Lecture
Computer Vision
Chapter 1 – Part 1
Introduction / Motivation

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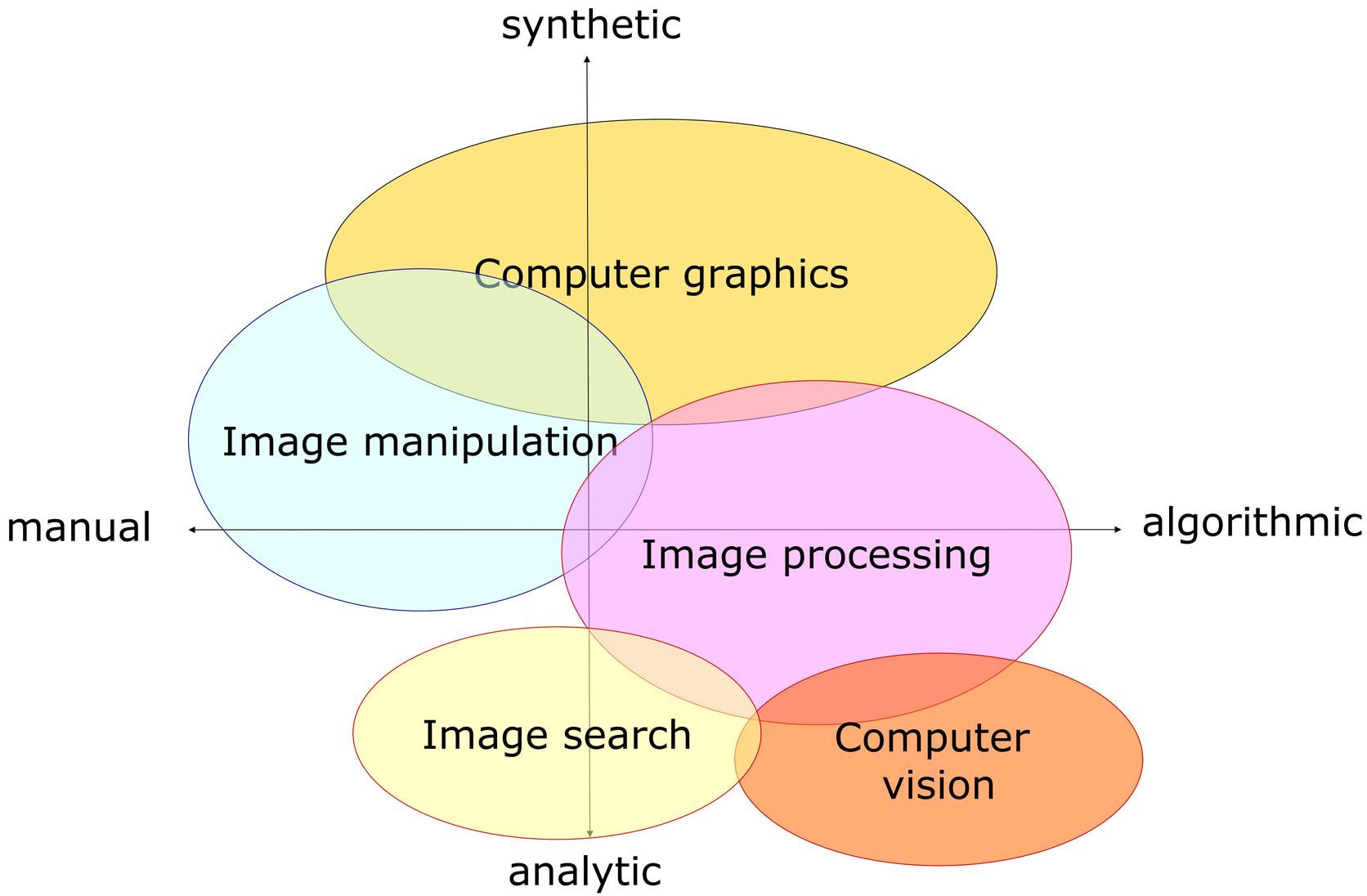
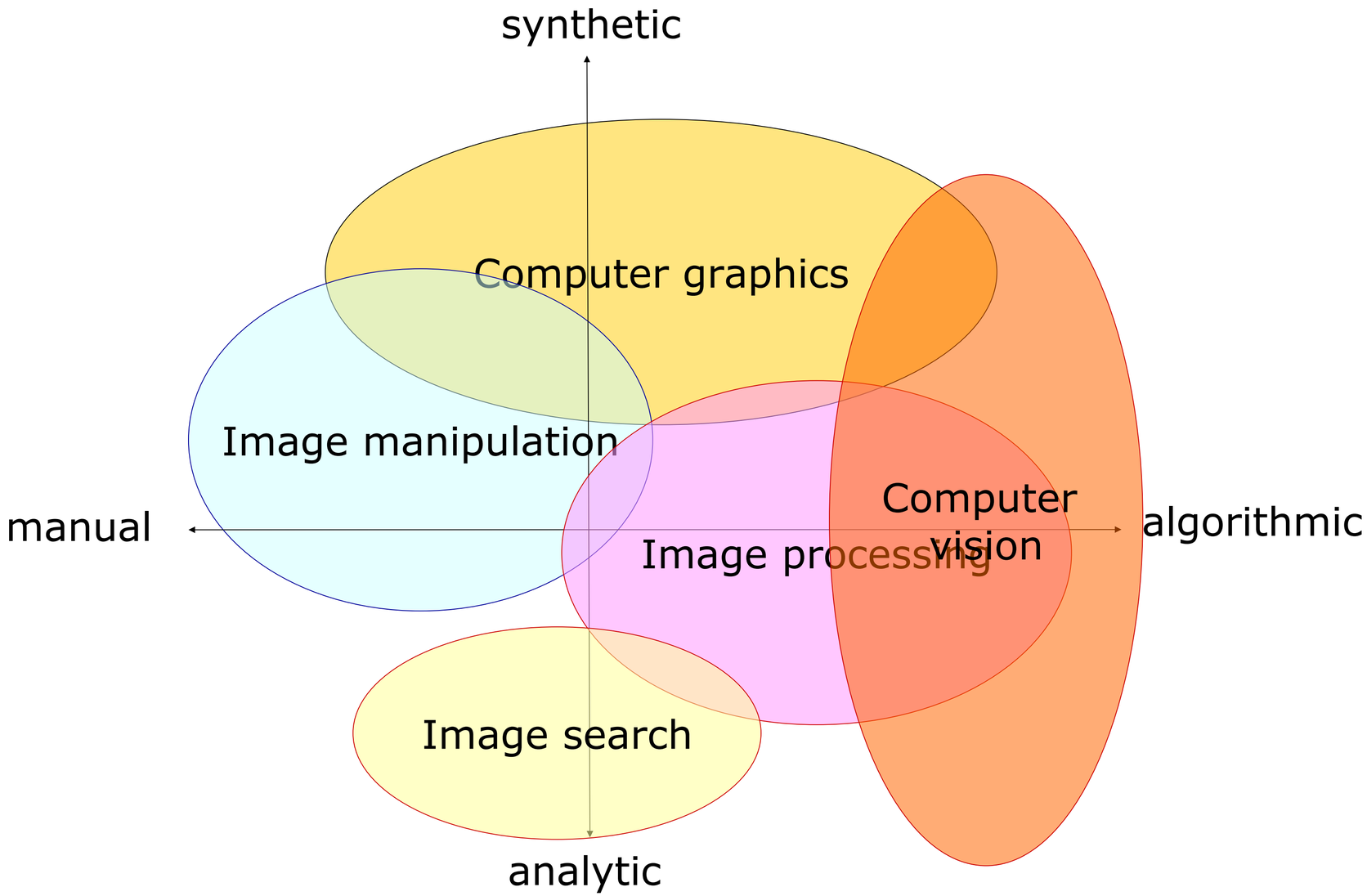
Marburg University & Hessian Center for Artificial Intelligence (hessian.AI)

Marburg University

Computer Vision & Visual Computing



Computer Vision & Visual Computing



Chapters 1 & 2

The Challenge of Vision

168	168	172	164	158	167	173	167	163	162	164
175	178	179	176	118	97	168	175	171	169	175
171	170	177	175	116	109	169	177	173	168	175
175	167	161	157	138	103	112	157	164	159	160
165	167	164	178	167	77	55	134	170	167	162
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147	169	180	163	51	24	32	119	163	175	182
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125	115	129	132	74	54	41	104	156	152	156
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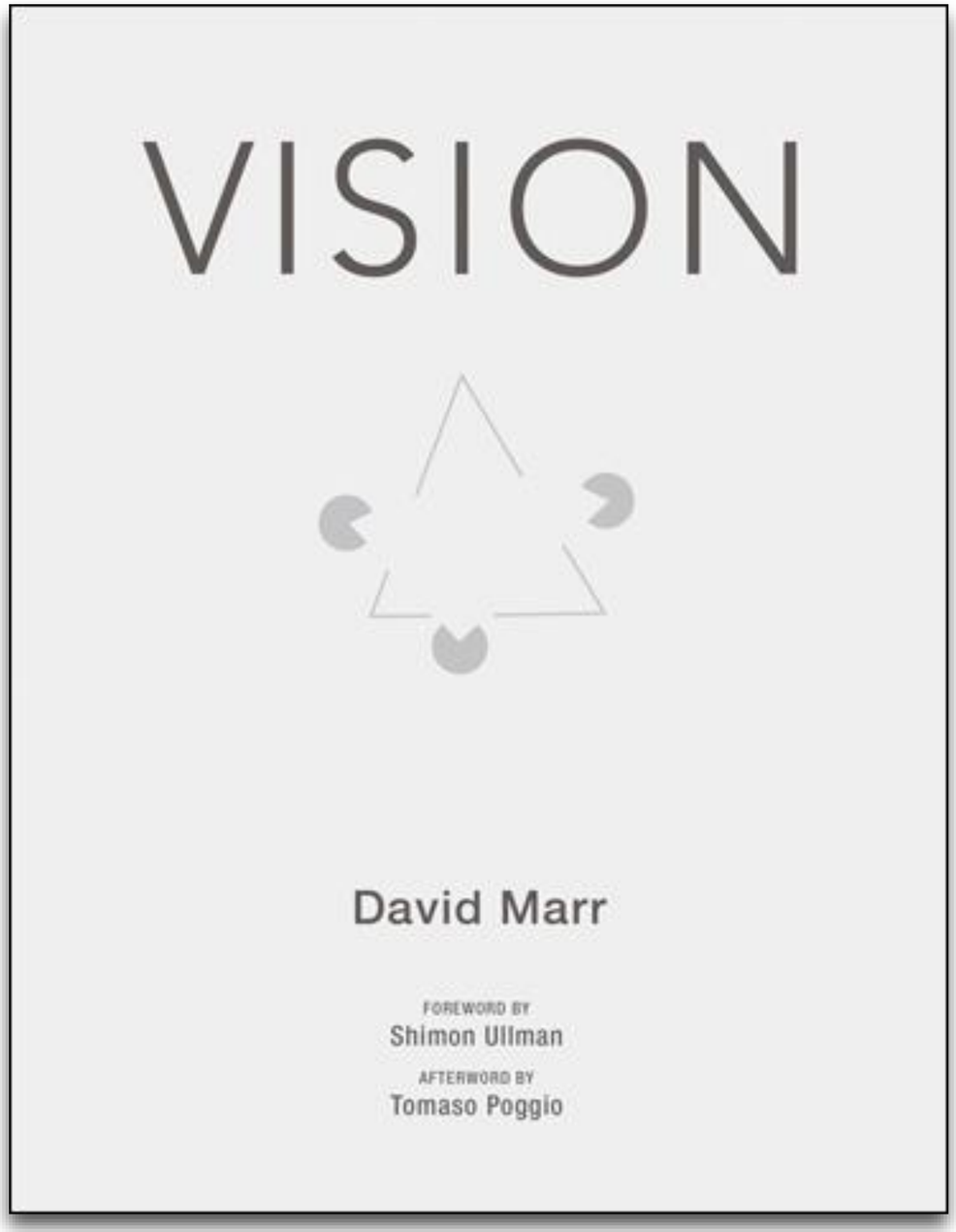
177	177	181	174	54	21	29	136	190	180	179
173	174	180	150	27	101	94	74	189	188	186
163	161	167	100	45	169	166	59	136	184	176
155	160	155	56	111	182	180	104	84	168	172
175	179	133	86	191	201	204	191	79	172	220
182	124	32	109	168	171	167	163	51	105	203
197	175	149	169	189	190	173	160	145	156	202
155	173	182	179	177	182	177	182	185	179	177

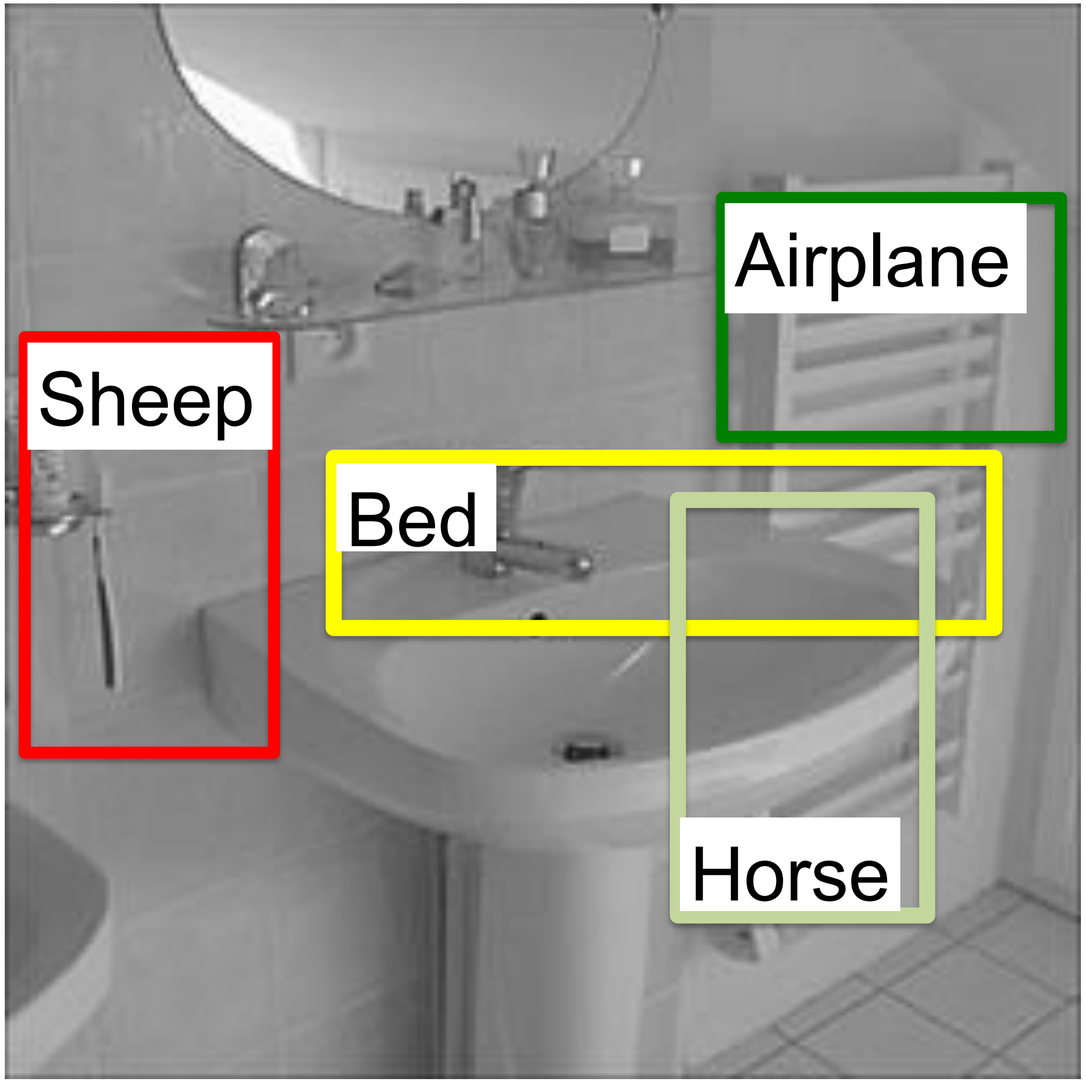
To see

"What does it mean, to see? The plain man's answer (and Aristotle's, too). would be, to know what is where by looking."

To discover from images what is present in the world, where things are, what actions are taking place, to predict and anticipate events in the world.



When some of us started…



Exciting times in computer vision

“A cup of coffee”

“A cat”

“A cup of cat”

https://www.reddit.com/r/dalle2/comments/y4mygn/a_cup_of_cat/

DALL-E 2 (Open AI)

Slide credit: Shuang Li

The challenge of vision

The input

What the machine gets

$$\mathbf{I} = \begin{bmatrix}
160 & 175 & 171 & 168 & 168 & 172 & 164 & 158 & 167 & 173 & 167 & 163 & 162 & 164 & 160 & 159 & 163 & 162 \\
149 & 164 & 172 & 175 & 178 & 179 & 176 & 118 & 97 & 168 & 175 & 171 & 169 & 175 & 176 & 177 & 165 & 152 \\
161 & 166 & 182 & 171 & 170 & 177 & 175 & 116 & 109 & 169 & 177 & 173 & 168 & 175 & 175 & 159 & 153 & 123 \\
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173 & 164 & 158 & 165 & 180 & 180 & 150 & 89 & 61 & 34 & 137 & 186 & 186 & 182 & 175 & 165 & 160 & 164 \\
152 & 155 & 146 & 147 & 169 & 180 & 163 & 51 & 24 & 32 & 119 & 163 & 175 & 182 & 181 & 162 & 148 & 153 \\
134 & 135 & 147 & 149 & 150 & 147 & 148 & 62 & 36 & 46 & 114 & 157 & 163 & 167 & 169 & 163 & 146 & 147 \\
135 & 132 & 131 & 125 & 115 & 129 & 132 & 74 & 54 & 41 & 104 & 156 & 152 & 156 & 164 & 156 & 141 & 144 \\
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172 & 174 & 178 & 177 & 177 & 181 & 174 & 54 & 21 & 29 & 136 & 190 & 180 & 179 & 176 & 184 & 187 & 182 \\
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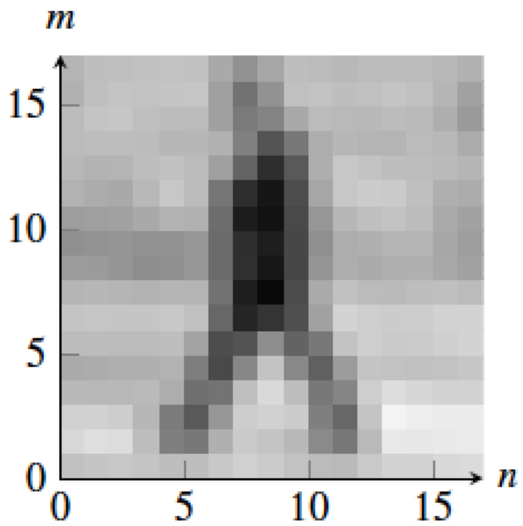
153 & 149 & 153 & 155 & 173 & 182 & 179 & 177 & 182 & 177 & 182 & 185 & 179 & 177 & 167 & 176 & 182 & 180
\end{bmatrix}$$

The input

What we see



What the machine gets

$$\mathbf{I} = \begin{bmatrix}
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149 & 164 & 172 & 175 & 178 & 179 & 176 & 118 & 97 & 168 & 175 & 171 & 169 & 175 & 176 & 177 & 165 & 152 \\
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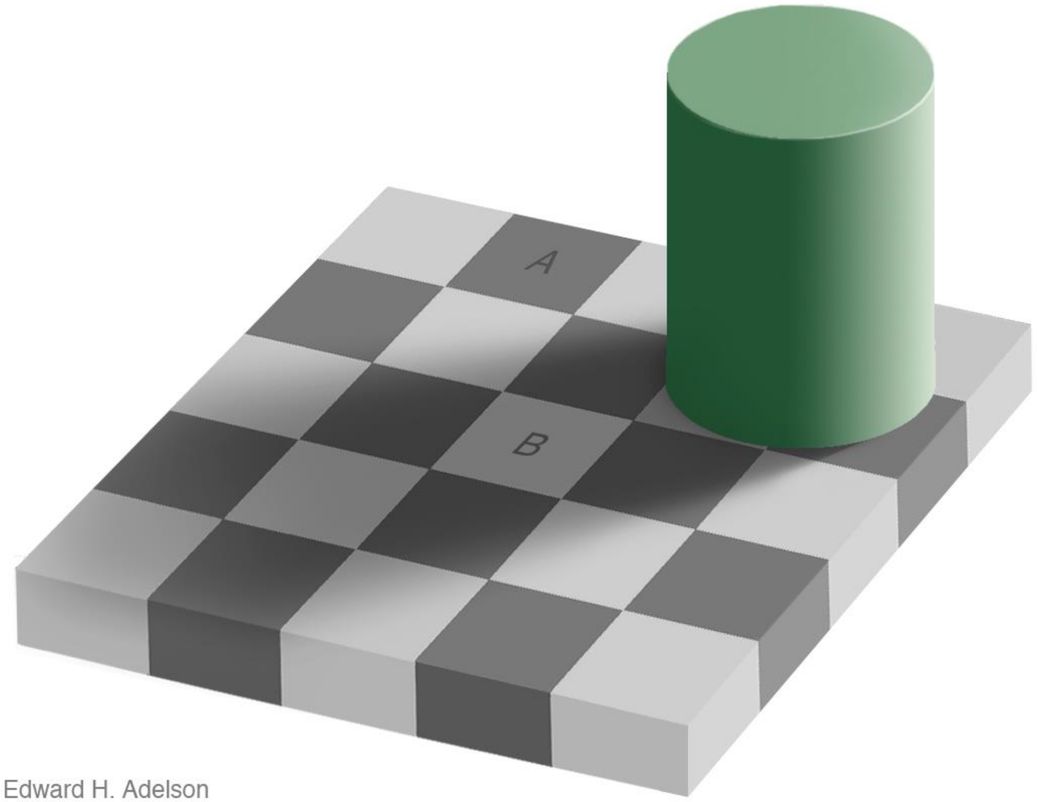
153 & 149 & 153 & 155 & 173 & 182 & 179 & 177 & 182 & 177 & 182 & 185 & 179 & 177 & 167 & 176 & 182 & 180
\end{bmatrix}$$

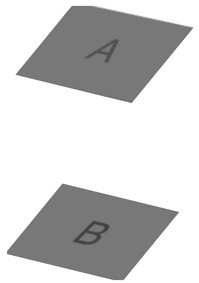
The camera is a measurement device, not a vision system

To see: perception vs. measurement

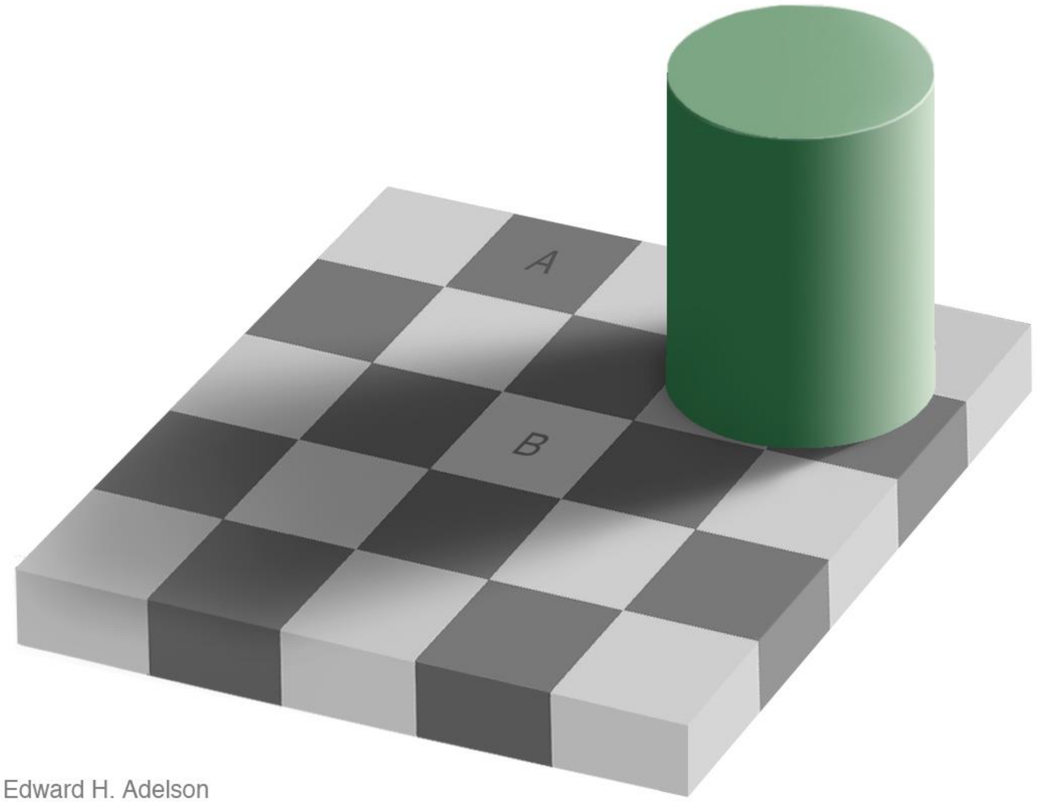


Edward H. Adelson

To see: perception vs. measurement



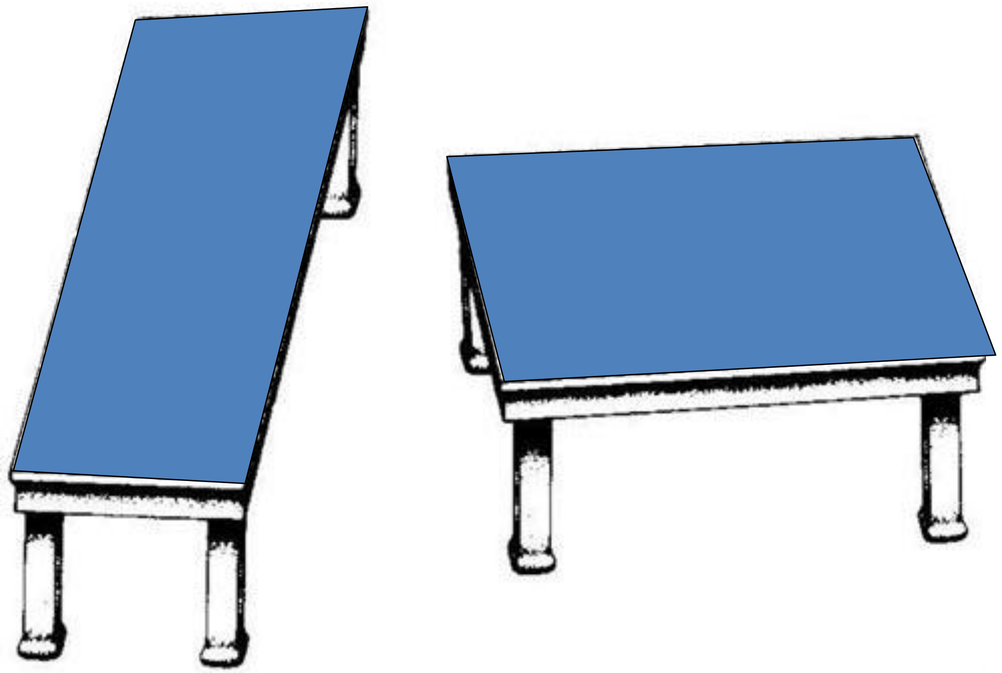
To see: perception vs. measurement



Edward H. Adelson

To see: perception vs. measurement

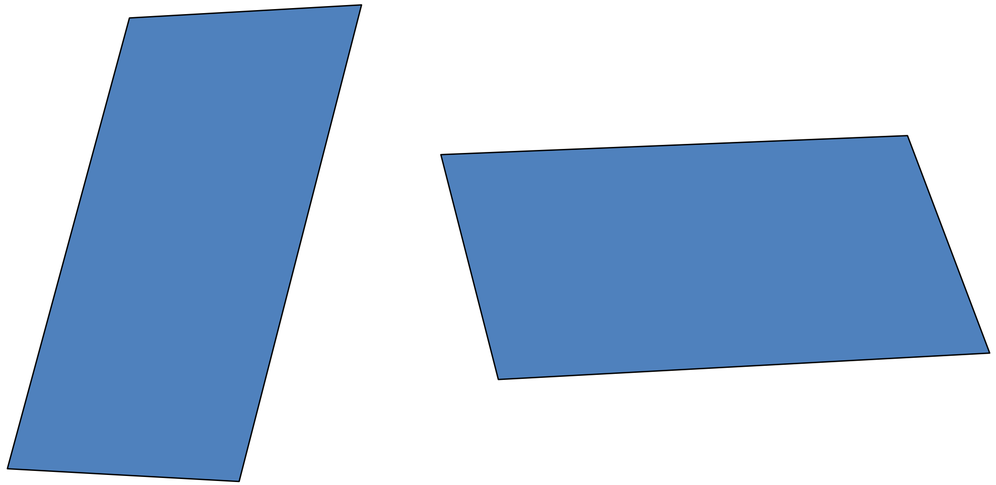
Depth processing is automatic, and we can not shut it down…



by Roger Shepard (”Turning the Tables”)

To see: perception vs. measurement

Depth processing is automatic, and we can not shut it down…



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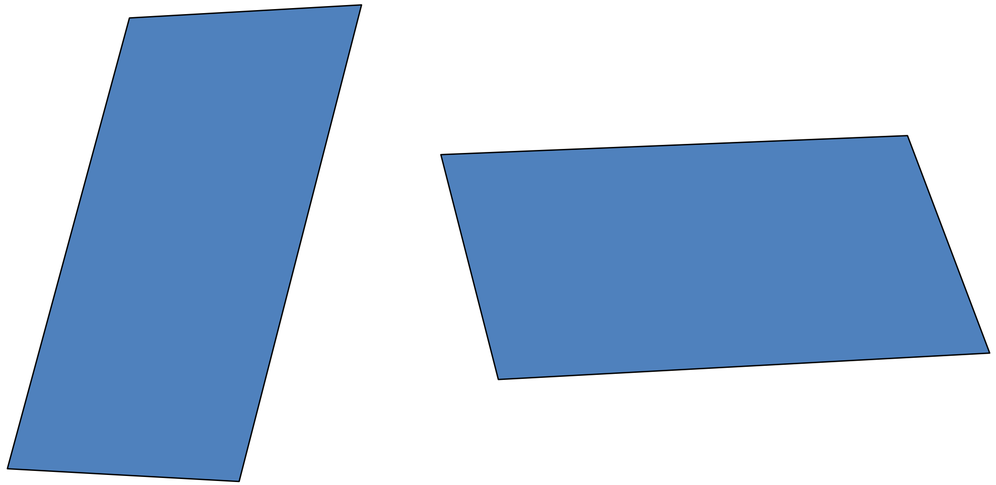
To see: perception vs. measurement

Depth processing is automatic, and we can not shut it down…



by Roger Shepard (”Turning the Tables”)

A Simple Vision System

The goal of this lecture is to embrace the optimism of the 60s and to hand-design an end-to-end vision system.

A Simple Visual System

- A simple world
- A simple goal
- A simple image formation model

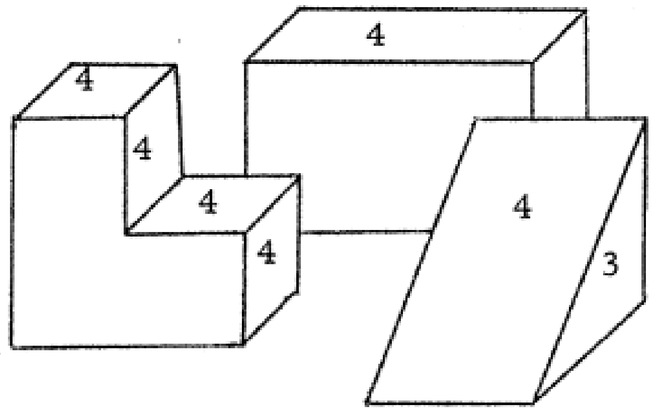
A Simple World

MACHINE PERCEPTION OF THREE-DIMENSIONAL SOLIDS

by

LAWRENCE GILMAN ROBERTS

Submitted to the Department of Electrical Engineering on May 10, 1963, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.



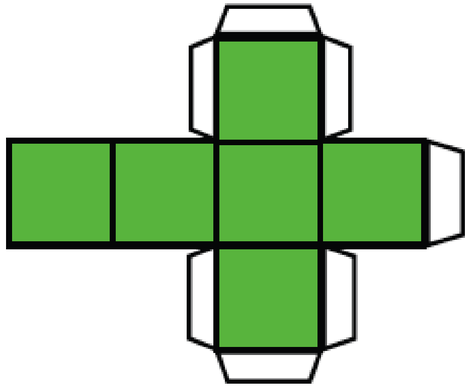
Complete Convex Polygons. The polygon selection procedure would select the numbered polygons as complete and convex. The number indicates the probable number of sides. A polygon is incomplete if one of its points is a collinear joint of another polygon.

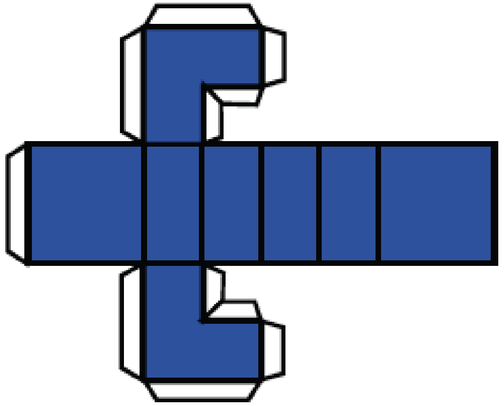
The problem of machine recognition of pictorial data has long been a challenging goal, but has seldom been attempted with anything more complex than alphabetic characters. Many people have felt that research on character recognition would be a first step, leading the way to a more general pattern recognition system. However, the multitudinous attempts at character recognition, including my own, have not led very far. The reason, I feel, is that the study of abstract, two-dimensional forms leads us away from, not toward, the techniques necessary for the recognition of three-dimensional objects.

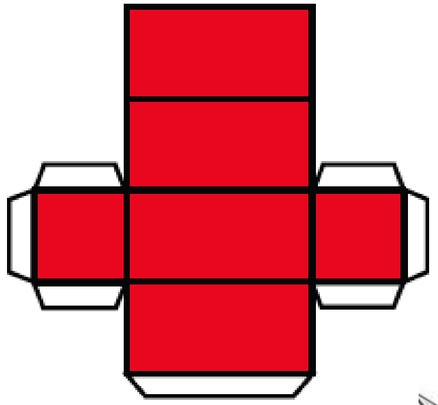
Probably the first computer vision PhD

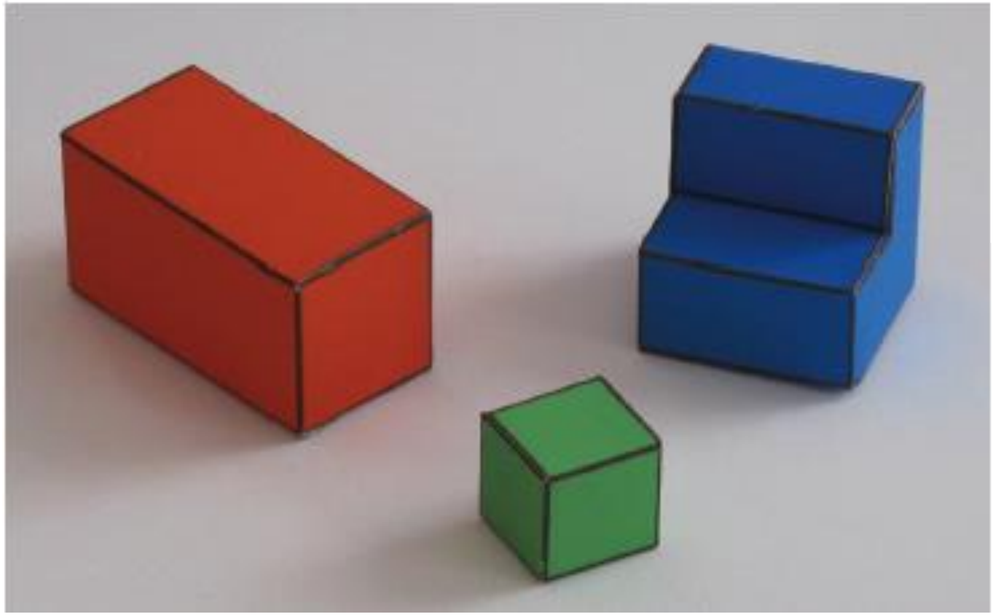
Lawrence Roberts ("**Machine Perception of Three Dimensional Solids," 1963**

Build your own simple world



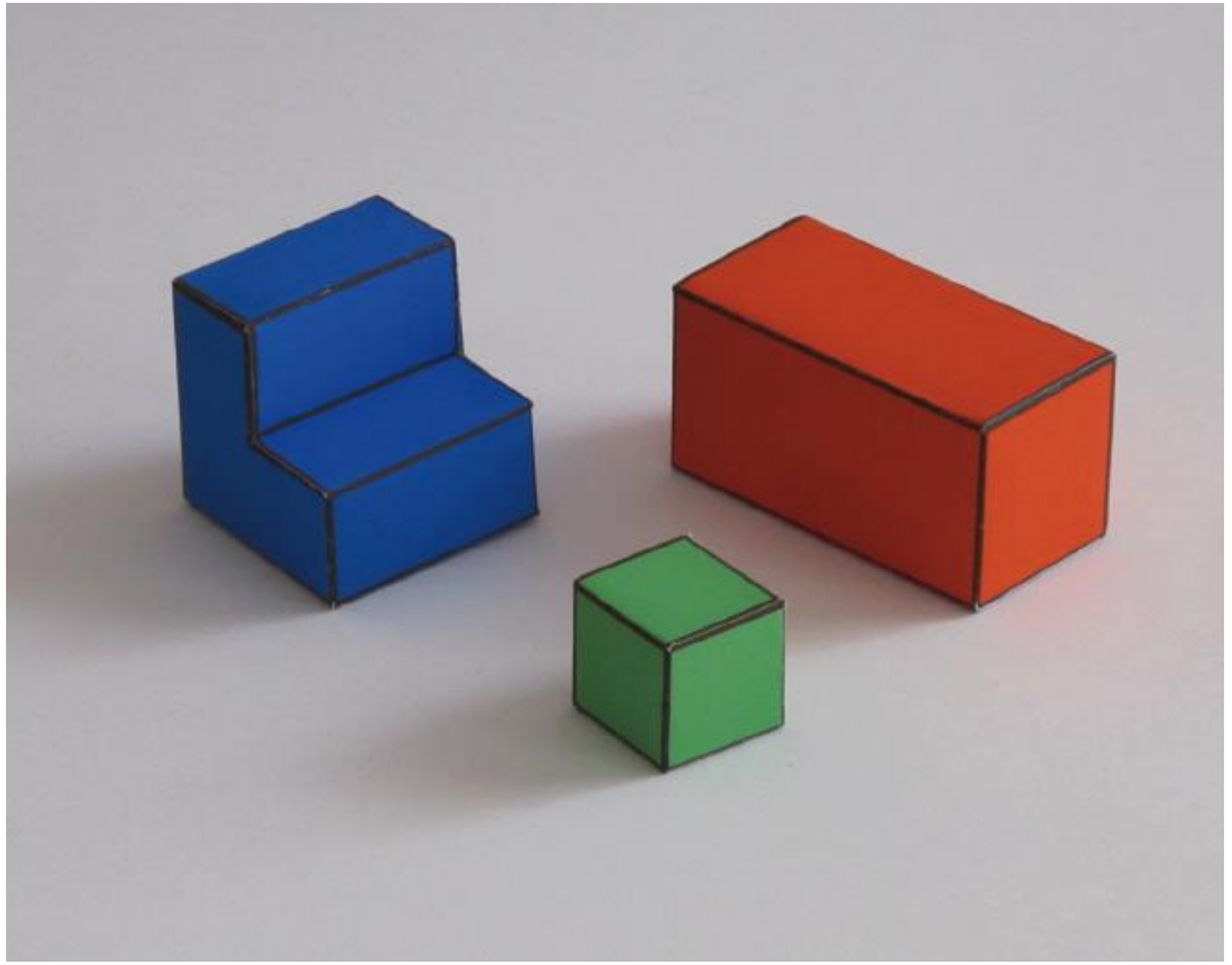






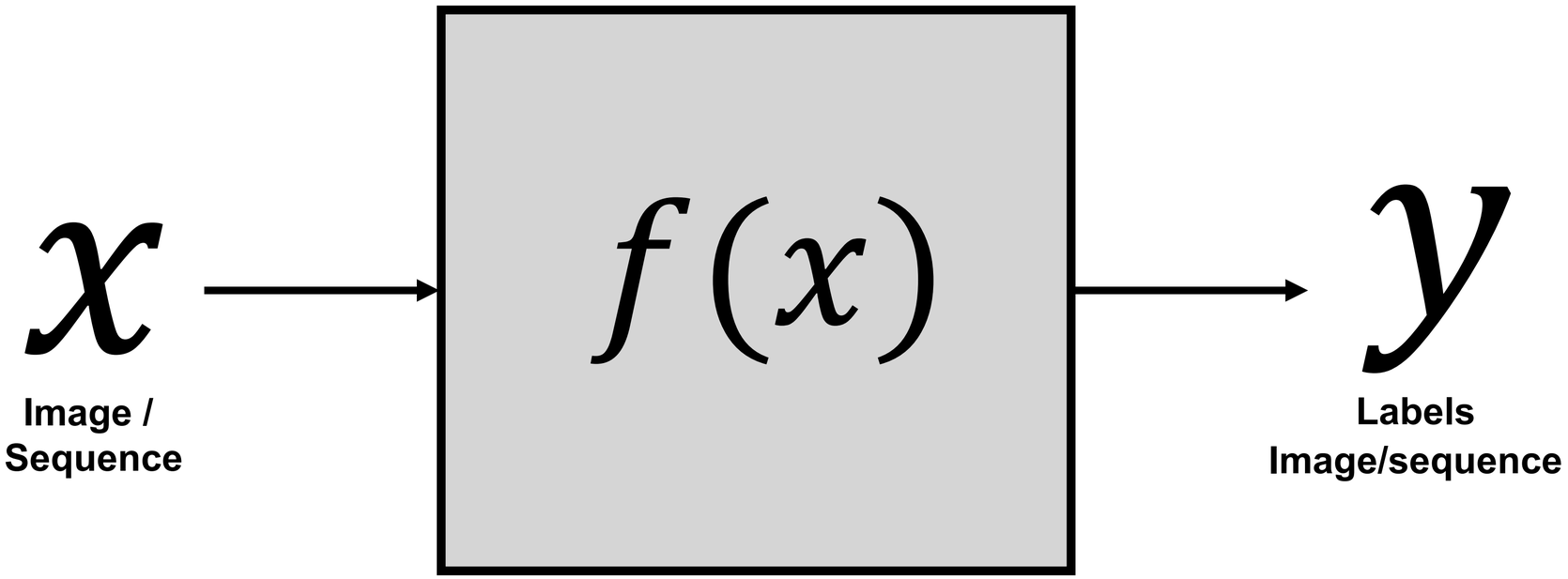
A simple goal

To recover the 3D structure of the world from the 2D image

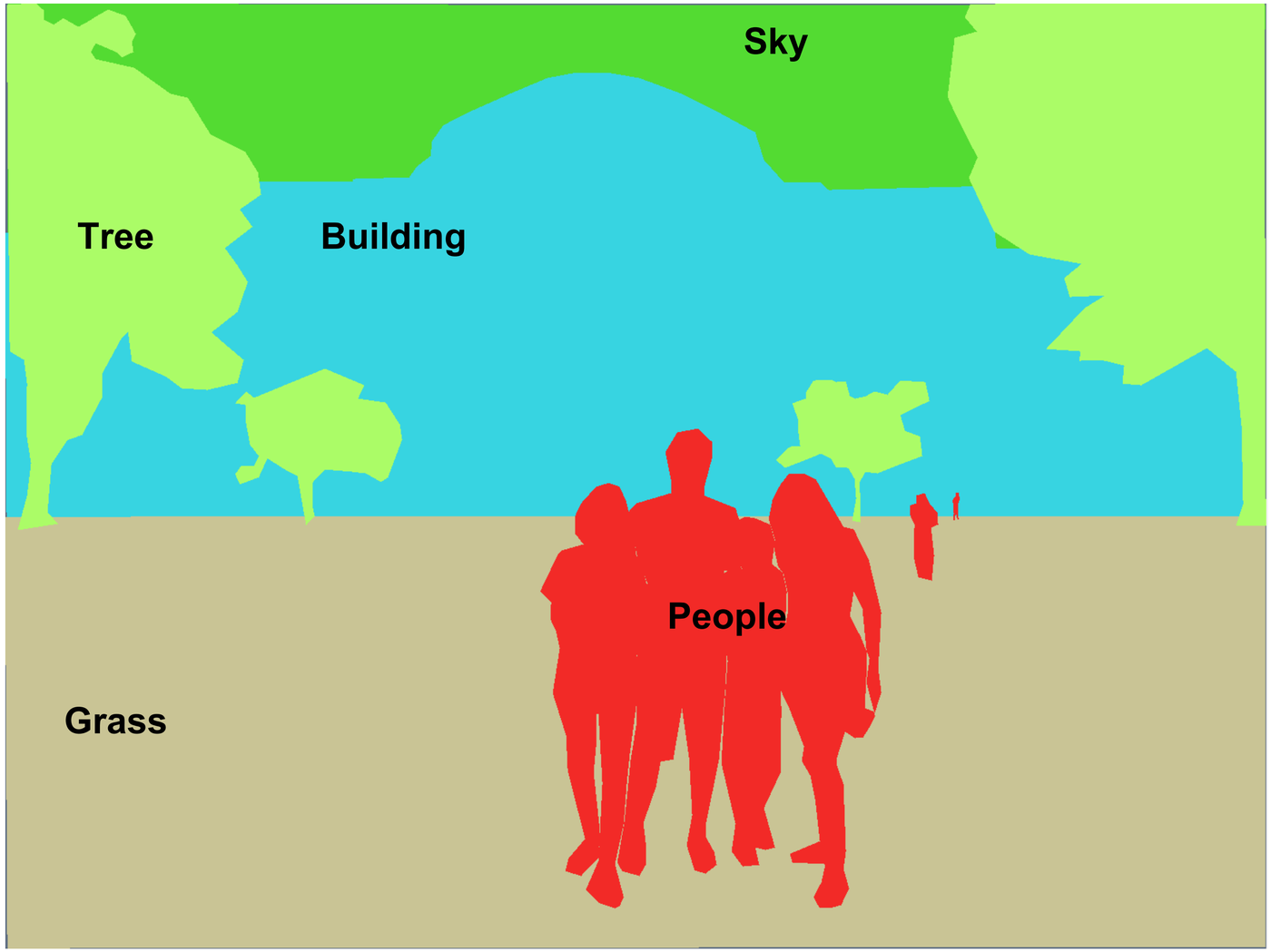


We will make this goal more explicit later.

Tasks: generic formulation



Tasks: what humans care about

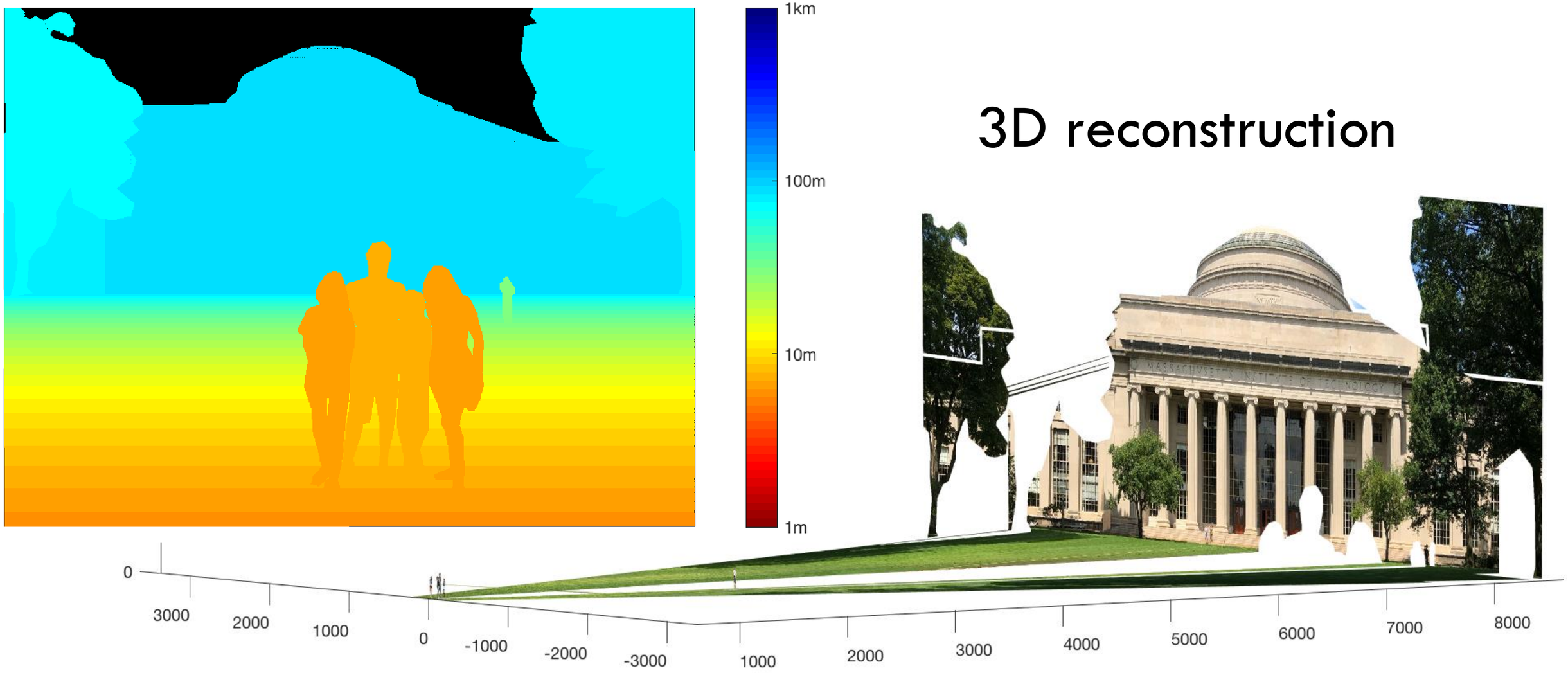


Semantic segmentation:
Assign labels to all the pixels in the image

Related tasks:

- **Semantic segmentation**
- **Object categorization**
- **Face detection and recognition**
- **Human body pose**
- **…**

Tasks: what humans care about



3D reconstruction

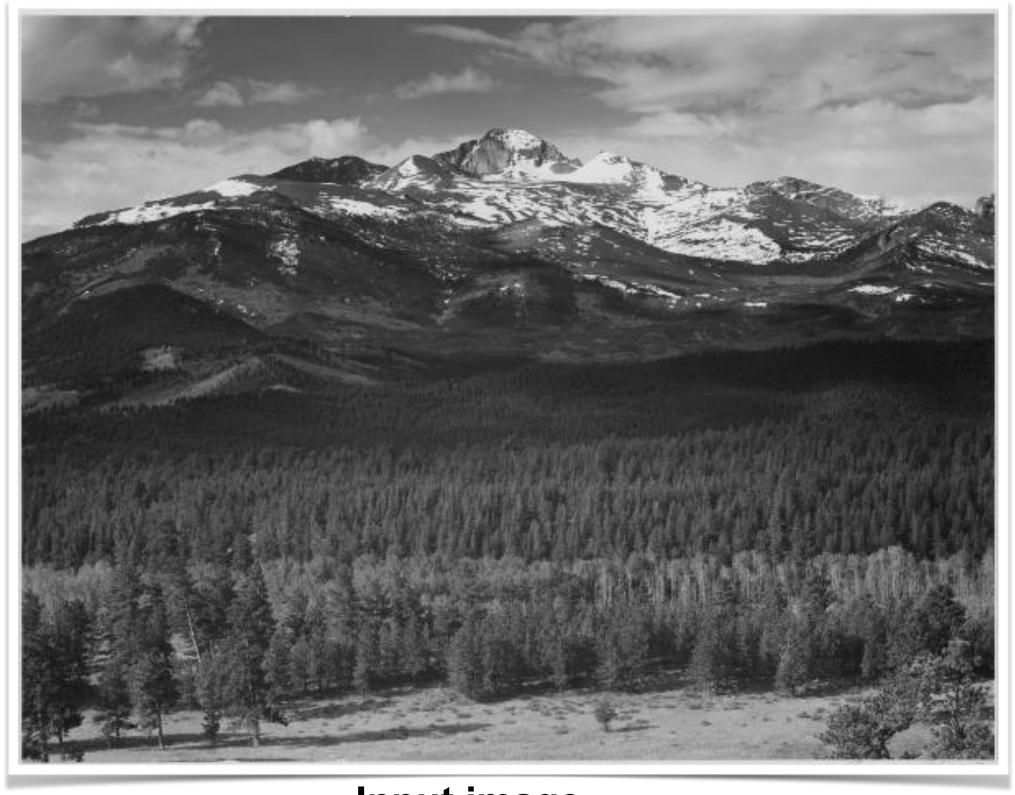
Tasks: what humans care about

https://www.reddit.com/r/dalle2/comments/y4mygn/a_cup_of_cat/

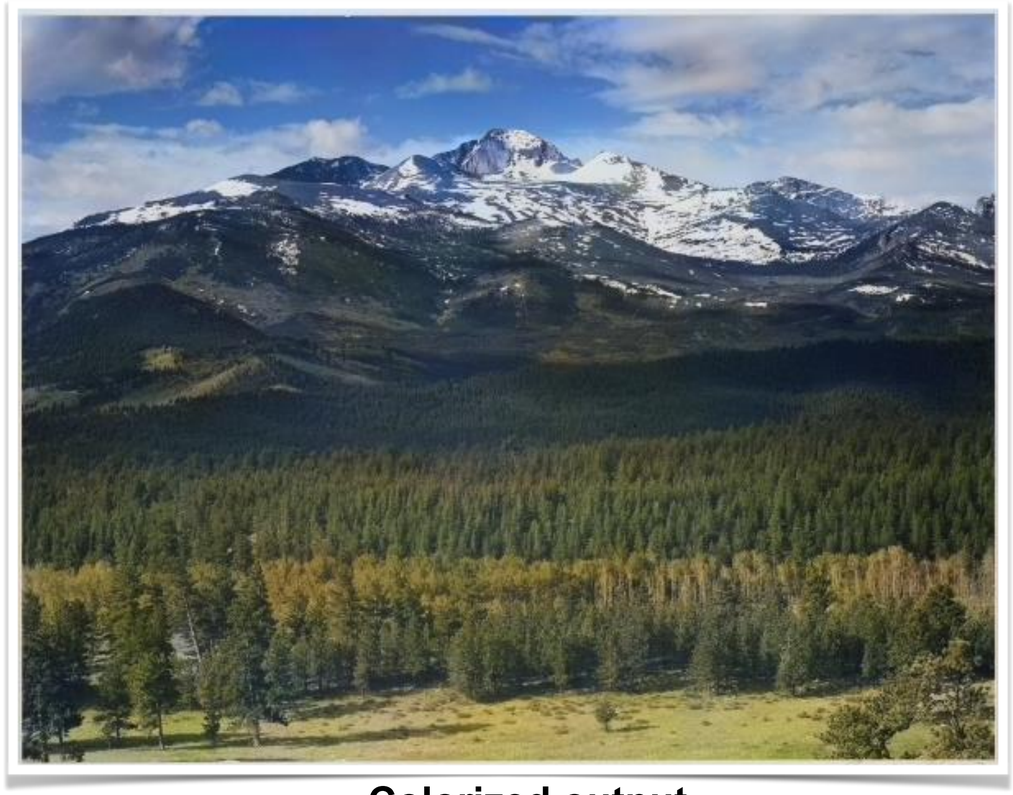
Making new images

Tasks: what humans care about

Adding missing content



Input image



Colorized output

https://richzhang.github.io/colorization/

Tasks: what humans care about

Predicting future events

What is going to happen?

https://hyperfuture.cs.columbia.edu/