AD-A264 092

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

2. REPORT DATE 3-26-93

3. REPORT TYPE AND DATES COVERED Final Report 1 Aug 88 - 31 Jul 92

4. TITLE AND SUBTITLE
Computing with neural maps: application to perceptual and cognitive function

5. FUNDING NUMBERS
AFOSR 88-0275
61102F
23B/A8
2305/B3

6. AUTHOR(S)
Eric L. Schwartz

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
New York University Medical Center
550 First Ave.
New York 10016 N.Y.

8. PERFORMING ORGANIZATION REPORT NUMBER
AFOSR-TR- 93 0315

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR/NL
Building 410, 110 Duncan Ave, Suit B115
Bolling Air Force Base DC 20332-0001
Dr John F Tangney

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. ABSTRACT *(Maximum 200 words)*

In this report, a series of studies concerning the use of neuronal map data structures for the solution of perceptual, attentional and pattern classification problems have been developed. Models for visual attention, based on the representation of an attentional space as a two dimensional map have led to a model of visual attention which has been successfully used in the application of a space-variant active vision system, described below. It has been demonstrated that stereo fusion limits, such as Panum's fusional area, scale in a manner which is determined by the size of a cortical hypercolumn, and the local value of cortical magnification factor, supporting a model in which stereo disparity is computed by a local correlational operator defined on the span of a single pair of ocular dominance columns. Methods for numerically modeling conformal topographic cortical maps have led to important insights into the pattern level description of these cortical systems. A prototype space-variant active vision system has been constructed, with funds for hardware support from DARPA, and a number of difficult algorithmic problems in motor control, attention, space-variant image processing, and space-variant pattern classification, have begun to studied. One book has been published in this project period: Computational Neuroscience, Eric Schwartz, MIT Press (1990) which presented the proceedings of an earlier conference which introduced the term "Computational Neuroscience" into its current widespread use.

14. SUBJECT TERMS
Visual cortex, vision, pattern recognition, active vision

15. NUMBER OF PAGES 5

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
(U)	(U)	(U)	(U)

FINAL REPORT

AFOSR Life Sciences 88-0275
P.I.: Eric L. Schwartz

Dept. of Cognitive and Neural Systems
Boston University
111 Cummington Street
Boston MA 02215
eric@thing4.bu.edu

SUMMARY

In this report, a series of studies concerning the use of neuronal map data structures for the solution of perceptual, attentional and pattern classification problems have been developed. A multiple map model for pattern classification [1] shows that the use of two dimensional representation, for an arbitrary high dimensional problem in pattern recognition, leads to an efficient approach to pattern classification, and provides insight into the wide-spread use of two dimensional map representation in the cortex. In other applications, models for visual attention, based on the representation of an attentional space as a two dimensional map [2, 3] have led to a model of visual attention which has been successfully used in the application of a space-variant active vision system, described below. Also, it has been demonstrated that stereo fusion limits, such as Panum's fusional area, scale in a manner which is determined by the size of a cortical hypercolumn, and the local value of cortical magnification factor [4]. This in turn supports the notion that stereo disparity is computed by a local correlational operator defined on the span of a single pair of ocular dominance columns [5].

Methods for numerically modeling conformal topographic cortical maps [6] and for modeling the structure of columnar maps, such as the ocular dominance column and orientation column systems [7] and [8] have led to important insights into the pattern level description of these cortical systems. The conformal topographic model of primate V-1 has been confirmed experimentally by 2-deoxyglucose mapping and computer brain flattening [9], and this model has been used to provide guidelines for the construction of VLSI space-variant sensing systems [10, 11].

As one consequence of this modeling effort, it appears that both of the major column systems of primate visual cortex are instances of band-pass filtered white noise, and that most existing (complex) models for the description of these systems are based on a filter, often hidden in the depths of other modeling mechanisms which are not essential to the production of the observed columnar patterns. In the case of the orientation column system, there are additional topological complexities to the band-pass filtered noise which suggest that the hypercolumn pattern of V-1 is a form of topological singularity whose structure is an unavoidable consequence of the representation of orientation in a two dimensional cortical surface [8, 12]. Finally, a generalized image warp technique has been developed, which we term the "protocolumn algorithm", which provides image level models of the mapping of ocular dominance and orientation column systems at the level at the level of primary visual cortex[13]

Finally, many of the ideas developed in this project period, and in two prior periods of AFOSR support, have reached fruition in the construction of a space-variant active vision system. The use of an image sensing architecture, such as the complex log or conformal structure shown in our work to provide an accurate model for primate vision, has begun to have an important influence on robot vision systems. An initial prototype system has been constructed under hardware support from DARPA, and a number of difficult algorithmic problems in motor control, attention, space-variant image processing, and space-variant pattern classification, have begun to studied [14, 15, 16, 17, 18].

One book has published in this project period: Computational Neuroscience, Eric Schwartz, MIT Press (1990) which presented the proceedings of an earlier conference which introduced the term "Computational Neuroscience" into its current widespread use.

PUBLICATIONS

BOOKS

Computational Neuroscience, Eric Schwartz, MIT Press (1990)

LIST OF PAPERS AND TECHNICAL REPORTS

[1] A. S. Rojer and E. L. Schwartz. A multiple map model for pattern clasfficiation. *Neural Computation*, 1:104–115, 1989.

[2] Alan Rojer and Eric Schwartz. The hough transform as bayesian inference. Technical Report 564, Courant Institute of Mathematical Sciences, 251 Mercer Street, New York, N.Y., May 1991.

[3] Alan Rojer and Eric L. Schwartz. A quotient space hough transform for space variant visual attention. In Gail Carpenter and Stephen Grossberg, editors, *Neural Networks for Vision and Image Processing*, pages 407–436. 1992.

[4] E. L. Schwartz and H. Yeshurun. Cortical hypercolumn size determines stereo fusion limits. *Bio. Cybernetics*, 1992.

[5] Y. Yeshurun and E.L. Schwartz. Stereo disparity estimation by cepstral filtering. *Bio. Cybernetics (submitted)*, 1992.

[6] Carl Frederick and Eric L. Schwartz. Conformal image warping. *IEEE Computer Graphics and Applications*, March:54–61, 1990.

[7] Alan S. Rojer and Eric L. Schwartz. Cat and monkey cortical columnar patterns modeled by bandpass-filtered 2d white noise. *Biol. Cybernetics*, 62:381–391, 1990.

[8] Eric L. Schwartz and Alan S. Rojer. Cortical hypercolumns and the topology of random orientation maps. Technical Report 593, Courant Institute of Mathematical Sciences, 251 Mercer Street, May 1991.

[9] David Rosenbluth, Amar Munsiff, Tom Albright, and Eric Schwartz. Computer reconstruction from 2dg serial sections of the topographic map of macaque visual cortex. *Society for Neuroscience Abstracts*, 18:742, 1992.

[10] Alan S. Roier and Eric L. Schwartz. Biological basis for space-variant sensor design: Implications for vlsi. In *SPIE Program on Computer Vision and Intelligent Robots IX: Advances in Intelligent Machines*, 1992.

[11] A. Rojer and E. L. Schwartz. Design considerations for a space-variant visual sensor with complex logarithmic geometry. In *Proceedings of the 10th International Conference on Pattern Recognition*, volume 10, pages 278–285, 1990.

[12] Eric L. Schwartz and Alan S. Rojer. A computational study of cortical hypercolumns and the topology of random orientation maps. *Society for Neuroscience Abstracts*, 18:742, 1992.

[13] Pierre Landau. Computer simulation of cortical polymaps:a proto-column algorithm. *Neural Networks*, 5:187–206, 1992.

[14] Richard S. Wallace, Benjamin B. Bederson, and Eric L. Schwartz. Voice-bandwidth visual communication through logmaps. *I.E.E.E. Workshop on Applications of Computer Vision*, page In press, 1992.

[15] Ben Bederson, Richard Wallace, and Eric Schwartz. Control and design of the spherical pointing motor. *Machine Vision and Applications*, page In press, 1993.

[16] Richard Wallace, Ping-Wen Ong, Ben Bederson, and Eric Schwartz. Space variant image processing. *International Journal of Machine Vision*, page In press, 1993.

[17] Ping Wen Ong, Ben Bederson, Richard Wallace, and Eric Schwartz. Space variant optical character recognition. *11th International Conference on Pattern Recognition*, page In press, 1992.

[18] Ben Bederson, Richard Wallace, and Eric Schwartz. A miniatureized active vision system. *Int. Conf. Pattern Recog.*, page In press, 1992.

[19] Eric L. Schwartz. Book reivew: Methods in neuronal modeling. *Trends in the Neurosciences*, 13, 1990.

[20] Alan S. Rojer and Eric L. Schwartz. Fusion of multiple fixations with a space-variant sensor: conditional optimality of maximum resolution blending. In *SPIE Computer Vision and Intelligent Robots IX: Symposium on Advances in Intelligent inesMach*, 1992.

[21] E. Ruppin, E. Schwartz, and Y. Yeshurun. Efficient packing of massively connected multi processor netowkrs: Implications for biological and artificial systems. *Biol. Cybernetics*, page (Submitted), 1992.