Three-Dimensional Model of Oculomotor Control in Nengo

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System Description

Experimental data supports the presence of an integrator converting velocity signals of pons and midbrain to position signals in driving the eye.

- Argued by some that integrator cannot generalize to three dimensions due to non-commutativity
  - However this leads to non-biologically plausible models
- Kinematic model of eye
  - Soft tissue sheaths or 'pulleys' in orbital tissue affecting dynamics
- Feedback system
  - Loop parameters

Implementation: overview

- For biological plausibility, need to develop a relationship between torque driving the eye and orientation in the head
- Orientation represented by a rotation from the primary position

  $$R(t) = \begin{bmatrix} \alpha_{11}(t) & \alpha_{12}(t) & \alpha_{13}(t) \\ \alpha_{21}(t) & \alpha_{22}(t) & \alpha_{23}(t) \\ \alpha_{31}(t) & \alpha_{32}(t) & \alpha_{33}(t) \end{bmatrix}$$

  using Euler's theorem (Φ about $\hat{n}$)
- Eye and surrounding tissue can be represented by a second-order system (overdamped, $\tau = 0.15s$)
- Restorative torque given as $T(R) = -K\Phi(R)\hat{n}(R)$

Implementation: feedback structure

- Three-dimensional extension of course example integrator
- Require a transduction matrix M to go from torque vector (commutative) to orientation (noncommutative)

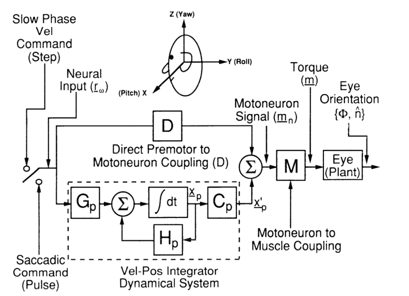

Figure: System diagram.

Some considerations

- How well does this model match experimental data?
- Will it apply equally well to saccadic and slow eye movement data?
- Does it obey Listing's law? How well?

References

Raphan et al. (1994).
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