NEUROSCIENCE 2007

Print this Page for Your Records Close Window

Control/Tracking Number: 2007-A-104245-SfN
Activity: Scientific Abstract
Current Date/Time: 8/1/2007 3:46:15 AM

Adaptive filter model of cerebellum improves performance of simulated optokinetic reflex

AUTHOR BLOCK

: *S. R. ANDERSON, J. PORRILL, P. DEAN;
Dept Psychol, Univ. Sheffield, Sheffield, United Kingdom

Abstract: Calibration of feedforward control, as in the vestibulo-ocular reflex, can be achieved in simulation by an adaptive filter model of the cerebellum using a covariance learning rule (Porrill, Dean and Stone 2004). The uniformity of cerebellar microcircuitry suggests the adaptive filter might be useful in other contexts, such as feedback control. Here we test its effectiveness in the optokinetic reflex (OKR), which uses retinal slip to stabilise the visual image, and is known to be partly dependent on cerebellar circuitry.
OKR input is delayed by ~100ms, potentially requiring low open loop gain values to avoid instability. At low frequencies (~0.1Hz) closed loop gain near unity can be achieved using velocity storage in the 'indirect' OKR pathway implemented primarily by the brainstem. A linearised version of this brainstem circuitry was connected to an adaptive filter model of the floccular region of the cerebellum ('direct' OKR pathway). The connections represented (i) mossy fibre inputs conveying visual signals or an efference copy of eye movements, i.e. both forward and recurrent architectures (cf. Morris and Lisberger 1987); (ii) a climbing fibre input conveying a retinal slip error signal; and (iii) an output fed into a compensated oculomotor plant.
Improvement in simulated OKR performance depended on two main factors. First, the covariance learning rule required the retinal-slip error signal to be related to a delayed version of the main filter inputs, some of which also carried a retinal slip signal. Since the learning rule attempts to decorrelate filter inputs from the error signal, absence of delay resulted in unstable learning. Secondly, the degree of improvement depended upon the temporal structure of the visual input. It was found the more predictable the signal, the greater the improvement produced by the adaptive filter. The overall pattern of results was qualitatively similar to that described by by Deno et al (1995) for smooth pursuit.
These results suggest that the adaptive filter model of the cerebellum can improve feedback control, in a manner similar to that achieved by the floccular region of the cerebellum for the OKR. However, delay of mossy fibre slip inputs relative to climbing fibre slip inputs is crucial, as found previously in models of predictive smooth pursuit (Kettner et al 1997) and of ocular following responses (Yamamoto et al 2002). It has been suggested that signalling mechanisms within the Purkinje cell, sometimes referred to as the 'eligibility trace', could implement the appropriate delay.
:

Theme and Topic (Complete): D.06.a. Brainstem, cerebellum, and muscles ; D.14.c. Plasticity
Keyword (Complete): CEREBELLUM ; OCULOMOTOR ; FEEDBACK ; LEARNING ; OPTOKINETIC REFLEX

Presentation Preference (Complete): Poster Only
Support (Complete):
Support : Yes
Grant/Other Support: : EPSRC (UK) Novel Computation Initiative GR/T10602/01

Linking Group (Complete): None selected
Special Requests (Complete):
Religious Conflict? : No Religious Conflict
Additional Conflict? : No

Status: Finalized