MODELLING INHERENT COMMUNICATION PRINCIPLES OF BIOLOGICAL PULSE NETWORKS

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A geometrical impulse length in the human nervous system in a range from 1 to 120 millimeters indicates the acute presence of wave properties at nervous signals. An examination [1] introduces logically the concept of optical interference to electrical circuits. Boolean threshold logic doesn't work correct under a pulse length shorter the time difference between any pulses. Thus impulses determine locations between sender and receiver in neural systems. Models of the medulla spinalis, of the chiasma opticum, of somatotopical effects, and of different behavioural properties of our mind demonstrate important effects to understand biological intelligence and psychological information processing at the physical level. An interference model of a neuron can store simultaneously a 'situation' consisting of picture-, amplitude- and motion-data.

KEY WORDS Spiking neurones, pulse-modulated networks, interference on electrical wires, neural wave properties, address principles of neural systems

SELF INTERFERENCE SYSTEMS

Free wave propagation in optical systems is often tied to straight lines. In opposite, impulse waves in nerve system have to follow the free curvature of the fibres. So optical interference principles appear as a special case of electrical interference systems for straight wave propagation.

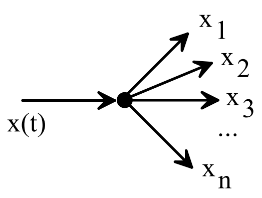

Figure 1a)
Firing neuron as transmitter.

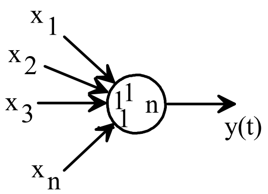

Figure 1b)
Multiplying neuron as AND- receiver.

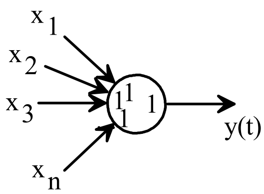

Figure 1c)
Collecting neuron as OR- receiver.

Supposed, any stochastic connection of neurons forces impulses, carrying a signal, to travel parallel on different wires. Then the probability to excite a neuron is higher, as more closed partial impulses reach the destination, if the destinated neuron has for example multiplying threshold properties (AND-characteristic, see figure 1).

$y = x_1 x_2 ... x_n$

Places of source- and destination excitement have the characteristics, that the delays τ_1, τ_2, ...,

τ_n at all possible transmission paths between source and destination have to be equal. It should be assumed for simplicity, that v_i is a constant propagation speed on each wire. The curvature length is s_i.

$$\tau_1 = \tau_2 = ... = \tau_n \; ; \quad \frac{s_1}{v_1} = \frac{s_2}{v_2} = ... = \frac{s_n}{v_n}; \quad \lambda << \tau_i$$ (*eqn. for self- interference; source [1]*)

The relevance of the above equation increases, as shorter the wavelength λ appears in opposition to the delay τ_i of any transmission way between source and destination, or as greater the system dimensions appear in relation to the impulse-length.

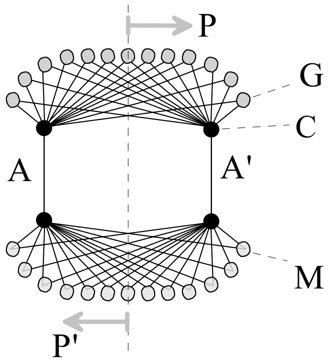

Figure 2 ('The Humunculus')
Biology oriented, 1dimensional
self interference circuit (source [1]).

C: connecting neurons (wired OR)
G: asyncronous pulse generating neurons
M: receiving neurons (AND multiplier)
A, A': transmission lines (axons)
P: pointer at the transmitter side
P': pointer at the receiver side

To understand the location sensibility of impulses we calculate the wavelenght: If we suppose, a neuron produces impulses of a duration τ, where the geometrical length of an impulse is $\lambda = v\tau$, any nerve impulse gets a typical pulse duration/speed product in the range of

$\lambda = (0.5 ... 2ms) * (2\mu m ... 60m/s) = (1\mu m ... 120mm)$.

This range of possible geometrical pulse widths occures in the human nervous system. The case of short wavelength correlates with somato- sensorical areas, long waves are close to the field of actor stimulation.

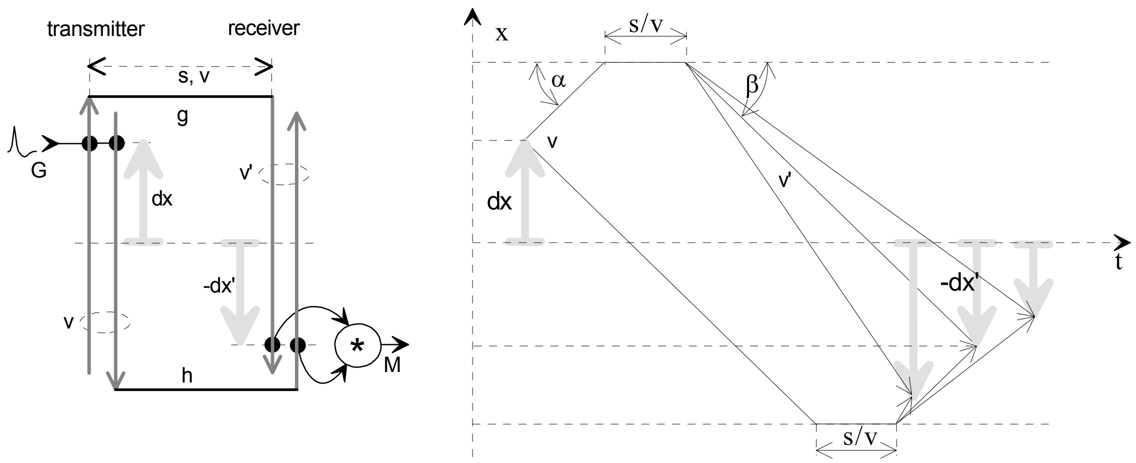

Figure 3
Mirroring zoom operation of a 1-dimensional interference circuit.
To move the picture, delay the wires g and h counteractive (source [1])

Figure 3 shows a generator *G* and a multiplier *M* in a delay-distance greater λ assigned to the transmitter- and the receiver side of a simplest transfer circuit. The receiver *M* is excited from the transmitter *G*, that lays in interference to. Dependend on *v/v'*, a position *dx* reaches the receiver side at (image) location *-dx'*. Different transmitter locations correspond to different receiving locations in comparable relation. The velocity ratio *v/v'* between transmitter and receiver produces the zoom ratio. Any one- (or higher-) dimensional input pattern passes the circuit in *mirrored* form.

The algorithm to construct an electrical interference circuit is easier, then to connect a home-ringing circuit with a comparable count of push buttons and bells [1]:

- design the transmission lines from and to defined coordinates,
- connect all generators (sensors) and all multipliers (actors) in the shortest way to the defined (end-) points of the transmission wires.

Note, that *all signals* between the transmitter and the receiver side use the same transmission lines *g* and *h*. Because all possible informations pass through them, in interference systems it is not possible to understand any signal information visiting only a single fibre *g* or *h*. Thus it is impossible, to identify the source of any impulse passing *g* or *h* without the possibility, to compare the signal with the signal of the referencing transmission wire(s).

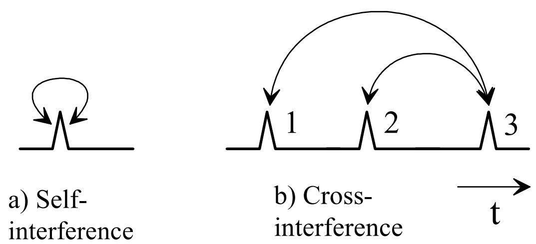

Figure 4
Interferences between impulses:
a) Self-interference
b) Cross-interference between different impulses 1,2,3

To ***zoom*** any picture, the propagation speed at the receiver side must be different to that of the transmitter side. Thus it seems possible, to model move- and zoom operations while dreaming. To ***move*** a picture over the screen (receiver field in Fig. 3), the propagation speed of *g* and *h* has to change counterwise.

CROSS-INTERFERENCE SYSTEMS

How is it possible to store frequency information? How is it possible, to combine static or dynamic moving picture parts with touch, sound or scent? For interference of optical waves self-interference of one wave or cross-interference of different waves seem not to be important. In opposite, for nerve interferences there is a dramatical difference, Fig. 4.

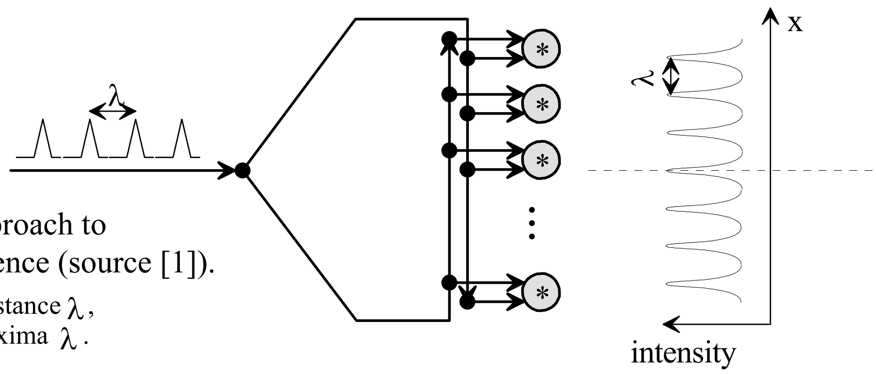

Figure 5
Experimental approach to diffraction/coherence (source [1]).
geometrical pulse-distance λ,
spacing between maxima λ.

A Huygenian diffraction of a light beam shows a large maximum and symmetrical, smaller interference maxima in nearly constant distance to each other. The middle maximum in Fig. 5 and 6 is the result of a self-interference, and the maxima that lie side by side are called cross-interferences between the puls and its foregoer or follower.

The effect in nerve networks has an important consequence in the organisation of interference fields (the pallium of the brain). Any correlation of impulses has different localities and will be stored on different places. The mind registers not only 2D- or 3D-pictures, together the 'neural photo' stores cross interferences (side-maxima), referencing any pulse densities.

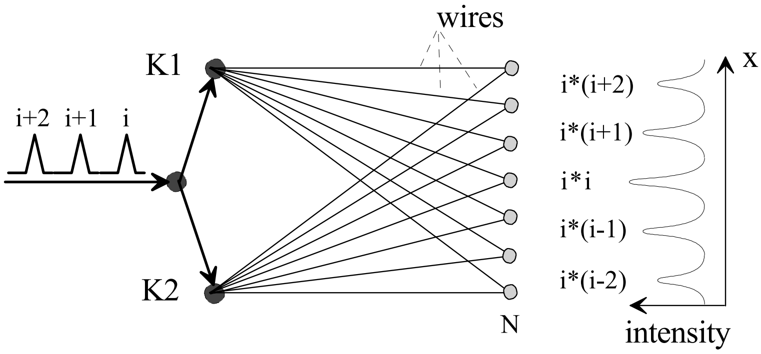

Figure 6
Neural diffraction. Interference of different impulses (source [1]).
The interference location (x) of maximum corresponds to the delay between different impulses i*(i-j).

While Fig.2 shows a (mirrored) projection of the optical type, Fig.5 shows a projection of a frequency. Both are characterized by channel data, by sets of time functions. Because all nerve behaviour is transferred on time functions, the neural interference network stores complex situations including touch, sound, scent and motion. An *elementary situation* consists of a *series of however correlated impulses*, representing

1) *monopulse- picture parts (self- interference),*
2) *sound modulated delays (cross- interference),*
3) *sensor amplitudes as frequency- (better: delay-) modulation between impulses and*
4) *motion parts as any auto correlation between following impulses.*

A dynamic interference scene includes parts of the informations together. If we use a delay circuit (Figure 7) with different delays between source *S* and destination *N*, the delay differences correspond to impulse distances. A resonance or detection occurs only, if the time- distances are equal to the delay differences.

Code versus Space

If all possible pairs of impulses t_b- t_a concerned with a situation correspond to pairs of delay differences τ_b - τ_a between any two wires, this code-series of pulses interferes with a neuron *N*. The neuron answers with a single impulse at any reference time t_0.

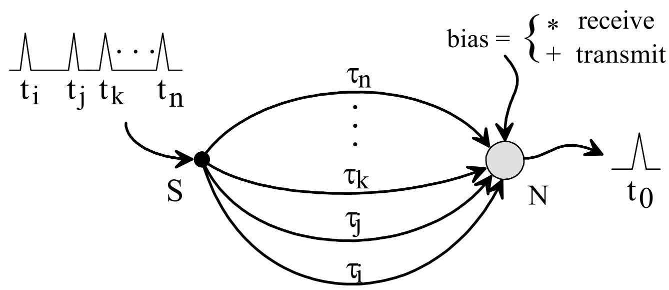

Figure 7: Code detection with a cross-interference structure.
The neuron N is able to recognize a complex situation, if the time-differences between impulses are equal to the delay differences of the circuit. Changing the bias, the neuron reproduces the learned code.
N: neuron (multiply / add)
S: impulse source

$$\tfrac{1}{v}(s_b - s_a) = \tau_b - \tau_a = (t_b - t_0) - (t_a - t_0) = t_b - t_a$$

The vector difference of geometrical properties (*S*) to be learned has to be equal to the vector difference (Υ) of the wired delays and to the vector difference of the delays between impulses

(T) (propagation speed v).

$$\frac{1}{v}(S_b - S_a) = \Upsilon_b - \Upsilon_a = T_b - T_a$$ *(eqn. for cross- & self-interference; source [1])*

Using a bias to move the threshold of a neuron N to additive type, the neuron is spiking on every single impulse excitement at the source S. Thus the function now appears inverted, the (learned) pulse-series (the 'situation') leaves the output of the neuron, the circuit remembers. Figure 8 may be interpreted as the natural way, to transmit any projection of Figure 2.

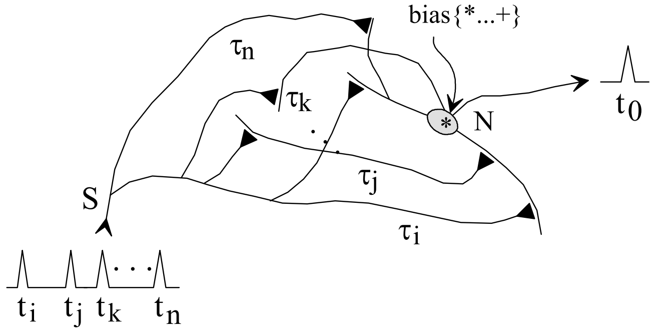

Figure 8: Neuron as part of an interference circuit.

The neuron N is able to recognize a complex situation, if the time-differences between impulses are equal to the delay differences of the circuit.
N: neuron (multiply / add)
S: impulse source

Any global transmission of pulse-series occurs only, if the 'situation' correlates to locations of interference, only information of interest passes combined interference systems. Thus they are very secure. It is nearly impossible, to excite false interferences from outside.

Supposed a neural field with matrix grid distance τ, and length in each direction of $k\tau$. All transmission wires connect with all neurones. The neurones lay in a distance τ in each direction. Then the field is able to interfere *every* pulse code or situation with a length $k\tau$. To learn, the synapses have to adapt the weights only. The structure of the network stays unchanged for all possible codes or situations.

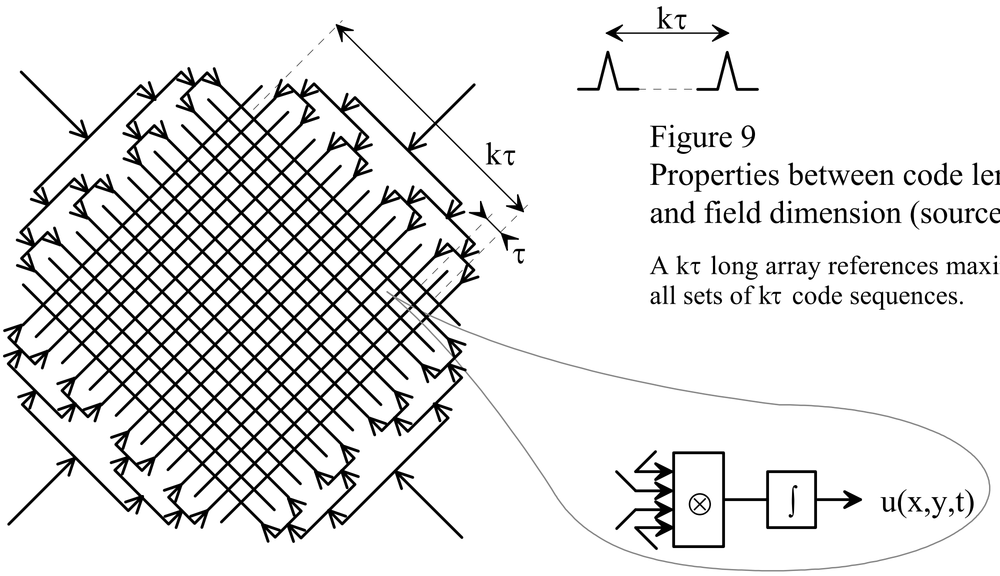

Figure 9
Properties between code length and field dimension (source [1]).

A kτ long array references maximum all sets of kτ code sequences.

Supposed further, we use layers of neurones above eachother with the same spacing but with a matrix grid distance $c^i\tau$, where i is the layer number and c is any constant value, it is possible, to expand the pulse code length to $c^ik\tau$.

In summary, *neural interference networks* can nearly be compared with photographic films. The difference is, that neural interference fields stores more than 2d-pictures: together they

store the dimensions of time, motion, touch, sound and scent.
To control the logical characteristics of any threshold-gate (neuron) with one or more bias gates, compare the bias control in Fig.7 and 8 with the thresholds in Fig.1b) and 1c). It is possible to use a white impulse noise of high frequency at some synapses of the neuron to generate a DC- potential, if the time function is unsymmetrical (average integral value different from zero). For more see [1].
The structures in Fig. 7 and 8 in combination give the chance, to generate large neural arrays including some million neurones to create very long sequences or 'behaviour'. For large arrays the problem of a maximum fanout at projective axons only can be solved, if the projective circuits in Fig. 8 are combined with interference clusters comparable to the structure in figure 9. The nature shows, that any chaotic configuration of neurones seems to solve this problems in an optimum way.

MODELS FOR PSYCHOLOGICAL PHENOMENA

Overlaying pictures

It is an important question, to understand easy interference structures that decentralise behaviour. If anybody learns to go, it needs all his attention. Later, the process moves out of the first brain, and we can do different things while going. How is this possible?

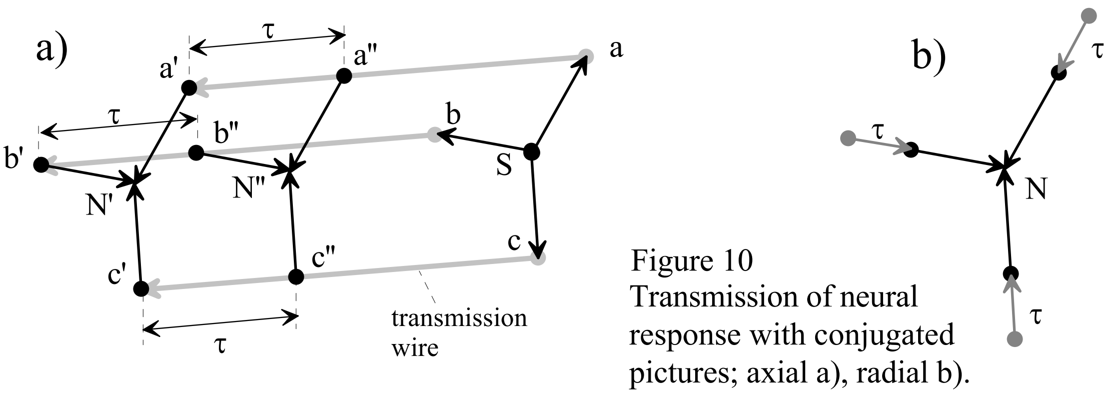

Figure 10
Transmission of neural response with conjugated pictures; axial a), radial b).

The correspondence of delay vectors on the wires of any picture element ϒ remains the same, if any global reference time t_0 changes by τ (Fig.10). In other words: if sources (*S*) or destinations (*N', N''*) of any interference circuit moves, the addition of any delay τ at all transmission lines axial *a*) or radial *b*) is without any influence to the behaviour. So, any projections *N′* and *N″* appears indifferent. The answers of *N′* or *N″* are the same, the response of *N′* appears only τ later. Thus any neuron pool *N″*, that gets comparable interferences as *N′* and is located with similar delay differences to source *S*, has the same possibility to control any behaviour that was controlled before by neuron pool *N'*. The circuit de-centralises control.

Permutation of scenes

Any interference projection consists of relative delays between impulses of groups of impulses on different transmission wires. It is possible, to construct a situation (called scene) using transmission vectors of different sources (Fig. 11, wires 1...4), supposed they are equal. Any scene can be stored in different dimensions in form of different hierarchies, dimensions or layers. It is possible further, to model 'ideas' as correspondence between any fractal information that creates accidental a known or usefull code, picture or scene.

So interference models of neural pulse systems show different properties of known, psychological phenomena. For more see [1]. In short form it seems impossible, to give more than some introductionary impressions about neural interference systems.

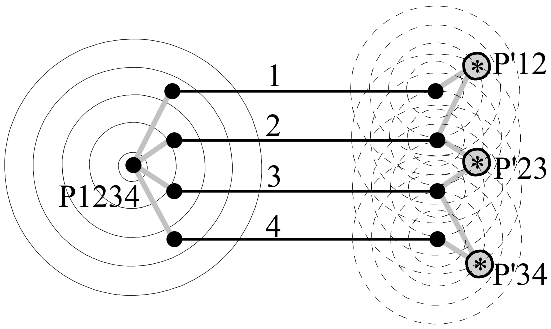

Figure 11
Changing the dimension of an interference picture. The high dim. scene P1234 corresponds to elementary scenes P'12, P'23, P'34.

Conjugations can be used to construct decentralised behaviour (conjugated pictures), or circuits generating 'ideas' (permutations, Fig.11).

SUMMARY

The introduction of short impulse length - in comparison to the dimension of a system - offers a new sight on biology- oriented neural systems: the addressing and storage principles of neural information as the conclusion between space properties and neural code.

Self interference circuits explain different projective transmissions in neural systems, comparable to optical systems (Penfields 'Homunculus'). Cross interferences between different impulses show the storage of complex sensorical scenes, consisting of pictures, touch, sound and scent. The sight on learning networks became easier with interference models in difference to actual AI- networks [3...9]. It is comparable with the storage of information on optical films used in holographic applications. Non-interferencial AI-principles for nerve networks are useful to interprete in areas with comparable wide impulse length (>1 mm).

Interference systems can become impact in the discussion of nerve system and for the design of new algorithms for massive systolic parallel computers in the field of until now not solvable real time problems (3D- virtual reality, 3D- real time pattern or situation recognition, intelligent 3D- sensors, ultrafast robotics) and for compact picture storage systems.

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Remark: Corrected version with revision of some idioms and phrases.