Visual Perception

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Image Formation (Visual Sensing)



Image Understanding (Perception)



Neuroscience

low-level vision: how the retina transduces light and how the visual system extracts features and surfaces from retinal stimulation.

mid-level vision: how surfaces are segmented into separable objects.

High-level vision: how the visual system recognizes what category each object belongs to – that this one is a "dog", that one a "car". While advancement by data-driven learning (deep learning), how we recognize objects remains something of a mystery.

Cognitive Science

From MIT Encyclopedia of Cognitive Science: Aspects of vision that reflect influences from memory, context, or intention are considered "high-level vision," a term originating in a hierarchical approach to vision. In currently popular interactive hierarchical models, however, it is almost impossible to distinguish where one level of processing ends and another begins. This is because partial outputs from lower level processes initiate higher-level processes, and the outputs of higher-level processes feed back to influence processing at the lower levels (McClelland and Rumelhart 1986). Thus, the distinctions between processes residing at high, intermediate, and low levels are difficult to draw. Indeed, substantial empirical evidence indicates that some high-level processes influence behaviors that are traditionally considered low-level or MID-LEVEL VISION. With this caveat in mind, the following topics will be considered under the heading "highlevel vision": object and face recognition, scene perception Baoquand^{Ch}context effects, effects of intention and object knowledge an noncontian and the mental atministrates used to intermeta

Observation of Contrast

- The feeling of contrast is nonlinear to color variance
- A better measure is the Δ Luminance
- Using this also helps if someone makes a gray scale photocopy of your color hardcopy

Color Alone Doesn't Cut It



Luminance Contrast is Crucial

I would prefer that my life depend on being able to read this quickly and accurately!

The Luminance Equation

$Y = 0.3 \times$ **Red** $+ 0.59 \times$ **Green** $+ 0.11 \times$ **Blue**



Luminance Table

/				
	R	G	В	Y
Black	0.0	0.0	0.0	0.00
White	1.0	1.0	1.0	1.00
Red	1.0	0.0	0.0	0.30
Green	0.0	1.0	0.0	0.59
Blue	0.0	0.0	1.0	0.11
Cyan	0.0	1.0	1.0	0.70
Magenta	1.0	0.0	1.0	0.41
Orange	1.0	0.5	0.0	0.60
Yellow	1.0	1.0	0.0	0.89

≈ Contrast Table

	Black	White	Red	Green	Blue	Cyan	Magenta	Orange	Yellow
Black	0.00	1.00	0.30	0.59	0.11	0.70	0.41	0.60	0.89
White	1.00	0.00	0.70	0.41	0.89	0.30	0.59	0.41	0.11
Red	0.30	0.70	0.00	0.29	0.19	0.40	0.11	0.30	0.59
Green	0.59	0.41	0.29	0.00	0.48	0.11	0.18	0.01	0.30
Blue	0.11	0.89	0.19	0.48	0.00	0.59	0.30	0.49	0.78
Cyan	0.70	0.30	0.40	0.11	0.59	0.00	0.29	0.11	0.19
Magenta	0.41	0.59	0.11	0.18	0.30	0.29	0.00	0.19	0.48
Orange	0.60	0.41	0.30	0.01	0.49	0.11	0.19	0.00	0.30
Yellow	0.89	0.11	0.59	0.30	0.78	0.19	0.48	0.30	0.00

 Δ L* of about 0.40 are highlighted and recommended Baoquan Chen 2018 11

	Black	Black	Black	Black	Black	Black	Black	Black
White		White	White	White	White	White	White	White
Red	Red		Red	Red	Red	Red	Red	Red
Yellow	Yellow	Yellow		Yellow	Yellow	Yellow	Yellow	Yellow
Green	Green	Green	Green	Green		Green	Green	Green
Blue	Blue	Blue	Blue	Blue	Blue	Blue		Blue

Color Rules

our perception of color changes with:

- The surrounding color
- How close two objects are
- How long you have been staring at the color
- Sudden changes in the color intensity

The Ability to Discriminate Colors Changes with Surrounding Color: "Simultaneous Contrast"



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Beware of Mach Banding



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The Ability to Discriminate Colors Changes with Size of the Colored Area

The Ability to Discriminate Colors Changes with Ambient Light

The Ability to Discriminate Colors Changes with the Age of the Viewer

Be Aware of Color Vision Deficiencies (CVD)

- There is actually no such thing as "color blindness"
- CVD affects ~10% of Caucasian men
- CVD affects $~\widetilde{}4\%$ of non-Caucasian men
- CVD affects $\sim 0.5\%$ of women
- The most common type of CVD is redgreen
- Blue-yellow also exists

Gestalt

Human visual system groups objects into forms and create internal representations for them. - [Wertheimer 1923]









ShapeLearner: Towards Shape-Based Visual Knowledge Harvesting

The deluge of images on the Web

[ECAI 2016]

• Achieve fine-grained image understanding



The Approach

- Manually build a seed shape knowledge base
- Only consider geometric features of the shape
- Transfer knowledge from seen to unseen shapes



Our Eyes Can Be 'Hallucinated'















Additional Reading

- Maureen Stone, *A Field Guide to Digital Color*, AK Peters, 2003.
- Roy Hall, *Illumination and Colors, in Computer Generated Imagery*, Springer-Verlag, 1989.
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