Vision Part 1

Informatics 1 Cognitive Science

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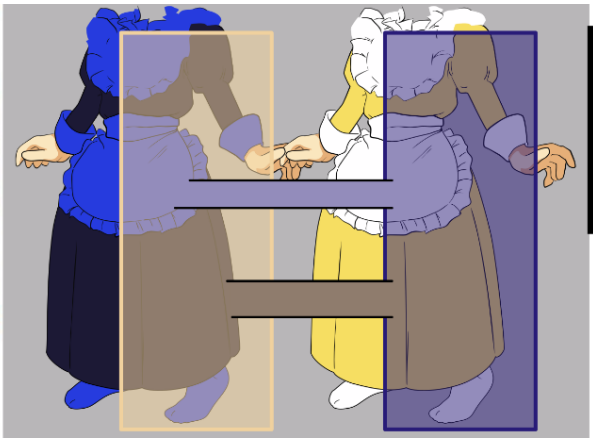
Topics

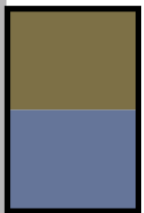
- Perception and reality
- Easy and hard problems: Moravec's paradox
- Sensory systems and the world
- Structure of the visual system: Visual pathways

Do we perceive the world the same?

Experiment: What is the colour of the dress?

In vision (interpretation of) context matters





Easy and hard tasks

Experiment: What is easy and what is hard?

Moravec's paradox

Articulated by Hans Peter Moravec, Carnegie Mellon University in 1988:

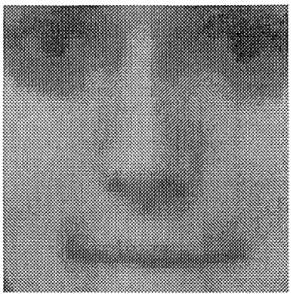
> *It is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility.*

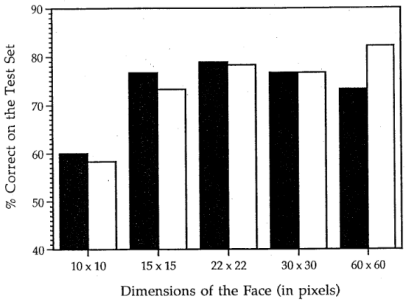
This was important at a time when it was believed symbolic approaches could be used to produce intelligent behaviour.

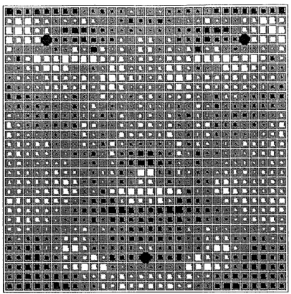
Rodney Brooks pointed out in 2002 that intelligence according top AI research is

> *...best characterized as the things that highly educated male scientists found challenging.*

1993: A perceptron recognises gender in images



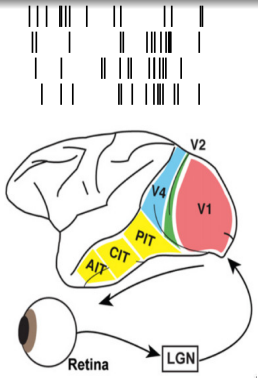




Source: Golomb, Beatrice A., and Terrence J. Sejnowski. (1993) A Perceptron Reveals the Face of Sex.

An everyday task for the brain

Sensory input



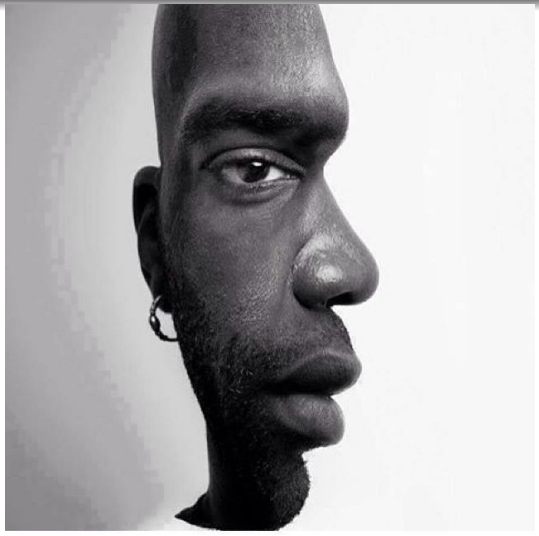
Motor output

In daylight conditions, about 6 million photoreceptors send their signals to various brain areas that process visual information. What we perceive is an interpretation of the image, much detail is discarded along the way.

An everyday visual scene?

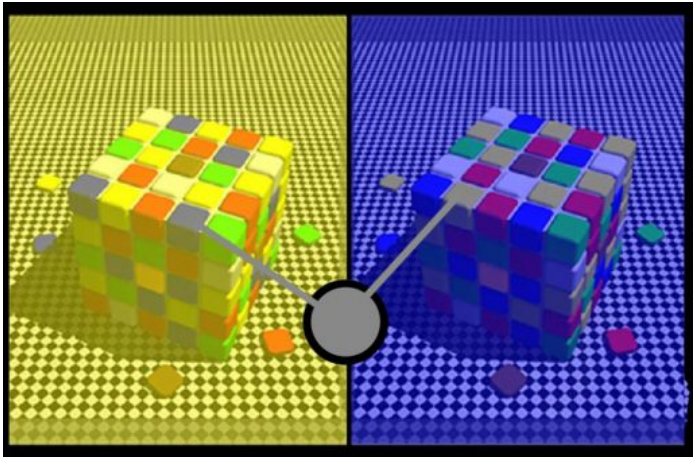
Three Sphinxes of Bikini - Salvador Dali

Are visual percepts unambiguous?



Bistable perception

Does the same always look the same?



Colour constancy

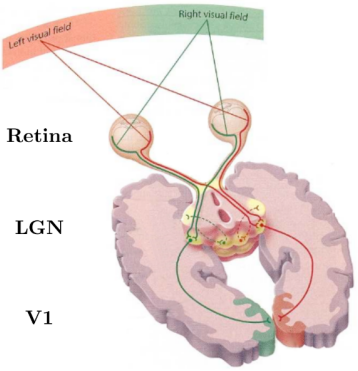
Is this the same Haystack?

Claude Monet's Haystacks

Understanding visual perception

- The sensory world is high-dimensional: Requires compression and simplification.
- Biological systems have limitations: Optimality under resource constraints.
- Elanor and James Gibson's ecological constraints: Environment and animal are inseparable, hence the senses are adapted to the environment.

The Occipital Lobe

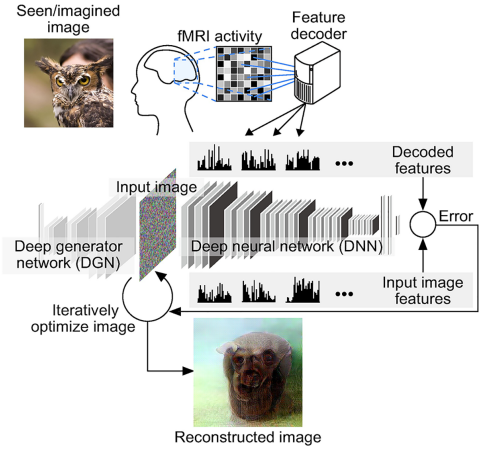


Light → Retina → Lateral Geniuclate Nucleus (LGN) → Primary Visual Cortex (V1)
Information also travels to other sub-cortical brain areas. Visual cortex activation is required for conscious perception.

Representation of the Visual Field

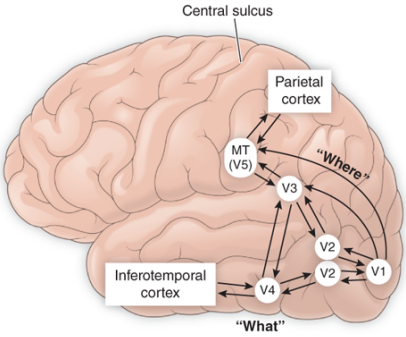
The projection from the retina to V1 is *retinotopic* – adjacent points in the image are represented by neighbouring neurons. The largest part of the visual cortex is dedicated to the central visual field - the fovea in the retina.

Retinotopy enables Image Decoding



A decoder (here a neural network) is trained on fMRI recordings. (Shen G, Horikawa T, Majima K, Kamitani Y (2019). PLoS Comput Biol 15(1): e1006633)

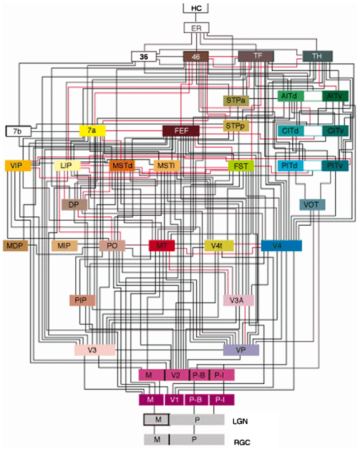
Higher Visual Cortices



Source: F.R. Amthor, A.B. Theibert, D.G. Standaert, E.D. Roberson: Essentials of Modern Neuroscience

Dorsal "where" pathway: Location and movement, spatial and attention.
Ventral, "what" pathway: Form, shape and object recognition.

Complexity of Anatomical Visual Pathways



Felleman & Van Essen, 1991