02458 Cognitive modelling E19

2nd Assignment

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Bayes Exercise 1

Bayesian approach in the study of perception is based on some fundamental concepts as the likelihood function, the prior, and the gain function/ posterior probability.

Many possible scenes can give the same sensory information (aka the image of the real scene we see from a specific prospective) and sometimes the visual perception of a scene is unstable and ambiguous. That’s the case of Necker Cube where the cube perception becomes unstable between from-above-prospective (fap) and from-below-prospective (fbp).

Re-constructing a 3D image with 2D information is an ill-posed problem, we just do not have enough information to get to a unique solution: in fact there are infinite number of possible interpretations.

Despite that, in the cases like the Necker cube, our human visual system experiences only two possible interpretation as compatible with the sensory information, over an infinite range. It is never an overlapping of the two at the same time, but an alternation of fap and fbp, in a reversal process determined by the observer internal fluctuations.

Likelihood and priors in the Bayesian framework give us a good interpretation of why that happens.

Likelihood captures how likely, how plausible, how probable is that a particular scene gives the image we see (and note that it is not a probability distribution function since its integral over all the possible values doesn’t have to sum to 1). In fact, we proceed by maximizing the likelihood (aka minimizing the minus log likelihood 🡪 this is mainly to move the problem from maximizing products to minimizing sums, its more handy ). Likelihood represents the probability that the word-matter-of-fact turns into out sensory information.

The other important factor is given by Priors: those are distributions that represent the observer prior believes (of which the observer is not necessarily aware of) and provide a “principled way of formulating constraints on possible scenes that lead to unambiguous visual perception”. In other words, I strongly expect a pheasant to cross my way, I will perceive I have driven over a pheasant - even if I haven’t . Priors represent what we think is more plausible in the word-matter-of-fact, independently from the current sensory information.

Bayes theorem:

* P(A|B)\*P(B) = P(B|A)\*P(A)
* P(A|B) = P(B|A)\*P(A) \* (1/P(B))

Where

* P(B|A) = Likelihood (Not a probability distribution)
* P(A) = Prior, characterized by bias and confidence in the bias. If we model the prior in the form of normal distributions, then bias = mean of the distribution and the confidence in inversely proportional to the std. Which means and which std to use then? Means can be given by the average perception, but confidence levels estimation, aka std, is trickier. Confidence can be tested by changing the condition of the stimulus - lightening or orientation, eg increasing the contrast in an image decreases the standard deviation of the Prior that encompass the luminance effect, which then is more stable.

Prior are not fixed entities but are in reality affected by the stimulus characteristics.

* (1/P(B)) = can be seen as a sort of correction term that turns the Likelihood into a Prob.distribution, but its not necessary and we can omit it.
* P(A|B) = is the posterior distribution that takes into account both geometrical knowledge and prior weights. If we don’t have a strong prior, then our final output will be coming mainly from sensory information given by the likelihood,

### Question 1:

### Question 2:

### Question 3:

Binocular vision allows us to perceive a single 3D image of our surroundings, gives a wide field of vision (ca 190 of which 120 for both eyes) and, very important, the different position of the eyes in the head (defined as parallax or binocular disparity) allows our brain to get to a precise depth perception via a process called stereopsis. In the model we have once again the real 3D Scene (S), with the real projection on 2D planes of vision of each eye (I1 and I2), there we have hp same elevation for both and a different azimuth angle (they differ for 60 degrees). We calculate the minimum of NegLogLikelihood given by the contributions of the squared errors for each eye (S\_guess as a contribution from both viewpoints and therefore the projections on the two different planes I\_guess\_1 and I\_guess\_2).

We see that, also without any prior on volume, lengths, angles o light, we get a perfect estimate of the original 3D scene.

## Bayes Exercise 2

### Question 1:

### Question 2:

### Question 3:

## Exercise 3

### Question 1:

### Question 2:

### Question 3: