- Thursday, March 5, 1998
  Visual Processing of Impending Collision

  1.0 Here are the minutes for YORKVIS, 5 March 1998.

  1.1 The next Yorkvis is by Peter Hallett (3 April, 1998, 10am 061BSB) entitled "Seeing variable stars".

  1.2 Also coming up.... Fri May 22th, 1998 Stephen Palmisano (post-doc with Ian Howard) "Perceiving self-motion in depth: the roles of stereoscopic, changing-size, ground plane and jitter information" (abstract on web page) 10am 061 BSB

  2.0 Hongjin Sun gave a seminar on "Time to Collision"

  2.1 If an object is moving at a constant velocity on a collision course with you (or you with it), then there is a very simple formula that allows you to calculate the time before collision occurs. Time to collision is (approximately equal) to the angular size of the object divided by the rate of change of its angular size. This ratio, discovered (apparently) by Fred Hoyle and investigated and popularized extensively by Dave Lee (from Edingburgh) is called TAU. Both the top and bottom of the ratio can be fairly easily derived from retinal information. This talk addressed the question of whether and how biological organisms might use this information.

  3.1 Hongjin recorded (in Barry Frost's lab) from an area in the pigeon brain called the Nucleus Rotundus. This nucleus receives information from the optic tectum and seems to be involved in large-field image processing. Cells here (a) responded to objects moving towards the bird, (b) started firing just before impact and (c) were tightly tuned to the direction of movement in three dimensions firing only when the direction of movement was within 10 degs of an impact course.

  3.2 These cells needed RELATIVE motion of an object and its background to respond, implying that they were not involved in self motion since self motion creates motion of all parts of the retinal image together. I suppose they might be involved in self motion involving parallax, though (LRH).

  3.3 Looking in detail at the timing of the cells responses allowed Hongjin to divide them into three categories. There was some discussion on this point about the arbitrariness of the division and the possibility of their responses being better descibed as a continuum.

  3.3.1 Type A cells started firing earlier for bigger objects. The could be modelled as firing at a rate proportional to the rate of angular expansion (which increases as the object approaches).

  3.3.2 Type B cells started to fire a fixed time before the collision of any sized object (in the range 5 to 50 cm anyway). They could be modelled as firing at a rate proportional to 1/tau.

  3.3.3 Type C cells were similar to type A cells except that, instead of building higher and higher as impact approached, their activity decayed from a peak that occurred before impact.

  3.3.4 The existence of these cells in the pigeon brain, even if they represent some kind of continuum, indicate that information useful to processing time to collision has been extracted from retinal motion.

  4.1 Hongjin described a simple type of model that could, potentially, account for the behaviour of these cells. The model involved summing the activity from cells with receptive fields arranged radially symmetrically around the fovea and each responding best to movement away from the fovea.

  5.1 In order to investigate whether humans are able to use TAU, Hongjin looked at the ability to ride and stop a bicycle before a target. He used a virtual reality system so as to be able to vary visual speed easily. It turns out that subjects tend to pedal at constant velocity, which makes the math simpler! When asked to stop as quickly and as accurately as possible, subjects commenced braknig at a constant time before impact suggesting that this value could be deduced from optic flow generated by movement at a variety of velocities.

  5.2 In another test, the visual target was made to either expand or contract during a subject's movement in addition to the expansion expected in response to the movement. It was found that expanding the size of the target caused the subject to decelerate sooner than braking in front of a target of constant size. Conversely, contracting the target led the subject to decelerate later. These results were also consistent with subjects using the tau strategy to control locomotion in this task.

  Hongjin Sun