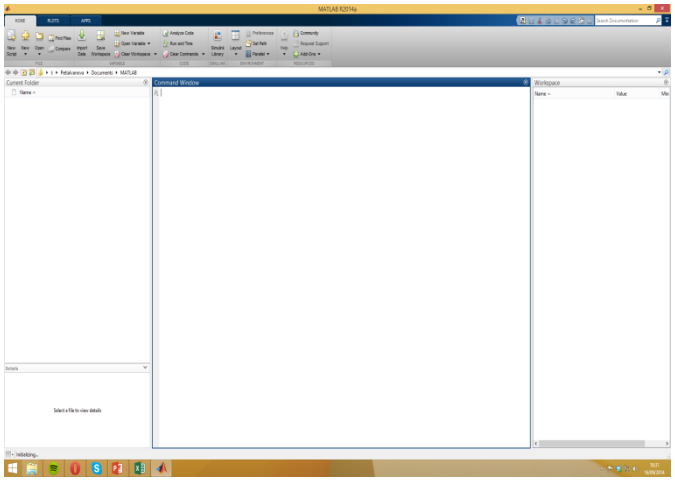
Recognition

• Object detection.

•Recognition based on appearance. Face recognition.

Laboratory environment

- Matlab



Laboratories

Will be based on the material seen in class.

- Some deliveries may include small abstracts, techniques, etc.
- Some deliveries can be done in the laboratory classes

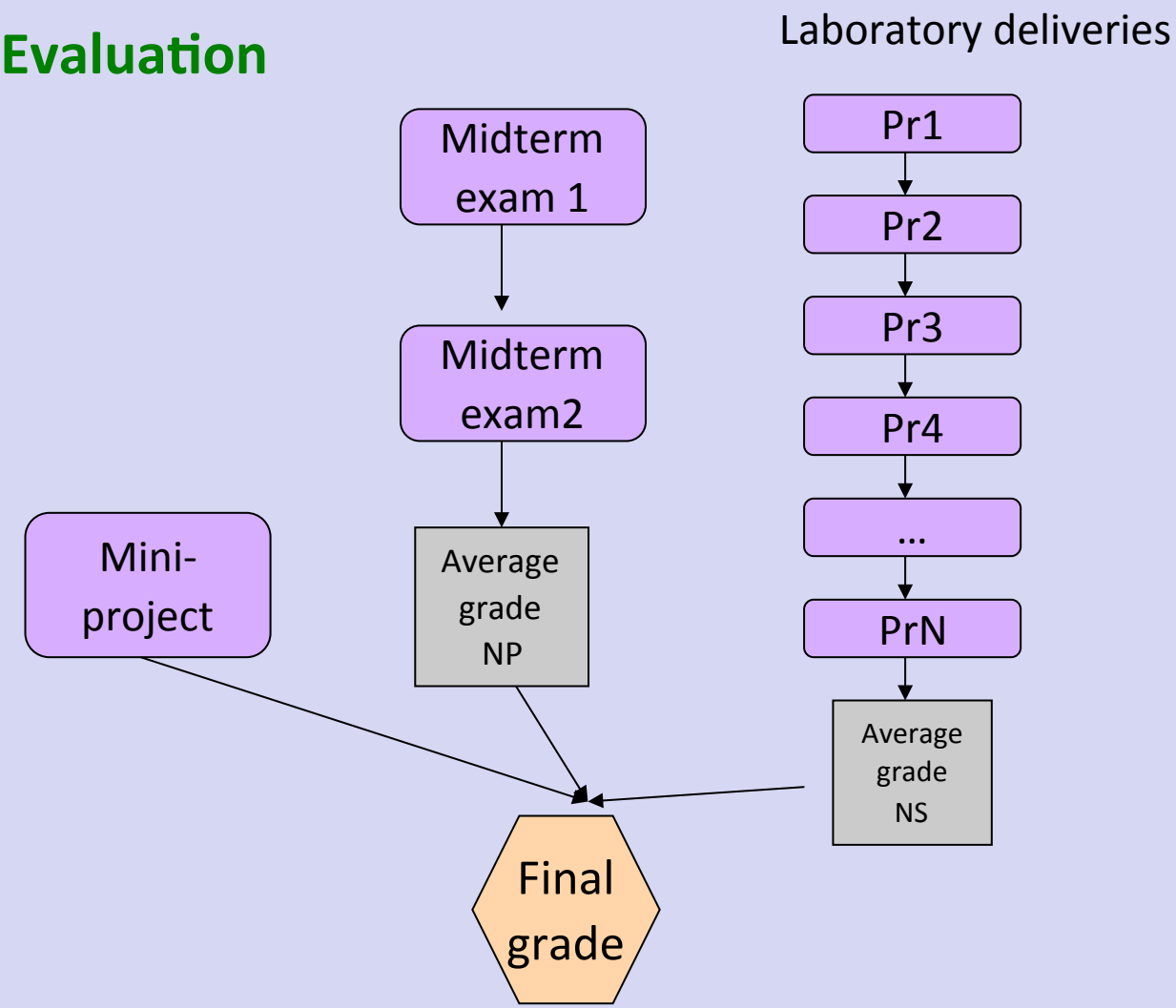
English:

- Theory slides
- Additional material:
  - Videolectures
  - Articles and other literature

Rough calendar

- In the middle of the semester there will be a partial exam.
- The II partial exam will be in December or January.
- All data will be confirmed 1-2 weeks before in theory classes.

Continuous Evaluation



NEC=0.5*NP+0.1*MP+0.4*NS

Avaluació continuada

La nota Final de l'assignatura, Nota_Final, es calcularà segons la següent fórmula:

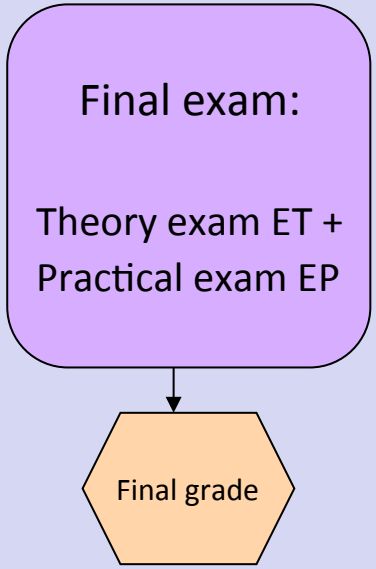
Nota_Avaluació_Continuadal = 0.5 * Nota_Examens_Parcials + 0.1*Nota_Adicional + 0.4 * Nota_Sessions_Pràctiques
on:
Nota_Examens_Parcials és la nota de les 2 proves parcials.
Nota_Sessions_Pràctiques és la nota promija de diferents lliuraments de pràctiques. Aquests lliuraments són presencials.
Nota_Adicional és la nota que contempla diferents activitats que es poden incloure per a valorar l'assignatura (nota del miniprojecte).

Nota_Examen_Final = 0.5 * Nota_Examen_Teoria + 0.1*Nota_Adicional + 0.4 * Nota_Examen_Pràctiques
on:
Nota_Examen_Teoria és la nota de l'examen de teoria.
Nota_Pràctiques és la nota de l'examen pràctic.
Nota_Adicional és la nota del miniprojecte.

Per a poder fer el càlcul de la Nota_Final, és condició imprescindible que l'estudiant obtingui:
Nota_Teoria >= 4.0 i Nota_Pràctiques >= 4.0

Qualsevol intent de frau realitzat durant el curs comportarà l'aplicació de la normativa acadèmica general de la UB i l'inici d'un procés disciplinari.

Unique Evaluation



FG=0.6*ET+0.4*EP

Approved if ET>=4, EP>=4 and Final grade >=5.

Avaluació ùnica (Finals d'Octubre – Termini)

L'estudiant que es vulgui acollir a l'avaluació única haurà de sol·licitar-ho a la secretaria de la Facultat dins dels terminis establerts a cada curs acadèmic.
Per avaluació única, ha de passar una prova final on s'avaluaran conceptes teòrics i pràctics de l'assignatura de la següent manera

Nota_Final = 0.6* Nota_Teoria + 0.4 * Nota_Pràctiques
On:
Nota_Teoria: nota de l'examen final on s'inclouen aspectes a avaluar propis de l'avaluació única de la part de teoria,
Nota_Pràctiques: nota de la part pràctica (preguntes i problemes sobre els continguts de les pràctiques de l'avaluació continuada, problemes específics pràctics de coneixements, etc.).

Per a poder fer el càlcul de la ***Nota_Final***, és condició imprescindible que l'estudiant obtingui:
Nota_Teoria >= 4.0 i Nota_Pràctiques >= 4.0

Reavaluació: Un alumne té dret d'anar a l'examen de reavaluació si NF>=3.5. L'examen de reavaluació tindrà part teòrica (RT) i part pràctica (RP) i la nota final de l'assignatura serà:

•NF=0.6*RT+0.4*RP.

Observacions:

•a) Les pràctiques no són recuperables. Una pràctica no presentada té una nota 0.

•b) Un "No presentat" en l'avaluació continuada és quan no s'ha presentat cap pràctica ni s'ha fet cap parcial.

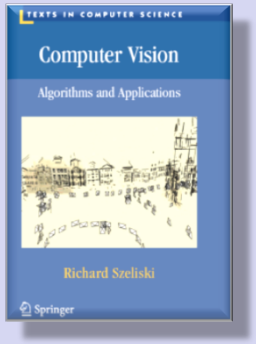
•c) Les notes no es guarden d'un any per a un altre.

•d) Si es suspèn alguna de les parts d'activitats (teoria o pràctiques) en l'avaluació continuada durant el semestre, s'ha de fer l'examen sencer; no es guarda la part aprovada.

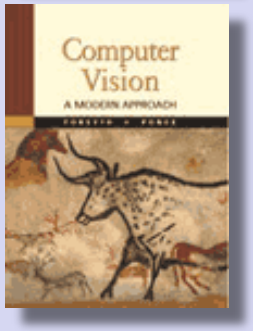
•i) Algunes de les pràctiques poden ser pràctiques avaluables, on el treball pràctic es defineix i es lliura al final de la sessió.

•f) Els estudiants que fan la reavaluació renuncien la nota anterior obtinguda.

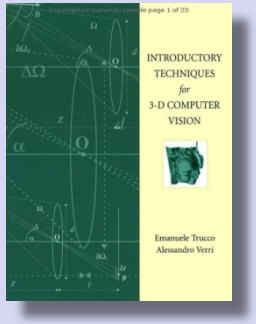
Bibliography



Computer Vision: Algorithms and Applications (c) 2010 Richard Szeliski, Microsoft Research
http://szeliski.org/Book/



David A. Forsyth, Jean Ponce, *Computer Vision: A Modern Approach*, Prentice Hall, Hardcover, August 2012, II edition.



Emanuele Trucco, Alessandro Verri. *Introductory Techniques for 3-D Computer Vision*. (March 6, 1998) Prentice Hall; ISBN: 0132611082

Mini-projects

Groups of 4 students should be formed to work on a mini-project. It should be submitted before 15/11/2016.

Memory of 5 pages should explain:

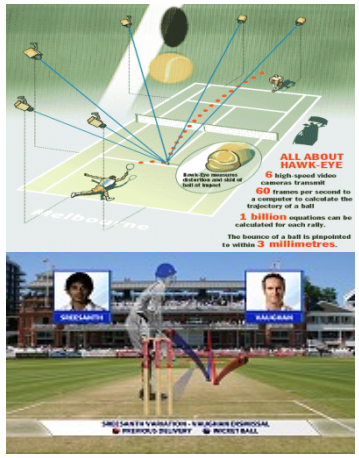
- target
- environment / context
- information about the implementation,
- alternatives and extensions to the application as seen in the course material.
- Introduction to Virtual Campus.

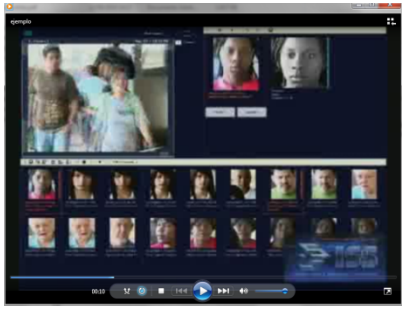
These mini-projects will have a weight of 10% of the final grade of continuous evaluation.

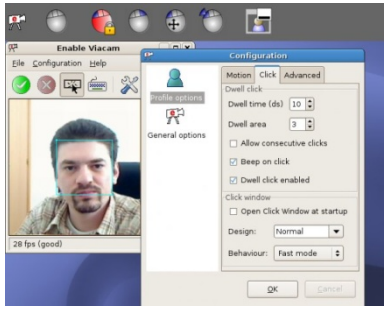
- The projects will be presented in the last two lectures.

UNIVERSITAT DE BARCELONA

Miniprojects







23:41

Petia Ivanova Radeva

Professor's messages

Lectures

- Vision & Mathematics & Algorithms

Transparencies

- Incomplete: they do not serve as the only means to study
- "Live"
- Images (many or few ?!), formulas (many or few ?!)

Practical classes

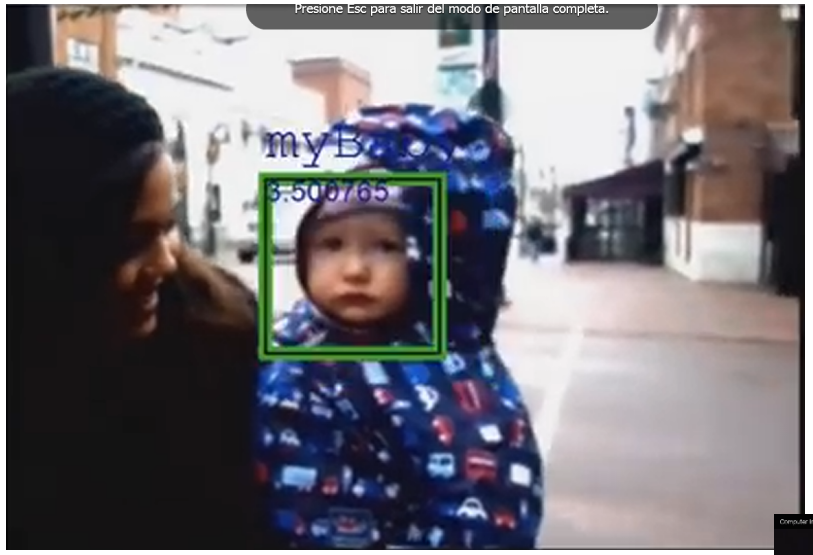
- Time, difficulty ...
- Tips to save time during laboratories:
  - "Be sure to know where to find information, and execute module by module, debug continually, use the possibilities of the MATLAB environment, ask questions ...."

23:41

Additional material

- Get inspired for the miniprojects!

Some more references of interest

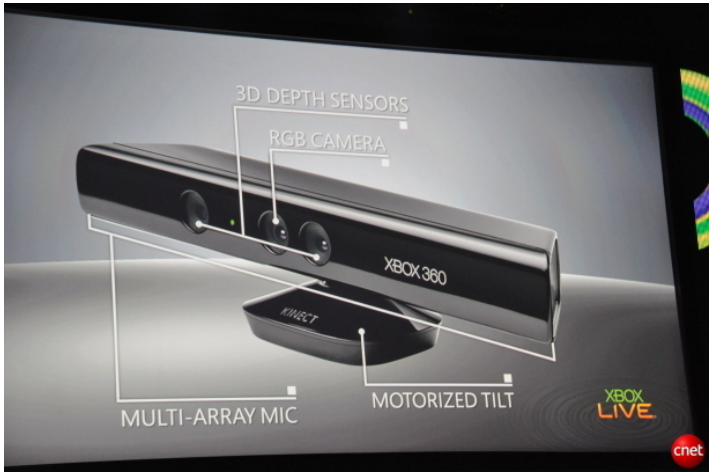


- https://www.youtube.com/watch?v=npj2K6Pb2JE
- https://www.youtube.com/watch?v=Tzv9T8wTykU
- https://www.youtube.com/watch?v=PT7Q9u9m5es
- https://www.youtube.com/watch?v=ty5QtslaAHM
- https://www.youtube.com/watch?v=XZAwtbkELRA
- https://www.youtube.com/user/CVOwebsite
- https://www.youtube.com/watch?v=_uwZrzLFizE
- https://www.youtube.com/watch?v=H4arwvdC7Z4
- https://www.youtube.com/watch?v=NHThkxUP-S8
- https://www.youtube.com/watch?v=1Ugo2KEV2XQ
- https://www.youtube.com/watch?v=5rQBH1TH9pA

23:41

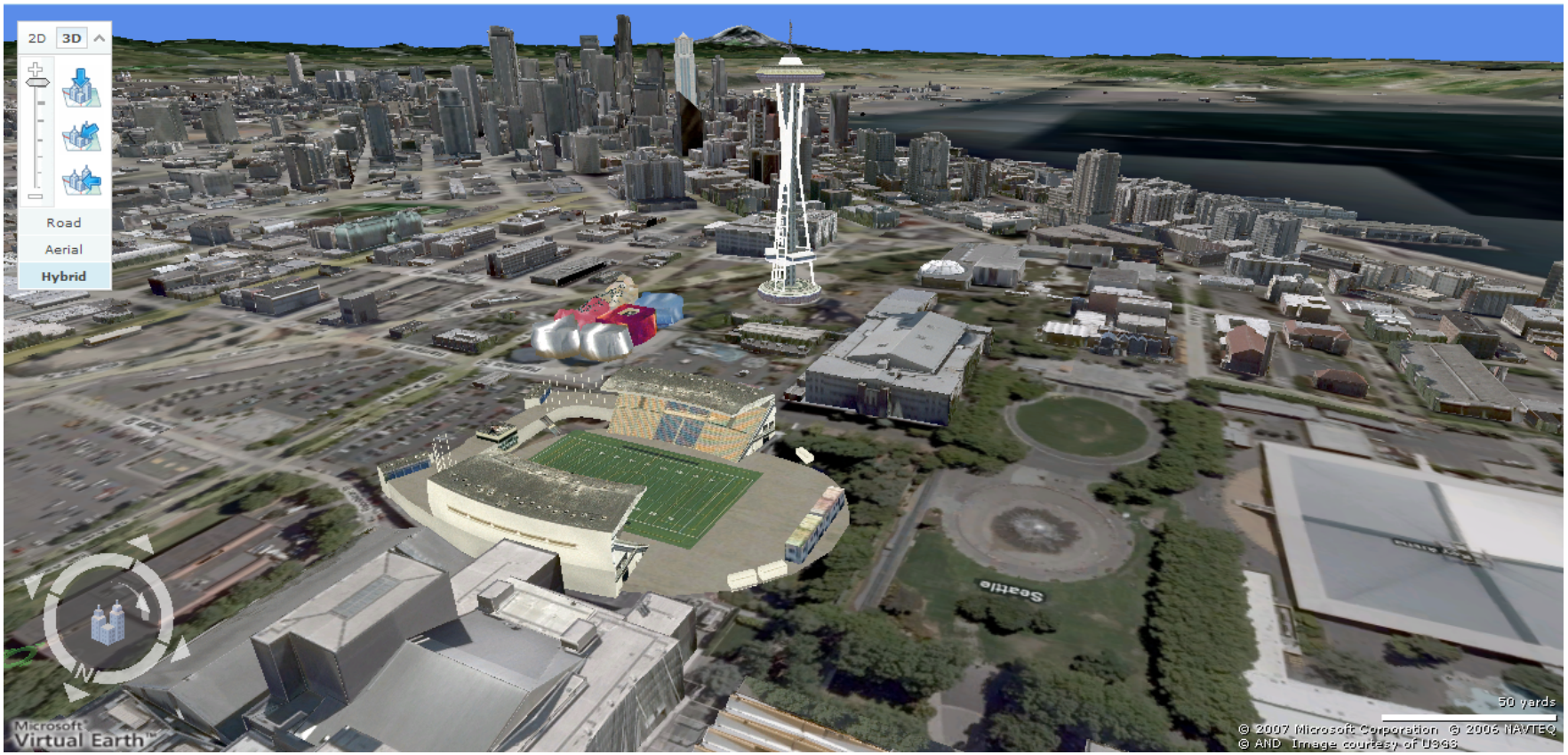
Interactive Games: Kinect

- Object Recognition
- Mario
- 3D
- Robot



23:41

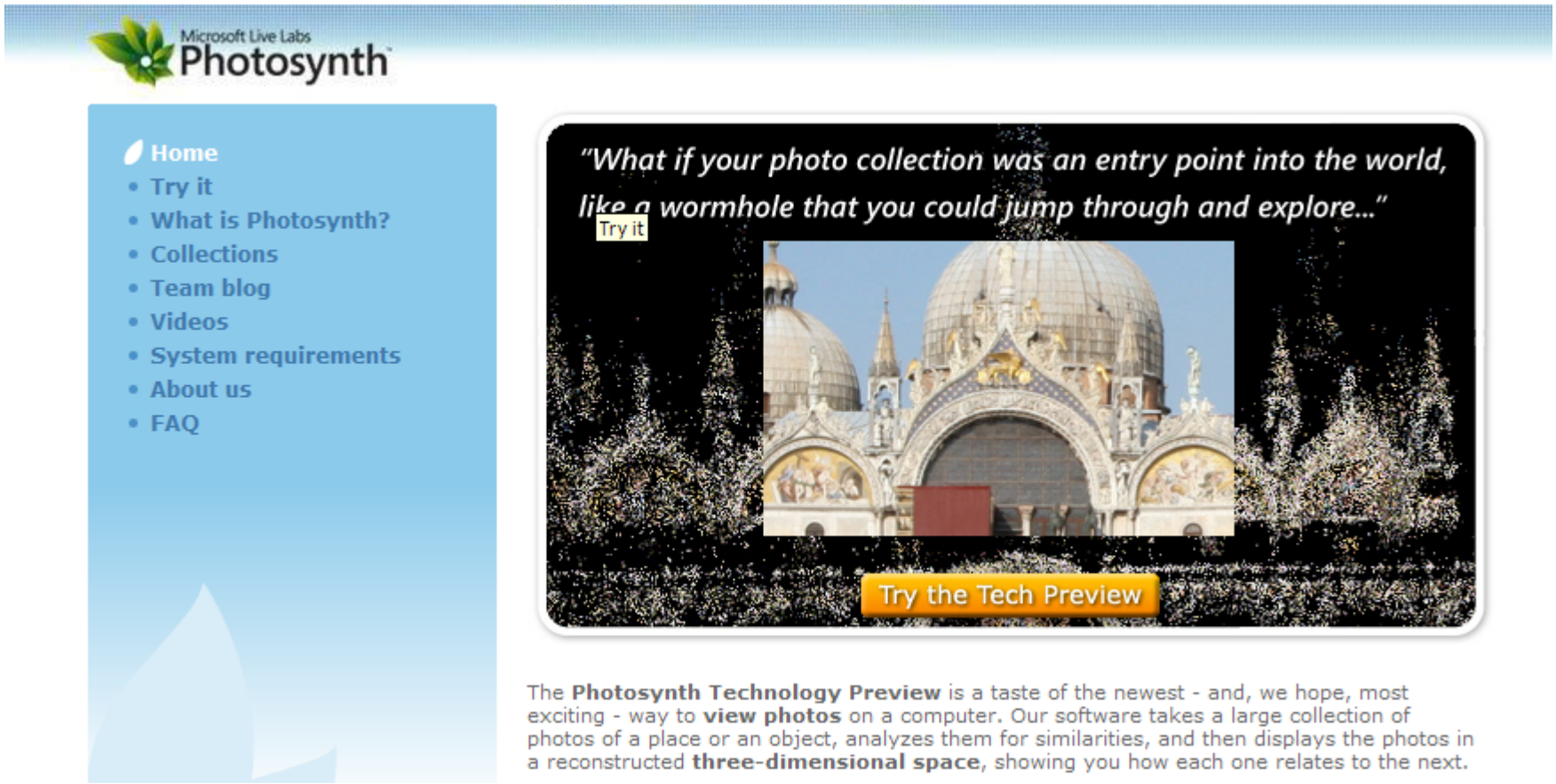
3D viewers



Earth viewers (modelatge 3D), Imatge des de Microsoft's Virtual Earth
(veure també: Google Earth)

23:41

Photosynth



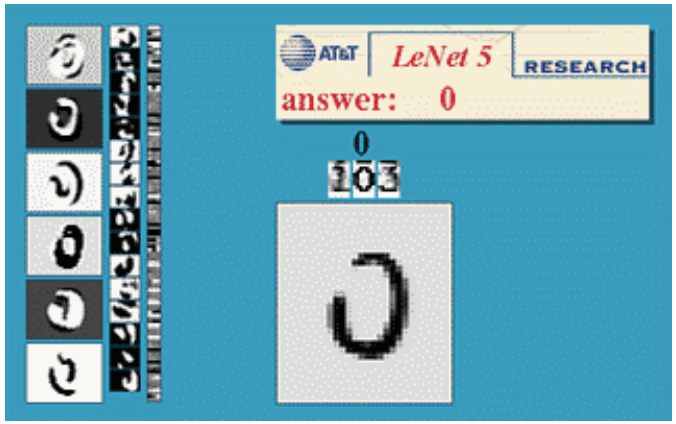
http://photosynth.net/

Photo Tourism technology

23:41

Optical character recognition (OCR)

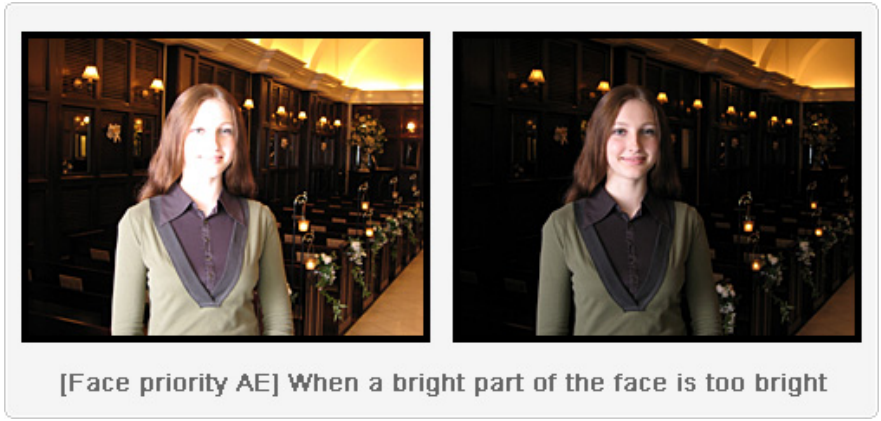
- Technology to convert scanned docs to text
  - If you have a scanner probably came with OCR software



Digits recognition, AT&T labs

Plates recognition
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

Face detection


[Face priority AE] When a bright part of the face is too bright

- Almost all digital cameras: Canon, Sony, Fuji, …

23:41

Face analysis

NEC Corporation

Google maps

23:41

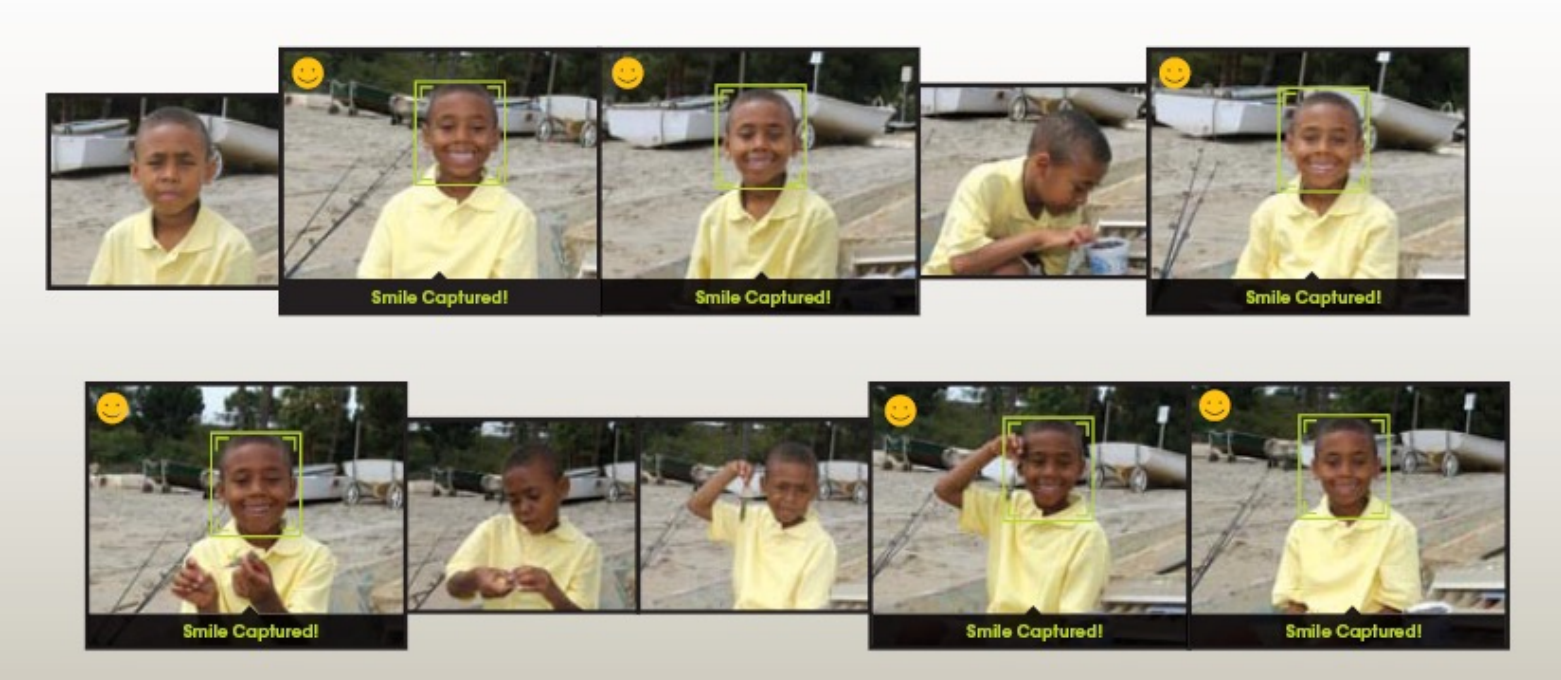
Picasa

23:41

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

23:41

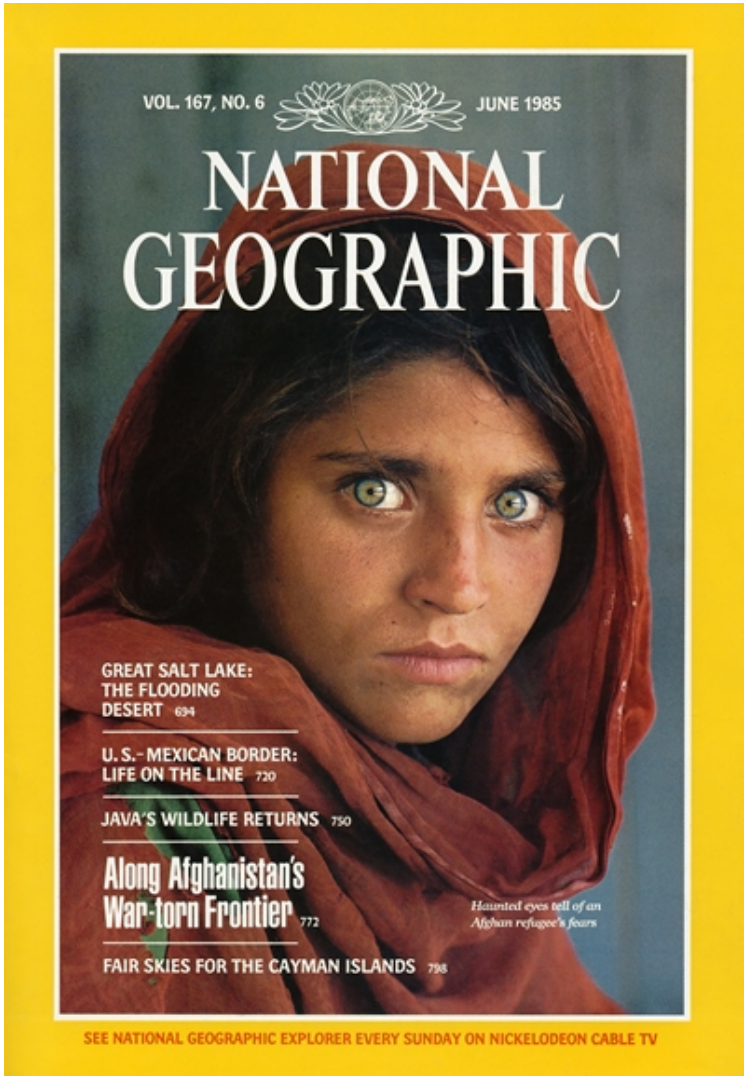
Object recognition in supermarkets

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… "

23:41

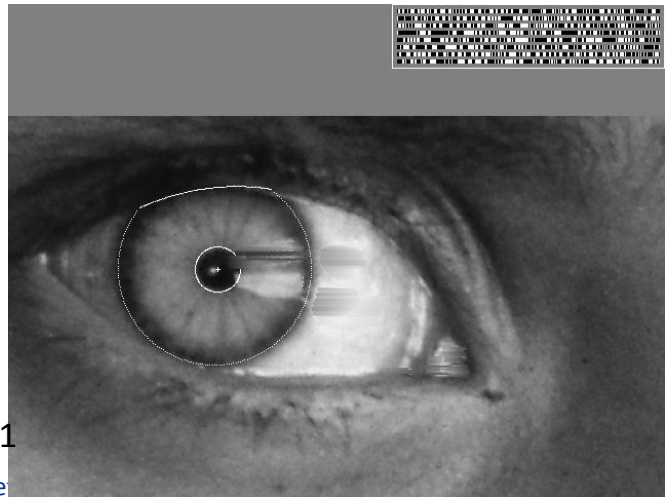
Face recognition

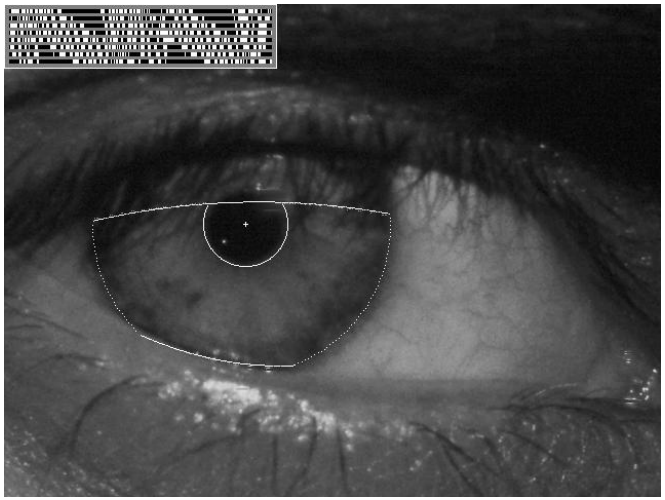


Qui és?

Vision based biometrics

"As an Afghan girl was identified by his employer iris",… Read the story





Mobile Apps

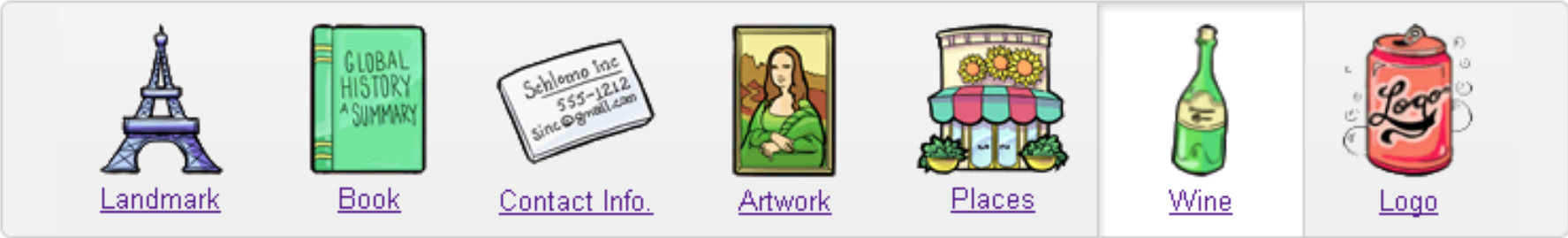
(www.kooaba.com)

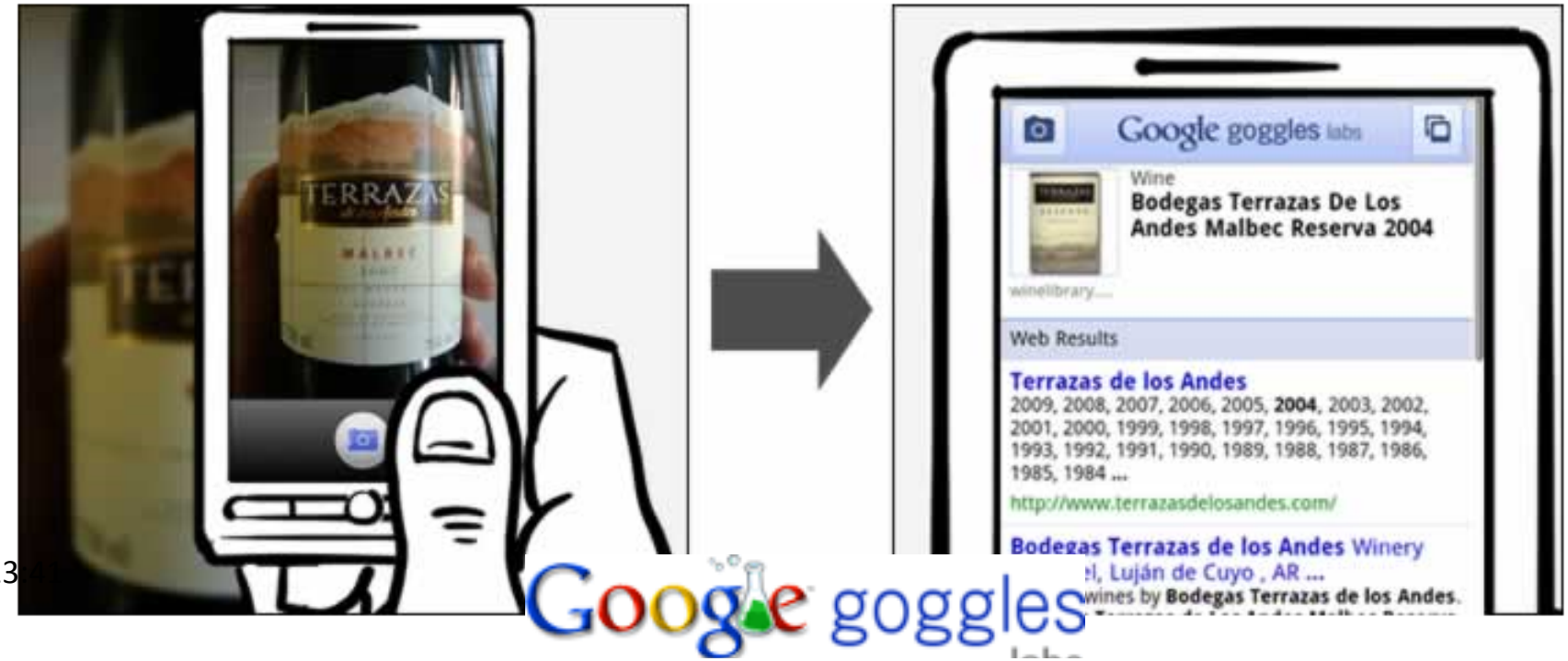
•Source: S. Lazebnik

Mobile visual search: Google Goggles

Google Goggles in Action

Click the icons below to see the different ways Google Goggles can be used.

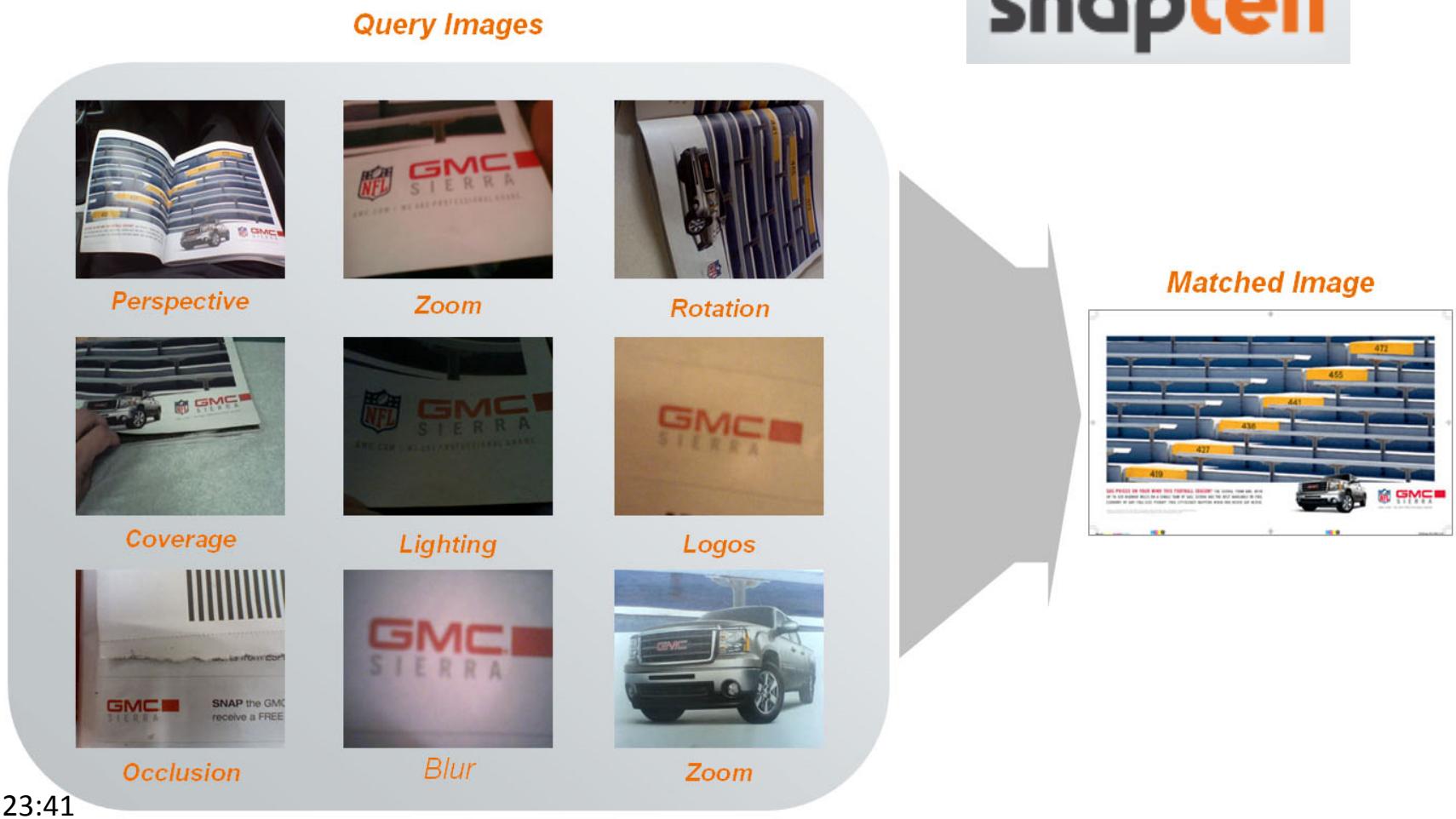




Google goggles

Mobile visual search: iPhone Apps

snaptell



23:41

Login without password…

Fingerprints for many portable scanners or other devices

Face recognition
http://www.sensiblevision.com/

23:41

Mobile recognition

- Microsoft Research
  - Point & Find, Nokia

Lincoln

23:41

Visual effects: shape capture

Matrix, ESC Entertainment, XYZRGB, NRC

23:41

Visual effects: shape capture

Pirates of the Carribean, Industrial Light and Magic

Sport

Sportvision first down line

23:41

Intelligent cars

- Mobileye
  - Vision systems in BMW, GM, Volvo, Folkswagen
  - In 2010: 70% of the manufactured cars.

- video

23:41

Google cars

- Oct 9, 2010. "Google Cars Drive Themselves, in Traffic". *The New York Times*. John Markoff
- June 24, 2011. "Nevada state law paves the way for driverless cars". *Financial Post*. Christine Dobby
- Aug 9, 2011, "Human error blamed after Google's driverless car sparks five-vehicle crash". *The Star* (Toronto)

Vision based interaction

Nintendo Wii. Work of Lee's from CMU how to use: multi-touch display!

Digimask: put the face of a person to the avatar.

"Game turns moviegoers into Human Joysticks", CNET
A camera following the audience: aquest treball.

23:41

Vision in the space

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

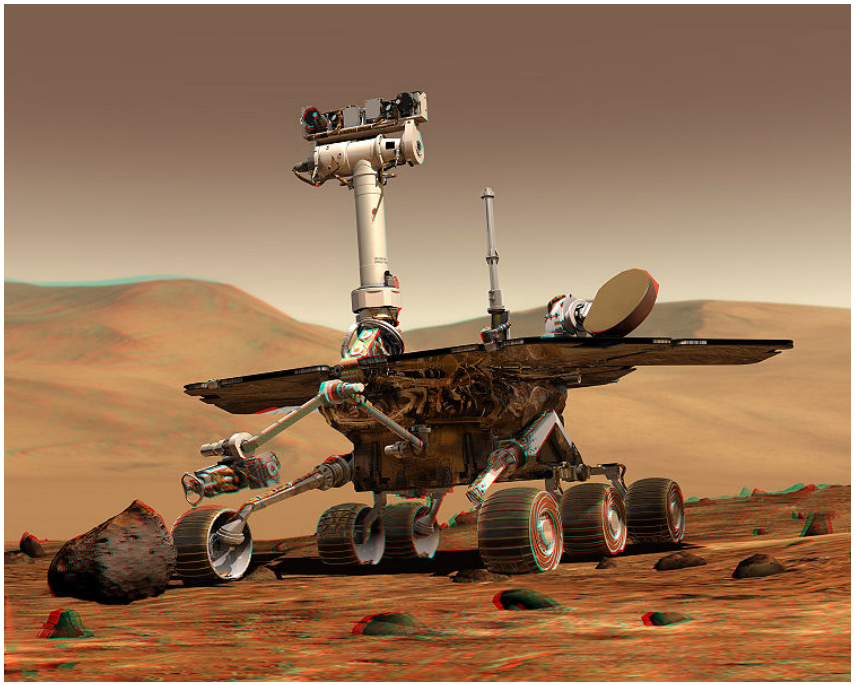
Vision systems (JPL) for:

- Panorama stitching
- 3D Terrain Modeling
- Obstacle detection, tracking the position
    - "Computer Vision on Mars" by Matthies et al.

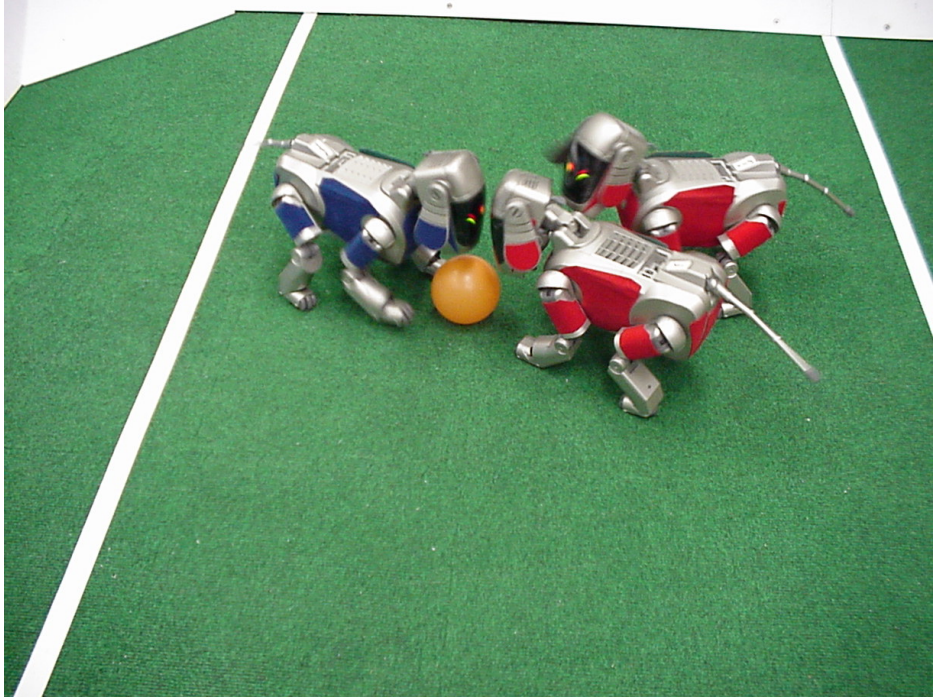
Industrial robots

- Vision-guided robots position nut runners on wheels

Robotics



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

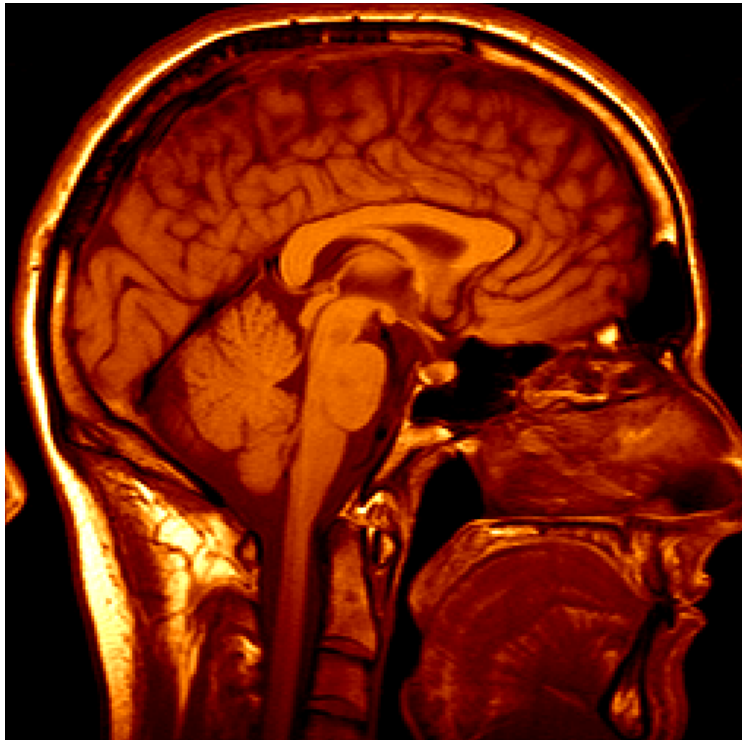


http://www.robocup.org/

Elder people assistance

23:41

Medical diagnosis and intervention



3D Images
MRI, CT

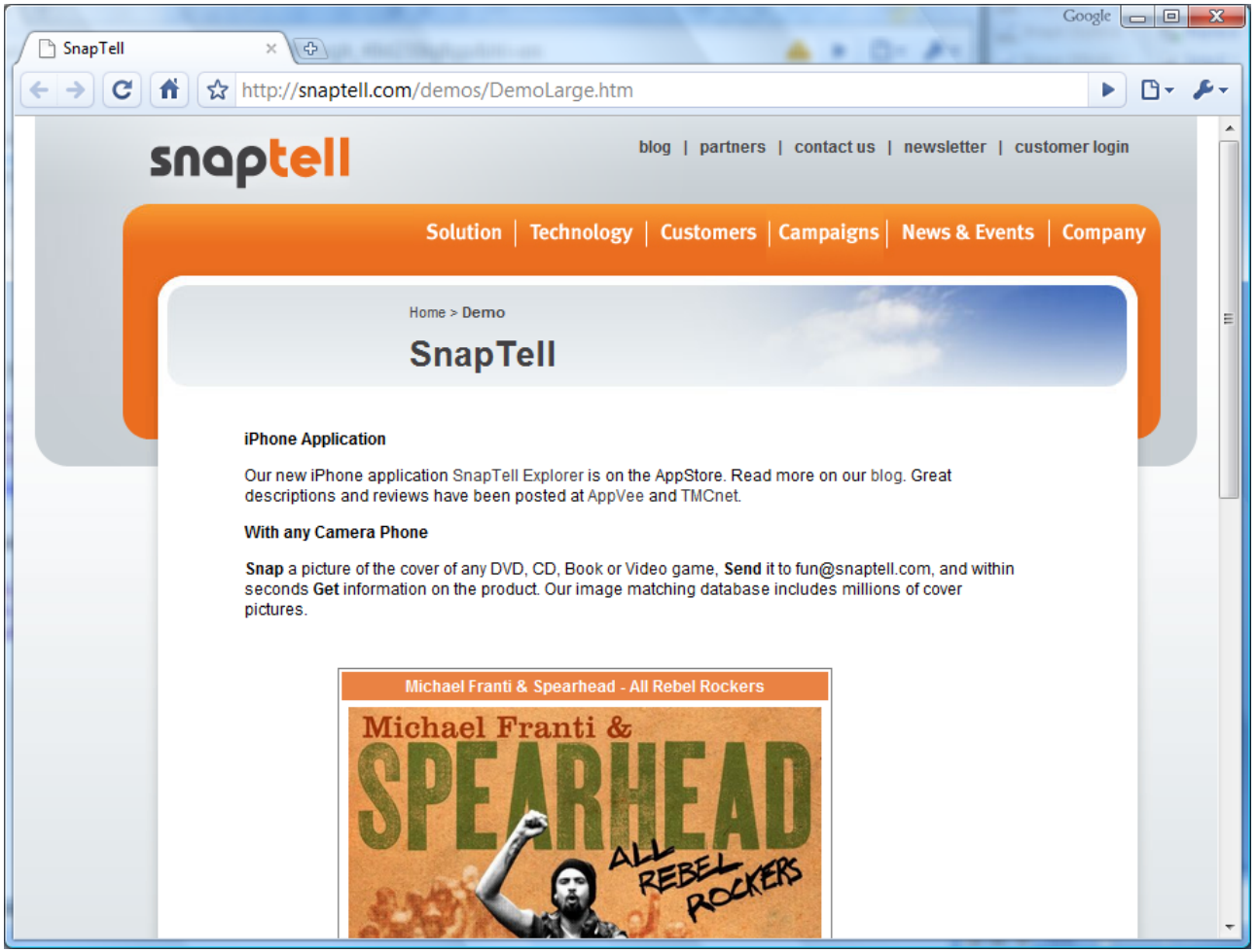
Grimson et al., MIT

Photo Tourism

Nokia Point and Tell…

23:41

Snaptell


SnapTell
http://snaptell.com/demos/DemoLarge.htm
snaptell
blog | partners | contact us | newsletter | customer login
Solution | Technology | Customers | Campaigns | News & Events | Company
Home > Demo
SnapTell
iPhone Application
Our new iPhone application SnapTell Explorer is on the AppStore. Read more on our blog. Great descriptions and reviews have been posted at AppVee and TMCnet.
With any Camera Phone
Snap a picture of the cover of any DVD, CD, Book or Video game, Send it to fun@snaptell.com, and within seconds Get information on the product. Our image matching database includes millions of cover pictures.
Michael Franti & Spearhead - All Rebel Rockers
Michael Franti &
SPEARHEAD
ALL REBEL ROCKERS