MODELLING INHERENT COMMUNICATION PRINCIPLES OF BIOLOGICAL PULSE NETWORKS

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The geometrical impulse length in the human nervous system in a range from 1 to 120 millimetres indicates the acute presence of wave properties at nervous signals. An examination [1] introduces logically the concept of optical interference to electrical circuits. Boolean else threshold logic doesn't work correct under a pulse length being shorter than time differences between the 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 behavioureal 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 tied to straight lines. Impulse waves in electrical systems follow the free curvature of the (nervous or technical) wires. Thus optical interference principles appear as a special case of electrical interference systems for straight wave propagation.

Supposed, any stochastic connection of neurones forces impulses carrying a signal to travel on different wires in parallel. Then the probability to excite a neuron is higher, as more closed partial impulses reach the destination, if the destined neuron has nearly multiplying threshold properties (AND-characteristic, see figure 1), and all sending neurones fire asynchronous.

\[ y = x_1 x_2 \ldots x_n \]
Thus places of source- and destination excitement have the characteristics, that the delays $\tau_1$, $\tau_2$, ... $\tau_n$ are equal at all possible transmission ways between source and destination. To beware a short form it shall be assumed, that $v_1$ is a constant propagation speed on each wire. The curvature length is $\lambda$.

$$\tau_1 = \tau_2 = ... = \tau_n; \quad \frac{x_1}{v_1} = \frac{x_2}{v_2} = ... = \frac{x_n}{v_n}; \quad \lambda << \tau_i$$

(eqn. for self-interference; source [1])

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

If we suppose further, a neural generator periodical produces impulses of a short duration $\tau$, where the geometrical length of an impulse is $\lambda = v \tau$. Then nervous impulses get a pulse duration/speed product in the range of

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

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

Figure 3
Zoom and move operations at a 1-dimensional interference circuit.
To move the picture, delay the wires g) and h) counteractive (source [1]).

Figure 3 shows some generators $G$ and multipliers $M$ in a delay-distance greater than $\lambda$. 
assigned to the transmitter- and the receiver side of a transfer circuit. Each receiver \( M \) is excited from that transmitter \( S \), that lays in interference to. That means, a picture as a pointer \( P \) reaches mirrored the receiver side as \( P' \). If all transmitters generate impulses not correlated to each other, nearly the most information of each transmitter is carried to the corresponding receiver. Any one- (or higher-) dimensional input picture passes the circuit in mirrored form. The algorithm to construct an electrical interference circuit is easier, then to hard-wire a home-ringing circuit with a comparable count of push buttons and bells:

- lay out the transmission lines precious 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.

Notice, that all signals between the transmitter and the receiver side use the same transmission lines \( A \) and \( A' \). Thus if \( A \) and \( A' \) are dendrites or axons of neurones, all possible informations pass through \( A \) or \( A' \). Thus it is impossible, to identify the source of any impulse passing \( A \) or \( A' \) without the possibility, to compare the signal with the signal of the opposite, referencing transmission wire(s).

To move a picture \( P' \) over the screen (receiver field in figure 3), the propagation speed of \( A \) and \( A' \) has to change counteractive. To zoom the 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.

**CROSS-INTERFERENCE SYSTEMS**

How is it possible to store moving picture parts with the feel of touch, sound or scent? The interference of optical waves doesn't differ causal between self-interference of one wave or cross-interference of different waves.

A Huygenian diffraction of a light beam shows a large maximum and symmetrical, smaller interference maxima in nearly constant distances to each other. The middle maximum in figures 5 and 6 is the result of a self-interference, and the maxima that lie side by side are
called cross-interferences between the each following waves. The same effect in neural networks has an important consequence in the organisation of interference fields (the pallium of the brain). Any correlation of impulses can be stored. Thus the mind registries not only 2D- or 3D-pictures. Together the 'neural photo' stores delays in the form of cross-interferences or side-maxima.

Because all amplitudes biologically are transferred in frequency- or delay-modulated form, the pictures that the neural interference network can store are complex situations including touch, sound, scent and motion. An elementary situation consists of a series of 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 each other 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 \( t_0 - t_a \) concerned with a situation correspond to pairs of delay differences \( \tau_b - \tau_a \), 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 \( t_0 \).

\[
\frac{1}{2} (s_b - s_a) = \tau_b - \tau_a = (t_b - t_0) - (t_a - t_0) = t_b - t_a
\]

In case of detection the vector difference of geometrical properties \( S \) to be learned has to be equal to the vector difference \( \Gamma \) of the wiring-delays and to the vector difference of the...
delays between impulses (\( T \)) (propagation speed \( v \)).

\[ \frac{1}{v} (S_{i} - S_{a}) - T_{b} - Y_{a} = T_{b} - T_{a} \]  

(eq. for cross- & self-interference; source [1])

Using a bias to move the threshold of the neuron \( N \) to additive character, the neuron spikes 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 picture of Figure 2.

Any 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. Supposing, a neural field has a matrix grid distance of \( \tau \), and a length in each direction of \( k\tau \). All transmission wires connect with all neurones. The neurones lay in a distance \( \tau \) 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.

If we suppose further, we use layers of neurones above eachother with the same spacing but with a matrix grid distance \( c'\tau \), where \( i \) is the layer number and \( c \) is any constant value, it is possible, to expand the pulse code length to \( c'k\tau \).

Thus, 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 understand the bias control in the figures 7 and 8 compare with the thresholds in figures (b) and 1c). It is possible, to control the logical characteristic of any threshold-gate (neuron) with one or more bias gates. In pulse networks this is possible using a white impulse noise of high enough frequency at some synapses of the neuron. The integration of different, stochastic distributed impulses ever generates a DC-potential, if the impulse-series own an average integral value, that is different to zero. For more see [1].
Thus the structures in the figures 7 and 8 in combination give the chance, to generate large neural arrays including some million neurones. For large arrays the problem of a maximum fanout at projective axons only can be solved, if the projective circuits in figure 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
As another question, it is important, to understand easy interference structures that decentralises behaviour. If anybody learns to go, it needs all his attention. Later, the process moves out of the brain, and we can do different things while going.

![Diagram](image)

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 Y remains the same, if any global reference time \( t_0 \) changes by \( \tau \). In other words: if sources (S) or destinations (\( N', N'' \)) of any interference circuit moves, the addition of any delay \( \tau \) at all transmission lines axial a) or radial b) is without any influence to the picture. Thus, the pictures of \( N' \) and \( N'' \) appears indifferent. The answers of \( N' \) or \( N'' \) are the same, the response of \( N' \) appears only \( \tau \) later. Thus any neuron \( N'' \), that gets a comparable interference as \( N' \) and locates closer to the source S, has the same possibility to control any behaviour that was controlled before by neuron \( N' \). The control decentralises closest to the neuron.

Permutation of scenes
Any interference picture consists of relative delays between impulses, or groups of impulses on different transmission wires. Thus it is possible, to construct a picture or situation (called scene) using transmission vectors of different sources (figure 11, wires 1...4), supposed they are equal. Thus it is possible, to store any scene in different dimensions in form of different hierarchies, dimensions or layers.
Thus it is possible, to model 'ideas' as correspondence between any fractal information that
creates accidental a known or useful code, picture or scene.
In the short form it seems impossible, to give more than some introductory impressions about neural interference systems. Interference models of neural pulse systems show properties of the most psychological phenomena. For more see [1].

Figure 11
Changing the dimension of an interference picture. The high dim. scene P1234 corresponds to elementary scenes P12, P23, P34.

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 picture transmissions in neural systems, comparable to optical systems (our 'homunculus'). Cross interferences between different impulses show the storage of complex situations, consisting of pictures, touch, sound and scent. Properties at interference circuits are usable to construct circuits with decentralised behaviour (conjugated pictures), or circuits having good or bad ideas (permutations). The sight to learning networks became easier with interference models in difference to actual AI-networks [3...9]. It is nearly comparable to the storage of information on optical films used in holographic applications. Non-interference AI-principles for biological, neural interference networks are useful only in areas smaller the considered impulse length (<1 mm). Interference systems become impact in the discussion of biological neural systems as in 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) as for compact picture storage systems.

REFERENCES/ RELATED WORKS


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