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COMPUTING WITH NEURAL MAPS: APPLICATION TO PERCEPTUAL AND COGNITIVE FUNCTIONS

12. PERSONAL AUTHOR(S): Dr. Eric Schwartz

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During the past year, we have completed two important steps in our program for understanding the biological and computational significantce of patterns of spatial mapping in the brain. First, we have found a simple algorith which is capable of describibg and synthesizing the patterns of ocular dominance colums and orientation colums in the cat and monkey. This algoithm is controlled by a small number of parameters, and we show that it produces patterns which are simular to those in our lab, and elsewhere, obtained from animal experimentation. Moreover, we show that a number of previously published algorithms for simular purposes can be shown to be equilivant to our algorithm. The significance of this work is that we can now describe and synthesize some of the major architectural features of cat and monkey sensory cortex with high accuracy. In addition, we have obtained some insight into the essential simplicity of these patterns. This work is currently in press in Biological Cybernetics. In addition, we have developed an algorithm for pattern recognition based on the use of multiple, parallel two dimensional mapping of the (OVER)

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input data. We veiw this as an important step in our goal of developing insight into into the use of multiple, parallel sensory mappings in the brain. We belive that this algorithm is the first pattern recognition algorithm to make explicit use of the kind of data format which is characteristic of the brain. This work is published in Neural Computation, vol 1. During the past year, we have also completed a volume of contributions from some thirty researchers, titled "Computational Neuroscience". This volume, to appear in the Spring of the present year, is part of the MIT Press benchmark series on Information Science.

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October 23, 1989

Dr. John Tangney 202 767 5021
Life Sciences Directorate
Department of the Air Force
Air Force Office of Scientific Research
Bolling Air Force Base, D.C. 20332-6448

Dear Dr. Tangney,

This letter constitutes the technical report for the period August 1, 1988 -> August 1, 1989 for grant #AFOSR-88-0275. Copies of the following publications are enclosed with this report:

1. A Multiple Map Model for Pattern Classification, by Alan Rojer and Eric Schwartz (Neural Computation, vol. 1, 104-115 (1989).

In this work, we develop a multiple parallel map based pattern recognition method, and apply it to a variety of test data sets. We believe that this is the first mulitple map classification method to be described; we plan to extend this in work during the present year to construct models of extra-striate cortex.

2. Visualizing and Understanding Patterns of Brain Architecture, by Alan Rojer and Eric Schwartz (To Appear in: NATO Advanced Research Series: Robots and Biological Systems, Springer-Verlag, 1989).

This work was presented in Italy, at the NATO ARW on Robotics and Biological Systems, and will be published during the next year (or two?) in a Springer-Verlag Proceedings of that meeting.

3. Design considerations for a space-variant sensor with complex logarithmic geometry, by Alan Rojer and Eric Schwartz (submitted to International Conference on Pattern Recognition-10 (ICPR-10), Computer Architectures for Visual Pattern Recognition section.

In this paper, we present detailed design considerations for VLSI fabrication of a space-variant "retina" chip. We believe this paper to be important, since it presents a thorough analysis of design paramters, spatial complexity, and geometric issues in the layout of this form of sensor, which is currently of interest to a number of research groups working in active vision.

4. A Parametric Model for synthesis of cortical column patterns, by Alan Rojer and Eric Schwartz (Proceedings of the International Joint Conference on Neural Networks, June 1989).

In this paper, we present preliminary modeling of a simple algorithm for the synthesis of columnar patterns in the monkey. This model was further developed below in a paper recently accepted by Biological Cybernetics, where a fuller discussion is presented.

5. Cat and monkey cortical columnar patterns modeled by band-pass filtered 2D white noise, by Alan Rojer and Eric L. Schwartz (Accepted for publication in Biological Cybernetics.

In this paper, we show that a wide variety of columnar systems (cat and monkey orientation and ocular dominance column systems) can be synthesized with a very simple and fast algorithm based on the properties of band-pass filtered white noise. We show that earlier ''columnar'' algorithms are equivalent to this model, although often requiring many orders of magnitude more computation. Also, since these earlier models rarely explored or stated their paramter space, they have not provided accurate fits to the data. In the present work, we demonstrate a thorough exploration of the parameter space of isotropic and anisotropic band-pass filtered noise, and show that manipulation of the parameters of center-frequency, bandwidth, and (for anisotropic filters), eccentricity, that we are able to reproduce the detailed appearence of the cat and monkey systems.

We feel that this is an important paper: it reduces a large number of previous models to a relatively simple statement, produces very high quality simulations, and may provide fundamental insight into the nature of columnar patterns in general.

6. The topographic map of Macaque V1 measured via 3D computer reconstruction of 2DG serial sections, numerical flattening of cortex, and conformal image modeling. Eric Schwartz, Amar Munsiff and Thomas Albright (ARVO 1989).

This work presents preliminary results on a long-term experiment aimed at precision measurement of the Macaque topographic map in V1, by 2DG autoradiogarphy and computer flattening, followed by numerical map fitting. We are currently in the final stages of writing this work up for final publication as a series of papers in the Journal of Neuroscience.

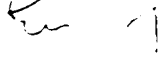
7. Computational Neuroscience Eric Schwartz (MIT Press, to appear April 1990).

We finished the last details on this book, which contains contributions from 30 researchers in the area of Computational Neuroscience, and which has just been put into galley proofs. The book is now slated for production in April of this year.

In this period, a number of our earlier IEEE Pattern Analysis and Machine Intelligence papers have appeared in print, but this work was completed during earlier funding periods, so will not be listed in detail here.

No patent applications have been filed during this period.

Sincerely yours,



Eric Schwartz

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