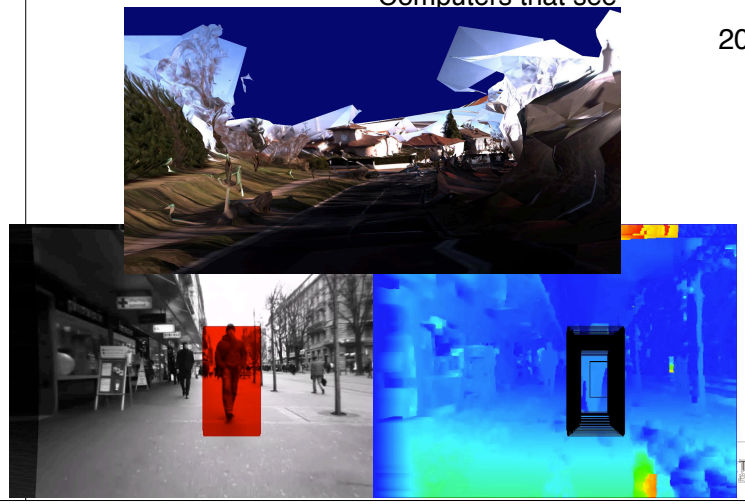
Pascal institute

ISPR/ComSee

Computers that see

2012



Structuration

INSTITUT PASCAL
sciences de l'ingénierie et des systèmes

Teams

- Mechanical, Materials and Structures
- Computer vISion, Perception systems and Robotics
- Process Engineering, Energetics and Biosystems
- Photonics, Microwave, Nanomaterials

Disciplinary topics

- Intelligent and Innovative Machines and Robots
- Innovations for Bioprocess
- Multiscale Materials and Model
- Probabilistic based methods
- Quantitative Imaging

Content

Relevant keywords about ISPR/ComSee

- **Topic 1** : Threedimensional Reconstruction of Rigid Scenes and Vision-Based Metrology
- **Topic 2** : Visual Identification and Tracking

ISPR/ComSee: Relevant Keywords

- **ComSee members (Jun. 2013):** (36)
  - Permanent members: 9 researchers
  - Non permanent members: 16 Phd, 5 PostDoc, 1 Engineers
  - 5 associate professors
- **Publications (2007-2010):**
  - 20 International journals articles
  - 96 articles in International Conferences
- **Publications (2010-2012):**
  - 10 International journals articles
  - 78 articles in International Conferences
  - **Patents, 2007-2010** (Systems and softwares): 5
- **Current funded projects**: 6

Introduction to Computer Vision

2015

T. Chateau

Computer Vision: Definition

Computer vision is a field that includes methods for **acquiring**, **processing**, **analyzing**, and **understanding** images and, in general, high-dimensional data from the real world in order to produce numerical or symbolic information, e.g., in the forms of decisions

Processing

Acquiring

High Dimensional data

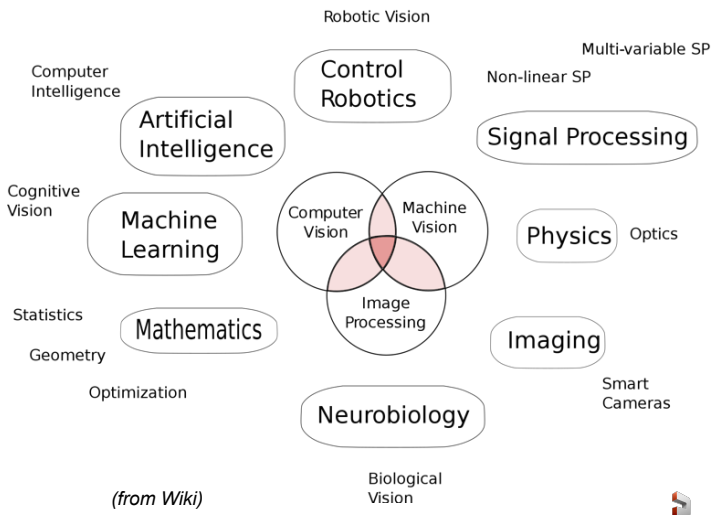
Analyzing

Understanding

T. Chateau

Institut Pascal

Computer Vision: Related Fields



(from Wiki)

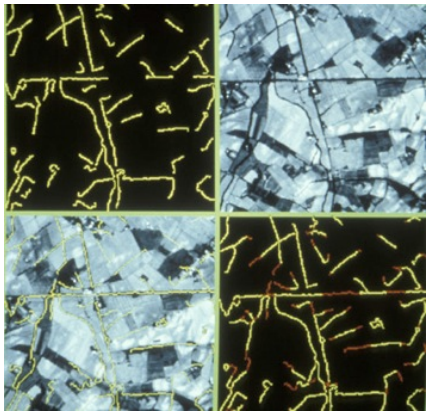
T. Chateau

Institut Pascal

Computer Vision: State of the art

1950: Image processing

1960: first image processing algorithms



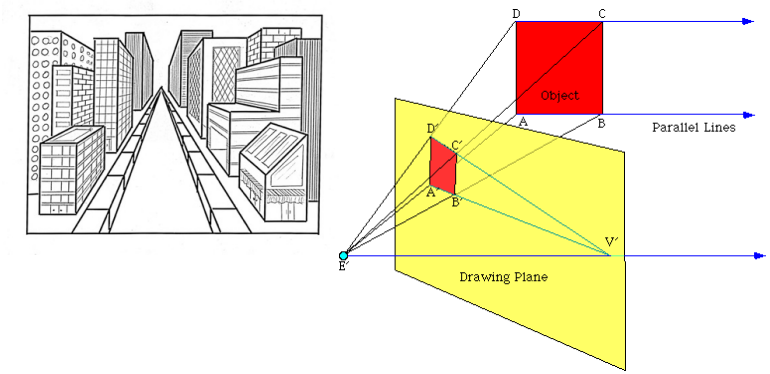
binary and edge based technics

T. Chateau

Institut Pascal

Computer Vision: State of the art

1990: projective geometry, a major contribution to Computer Vision



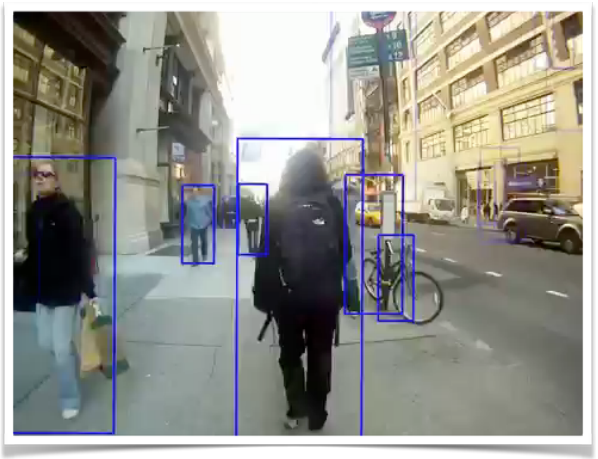
Computer Vision: State of the art

>2000: toward robust and realtime algorithms

ComSee, Pascal Institute, 2005

Computer Vision: State of the art

>2000: Learning based methods



Deep learning

Why Computer Vision is Challenging ?

- what about the animal vision system ?
- perspective projection (from 3D to 2D)
- object reflectance
- visual features

Why Computer Vision is Challenging ?

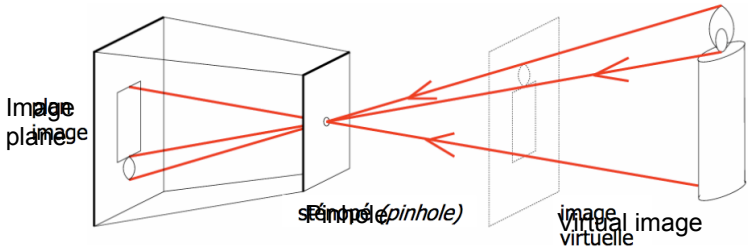
what about the animal vision system ?

prey: 360° field of view

predator: stereoscopic vision

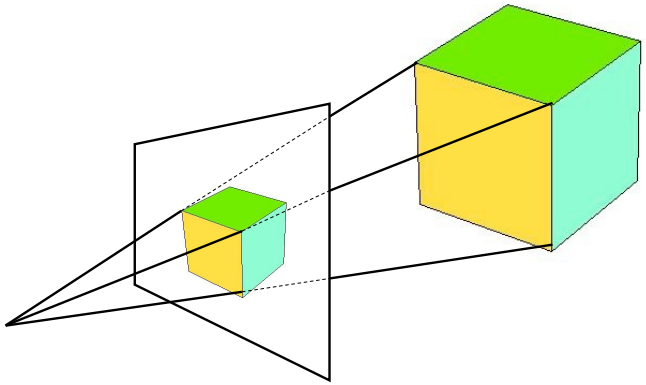
Camera Models

Pinhole model



Why Computer Vision is Challenging ?

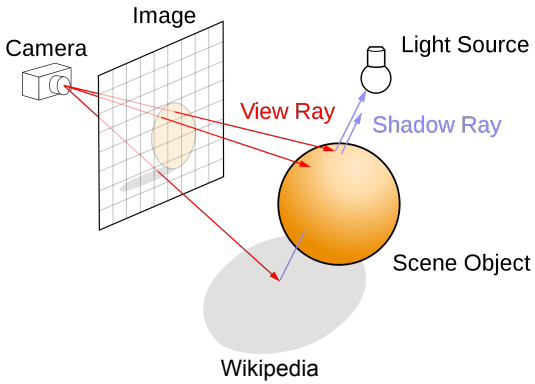
perspective projection (from 3D to 2D)



Why Computer Vision is Challenging ?

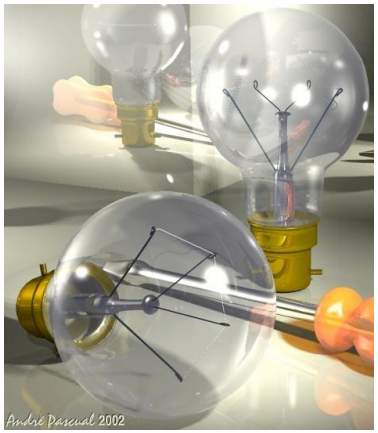
Scene rendering : the direct problem

Produce an image from parameters



Why Computer Vision is Challenging ?

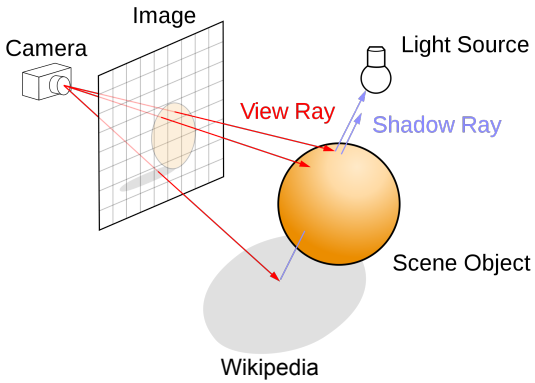
exemples of virtual images



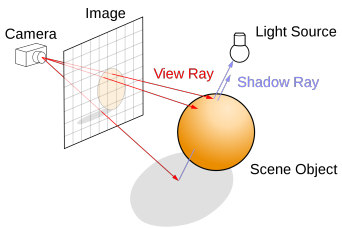
Why Computer Vision is Challenging ?

Computer Vision: the inverse problem

Estimate parameters from images



Why Computer Vision is Challenging ?



To solve the inverse problem, we need
to extract image features

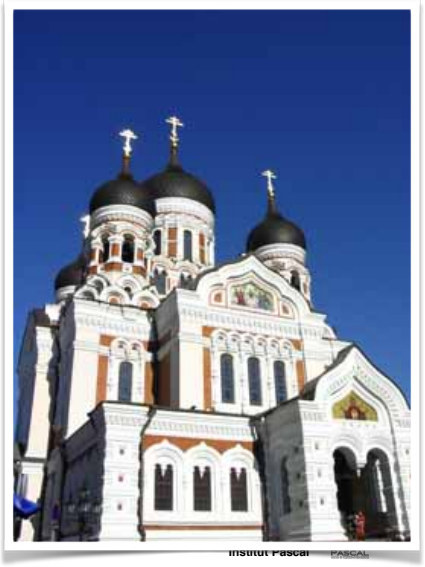
Wikipedia

Why Computer Vision is Challenging ?

visual features:
edges

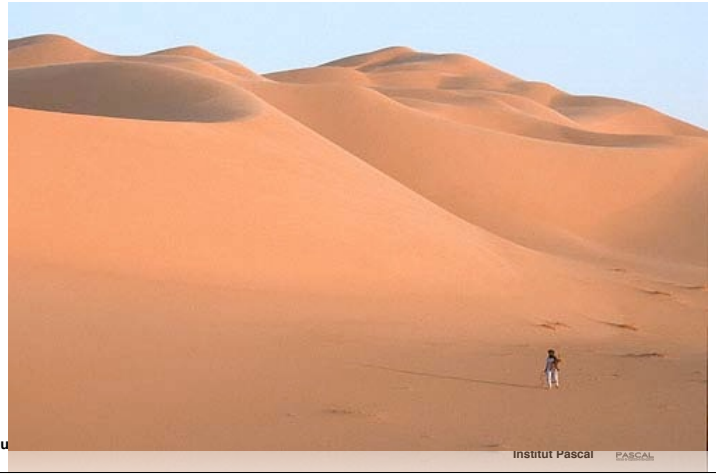
Why Computer Vision is Challenging ?

visual features:
edges



Why Computer Vision is Challenging ?

visual features:
shadow



Why Computer Vision is Challenging ?

visual features:
texture

Why Computer Vision is Challenging ?

Relevant human features for still images

- Edges
- Shadow
- Texture and color

Why Computer Vision is Challenging ?

Most popular geometric features used in Computer Vision

Why Computer Vision is Challenging ?

Edges

Why Computer Vision is Challenging ?

Interest Points

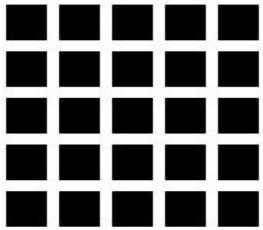
Why Computer Vision is Challenging ?

But: should we rely on human vision?

Why Computer Vision is Challenging ?

Should we rely to the human vision ?

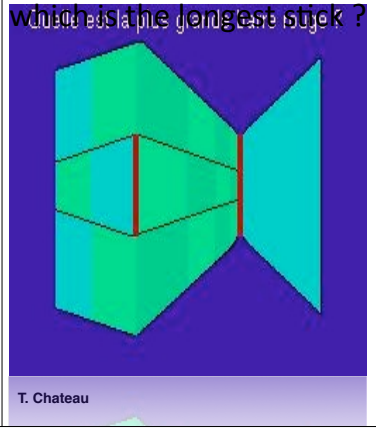
Que voyez-vous entre les carrés ? Du gris ?



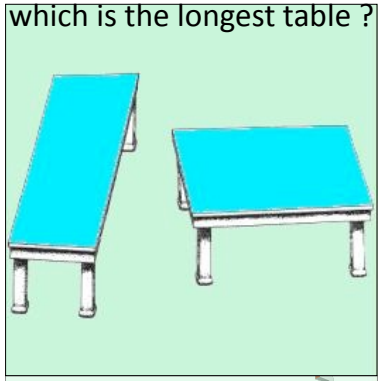
Why Computer Vision is Challenging ?

Should we rely to the human vision ?

which is the longest stick ?



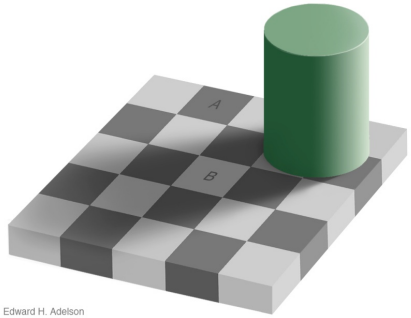
which is the longest table ?



Why Computer Vision is Challenging ?

Should we rely to the human vision ?

which is the darkest square between A and B?

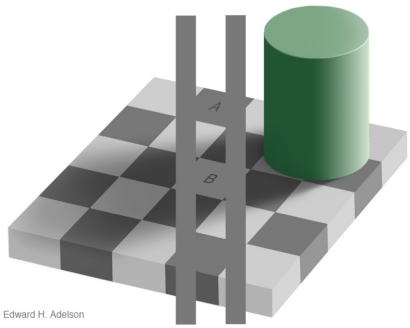


Edward H. Adelson

Why Computer Vision is Challenging ?

Should we rely to the human vision ?

which is the darkest square between A and B?



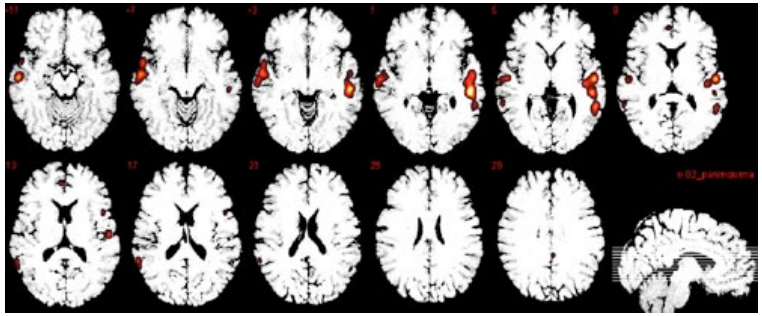
Edward H. Adelson

Typical tasks in Computer Vision

- Image Processing
- Object detection and tracking
- 2D geometry
- 3D geometry

Typical tasks in Computer Vision

Image Processing/Analysis



for medical applications

Typical tasks in Computer Vision

Image Processing/Analysis

Original

Noisy image

Denoised image

denoising

Typical tasks in Computer Vision

Image Processing/Analysis

original mask image result

Inpainting

Typical tasks in Computer Vision

Object detection and tracking

face detection

Typical tasks in Computer Vision

Object detection and tracking

pedestrian detection

Typical tasks in Computer Vision

Object detection and tracking

object tracking: meanshift

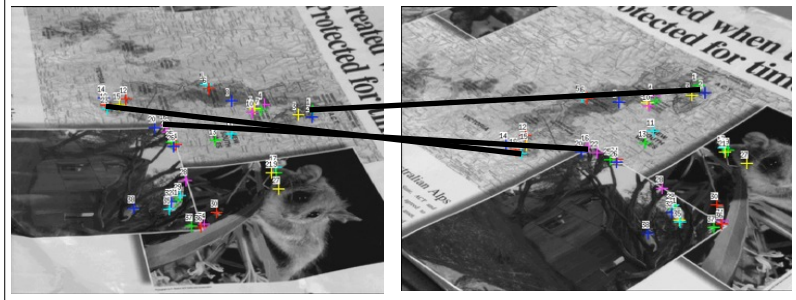
Typical tasks in Computer Vision

Object detection and tracking MOT: Multi objects tracking

ComSee, Pascal Institute, 2009

Typical tasks in Computer Vision

2D geometry



Interest point matching

Typical tasks in Computer Vision

2D geometry: 2D pattern tracking

V. Lepetit, EPFL, Lausanne, 2006

Typical tasks in Computer Vision

2D geometry: video stabilization

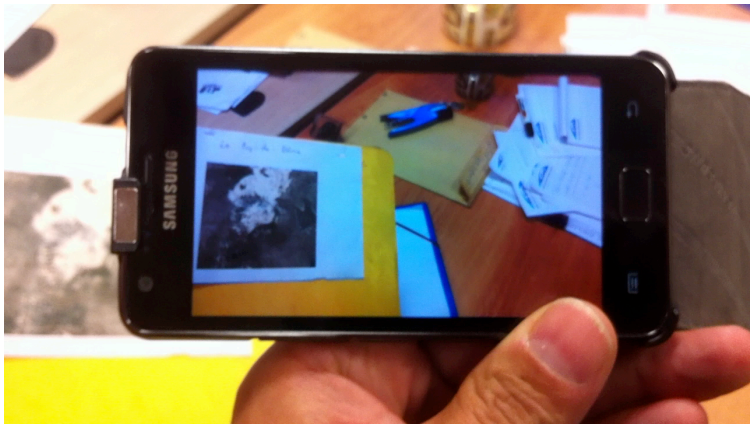
before

after

Pascal Institute, France, 2006

Typical tasks in Computer Vision

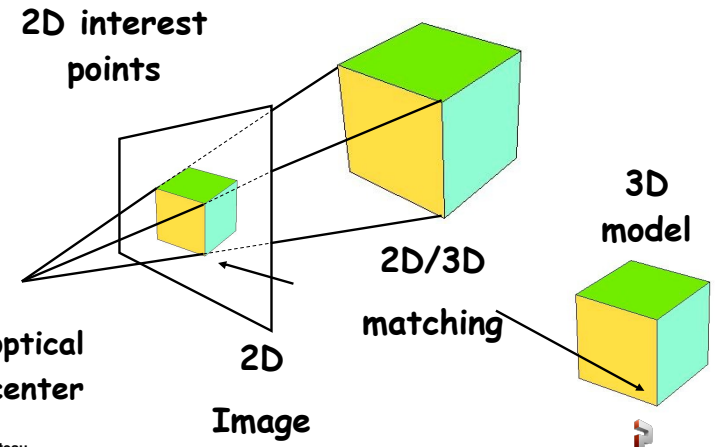
2D geometry: augmented reality



ComSee, Pascal Institute, France, 2011

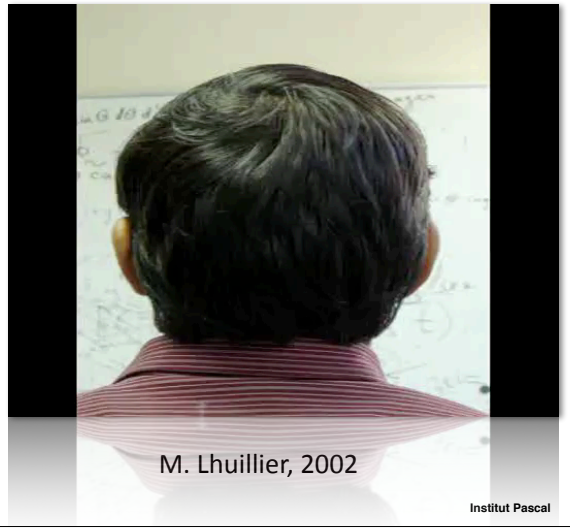
Typical tasks in Computer Vision

3D geometry



Typical tasks in Computer Vision

3D geometry: 3D reconstruction



M. Lhuillier, 2002

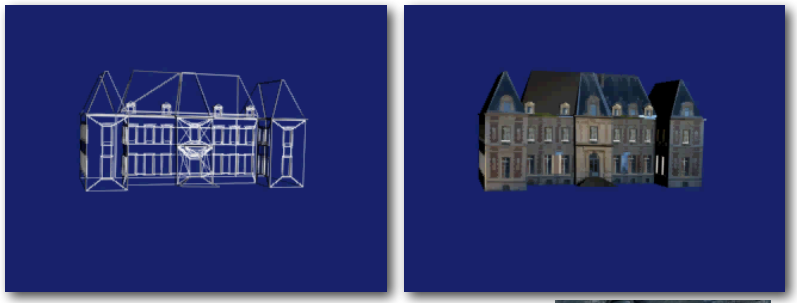
Typical tasks in Computer Vision

3D geometry: 3D reconstruction

ComSee, Pascal Institute, 2008

Typical tasks in Computer Vision

3D geometry: 3D reconstruction



ComSee Pascal Institute/Cea, France, 2005

ISPR/ComSee: 3D-Localisation

Monocular based localisation for automatic guidance

Step 1: supervised guidance and video recording

Visual Memory: Matching

Step 2: 3D reconstruction

- Interest point detection (1500 per image)
- Correlation ZNCC (11x11 pixels ROI)

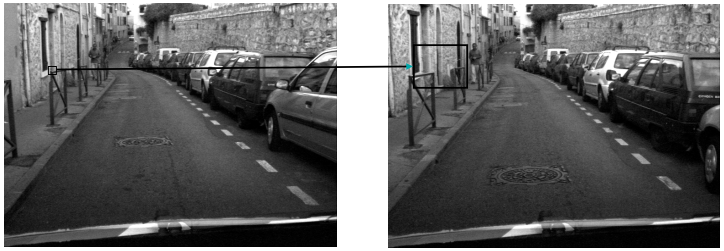
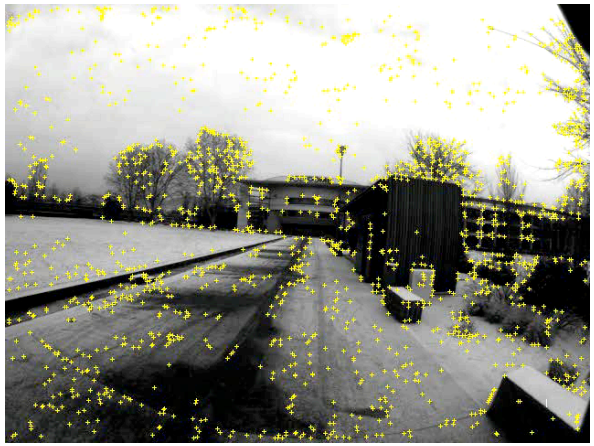


image t image t+1

Visual memory: interest points detection

Step 2: 3D reconstruction

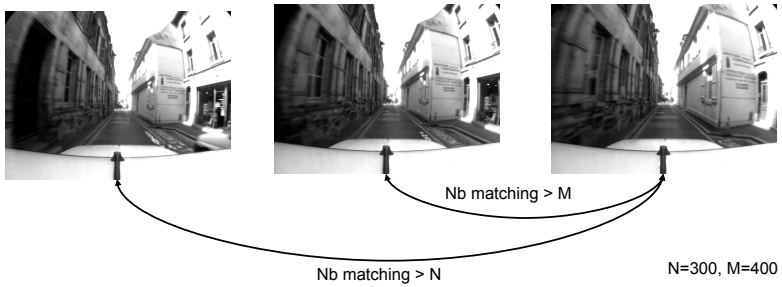


Interest point detection

Visual Memory: key images selection process

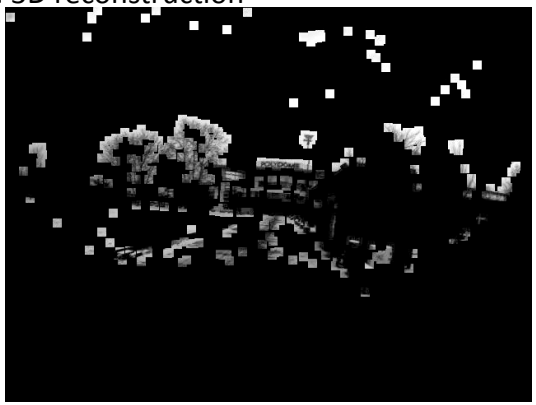
Step 2: 3D reconstruction

- Key images:
  - far enough to produce a precise 3D reconstruction
  - close enough to keep matching points.



Visual Memory: 3D textured points

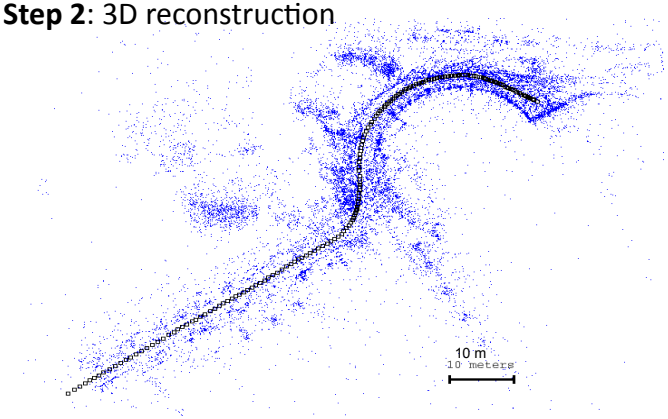
Step 2: 3D reconstruction



(125 m, 172 key images, 23000 3D points)

Visual Memory: 3D points

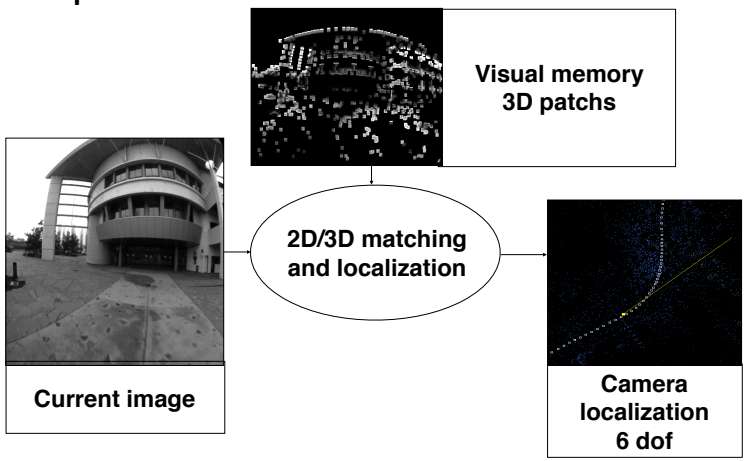
Step 2: 3D reconstruction



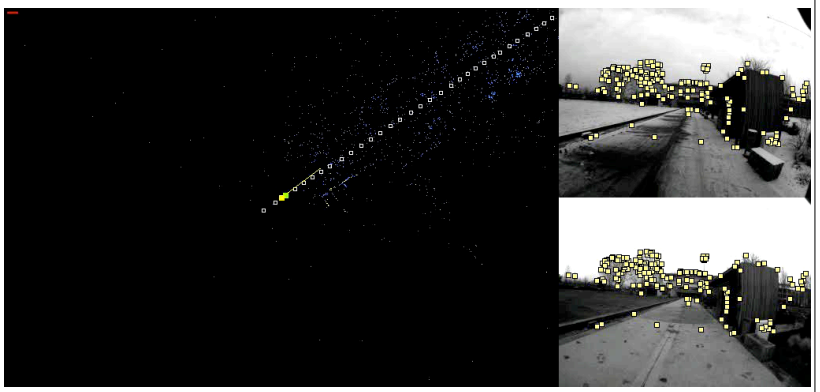
3D reconstructed points
(125 m, 172 key images, 23000 3D image)

Visual based localization

Step 3: realtime online localization



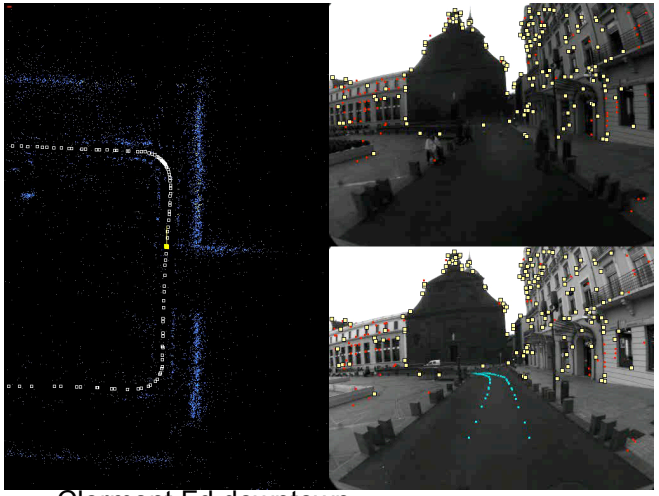
Processus Innovant : Guidage Temps Réel vidéo



Realtime localization (15 fps) – precision: 10cm

Eric Royer, Maxime Lhuillier, Michel Dhome and Thierry Chateau, Localization in urban environments : monocular vision compared to a differential gps sensor. IEEE **CVPR2005**, Computer Vision and Pattern Recognition. San Diego, USA, June 2005

Expérimentation en milieu urbain : Place de jaude



Clermont Fd downtown

ISPR/ComSee: 3D-Localisation

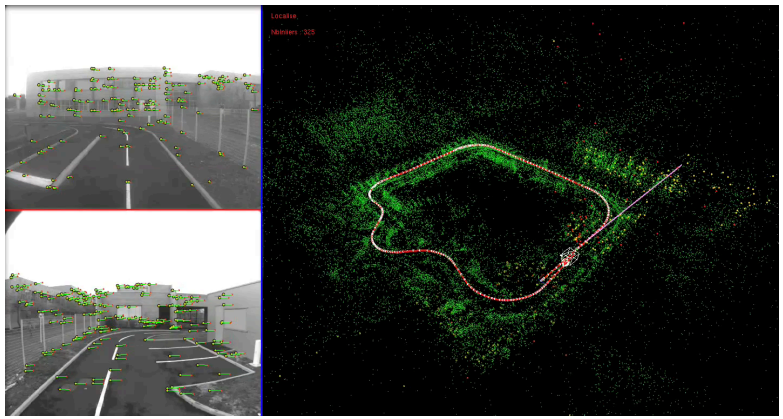
Monocular based localisation for automatic guidance

Toward the Vipa Project: using two cameras (rear-front)

ISPR/ComSee: 3D-Localisation

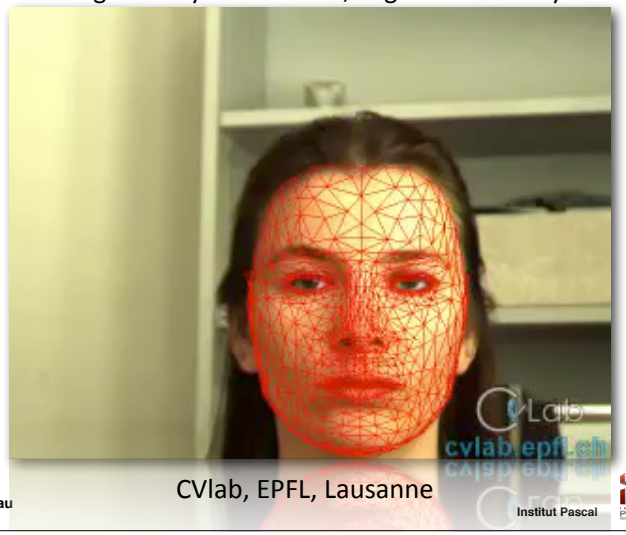
Monocular based localisation for automatic guidance

Toward the Vipa Project: using two cameras (rear-front)



Typical tasks in Computer Vision

3D geometry: localisation, augmented reality



CVlab, EPFL, Lausanne

Typical tasks in Computer Vision

3D geometry: localisation, augmented reality,

ComSee, Pascal Institute/Cea, France, 2013

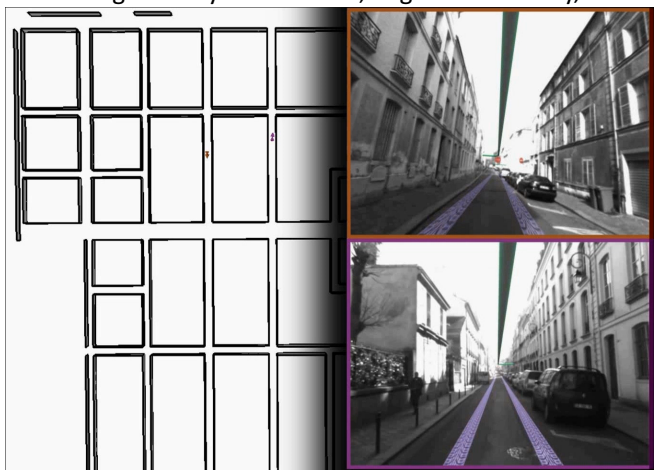
Typical tasks in Computer Vision

3D geometry: localisation, augmented reality,

ComSee, Pascal Institute/Cea, France, 2011

Typical tasks in Computer Vision

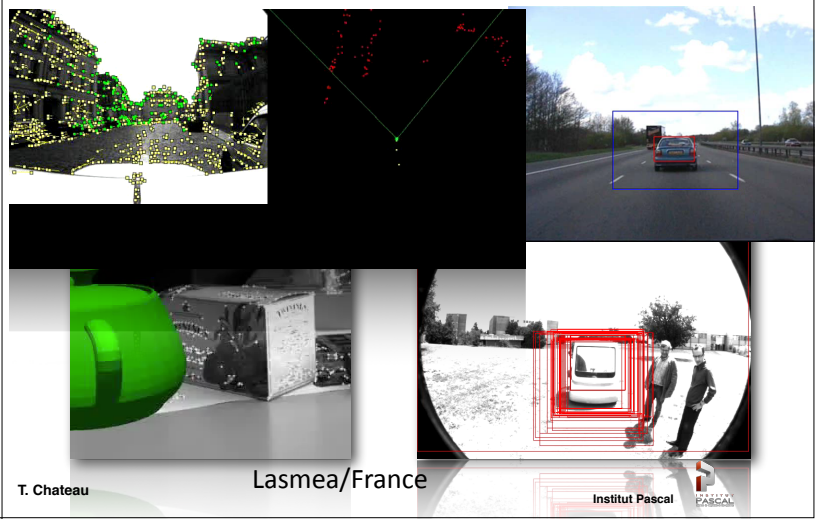
3D geometry: localisation, augmented reality,



ComSee, Pascal Institute /Cea, France, 2011

Typical tasks in Computer Vision

And many other applications ...



Lasmea/France

Computer Vision Systems

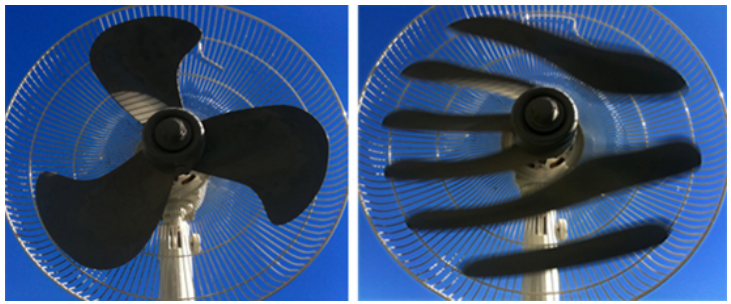
- Image acquisition
- Pre-processing
- Feature extraction
- Detection, segmentation
- High level processing

Computer Vision Systems

Image acquisition: sensors

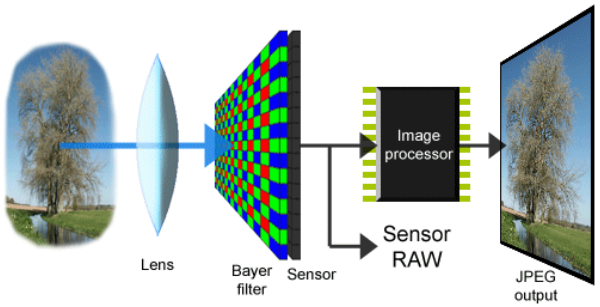
Computer Vision Systems

Rolling shutter Vs Global shutter

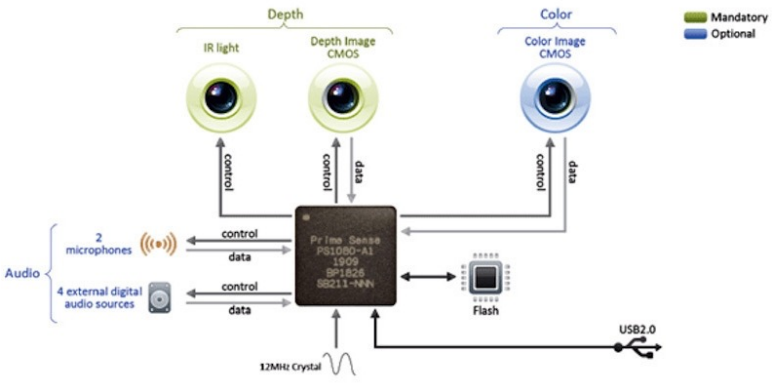


Computer Vision Systems

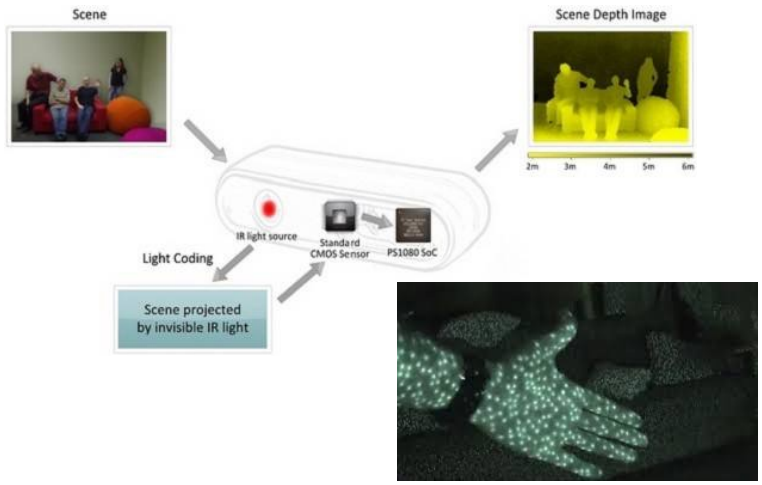
color cameras



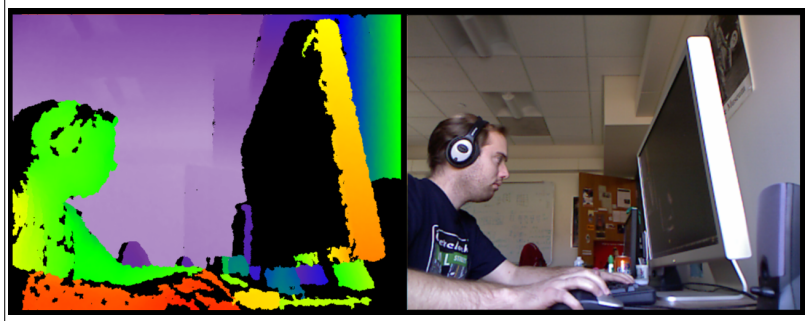
Kinect 1 : structured IR active camera



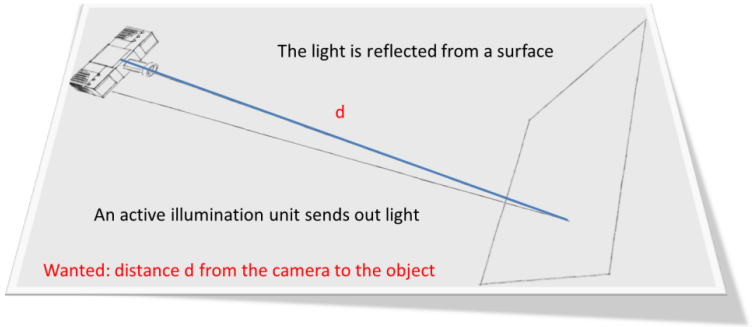
Kinect 1 : structured IR active camera



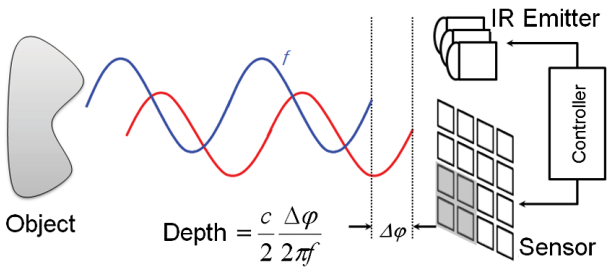
Kinect 1 : structured IR active camera



Kinect 2 : time of flight camera



Kinect 2 : time of flight camera



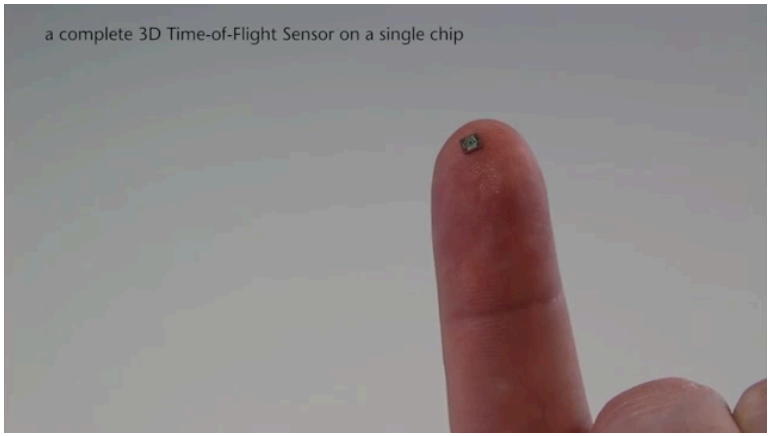
Kinect 2 : time of flight camera

Kinect 2 : time of flight camera

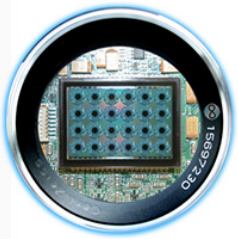
Kinect 2 : time of flight camera

1.) Low Resolution
3D-Scan of a Room

Kinect 2 : time of flight camera



plenoptic cameras



Computer Vision Systems

Image acquisition: communication

Computer Vision Systems

Image processing: hardware

Computer Vision Systems

Image processing: software

python™

MATLAB® R2008a

Java

C/C++

OBJECTIVE-C

```
ADD     R3, SP, #0x218+var_210
MOV     R0, R3          ; char **
LDR     R3, =(aSshpassPSSsh0S - 0x2510)
ADD     R3, PC, R3      ; "sshpass -p %s ssh -o Str
MOV     R1, R3          ; char *
LDR     R3, =(aAlpine - 0x251C)
ADD     R3, PC, R3      ; "alpine"
MOV     R2, R3
LDR     R3, [SP,#0x218+var_214]
```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