Modelling

Mo1

AUTOMATIC RECOGNITION OF FUNCTIONAL NEURONAL INTERACTIONS

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Simultaneous recording of spike trains is a common practice in several neurophysiological experiments. Interactions between single units in the time domain are performed by cross-correlogram analysis. The purpose of the current study is to develop a system for automatic classification of cross-correlogram histograms into classes corresponding to functional neuronal interactions. This system is based on the inductive Group Method of Data Handling (GMDH). Firstly, the system is trained on a large data set of cross-correlograms (several hundreds) for which information about classification into classes is provided by a human expert. The cross-correlograms are computed for 0 to 500 ms time lags at a resolution of 1 ms. A set of primary features describing shapes of cross-correlograms in the area of their maximum value is used for the analysis. These features include coordinates of peaks of the cross-correlograms, the first four central moments calculated for the empirical density function of the delay distribution in the range from ñ10 to +10 ms, and the confidence levels. Decision rules for classification of histograms are constructed by regression analysis using GMDH algorithm. Cross-validation of the regression model is done according to the "leave-one-out" method in order to prevent model from overfitting. Several different GMDH approaches were used: iterative, clusterization and variable threshold algorithms. We have observed that on a limited set of the "common input" types of cross-correlograms our system performed with a very high accuracy, with error levels of 1-3% with respect to the expert classification. The increase in number of cross-correlograms obtained from large numbers of pairs of single units makes our system an important tool for analysis of neuronal interactions in multiple electrode recordings.
The work is partially supported with INTAS-OPEN 97-0168 grant.

Mo2

EXTRACELLULAR SPIKE DETECTION USING NONLINEAR MODELS

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Most extracellular electrophysiological recordings are performed with microelectrodes characterized by

impedance in the range of 300 KW - 2MW. The electric signals detected by these microelectrodes contain action potentials generated by different neurons. In order to study the interactions between neighboring neurons it is important to discriminate the potentials of closely-related cells recorded by the same electrode. The methods used to do such discrimination assume that specific potential shapes correspond to different neurons. We have developed a new method using a template matching in the phase space. The action potentials of neurons are considered as solutions of nonlinear dynamic equations with perturbation. This allows to take into account two different types of noise that can be observed in the experimental recording, i.e. distortion of the signal in amplitude and in time scale. The use of nonlinear models reduces the problem of the signal identification to the separation of the mixture of asymptotically normal distribution in the transformed feature space. The template matching in the phase space is compared to traditional spike discrimination in the time domain using simulated time series. We report case studies of application to real data recorded from anaesthetized and freely-moving animals. The new method achieved similar or even improved separation of the signals with respect to other known commercial software.The advantages of our method are its fast computational implementation, its tolerance to shift of action potentials in phase and low sensitivity to noise and the possibility to develop an application to on-line analysis of behavior-related experimental data

Partially supported by INTAS-UA 95-0060 and INTAS-OPEN 97-0168 grants.

Mo3

NEURAL NETWORK MODEL OF MULTIPLE TRACES IN HIPPOCAMPUS AND RETROGRADE AMNESIA

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While it is widely agreed that the hippocampal formation and neocortex interact in the formation of human memory, the exact nature of this interaction is unclear. The traditional view is that information is initially encoded in a way that necessarily engages the hippocampal formation, but that over time (the "consolidation" period) this information is encoded within the neocortex, and can be retrieved without hippocampal partocipation (eg., Squire et al., 1984; Squire, 1987; McClelland et al., 1995). This view has received support from studies of temporally-graded retrograde amnesia (RA) in humans, but recent evidence showing that the RA can extend back as far as 15-25 years (cf. Nadel & Moscovitch, 1997) argue against this notion. According to multiple trace theory (MTT: Nadel & Moscovitch, 1998) autobiographical memory always depends upon the hippocampal complex and its provision of contextual information. As episodic memories age, they will either be forgotten, or as a consequence of reactivation they will have benefitted from the formation of multiple traces in hippocampal complex and neocortex. Older memories will be associated with a greater number of traces. This increase in traces multiplies access routes and hence should facilitate retrieval. And, because these traces are presumed to be sparse

and distributed, multiplying them should render the memory they support less susceptible to disruption. As a result, partial damage to the hippocampal complex will affect remote episodic memory in relation to its age - that is, one will observe a graded RA. We have developed a neural network model of MTT in which memories are replicated within hippocampus as they age. Lesions of various extent were then implemented in the hippocampal module within this neural network, and the effect on retrieval of memories of various "ages" assessed. As predicted, partial lesions led to a temporally-graded RA, with recent memories more susceptible to loss than remote ones, while complete lesions resulted in a flat gradient reflecting loss of almost all episodic memories.

Supported by McDonnell Foundation and Flinn Foundation Cognitive Neuroscience Center Grants to the University of Arizona

Mo4

DATA INTERPOLATION BY FUZZY NEURAL NETWORKS

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In a fuzzy approach, poorly specified inputs due to either noisy and/or incomplete data, or because of imprecise measurements and characterization are available. As both types of uncertainty can be specified as fuzzy sets, data analysis may be carried out independently of the observation type (1). The feasibility of using artificial neural networks (ANN) to perform fuzzy pattern recognition was evaluated and experimentally investigated on data interpolation. To design new potentially interesting neural-inspired nets, one may solve two major problems. The first concerns the architecture of the net and the second deals with an adequate learning algorithm for which a convergence theorem holds (or the probability of success and the time it takes to be estimated). Much of the interest in neural nets arises from their remarkable ability to robustly process information containing some degree of uncertainty. No previous statistical assumptions on the behavior of the data are necessary either if adequate test patterns are employed during learning session. Simulation methods of ANN have many advantages, such as adaptability to a wide variety of circuit configurations and parameters, easy implementation of parallel distributed processing, perform various tasks in identical architecture, best opportunity to study the convergence of new training algorithms, etc. A three-layered perceptron type network was developed for data interpolation. The algorithm was an adapted version of the generalized delta rule which is commonly used for multilayered networks (2). Though there are no convergence theorems associated with the back-propagation algorithm in the case of multilayered perceptrons, complete convergence was proved unnecessary for usable networks, as long as the credit assignment problem is solved (3). Since the advantages of employing hidden units are achieved only if the output of each stage is a nonlinear function of the input, a sigmoidal logistic function was used throughout. Training procedures require numeric values for a number of parameters; as there is not enough information available for a priori choice, these values were determined by experiment. The training session was repeated until stable

output values were obtained. One hidden layer only proved to be necessary. The backpropagation algorithm minimizes output mismatch over the space of weights and thresholds. The feed-forward fully-connected formal neural networks, though clearly deterministic, were proved to be competitive in applications that involve fuzzy data but require fast and efficient pattern recognition.

(1) Bezdek& Pal.(1992) *Fuzzy Models for Pattern Recognition,* IEEE New York; (2) Mutihac (1992) *Rev. Roum. Phys.*, 37:535; (3) Munk *et al.*, (1991) *Mikrochim. Acta* [Wien], 1991, (2), 505.

Mo5

NEUROPHYSIOLOGICAL DATA ANALYSIS ON THE WEB

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One of the major hindrance to the practice of statistical analysis of brain activity is due to poor interfaces of computer programs with the neurophysiologists and to the difficulty to access software packages that are certified by recognized experts. We have developed a client-server software framework that allows scientists to make accessible their software packages for analysis through Internet.This software includes three main parts and two specific protocols to interface between them. *The first part*, the general client application, provides visual interface for the analyzed task. The user selects one out of the available data analysis modules, supplies his data using an interface protocol and configures the calculation procedure. *The second part*, the server, provides Internet connections to *the third part*, the application libraries, that analyze the data and send the results back to the client. We have used Java object-oriented language to implement client and server parts. Application libraries are implemented using ANSI C++ language. These libraries have to fulfill requirements of developed data interface protocol. The Java language provides a flexible opportunity to have the client part running identically on many different platforms, while the implementation of application libraries as native C++ calls makes possible very efficient calculations. New computational and graphical modules can be easily added to the existing software.This system will allow neurophysiologists from all over the world the possibility to visualize rasters of recorded spike train data, to select data of interest and to process the data using several methods such as dynamical system analysis, auto-, cross- and peristimulus histograms, pattern detection algorithm, etc. that have been developed by experts. The system is available at http://www-lnh.unil.ch/ and the calculations are done using several UNIX servers of University of Lausanne.

Partially supported by INTAS-OPEN 97-0168 and 97-0173 grants.

Mo6

MODIFICATION OF THE EFFICACY OF EXCITATORY AND INHIBITORY SYNAPTIC INPUTS TO DIVERSE CEREBELLAR CELLS: A HYPOTHESIS

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Postsynaptic mechanisms of long-term modification (potentiation, LTP and depression, LTD) could play a role in the efficacy of excitatory and inhibitory synaptic inputs to different cerebellar cells. In contrast with commonly accepted point of view, we postulated that properties of receptors on cerebellar cells are similar to those on neocortical or hippocampal cells. Therefore, in cerebellum LTP/LTD of excitation is the result of AMPA receptors phosphorylation/dephosphorylation, while LTP/LTD of inhibition is the result of GABAa receptors dephosphorylation/phosphorylation. A special feature of cerebellar plasticity is the involvement of cGMP-dependent protein kinase G which activity is down-regulated by calcium. We assume that opposite calcium-dependent modification rules in Purkinje cells and neocortical/hippocampal cells is the result of the involvement of cGMP and cAMP in synaptic plasticity correspondingly. We have shown that cGMP concentration could be increased not only due to NO action on soluble guanylate cyclase, but also due to activation of membrane-bound guanylate cyclase via GABAb receptors. Mechanism of synaptic plasticity of Purkinje cells, cerebellar granule cells and deep cerebellar nuclei cells that contained GABAb receptors and cGMP must be identical. Modification rules for Golgi cells and others inhibitory interneurons wherein cAMP is possibly expressed must be similar to those of hippocampal/neocortical cells. The modification of excitatory and inhibitory inputs is interrelated since activation of glutamate-sensitive receptors and GABA-sensitive receptors changes in opposite direction the calcium level and activity of intracellular metabolites. Modification of excitatory transmission between parallel fibers and Purkinje cells, mossy fibers and granule cells, mossy fibers and deep cerebellar nuclei cells essentially depends on additional inhibition effected by stellate/basket cells, Golgi cells and Purkinje cells correspondingly. The strengthening (decrease) of inhibition promotes simultaneous LTP (LTD) of excitatory transmission together with LTD (LTP) of inhibitory transmission to the same postsynaptic cell. So, LTD in parallel fibers – Purkinje cells synapses and decrease of inhibition of deep cerebellar nuclei cells by Purkinje cells must promote LTD of excitatory inputs to deep cerebellar nuclei cells. Climbing fiber and its collaterals simultaneously activate Golgi cell (controlling granule cells activity), Purkinje cell and deep cerebellar nuclei cells. Therefore, the signal from inferior olive could influence simultaneous and interrelated changes in the efficacy of synaptic inputs to different cerebellar cells. According to suggested model, the ending effect would be LTP (LTD) in the mossy fiber – deep cerebellar nuclei cell pathway in the absence (presence) of a signal from inferior olive. This result is in accordance with the known data that olivary cell are strongly inhibited during the reaching and different phases of the behaviour.