IIT Jodhpur

Biological Vision and Applications
Module 03-02: Reasoning for Vision

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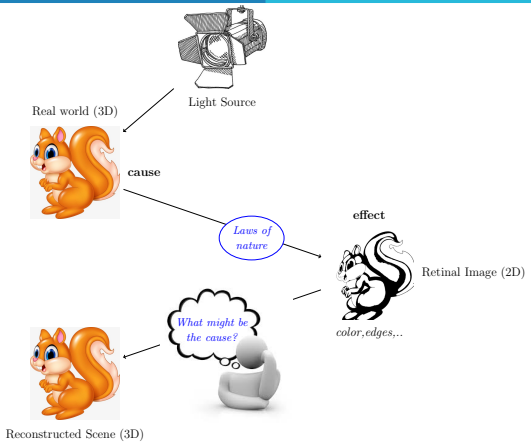
Vision is an "inverted problem"



- Naturally suited for abduction

Diversity in the natural world

Challenge for Computer Vision

Each human face is different

- How do we recognize a new human face?

Statistical similarity

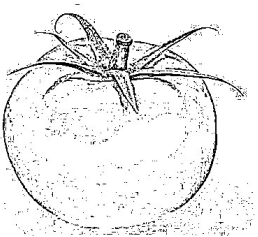
- Fortunately, the images exhibit strong statistical similarity
- Super-imposition of several natural images
  - scale and pose normalized
  - Does not result in a blur background
  - Some statistical features stand out
- Possible to construct a statistical model (object/scene)

Source: Oliva and Torralba. The role of context in object recognition.

Imperfection in signal processing

Early vision

- An image is characterized by continuous homogeneous areas with interspersed discontinuities
  - Signify object contours in the scene
- Early vision detects the discontinuities (accentuates the contrasts)
  - Contour fragments are recognized
  - Noisy: Discontinuities / spurious edges
- Statistical properties of the contour fragments distribution leads to object recognition



Sparsity in image space for natural images

- Natural scenes: images captured with devices operating in the range of visual spectrum.
  - Includes scenes of natural and man-made objects
  - Excludes text images, computer graphics, animations, paintings, cartoons, X-ray images, etc.

- Combinatorially, it is possible to have $w \times h \times d$ distinct images
  - w, h: width and height of the image
  - d: number of possible color values
  - For a 1024×1024 gray-scale image, we have 256 million possibilities

- All the possibilities never arise in natural images
  - An image can be represented as a point in an image space with volume $w \times h \times d$
  - Natural scenes are localized in very narrow regions in the image space

Vision as statistical interpretation

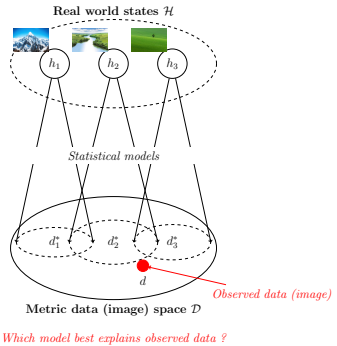
- Human eyes have adapted to the statistics of the natural scenes
  - Key to robust vision despite noisy image data
  - e.g., we can "intuitively" reconstruct the occluded contour of the flower
- The statistical regularity is exploited to model vision as a process of statistical interpretation
  - Robust to natural variations / imperfections

Feature based representation in Computer Vision

- Image space ($w \times h \times d$) is sparse
  - Scope for compressed representation
- A feature is an abstraction that characterizes the visual contents
  - It is a lower dimensional representation of an image
  - Results in data compression
- Examples of features
  - statistics of edges, colors, etc.

Abductive reasoning for vision

- The real world is in a conceptual state $h_i \in \mathcal{H}$
- A state manifests itself in observable data space $\mathcal{D}$
  - Each state has h_i has a statistical model d_i
- We observe some data d
- Which model best explains the observed data?
- Use statistical match – possible because
  - Statistical similarity of concepts
  - Sparsity of data space



Quiz

Quiz 03-02

End of Module 03-02