

I. On Recursive Estimation and the Brain

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Some years ago, I watched with great interest a series of programmes on BBC TV presented by Baroness Susan Greenfield, Professor of Synaptic Pharmacology at Lincoln College, Oxford, entitled *Brain Story: Why Do We Think and Feel as We Do?*. It was a popular TV series but it was well presented and interesting to me personally since it enhanced my previous knowledge of the brain gained from my brother, John F. Young, in his studies of cybernetics and robotics (Young, 1969, 1973ab). In particular, I was interested in one episode of the series where Professor Greenfield referred to the relationship between the rather crude image projected on to our retina by the eye lens, and the much clearer picture that we ‘see’, after this information has been processed by the brain. Figure 1 illustrates this well (from Article 997 at <http://www.digitalversus.com/>): in the right hand panel is the kind of image that appears on the retina; while in the left hand panel there is a photograph of the same scene that is much more like what we actually ‘see’ after the brain has processed the information received via the optic nerve. What a difference! How does the brain achieve such an improvement?



Figure 1. The image on the retina (right panel) and what we see (left panel).

As I recall, Professor Greenfield suggested an answer to this question. She said that, from the beginning of our life as a baby, the brain is building *detailed, high resolution* models of visual objects on the basis of the retinal observations and what we ‘see’, at any time, is an image constructed from these modelled objects;

an image that is being *continuously corrected* on the basis of the error between the observations sent by the optic nerve from the retina and the model predictions. In other words, she implied that what we are seeing is the corrected model predictions *not* the enhanced retinal image.

This was a revelation to me: it was as though she was describing the brain as acting like a *Kalman Filter*! Here, the predictive model would have to be some representation of three dimensional moving objects; and the estimates of the model ‘states’ would have to be continually updated on the basis of the noisy measurements from the retinal ‘sensors’ in our two eyes. It is an attractive hypothesis. Moreover, the computational efficiency of such a recursive algorithmic solution would seem to be well suited to a task that has to be implemented in real-time by the neural networks of the brain.

But if this interpretation has any merit, it suggests that there is no ‘reality’: what we ‘see’, which seems so clear and deterministic, is not reality but the brain's interpretation of the imperfect image on the retina. And these interpretations must be probabilistic, not deterministic. In other words, the ‘reality’ we perceive looks real but this is, literally, an illusion, albeit one that gives us a normally excellent idea, enhanced by information from our other senses, of the world around us.

Of course, there are many publications concerned with the use of recursive algorithms, such as the *Kalman Filter*, *Extended Kalman Filter* and *Ensemble Kalman Filter* (see Young, 2011), for the *computer* enhancement and processing of images: recently, for example, Butala et al (2009) have considered the latter for the tomographic imaging of dynamic objects. And the reader will find that there are many other such publications revealed from a Google search on this subject. While it is a long way from finding out how the brain is carrying out its tasks in this regard, it is possible that such research, coupled with associated physiological research, may eventually throw some light on how the brain carries out its processing in order to achieve such amazing results.

Interestingly, there has been research on whether quantum mechanical concepts can be linked with neuroscience to explain human consciousness (see Hameroff and Penrose, 1996; Penrose and Hameroff, 2011). Moreover, this is linked with the

‘state reduction’ phenomenon that occurs when measurements are taken, as discussed in my thoughts ‘On Recursive Aspects of Quantum Dynamics’.

Such topics as these are certainly a fascinating topics for future research. They are surely amongst the greatest research challenges to science at the start of the twenty first Century and I believe that recursive estimation, in one of its many forms, could well figure strongly in such research.

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