Friday, October 20, 1995
3D Eye Movement Control

1 Apologies for not getting this YORKVIS summary sheet out sooner. As you know, I am usually much more prompt. I will try harder in future.

2 I am not sure whether it is helpful to give an attendance register, so I won't bother. Let me know if you think it would be helpful. Or maybe I should provide a tree of everyone who is on the mailing list at this time? Let me know if you would like such things.

3 Next meetings:
3 Nov 95 DM Regan and his group. Usual place (061), usual time (10am).

1 Dec 95 Demetri Terzopoulos, from U of T.

5 Jan 96 open (we could cancel or postpone the Jan 96 meeting on the basis that it is too early, cold etc... - opinions please.)

4 Brief reminder of Desimone's talk, 4pm, Fri 20th Oct. Earth Sciences Auditorium, 5 Bancroft Ave, Room 1050.

5.0 The Oct/95 meeting was given by Doug Crawford on 3D eye-movement control. Here is a brief summary of the talk, as I saw it (any errors are entirely mine):

5.1 There are essentially two competing models to describe saccadic control: the 'spatial model' originating from David A Robinson in the mid 70's and the 'displacement feedback model' originating from Jurgens in the early 80's.

Spatial model of eye movement control:

The input to the brain stem plant (plant as in factory for manufacturing eye movements, rather than in vegetable-like reflex processor) is the difference between where the eye IS (derived from a copy of the eye's driving signal - a classic efferent copy model) and where it WANTS TO BE. Where it wants to be is calculated from where it is + the displacement required (retinal error: the 'error' between the fovea and where the fovea wants to be: ie. retinal error is RELATIVE to the position at that moment). This representation of where it wants to be is therefore in SPATIAL coordinates: hence the name of the model. The representation of where the eye is, appears, on the face of it, to be redundant since no sooner is it introduced than it is taken away again. However, it does give the mechanism the option of being sensitive to eye position. Perhaps because it was the first Really Useful Model (RUM) of eye movement control, this model has tended to dominate the field.

Displacement model of eye movement control:

The literature has argued back and forth over the relative merits of these models (and their spawn) for a quarter of a century. However they both were conceived under the paradigm: "let's get horizontal eye movements sorted out first and then we'll generalize". Now we are ready to 'generalize'. Recording three dimensional eye movements is now available to anyone motivated enough to instal it: how do these models perform in modelling REAL 3D eye movements?

5.2 Representing eye position is a bit tricky since the eye, of course, doesn't actually GO anywhere, it just points in different directions. There are lots of ways of representing eye position but one particular way is becoming dominant in 3D eye movement research. Unfortunately this method is not particularly intuitive but it seems to have some biological plausibility. In this method, each eye-movement-in-response-to-a-target is treated separately. After each movement the brain tidies up its toys and forgets about it.

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5.4 Anyway, it turns out that both the DISPLACEMENT and SPATIAL models are pretty good at reproducing the basic properties 3D saccades. They reproduce both the restricted 2D plane of EYE POSITIONS (when represented in the above system) as well as the constraints on the VELOCITY of the eye. We need a more sophisticated test if we are to distinguish the two models. The essence of the talk was to describe an experiment that might do it. Stimuli were devised that generate different INPUT signals to the two models. Over a range of vertical eccentricities, stimulus pairs are positioned on lines of latitude around the subject such that the DISPLACEMENT ERROR between the members of the pair is always the same: that is when one stimulus is fixated, the other (target stimulus) falls on exactly the same retinal location each time. The displacement error is thus constant since it doesn't take into account anything to do with start position of the eye. The SPATIAL ERROR on the other hand varies since it DOES take into account starting eye position which varies systematically with eccentricity.

5.3a It turns out that only the SPATIAL model generates accurate saccades between targets of this kind. The DISPLACEMENT model evokes the same pattern of eye muscle contraction independent of starting position and thus misses the target when the eye is eccentric. We do not yet know what humans do. Doug will be in a position to tell us soon!

5.4 The above description of the constraints on eye position and movement only apply when the head is still and upright and gaze is at infinity. If the eye is moving to compensate for a head movement, then, since head movements can be around any axis, it doesn't make any sense to constrain the eye movements under these circumstances. If the head moves around an unusual axis, then so does the eye, resulting in 'illegal eye positions'. However you don't want to LEAVE the eye in illegal positions. It turns out that under these conditions, corrective saccades occur which bring the eye back to legal positions. Now these corrective saccades must saccades. How do the two models (SPATIAL and DISPLACEMENT) perform for THESE rather unusual saccades? Again the displacement model fails. Since the input signal doesn't care about the starting position of the eye, it doesn't know that its starting position is illegal. Thus the illegality remains uncorrected. The spatial model however, which DOES take into account start position, makes saccades whose properties depend on the initial, illegal position and correct it.

5.4a So all this suggests that the SPATIAL model is the winner. However there is this titchy, teeny problem that at pretty nearly all relevant sites the starting position of the eye, it doesn't know that its starting position is illegal. Thus the illegality remains uncorrected. The spatial model however, which DOES take into account start position, makes saccades whose properties depend on the initial, illegal position and correct it.

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