

Computer Vision

Introduction

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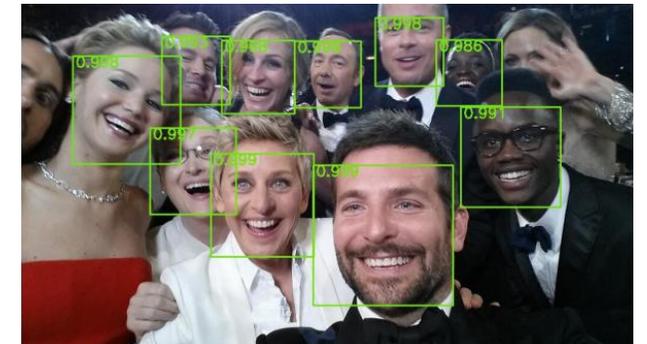
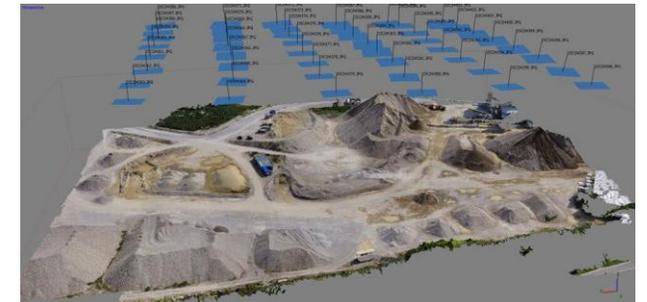


Definition

Computer vision is an *interdisciplinary field* that deals with how *computers* can be made to gain high-level *understanding* from *digital images*.

Related Disciplines

- Image Processing
- 3D Reconstruction
- Pattern Detection
- Computer Graphics (CGI)
- Virtual / Augmented / Mixed Reality



From image to understanding

Extract information from images to build a model for understanding a specific environment.

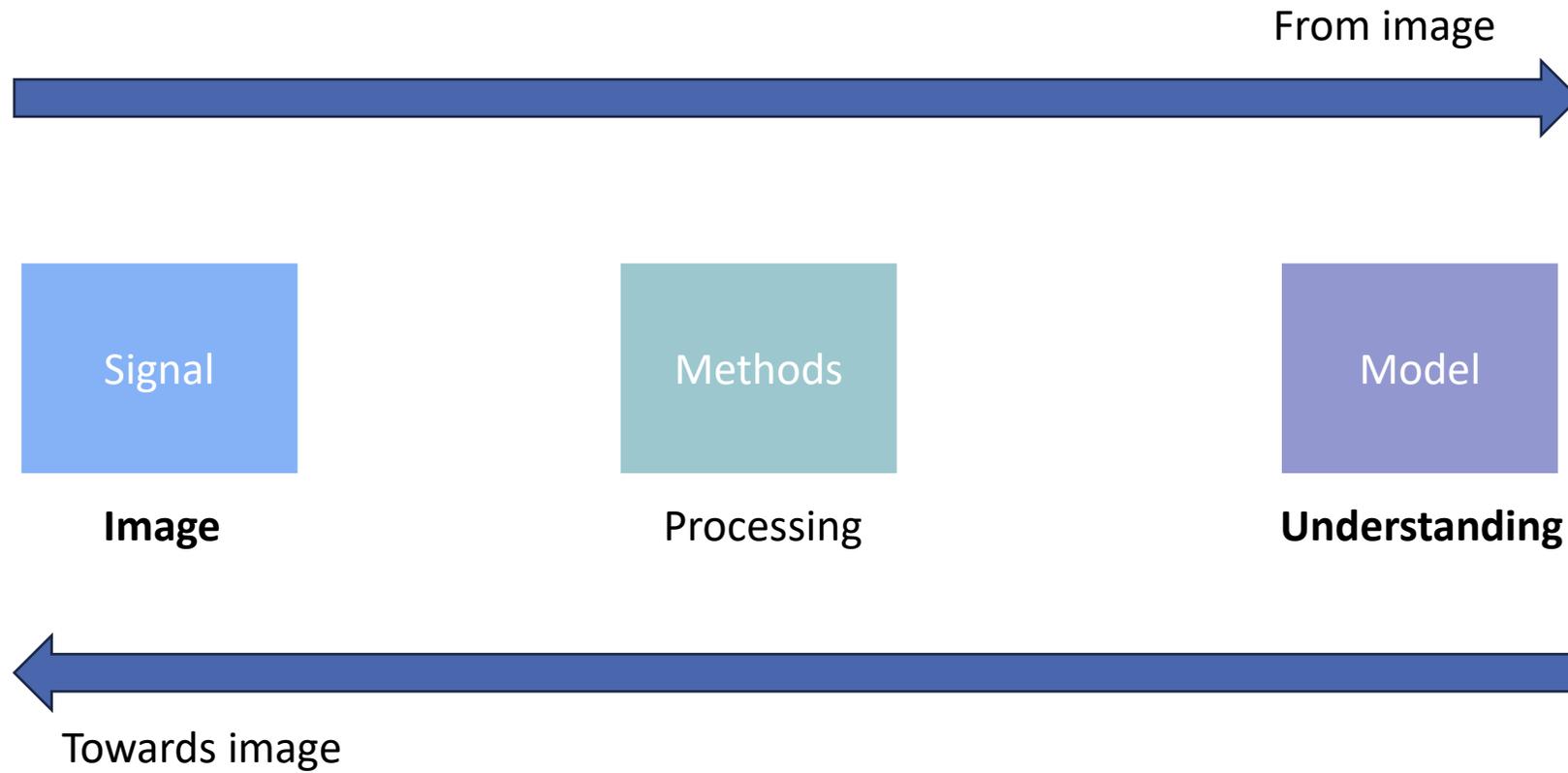
- 3D Reconstruction
- Pattern Detection

From understanding to image

Producing images that illustrates the understanding of a model.

- Computer Graphics (CGI)
- Virtual / Augmented / Mixed Reality

Pipeline



Example

■ Lost longline modeling



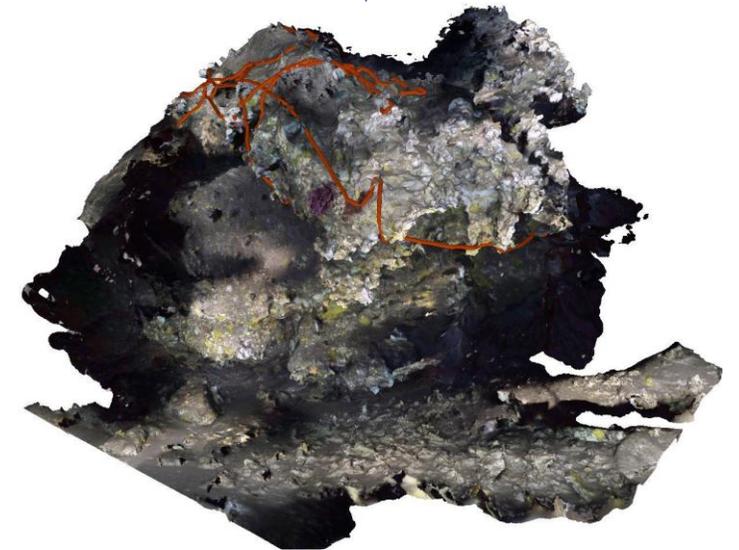
Robot (ROV)



Images



3D Reconstruction



AR / VR Result

Example

- Generative Artificial Intelligence

Prompt: *A class of students learning computer vision*



Chapter 1

History Part 1.

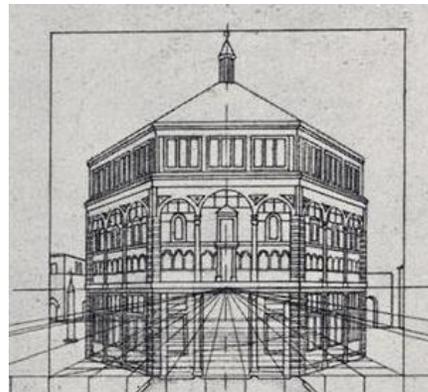
The perspective

Understanding the perspective

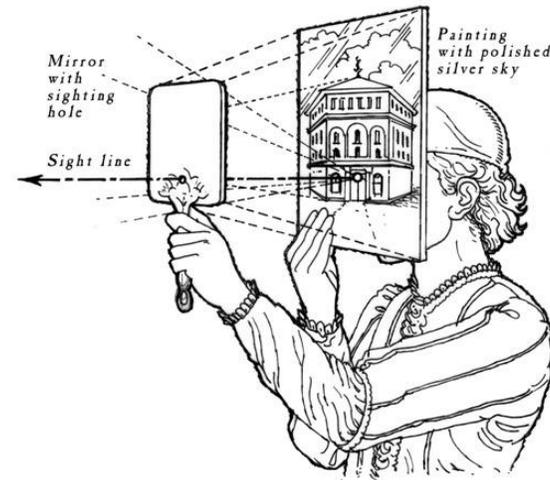
- **1425:** Filippo Brunelleschi demonstrates the principles of linear or "artificial" perspective.



Battistero di San Giovanni, 1059-1128,
Firenze (Italy)



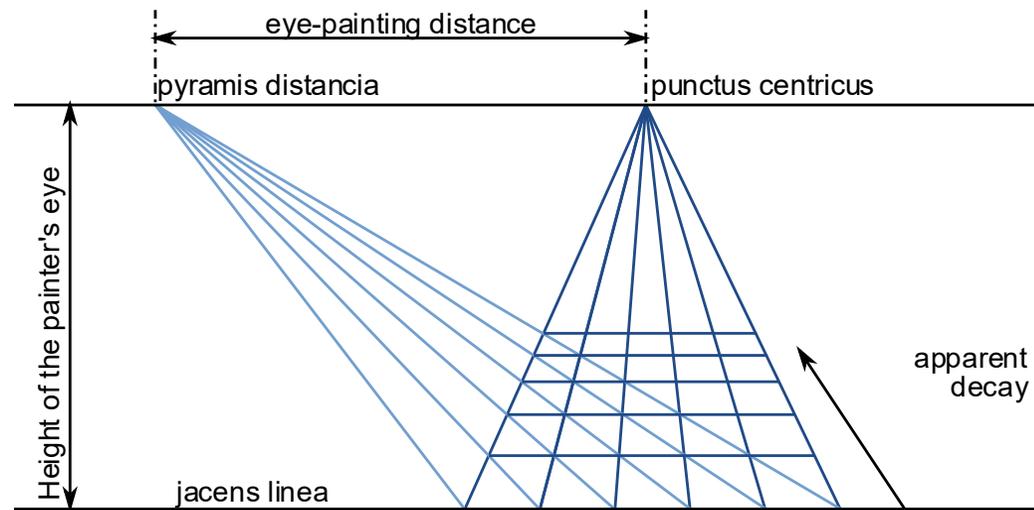
Brunelleschi Filippo, *Lost Painting of the Battistero di San Giovanni*,
Kunsthistorisches Institut in Florenz,
Max-Planck-Institut



See <https://www.youtube.com/watch?v=bkNMM8uiMww>

Theorizing the perspective

- **1435:** Leon Battista Alberti (1404 - 1472) theorize the perspective within the treatise *De Pictura* (1435).



Construzione Legittima



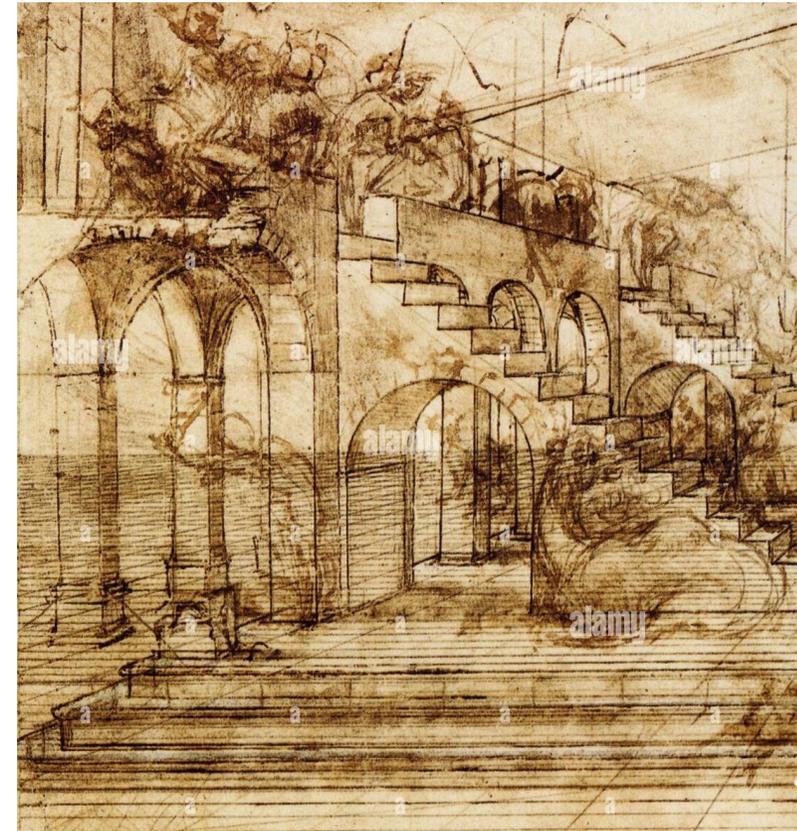
Paolo Uccello, ar. 1430, *Perspective Study of a Vase*, pen and ink, 29x24.1cm, Galleria degli Uffizi (Firenze)

Thinking the perspective

- **1480:** Leonardo da Vinci (1452 – 1519) use perspective for abstract geometric representation.



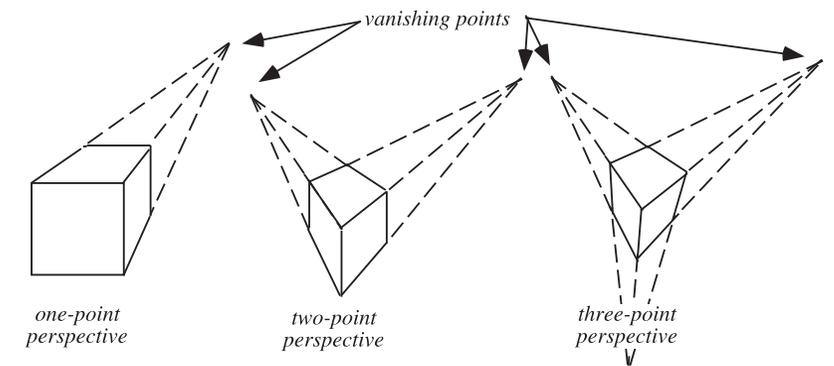
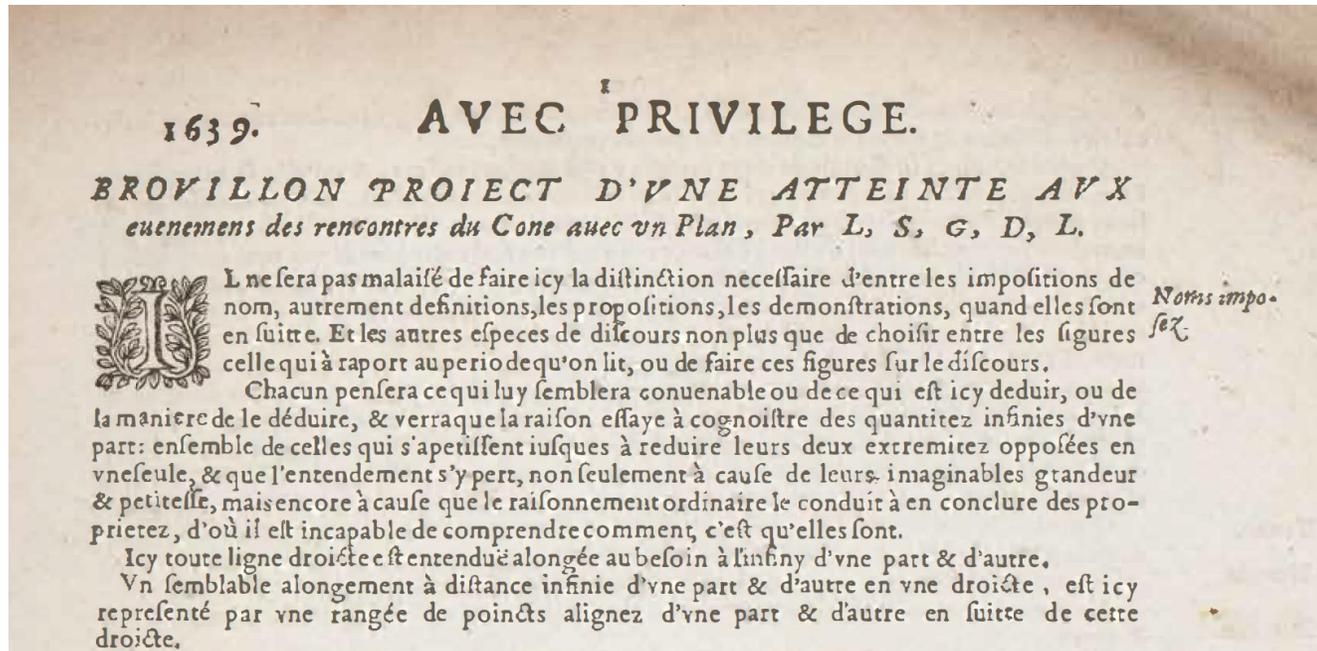
Da Vinci Leonardo, 1481, *Adorazione dei Magi*, oil on wood, 246x263cm, Galleria degli Uffizi (Firenze)



Perspectival study for The *Adorazione dei Magi*, c. 1481

Vanishing point

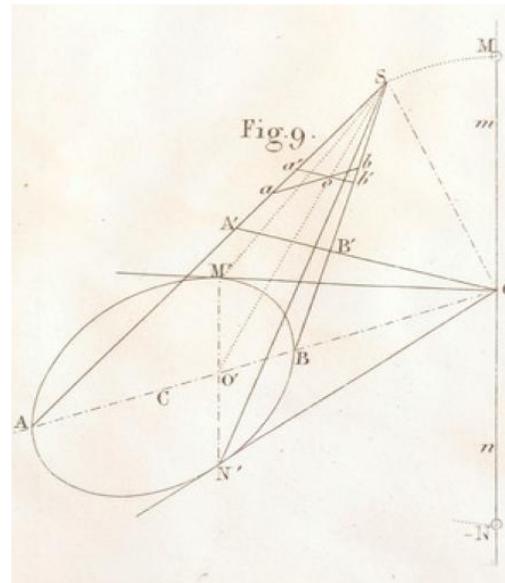
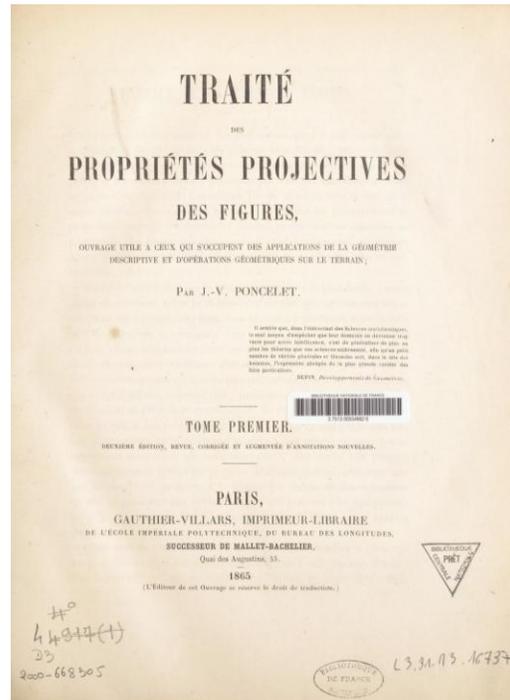
- **1625:** Girard Desargues (1591- 1661) defines projective geometry generalizing the use of vanishing points.



Desargues Girard, 1639, *Brouillon projet d'une atteinte aux évènements des rencontres du cône avec un Plan*, Gallica BNF (France)

Projective geometry

- **1820:** Jean-Victor Poncelet (1788-1867) and Joseph Diez Gergonne (1771-1859) formalize projective geometry using mathematics.



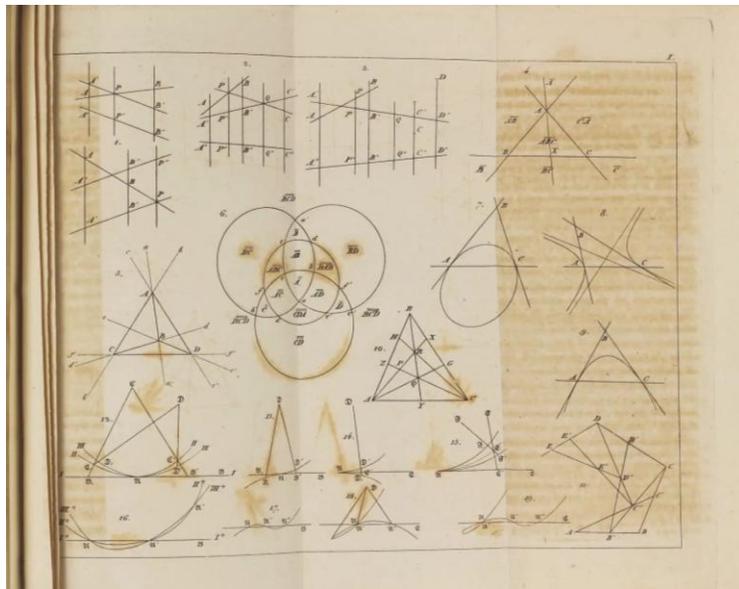
$$p \cdot OA \cdot OB = p' \cdot OA' \cdot OB'$$

Projecting from one space to another
=
Computing equations

Poncelet Jean-Victor, 1822, *Propriétés projectives des figures*, Gallica BNF (France)

Homogeneous Coordinates

- **1827:** August Ferdinand Möbius (1790-1868) propose Homogeneous Coordinates for projective geometry.



August Ferdinand Möbius, 1827, *Der barycentrische Calcul*, Verlag von Johann Ambrosius Barth, Leipzig

$$\begin{matrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} \\ \text{Euclidean} \\ \text{space} \end{matrix} \iff \begin{matrix} \begin{bmatrix} sx \\ sy \\ sz \\ w \end{bmatrix} \\ \text{Projection = Affine transform} \end{matrix} = \begin{matrix} \begin{bmatrix} m_{00} & m_{01} & m_{01} & m_{03} \\ m_{10} & m_{11} & m_{12} & m_{13} \\ m_{20} & m_{21} & m_{22} & m_{23} \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \end{matrix}$$

Projecting from one space to another
 =
Matrix calculus