- Friday, September 26, 1997
  Mobile Reference Frames

1.0 These are the minutes of the 26 Sept 97 meeting of the YorkVis discussion group. The reason they are a little late is that I sent them to the speaker, Dejan Todorovic, to check for howlers but he has not replied. So I thought I'd send them round anyway and then correct any errors later.

1.1 Minutes for James Elder's talk will circulate after he has checked them.

1.2 Hiro Ono is talking this Friday (7th Nov; 061 BSB; 10am)

1.3 James Elder who has kindly taken responsibility for a Poster that the York Vision people are going to distribute to advertise ourselves to prospective graduate students etc. He showed us the first draft. Most people felt the photographs chosen were not flattering enough and didn't make us look scientific enough so new photographs will be taken shortly! I will let you know the web address when it is available.

2.0 The talk today was by Dejan Todorovic who is visiting from the University of Belgrade. I think he plans quite a long visit in the future. His talk was entitled "Perception of dynamic point configurations: role of mobile reference frames and minimum principles."

2.1 The talk used as its basic example the perception of two dots moving on a screen. One starts from the top left and moves down, the other starts from the bottom right and moves to the left. The dots are all that is visible. The percepts that this simple stimulus evokes are various. A typical one is that an observer sees the dots as moving towards each other; another is that the direction of one is distorted by the motion of the other, for example the horizontally-moving one might appear to move up a little too.

2.2 The various percepts can be MODELLED by a simple formula involving the weighted vector sum of the movement of each dot against a STATIC (earth-fixed) reference frame and the movement of an additional imaginary point (also relative to the static frame) to which the dots are related. This latter point represents what Todorovic calls a "mobile reference frame".

2.3 By choosing various directions and amounts of movement of the (imaginary) mobile reference plane and by differentially weighting its contribution and the contribution of the dots, various percepts can be reconstructed. The question becomes, how does the BRAIN choose a particular mobile reference frame (if the brain's response can be modelled in this way at all) and the particular weightings?

3.0 Todorivic proposes a minimum principle. Some phenomena governed by physical laws (eg, refraction of light and the path of a projectile) can be mathematically modelled by minimizing something (eg, total journey time in the case of refracted light, since light travels at different speeds in different media, or total "action" - whatever that is - in the examples suggested). Doug Tweed has spent some time trying to explain Listing's Law as a minimal energy model, for example. I personally find this approach a little teleological - especially when applied to physical laws. Why should light care? Anyway, to apply this idea to selecting a percept for the movement of two lights, first we have to decide what it is that might be minimized.

3.1 Let's take all possible reference frame movements. Possible things to minimize included total distance; average velocity; or the average distance of the dots from the reference frame.Todorivic choose the latter: to minimize the average distance of the dots from the mobile reference frame. In fact it turns out (as was explained to me later) that choosing the others can be made to result in a very similar formulation.

3.2 This plan turns out to RESTRICT the possible reference frame movements and the weightings used but not to specify a unique solution. That is although the ACTUAL percept is one of the family of the possible solutions found by this method, there are lots of other possible solutions.

4.0 What about taking eye movement into account? Might that then uniquely specify the moving reference frame? We can treat the eye itself as the 'mobile reference frame'. Now we can easily predict which percept should be experienced by just measuring the eye movements. For many examples, this works.

4.1 However, there are several COUNTEREXAMPLES of arrangements of moving dots in which the percept is not the solution predicted by the minimum principle model using eye movements to guide the mobile reference frame. Examples of these include when a single dot moves down while a dot above and below move sideways. Here the percept is of the central dot moving diagonally. Amazingly the percept is apparently not altered by following the movement of the central dot with your eyes where the model would predict a difference of adding in the eye movement vector.

4.2 So the conclusions are that this way of describing the percept induced by combinations of moving dots cannot exactly specify the percept but at least it can rule out some percepts under many conditions.

ABSTRACT (provided by Dejan Todorovic):

Dynamic point configurations (studied by Duncker, Johansson, Wallach, Cutting & Proffitt, etc) are stimuli constituted by a few points moving on homogeneous background. The perceived motions of such stimulus points may deviate drastically from their absolute motions (motions with respect to the static background). Furthermore, the same stimulus may induce several different motion percepts. The structure of perceived motions can be accounted for by the introduction of mobile reference frames. An important problem is to single out the perceptually relevant reference frames from the infinity of geometrically possible ones. A simple vector formula for such reference frames is proposed and its application is illustrated with several examples. It is shown that this formula may be deduced from a minimum principle. The roles of eye motions and stimulus structure in the establishment of reference frames are discussed.

Dejan Todorovic