Biological Vision and Applications
Module 05-03: Surprise based attention models

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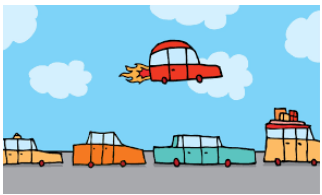
Surprise based model

- Information-theoretic model
- Probabilistic (Bayesian) model

Information theoretic model

- Info theoretic model is based on Shannon's information theory:

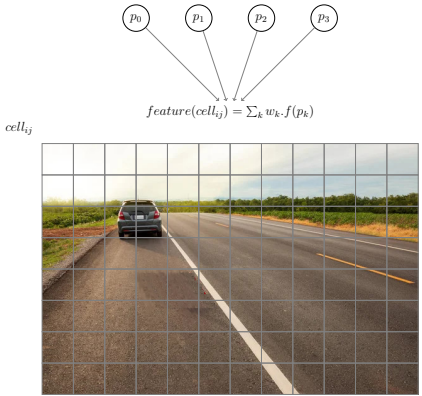
  - The event that is least likely to occur has the maximum information value
  - Self-information of an event x: $-\log P(x)$



- Image region that is least likely to occur in an image is the most salient one
- How to decide what is least likely to occur?

Shannon's Information theory

A generative model of an image

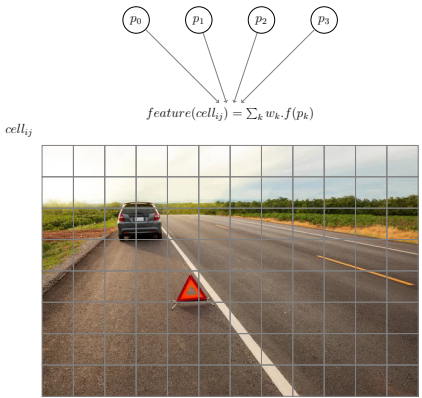


- An image region is a manifestation of some underlying hidden processes
  - A weighted sum of contributions from each process
  - The processes are unknown, hidden, independent of each other
  - The weights are not à-priori known
- Use Natural Scene Statistics
  - Learn the processes and the weights from many observations (different types of scenes)

Independent Component Analysis

A generative model of an image

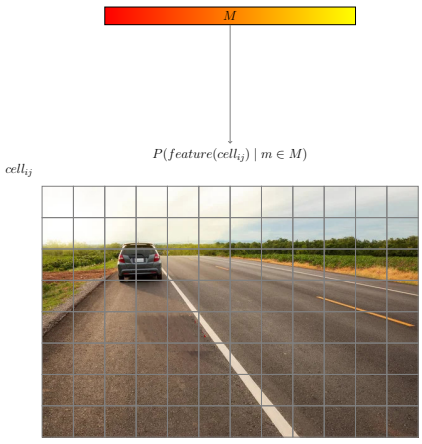
contd ... What is unexpected?



- Model a new scene with the learned features & weights
  - Select weights for the processes for best fit for the overall image
- There will be some outlier regions, which do not fit
  - Have least probability to occur (most informative)
- These image regions are the salient ones

Bayesian model

Based on "surprise" – brings in experential factor



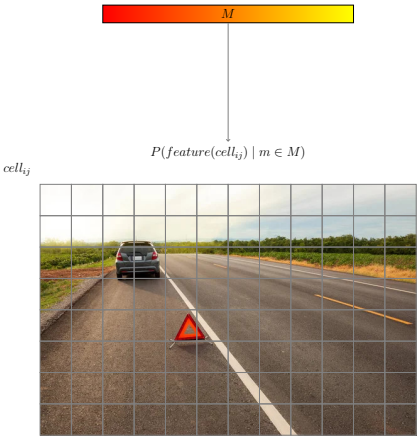
- D: observed data (features in a cell)
- M: a continuous range of states
- $p(m)$: the prior pdf for states
- $p(m \mid D)$: the posterior pdf for the states
  - after experiencing some data D
- The surprise factor of the data D:
  - Change in pdf of M as a result of observing D

$$S(D) = KLD(p(m), p(m \mid D))$$

$$= \int_m p(m).\mathbf{log}\frac{p(m)}{p(m|D)}.dm$$

Surprise ... Bayesian Model

... contd.



Surprise factor for data D:

$$S(D) = \int_m p(m).\mathbf{log}\frac{p(m)}{p(m|D)}.dm$$

Baye's Theorem:

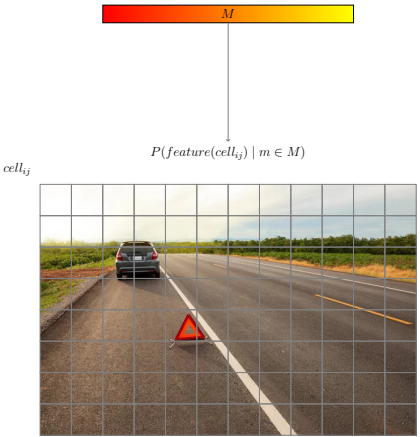
$$P(m \mid D) = \frac{p(m).P(D|m)}{P(D)}$$

Using Baye's theorem and simplifying:

$$S(D) = \mathbf{log}P(D) - \int_m p(m).\mathbf{log}P(D \mid m).dm$$

Surprise ... Bayesian Model

... incremental update and change awareness



- Let data $D = D_1, D_2, \ldots$ (a time series)
- After observing D_1:
  - $p_1(m) = p(m \mid D_1) = \frac{p(m).P(D_1|m)}{P(D)}$
  - This serves as the prior for next observation D_2
- The model of the environment is incrementally built
- Leads to change awareness

Itti & Baldi. Bayesian Surprise Attracts Human Attention (2005)

Eye movement ?

- Fixations and saccades are guided by WTA and RI policies
  - ... as in Cognitive models

Quiz

Quiz 05-03

End of Module 05-03