10. Medicine

10.1 Parallel Interference Transformation to Simulate Nervous Activity

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Research Project

Until now the interpretation of nervous activity in biological systems is difficult. On the basis of interference theories [1...4] of the nervous system we try to compute addresses and contents of bio-neural data streams. The main topic of the project is the development of a prototype hardware to receive neural data and the development of a simulation and analysis tool called 'Bio-Interface' [5] to perform Heinz's Interference Transformation (HIT).

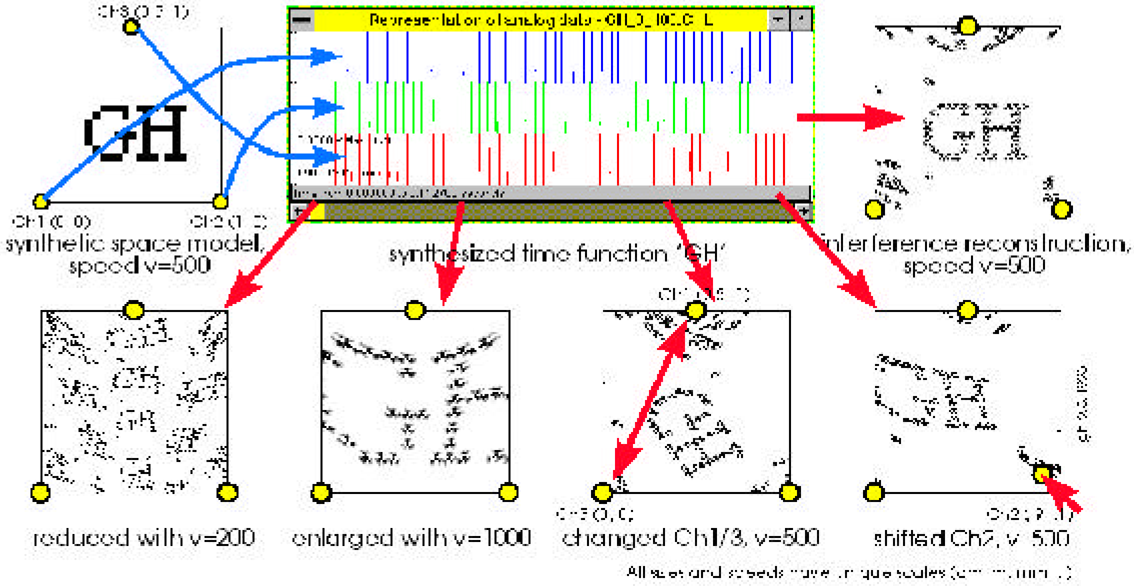

Fig. 10.1: Interference reconstructions of a synthesised neural data stream. To test the algorithms, known, synthesised data streams 'GH' yield the best results. Each black point of the space model symbolises a spiking neuron. After a refractivity period the next neuron is able to spike. With the marked speed the wave front of one impulse reaches the channel destinations (Ch1...3) at different times. Dependent on the medial speed, or variations of the channel source points, the reconstruction shows interesting variations of the resulting interference figures.

Dynamics of Neural Systems

With currently known methods understanding of neural activity is difficult. A key experiment [2] shows that the nervous system has the ability to propagate pulse-coded information in different directions. Pulses reach their destination(s) on different ways (nervs). The relative forthcoming of partial pulses codes the location or destination address. The energy to stimulate any neuron has maximum values at the locations of pulse interference. Thus, to prove locations of excitement, we have to calculate the energy field, called the interference image or the interference map. Interference mechanisms define the relations between source and destination addresses of any neural information.

Also biological systems fix the references between motion, code and the location of storage places through interference mechanisms. Comparable with optical diffraction, a neural system stores its information in a holographic form. Only if we are able to measure neural interference spaces, we get some possibilities to understand main information processing principles of biological systems.

HIT-Task

The task is, to get different located serial data streams from an object (bio-neural network, acoustic space), and to reconstruct the observed space in form of two or three-dimensional (interference-) maps. To measure neural systems, the PC-AT has electrode preamplifiers and analog-digital converters for all channels. For example, the PC-system performs sample rates up to 100 000 kHz for 8 channels.

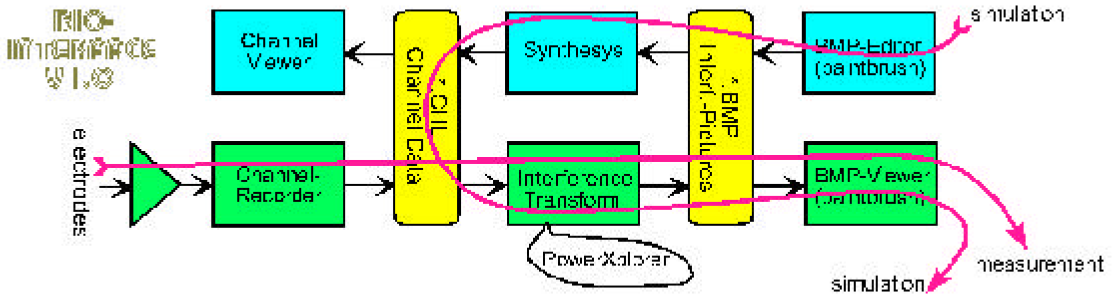

Fig. 10.2: Structure of the neural interferometer 'Bio-Interface'. Beside EEG-, EKG-, ENG- and EMG-measurements it is possible to synthesise time functions for simulations

Dependent on the measured time, channel data with 12 bit solution have typical sizes from 1k to 100k samples. To calculate an interference integral for each point of the receiving space means the numerical integration about 1k to 100k long channel data for each pixel of the interference map. The PC-AT based prototype solution produces neural interference images usable for tasks in medical research as well as for scientific applications. A gigantic amount of computational power is necessary to solve such interference transformations within a few hours.

To test the system, we use a unique test channel data stream. A DOS 6.1 version running a PC-AT 486-DX2-66MHz terminates after 15:23 hours. A much more comfortable program version with some user interaction (it outputs the current mask and the mask number and it processes the entry queue after each integration) under MS-Windows for Workgroups (WfW) needs 28:30 hours - to much to finish this job over night. Hence, only parallelization can speed up the computation.

Power Xplosion

As we can calculate the HIT for each point of the result-space independent of eachother, the pixel maps to be computed share among the nodes. In this way, a coarse grained parallelization is feasible – with a very low demand for communication between PowerXplorer and host and no demand for communication between various PowerXplorer nodes. Hence, we can speed up the interference transformation linearly with the number of nodes in a parallel computing environment.

A transputer based hardware accelerates the PC-AT with eight INMOS T805 TRAMs on a PC-board. The computation time for the same task decreases to 54 minutes.

An eight node PowerXplorer cluster shows an increasing speed up (Fig. 3). For one PowerPC-node we find a speed up factor 30 against a PC-WfW standard solution with one node. The total speed-up for eight PowerPC-nodes compared to the WfW-solution is 244 - nearly a power explosion.

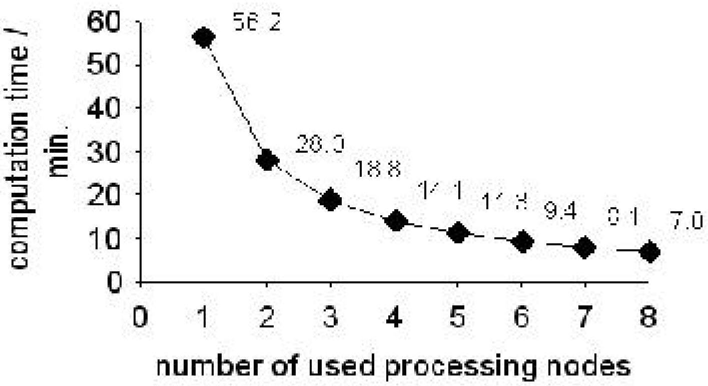

Fig. 10.3: Computation time for a PowerXplorer using up to eight nodes

Test data:

image size (x * y * z):	300 * 300 * 1
samples of neural data stream:	4285
number of channels:	8
algorithm:	exp(3 channel's_sum)
test picture:	synthetic channel generation 'GH' with 46 pulses

Bibliography

[1] Heinz, G.: Neuronale Interferenzen oder Impulsinterferenzen in elektrischen Netzwerken. Autor gleich Herausgeber. GFaI Berlin, Dez. 1994, 400 S., in Vorbereitung zur Publikation.

[2] Heinz, G.: Relativität elektrischer Impulsausbreitung als Schlüssel zur Informatik biologischer Systeme. 39. Internationales Wissenschaftliches Kolloqium an der TU Ilmenau 27.-30.9.1994, Abgedruckt in Band 2, S. 238-245

[3] Heinz, G.: Modelling Inherent Communication Principles of Biological Pulse Networks. Systems- Analysis- Modelling- Simulation (SAMS), Gordon & Breach Science Publ., SAMS 1994, Vol.15, pp.151-158

[4] Höfs, Sabine; Heinz, Gerd: Bio-Interface: Vorstellung eines neuartigen Meßgeräts und Simulators für Räume neuronaler Interferenz. Votrag zum Workshop 'Biologieorientierte Informatik und pulspropagierende Netze', GMD-FIRST Berlin, 18.11.94, Veranstalter GFaI e.V. Berlin.

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