Computer Vision: Course 2025/2026

USTHB, Prof. Slimane Larabi

Computer Vision: Syllabus

1- Course Description

Chapter 0. Computer Vision: Past, Present and the future

Chapter 1. SIFT Descriptor and Applications

1.1 Introduction
1.2 What is an interest point?
1.3 Detecting blobs
1.4 SIFT Detector
1.5 SIFT Descriptor
1.6 Image Stitching
- Overview
- Image Transformations
- Computing the Homography
- Dealing with Outliers: RANSAC
- Warping and Blending Images

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Chapter 2 Camera Calibration

2.1 Introduction
2.2 Linear Camera Model
2.3 Calibrate a Camera
2.4 Simple Stereo
2.5 Project

Chapter 3. Uncalibrated stereo

3.1 Overview
3.2 Problem of uncalibrated stereo
3.3 Epipolar Geometry
3.4 Estimating Fundamental Matrix
3.5 Finding Correspondances
3.6 Computing Depth

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Chapter 4. Structure from Motion

4.1 Overview
4.2 Structure from motion problem (SFM)
4.3 SFM Observation matrix
4.4 Rank of Observation Matrix
4.5 Tomasi-Kanade Factorization

Chapter 5. Object Recognition from Visual Appearance

5.1 Overview
5.2 Shape vs. Appearance
5.3 Learning appearance
5.4 Dimensionality reduction: PCA(Principal Component Analysis)
5.5 Finding Principal Components
5.6 Parametric Appearance Representation
5.7 Appearance Matching
5.8 Example of Applications

Chapter 6. Computer Vision Using Deep Learning

Computer Vision: Syllabus

2- Prerequisites

Programming

Python

Array Manipulation (numpy)

Linear Algebra

Calculus (gradients and partial derivatives of vector-valued functions).

Computer Vision: Syllabus

3- Textbooks

Free on line

[1] Richard Szeliski, Computer Vision: Algorithms and Applications Springer, 2010
[2] Jan Erik Solem, Programming Computer Vision with Python, 2012, Creative Commons
[3] Simon J.D. Prince, Computer vision: models, learning and inference Cambridge University Press 2012.
[4] Forsyth Ponce, Computer vision : A modern approach,
[5] J.R. Parker, Algorithms for Image Processing and Computer Vision, Wiley Publishing, Inc. 2011.
[6] Mubarek Shah, Fundamentals of Computer Vision, 1997.

To purchase

[7] Linda Shapiro, George C. Stockman, Computer Vision, Ed. Prentice Hall. 2001

Computer Vision: Syllabus

4- Practical projects

Home Project (13 pts)

Class project (7pts)

Computer Vision: Past, Present and the future

USTHB, 2025/2026

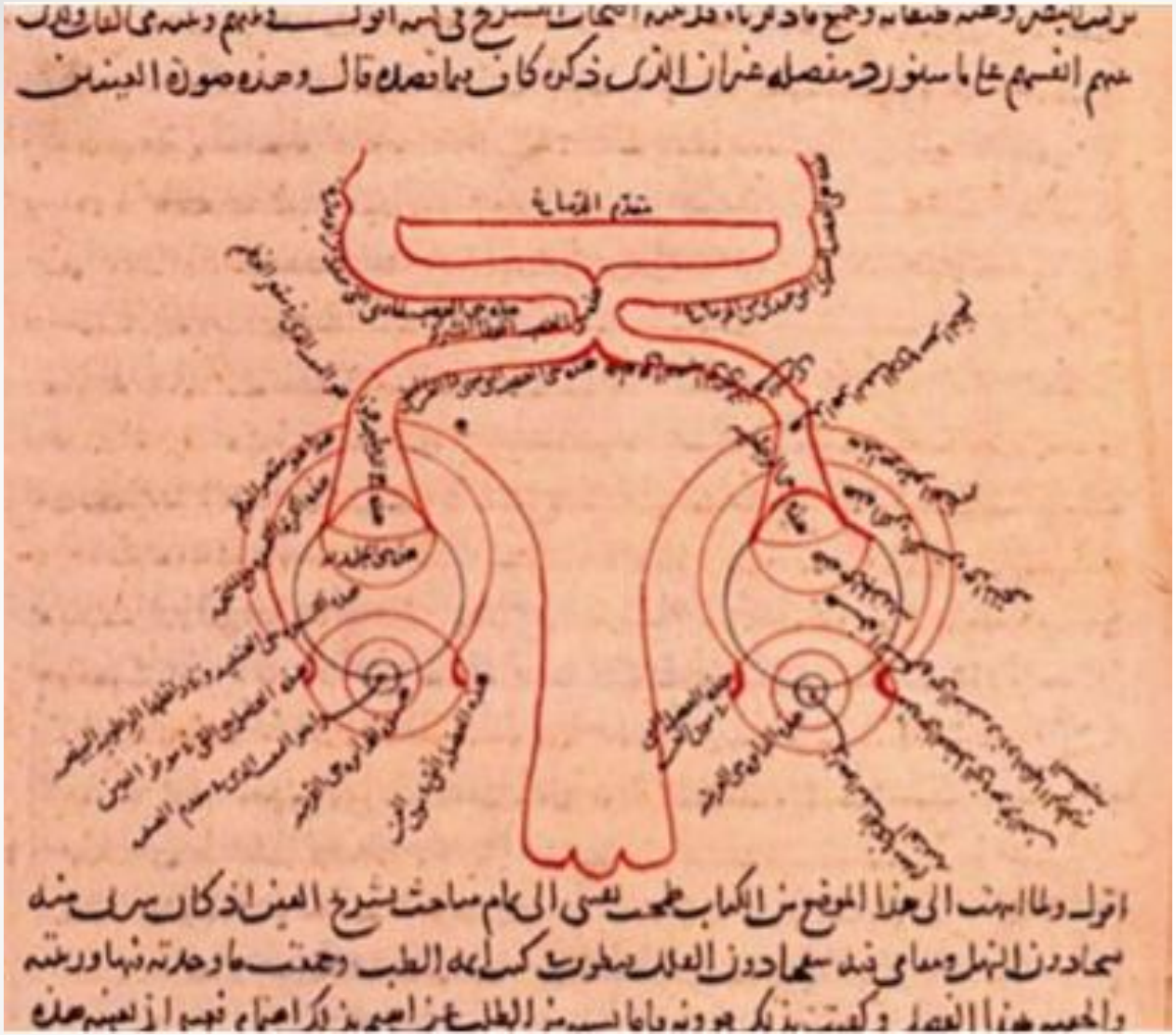
Prof. Slimane Larabi

The Past

Before Photography

Alhazen, (ابو علي، الحسن بن الحسن بن الهيثم)

is credited as being the first person to study how we see



From the book “Manazir “, Ibn al Haytham (965–1040)

ابو علي، الحسن بن الحسن بن الهيثم

He is one of the pioneers of quantitative physics and physiological optics. He was also the first to illustrate the anatomy of the eye with a diagram.

Early photographic camera (18th–19th centuries)
The daguerreotype was the first commercially successful photographic process (1839-1860) in the history of photography. Named after the inventor, Louis Jacques Mandé Daguerre, each daguerreotype is **a unique image on a silvered copper plate**.

The earliest surviving photograph, 1825
[ref] Gustavson, Todd (2009). *Camera: a history of photography from daguerreotype to digital*. New York: Sterling Publishing Co., Inc. ISBN 978-1-4027-5656-6.

Daguerreotype camera built by La Maison Susse Frères in 1839, with a lens by Charles Chevalier

Daguerre

HISTORIQUE ET DESCRIPTION

DES PROCÉDÉS

DU

DAGUERRÉOTYPE

et du Diorama,

PAR DAGUERRE,

Peintre, inventeur du Diorama, Officier de la Légion-d'Honneur, membre de plusieurs Académies, etc.

Nouvelle Édition,

CORRIGÉE, ET AUGMENTÉE DU PORTRAIT DE L'AUTEUR.

Paris,

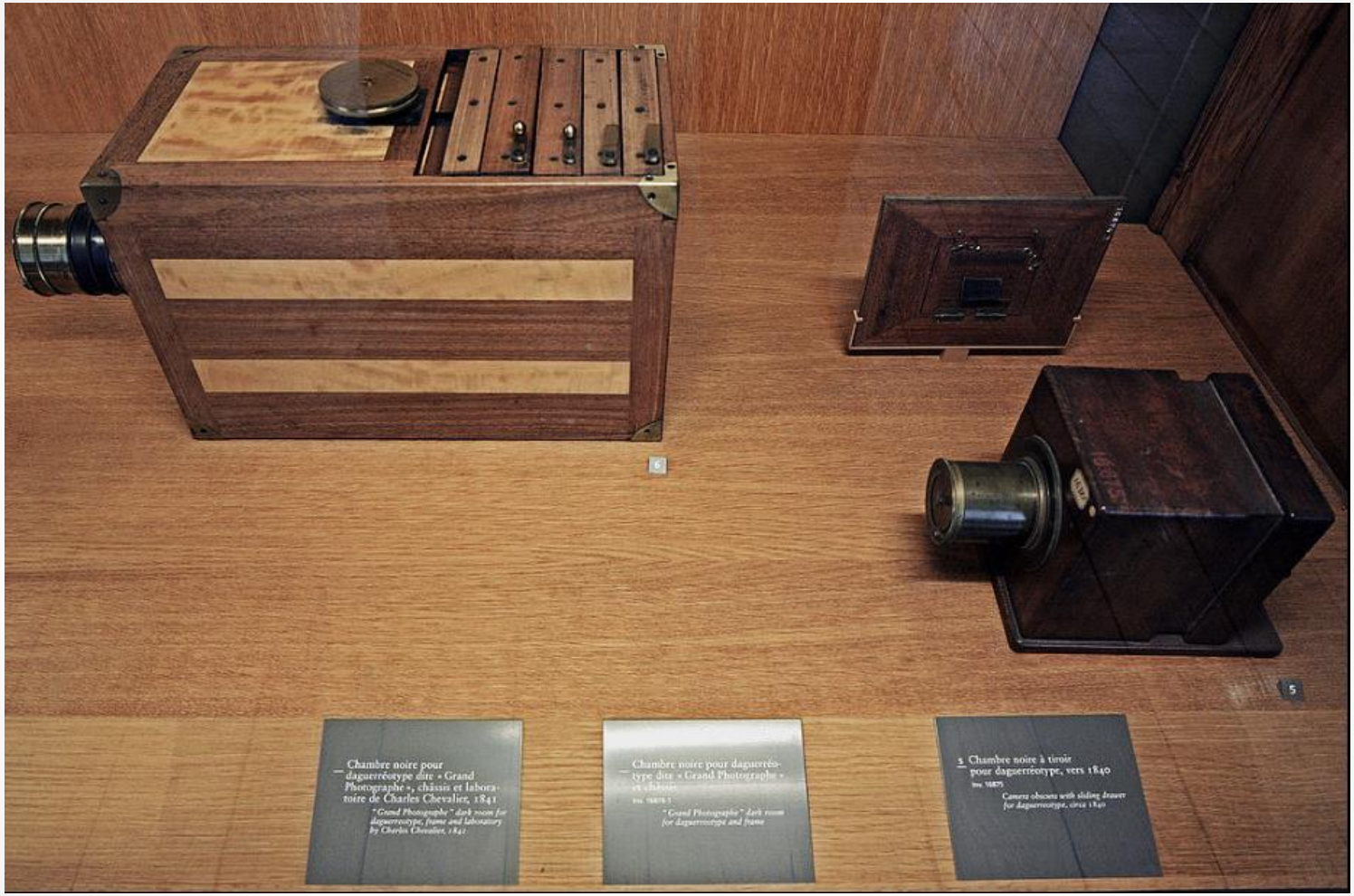
ALPHONSE GIROUX ET Cᵉ, ÉDITEURS,

RUE DU COQ-SAINT-HONORÉ, N° 7.

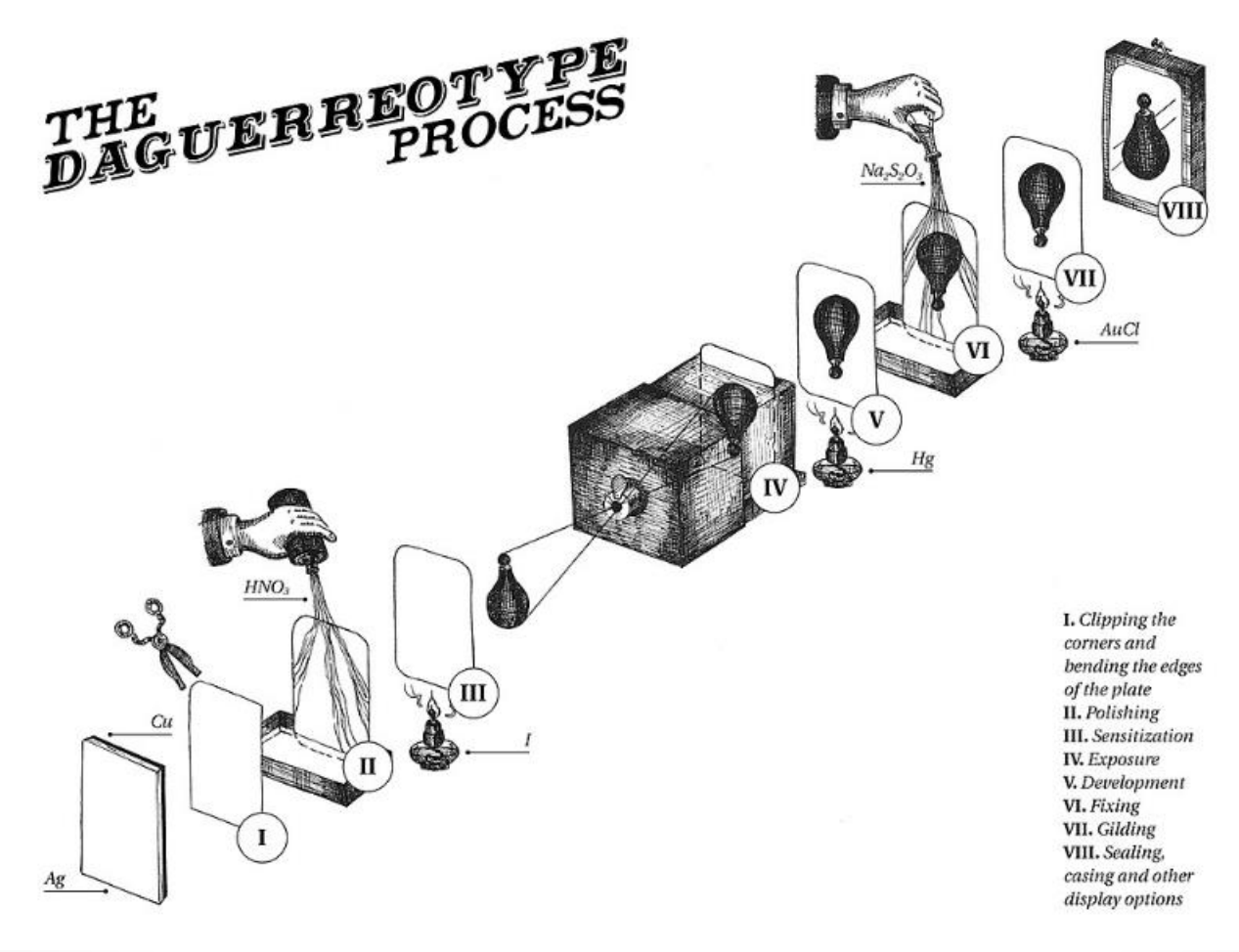
où se Fabriquent les Appareils;

ET CHEZ LES PRINCIPAUX LIBRAIRES, PAPETIERS, Marchands d'Estampes et Opticiens.

1839.

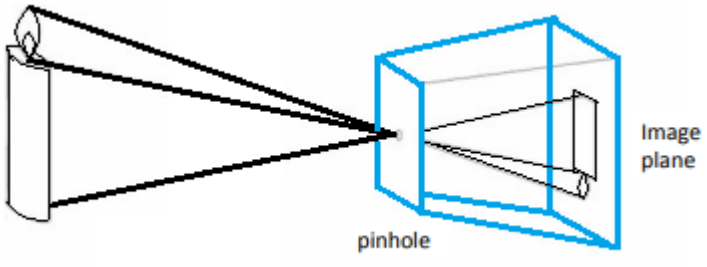


1840–1841 camerae obscurae and plates for daguerreotype called "Grand Photographe" produced by Charles Chevalier (Musée des Arts et Métiers)

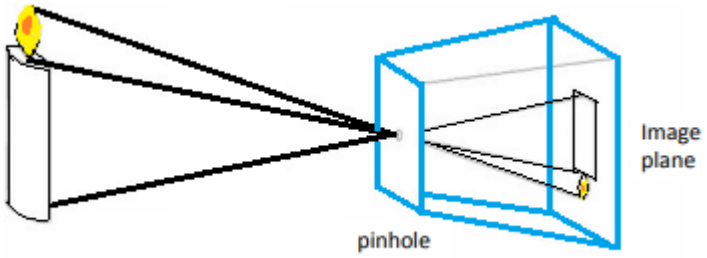


Graphic representation of the steps involved in making a daguerreotype

Basic principle of image formation.



Basic principle of image formation.



High quality cameras have been invented delivering high quality images

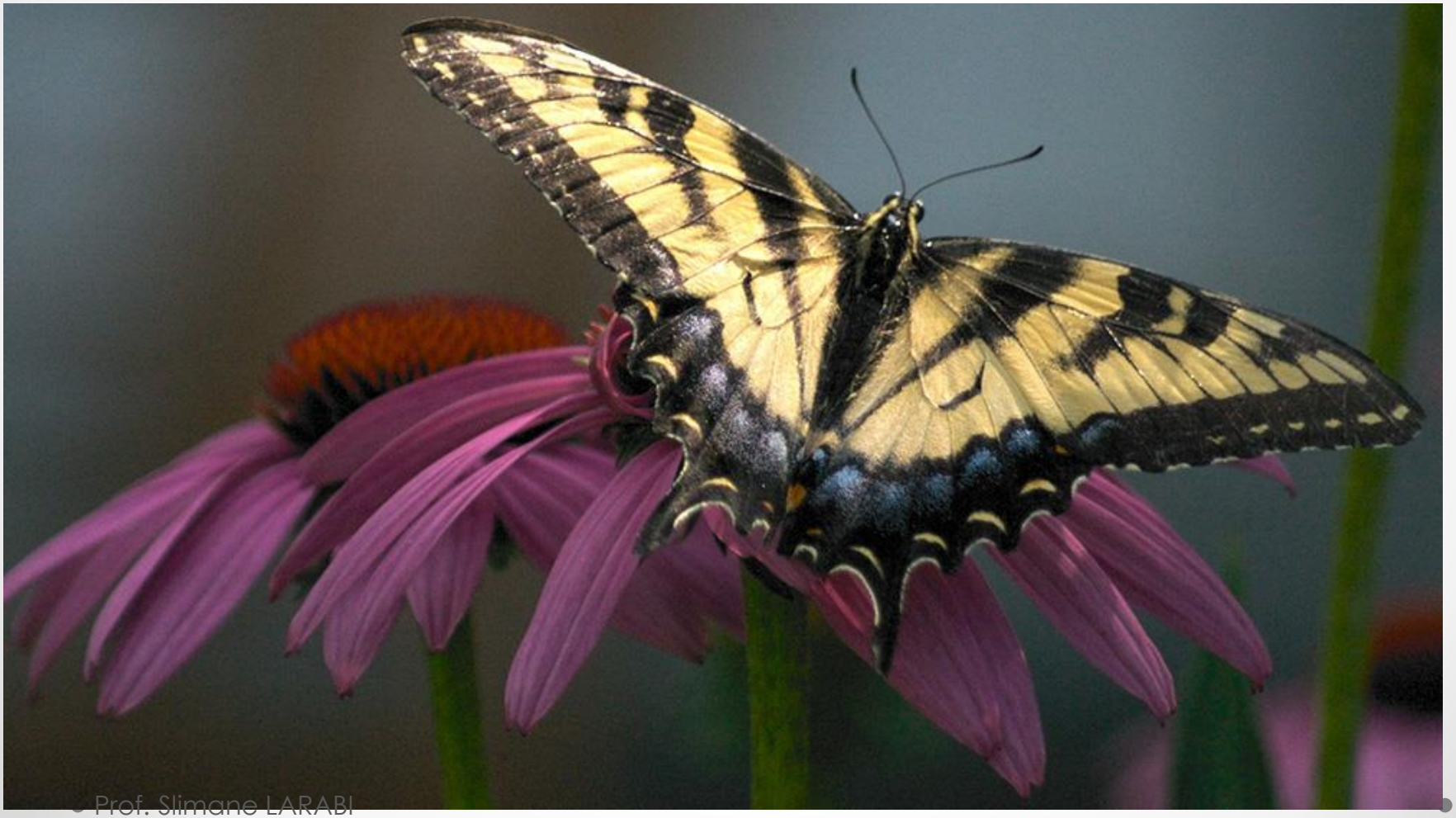


Image = Array of values

154	163	191	204	214	225	232	237	238	238	233	222
152	161	189	204	213	225	231	235	236	233	211	208
154	162	188	202	214	225	231	236	231	225	211	194
154	161	186	201	213	224	230	229	225	215	197	179
152	161	186	201	212	223	228	229	217	202	183	166
153	159	186	200	210	221	225	222	207	190	172	158
154	160	187	201	210	221	221	211	195	178	162	150
154	159	185	198	209	216	215	199	184	168	155	147
155	162	186	199	209	211	207	189	173	160	148	143
156	161	183	195	205	203	196	179	165	154	147	141
156	161	182	194	201	195	187	171	158	149	143	140
157	162	182	192	195	186	177	162	152	145	143	140
164	184	190	189	177	167	155	149	145	142	139	255

The Dream: From first computers to Intelligent system

1960- PDP-1

1964-The IBM System/360

1965-The PDP-8

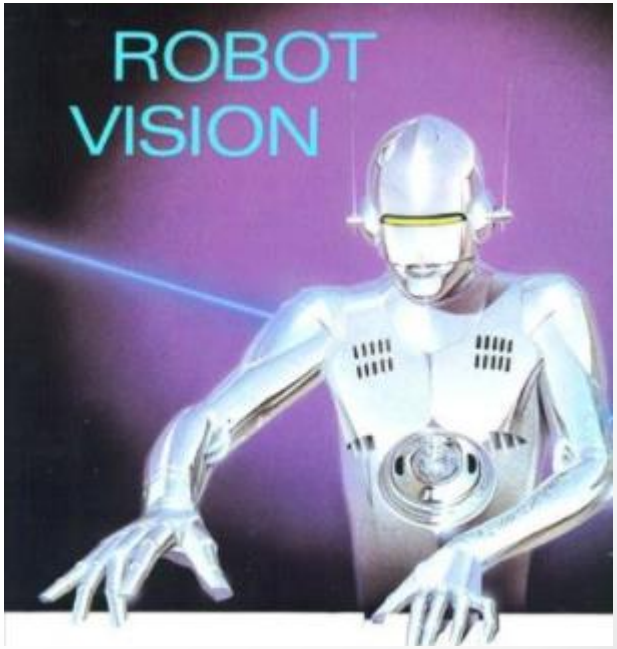
1968-Hewlett-Packard 9100A and 9800 series

1969- CDC 6000 series
(First supercomputers)

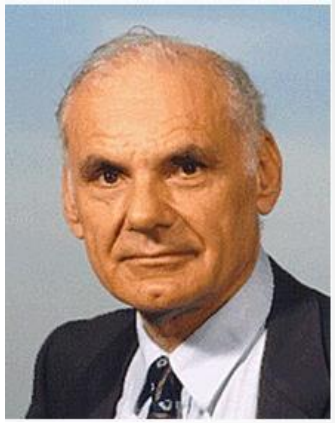
From Computer towards Computer Vision

Computer vision began in earnest during the 1960s at universities that viewed the project as a **stepping stone** to artificial intelligence.

Early researchers were extremely optimistic about the future of these related fields and promoted artificial intelligence as a technology that could transform the world.

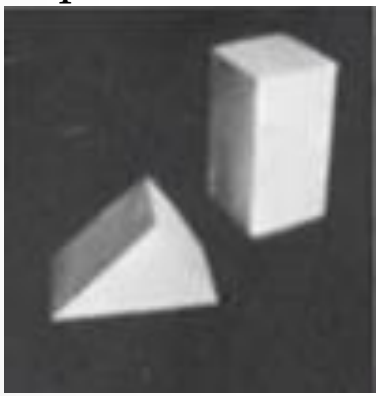


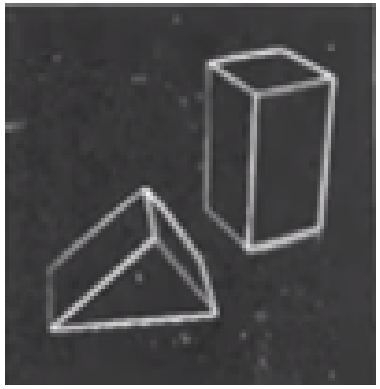
Roberts, Lawrence GILMAN
Ph.D. (1963), in electrical engineering.



His Ph.D. thesis "Machine Perception of Three-Dimensional Solids“ is considered one of the foundational works of the field of computer vision.

https://dspace.mit.edu/handle/1721.1/11589





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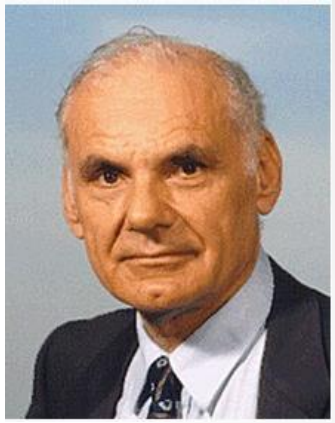

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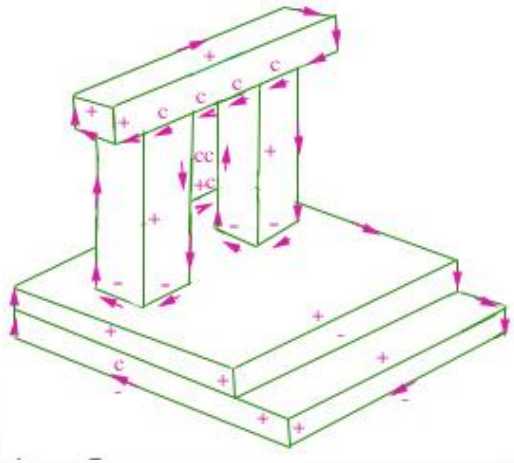
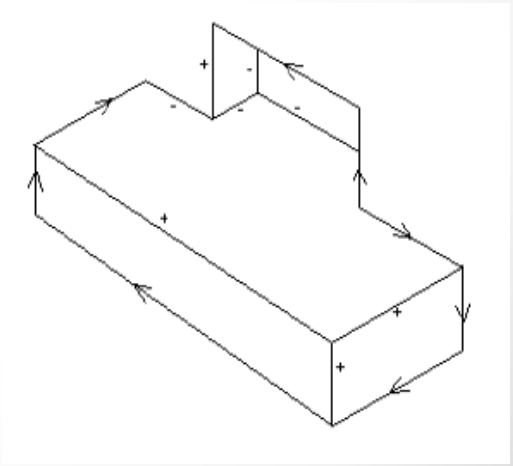
1971: M. B Clowes
and D. A. Huffman:

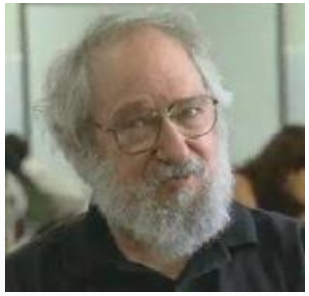
Labelling contours
of images for
understanding





Marvin Minksy & Seymour Papert: 1966, MIT Summer Vision Project

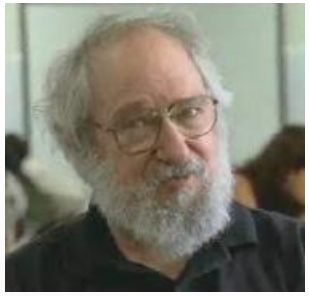
They instructed a graduate student to connect a camera to a computer and have it described **what it sees**.



Marvin Minsky in a lab at M.I.T. in 1968. M.I.T.

Marvin Minksy & Seymour Papert: 1966, MIT Summer Vision Project

They made the **first attempt to mimic the human brain**, triggering further research into computers' ability to process information to make intelligent decisions.



Marvin Minsky in a lab at M.I.T. in 1968. M.I.T.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROJECT MAC

Artificial Intelligence Group — July 7, 1966

Vision Memo. No. 100.

THE SUMMER VISION PROJECT

Seymour Papert

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system.

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition".

Goals - Specific

We plan to work by getting a simple form of the system going as soon as possible and then elaborating upon it. To keep the work reasonably coordinated there is a graduated scale of subgoals.

Subgoal for July

Analysis of scenes consisting of non-overlapping objects from the following set:

balls

bricks with faces of the same or different colors or textures

cylinders.

Each face will be of uniform and distinct color and/or texture. Background will be homogeneous.

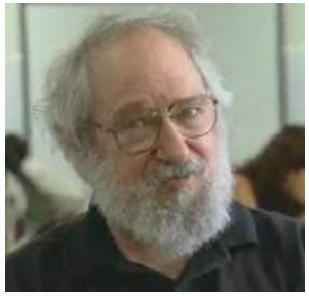
Extensions for August

The first priority will be to handle objects of the same sort but with complex surfaces and backgrounds, e.g. cigarette pack with writing and bands of different color, or a cylindrical battery.

Then extend class of objects to objects like tools, cups, etc.

Marvin Minksy & Seymour Papert

1969: Minsky and Papert proved that a single perceptron (Frank Rosenblatt, 1957)— a grandparent to the computational units which compose **modern neural networks — was incapable of learning the exclusive-or (XOR) function**.
Book: 1969: Perceptrons: an introduction to computational geometry



This project, M. Minsky underestimated the challenge of Computer Vision, committed to « blocks world »

https://www.youtube.com/watch?v=lMfyRx8rzJo

The first of two films shown here, "Eye of a Robot" (to 18:30) summarizes computer vision research being carried out in the 1950s at the MIT Laboratory for Artificial Intelligence, under the direction of Marvin Minsky and with Patrick Winston and Berthold Horn supervising the robotics work. The film shows how "experimental computer programs extract line drawings from pictures and use knowledge about the three-dimensional world, and also how new ideas about artificial intelligence are used in these processes." The second film is silent and shows the TX-O computer at work, e.g on a tic-tac-toe game. Courtesy of MIT Museum.

David Marr: A Pioneer in Computational Neuroscience

David Marr (1945-1980):
is a British neuroscientist and physiologist.

Marr integrated results from psychology, artificial intelligence, and neurophysiology into new models of visual processing.

The model of David Marr

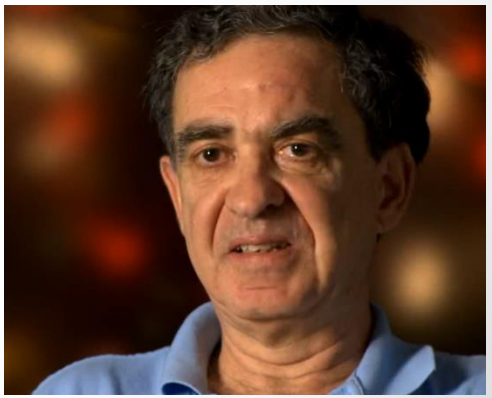
MASSACHUSETTS INSTITUTEOF TECHNOLOGY
ARTIFICIAL INTELLIGENCE LABORATORY

A. I. Memo 645

August, 1981

Marr's Approach to Vision

Tomaso Poggio

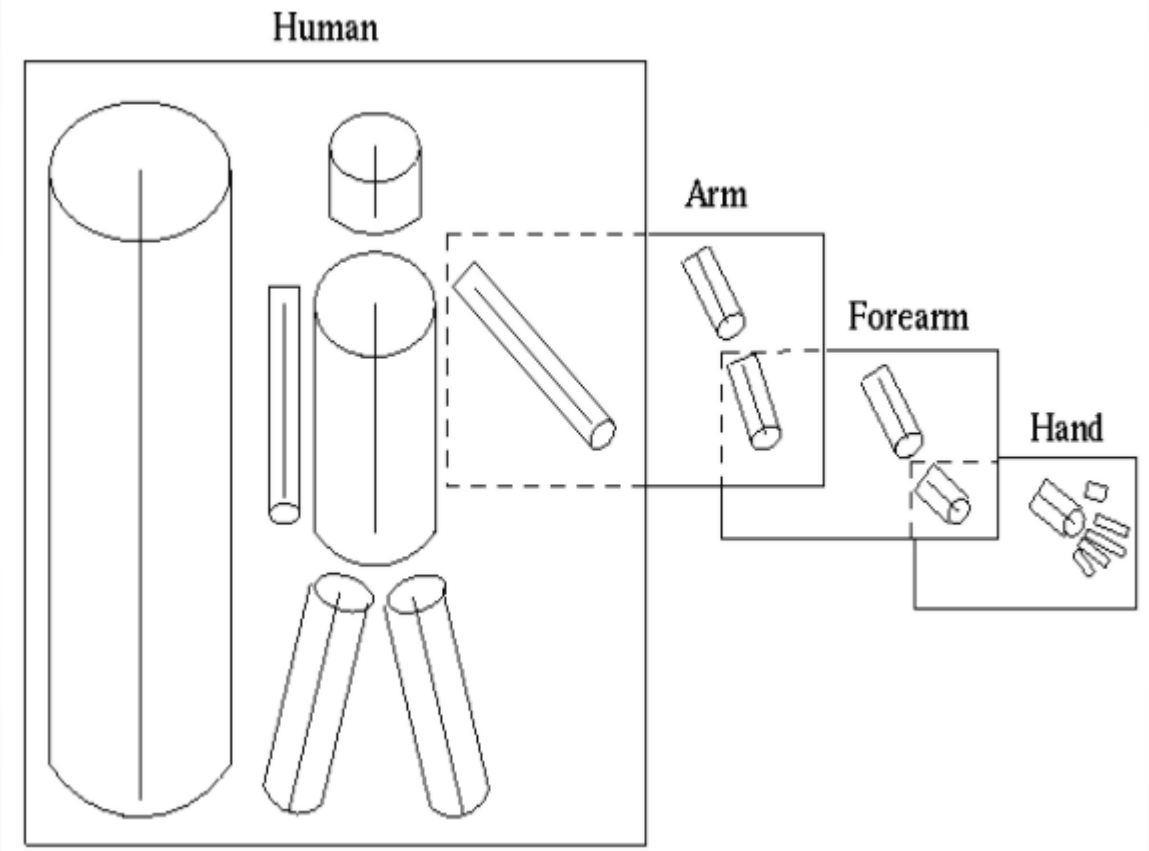


The model of David Marr

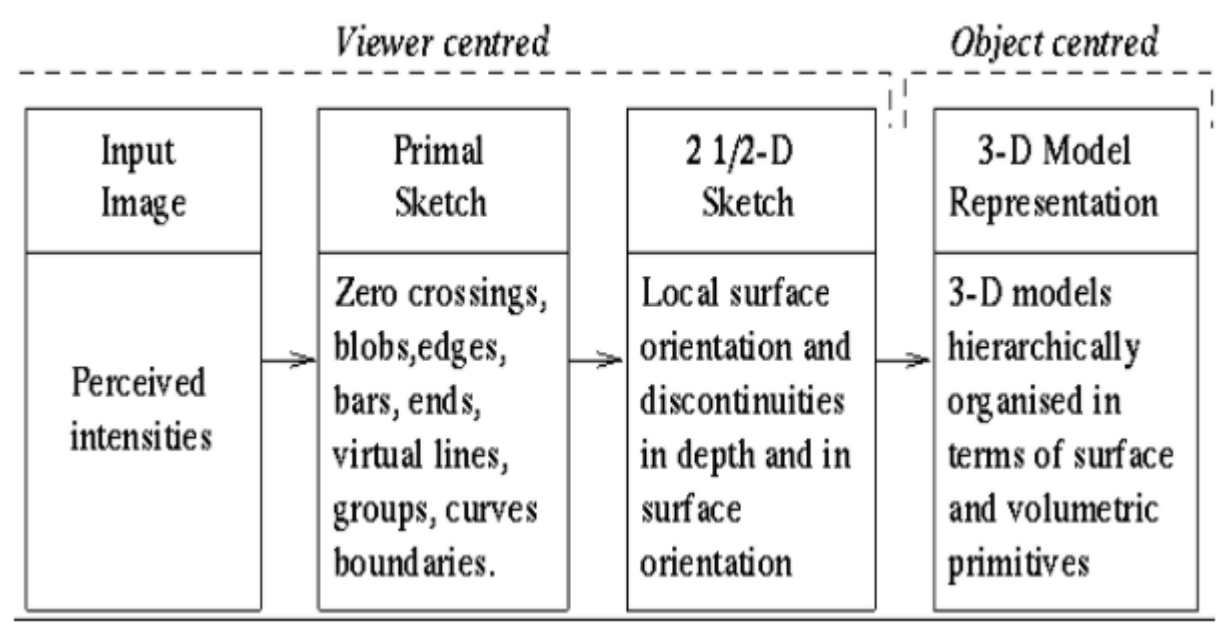
Tomaso Poggio

In the last seven years a new computational approach has led to promising advances in the understanding of biological visual perception. The foundations of the approach are largely due to the work of a single man, David Marr at M.I.T.

The model of David Marr



The model of David Marr



Investigations for understanding the Human Visual System
Binocular Fusion: What are the origins?

Béla Julesz (Julesz, 1971).
Invented random dot stereograms

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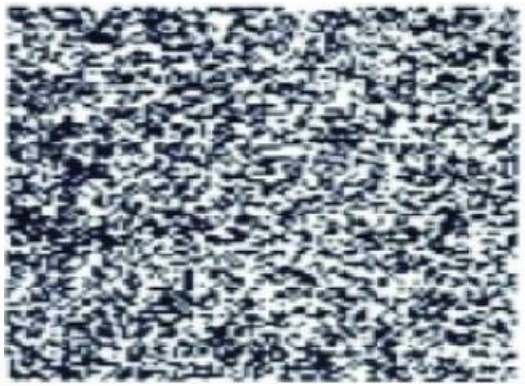

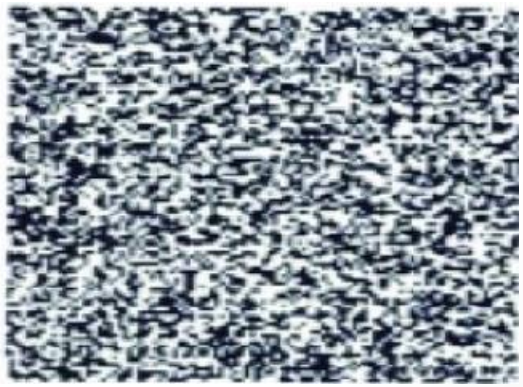

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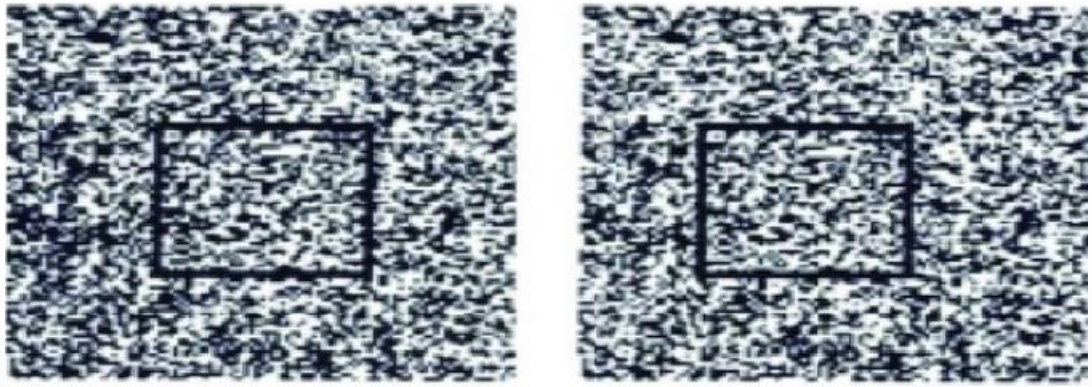
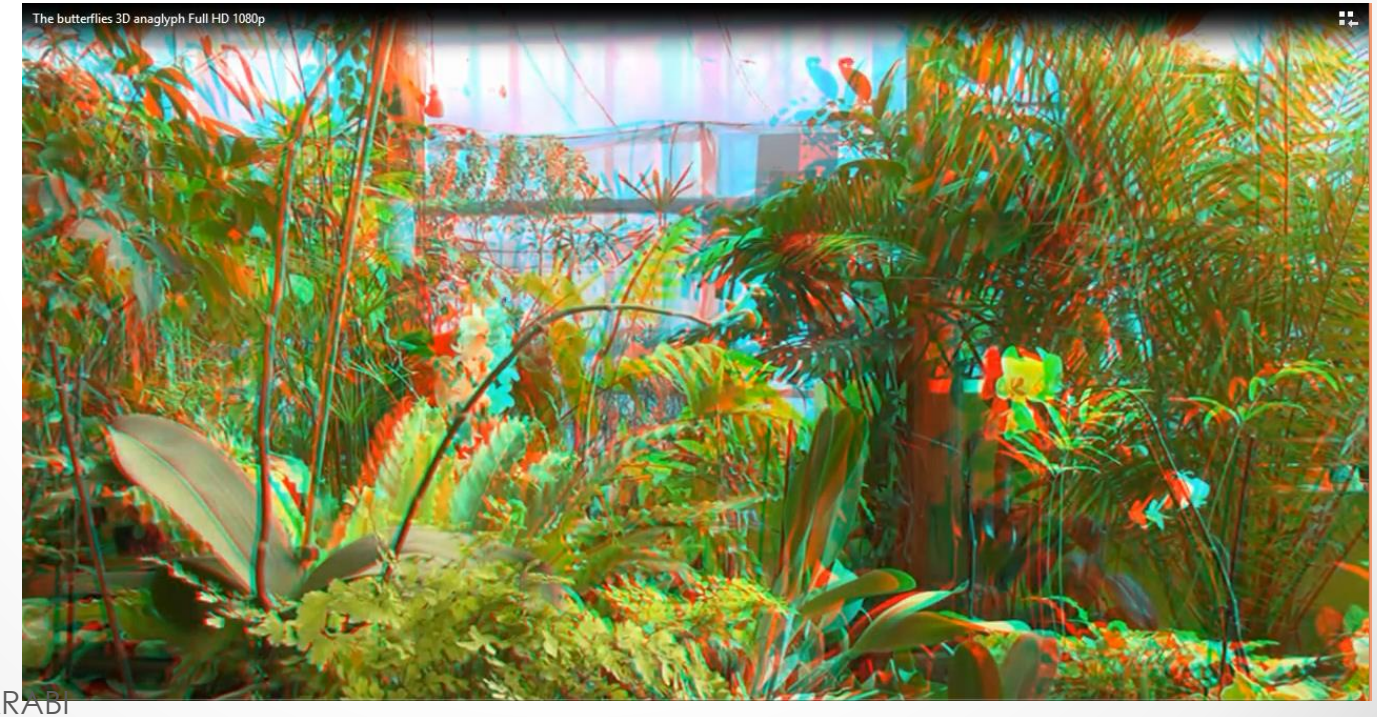


Anaglyph

Anaglyph

Anaglyph

Link to the video: « The butterflies 3D anaglyph Full HD 1080p.mp4 »



Anaglyph

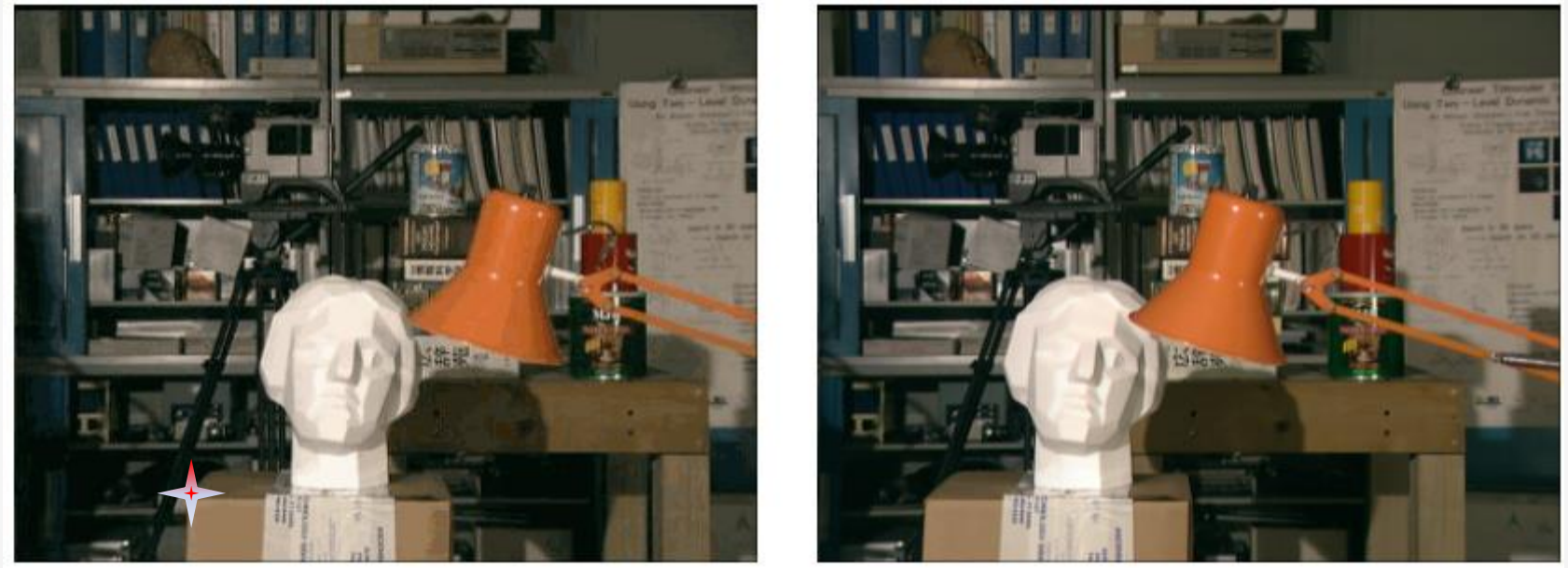
Link to the video: « Anaglyph 3d.mp4 »

The Present

From 1980 to 2021

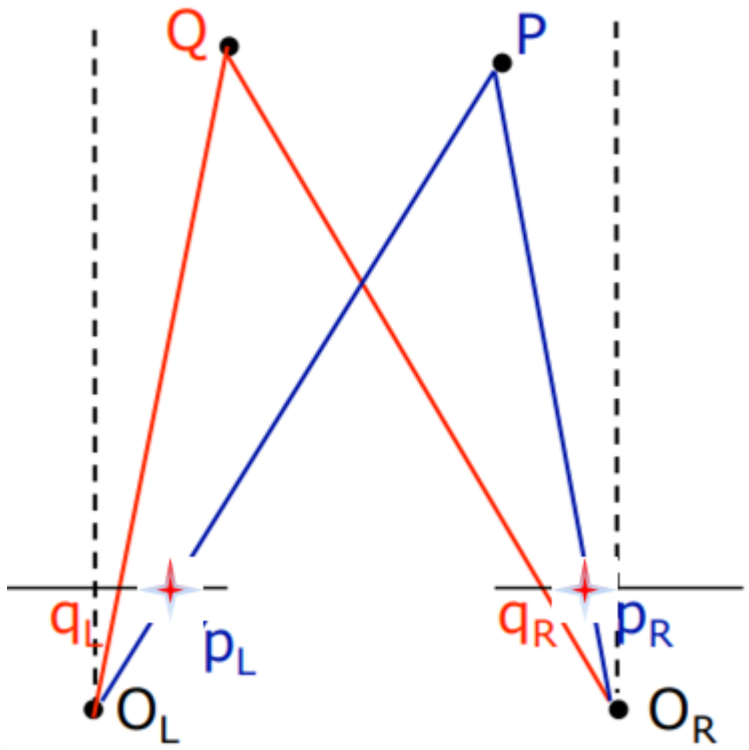
1981- Binocular Scanline Stereo

1981- Binocular Scanline Stereo



1981- Binocular Scanline Stereo

1981- Binocular Scanline Stereo



1981- Binocular Scanline Stereo

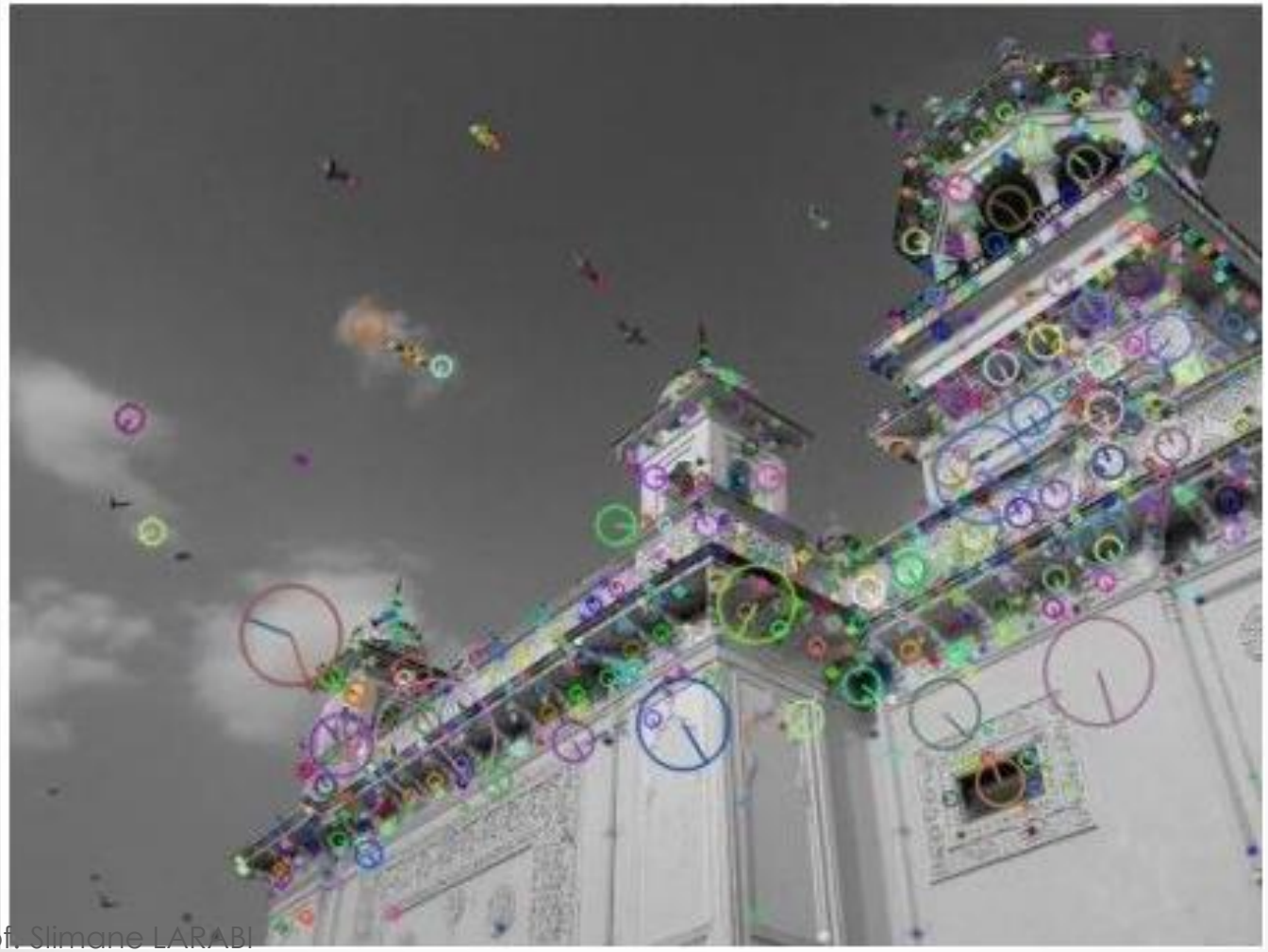
1992- Structure from motion

Link to the video: ''The Structure from Motion Pipeline.mp4"

1998- CNN (Convolutional Neural Networks) on MNIST

MNIST (Modified or Mixed National Institute of Standards and Technology): 60,000 grayscale images under the training set and 10,000 grayscale images under the test set.

2004- SIFT Descriptor (**Scale-Invariant Feature Transform**)



2011- Kinect

2012- Oculus

2009-2012- ImageNet and AlexNet

The **ImageNet** dataset contains 14,197,122 annotated images.

Since 2010 the dataset is used in the ImageNet Large Scale Visual Recognition Challenge (ILSVRC), a benchmark in image classification and object detection.

2009-2012- ImageNet and AlexNet

AlexNet is the name of a convolutional neural network (CNN) architecture, designed by **Alex Krizhevsky** in collaboration with Ilya Sutskever and Geoffrey Hinton, who was Krizhevsky's Ph.D. advisor.

AlexNet competed in the ImageNet Large Scale Visual Recognition Challenge on September 30, 2012

2015-2017- Semantic segmentation

Link to the video: " Semantic Segmentation with a FCN network.mp4"

The Future

Computer Vision for autonomous vehicles

The Challenges are:

- Autonomous Car Sensors
- **Datasets**
- Real time **Object Recognition**
- **Semantic Instance Segmentation**
- **Stereovision And Multi-Camera Vision**
- **Object Tracking**
- **3D Scene Analysis**

Computer vision for agriculture.

Link to the video: " AI and the future of agriculture.mp4"

Link to the video: " Machine Learning_ Using Algorithms to Sort Fruit.mp4"

Computer Vision for video surveillance.

Link to the video: " China_The world's biggest camera surveillance network"

Computer Vision for Health

Link to the video: " Detecting cancer in real-time with machine learning.mp4"

Computer Vision for Health

Measure vital sign of someone