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HOLOGRAPHIC CODING OF PROCESS ACTIONS AND INTERACTIONS

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Digital holography, process state, process action, holographic machine

1. Introduction

Distributed intelligence manufacturing and ambient intelligent systems have been under development and small scale application during the last five years [1,2]. Basically such machine consists of distributed intelligence that uses computing and process control infrastructure at hand and serves for process identification and surveillance mainly for security purposes.

Following a biomorphic Damasio's model [3] the machine can be organized mainly as a memory surface that enables recognition of complex interactions among surveilled objects by means of a trained decision making intelligence. Decisions are performed for example in manufacturing process such as secure software or material processing.

We shall describe hereby another machine structure based on the holographic transformation of objects-states-action paradigm on an active surface. Main feature of the paradigm is active mobility of the scene follow-up because of the specific features of the holographic data surface.

2. Holographic data transformations, active surface

Active surface is a memory surface that exhibits activity movement on the surface dependent on the memory scenery. Such a memory has been announced by Edward deBono [4] as a simple mechanism model of human mind. It just mimics the movement of consciousness point on the memory surface of a human brain.

We have tried to introduce a series of artificial line holograms [5,6] that can exhibit a unit step movement on the hologram at hand. Hereby we have used one-dimensional digital hologram for point objects.

An in-line method for digital hologram construction means that the referent beam and object beam possess the same source. Because a one-dimensional point-object hologram is created, the picture of the point-object and holographic surface are represented as a one-dimensional finite length field. These two fields are at the distance z. The difference between neighboring points of the holographic surface is s. Digital hologram is constructed from spheric wave superposition. The value of the hologram point (x,y) is given as

$$H_{x,y} = \sum_{i,j}^{M,N} A_{i,j} \sin(2\pi \frac{d}{\lambda}) \tag{1}$$

For each point of the one-dimensional field the influence is calculated on the holographic surface. This is repeated for each point of the holographic surface. The amount A in equation (1) is beam source intensity, d is distance between hologram surface point and original point and λ is beam wavelength. Hologram reconstruct is described with equation (2)

$$A^{*}_{x,y} = \sum_{x,y}^{M,N} H_{x,y} \sin(2\pi \frac{d}{\lambda}) \tag{2}$$

Distance of each original point and each hologram surface point is calculated according to equation (3)

$$d = \sqrt{(i-j)^2 \cdot s^2 + z^2} \tag{3}$$

Noise measure of the reconstruct is calculated for each reconstruct as a quotient of the sum of absolute reconstruct values decreased for a dominant reconstruct member (this is usually the original picture reconstruct) divided by the number of points that participate in the calculation. The obtained hologram is quantized on the 256 grey scale levels (grey scale hologram). Hologram construction and reconstruction are processor time consuming taking the square of the field point number as operation number. Thus 1000 point hologram requires million processor operations for a full transformation process.

Basic data transformations in the process consist of series and/or concurrent processes such as: manufacturing scene acquisition – object recognition – object hologram production – holographic data processing – holoreconstruct analysis – holo action recognition – machine reconstruction of the scene. These steps are not simple to implement. Nevertheless they are quite more natural in their functionning than their finite state machine representation counterpart. The core transformation in the process are digital holographic data transformations (4,5), simply depicted in Figure 1.

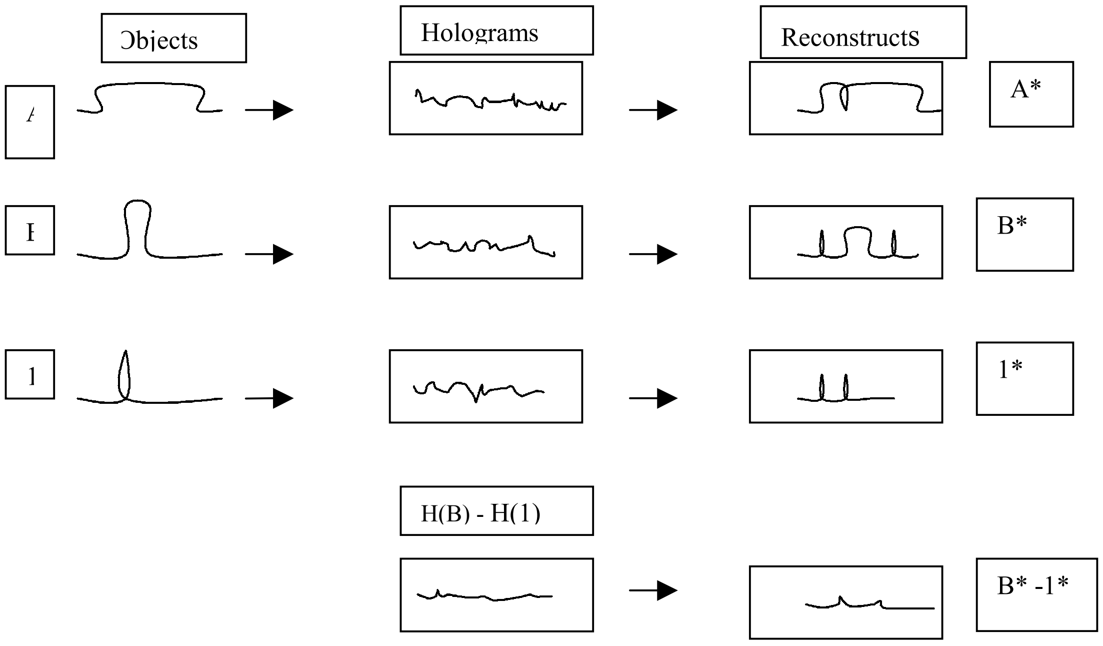


Fig. 1. Core transformations of objects, holograms and their reconstructs

Here two types of results of the process holographic transformations are observed: one with the monotonous holoreconstruct depicted as object A and the other with dominant holoreconstruct depicted as object B. The following definitions are proposed as extensions of previous works (5,6):

Def. 1 Digital hologram H(A) of the object A is a linear transformation of the spheric wave on the holosurface.

Def. 2 Active holosurface produces the holoreconstruct of the object A named A* = H^{-1} (H(A)) using the same spheric wave generated from each and all holographic surface data points.

Reconstructed object consists of parts named hi.

Def. 3 Monohologram M = H(1) is produced from a distinct data point object named unit object.

Def .4 Holoreconstruct of the monohologram is named 1* and it is equal to $1^* = H^{-1}(M)$.

Def. 5 Extreme part h_k of the reconstruct is dominant compared to other reconstructed object parts. Dominant reconstructed parts form the so called k-set. The dominance can exceed 5% above other nondominant parts.

Def.5 Holoreconstruct noise factor is the following measure:

$$N_h = \sum \left| h_i \right| / (n-k)\,,\quad i \notin k \text{ set} \qquad (4),$$

where $| h_i |$ is the absolute value of the i-th holoreconstruct part, and among total of n parts are excluded those k holoreconstruct parts that are dominant.

Def. 6 There exists object X possessing hologram H(X) with one dominant reconstruct part. Such hologram and reconstruct are depicted in Fig 1 as object B.

Producing another monohologram from 1’ that possesses the same position of the dominant component reconstruct as the hologram reconstruct of the object X gives the oportunity to mathematically recombine both holograms. As the most appropriate operations have been shown the addition and subtraction of holograms. The reconstruct of such subtracted complex hologram i.e. H^{-1} (H(X) – H(1’)) gives the object X without the dominant point 1’component. It was experimentally proven that noise factor of the reconstruct of the difference of two holograms, that resembles to the reconstruct of the original hologram but without the dominant part, possesses noise approximately equal to the difference of the noise factor of both components, i.e.

$$N_h \langle H^{-1}(H(X) - H(1'))\rangle \approx N_h \langle H^{-1}(H(X))\rangle - N_h \langle H^{-1}(H(1'))\rangle \qquad (5).$$

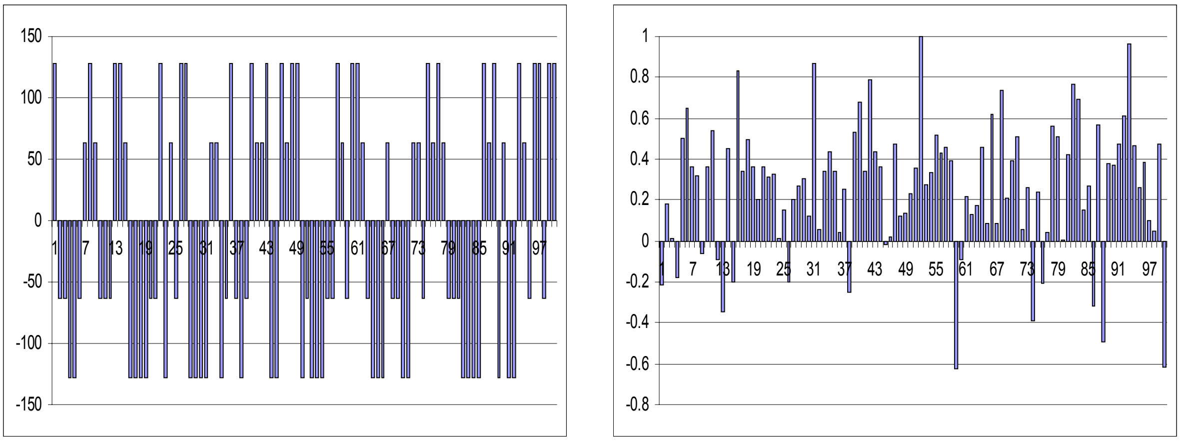
Beside the explanation that holograms reconstruct proper object originals there is also the hidden feature of the relation (5) that holoreconstructs are tending to decrease their noise factor when used for some specific actions. Holograms of such holoreconstructs are regarded as active holograms and their surface as active holographic surface. Moreover, hologram reconstructs that have exhibited such behavior can be selected from other similar hologram reconstructs due to their previous activity.

This opens another question in the form of the relation between object actions and event coding on the holographic surface, because holograms can be evaluated only after the analysis of their holoreconstruct parts.

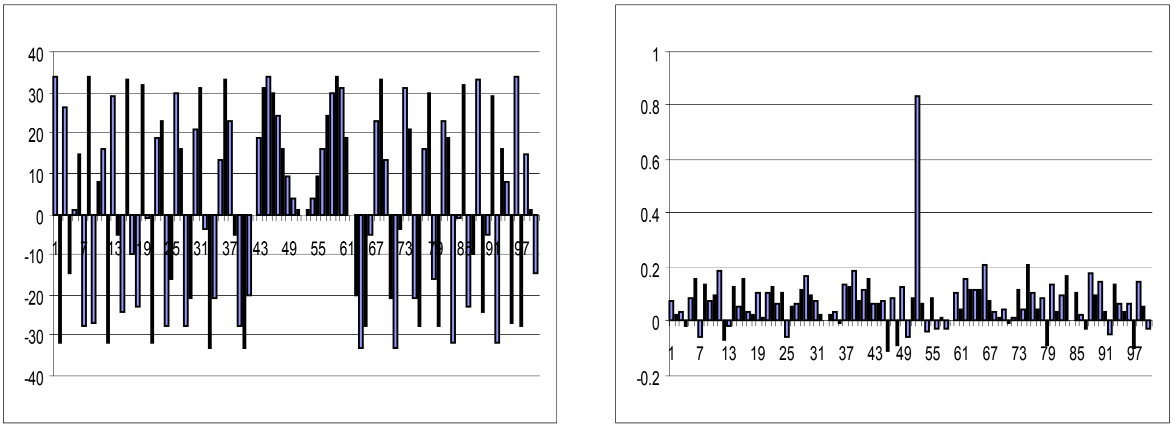
3. Objects, actions and event coding – example of the short part of the Escherichia coli code

The question arrises on the possibility to find dominant holograms in the real world. In other words are there such objects as defined in the Domasios concept but based on holographic content. Selecting meaningfull objects for holographic coding can be simplified in the form of taking holograms of real objects and trying to code them properly. Or put in the form of an example it means taking DNK data as already holoographic data. A simple life forms as bacteria escherichia coli presents such possibility. The problem presents its proper coding. We have taken a short code sample of the E coli type K12 MG1655 section 342 to 400 of the complete genome with the length of 100 data namely (g stands for guanin, t for tiamin, c for citosin and a for adenin): “gttaatcgctttggcaaaattgactggaaaaccatgtatgccgaagcggataaattgctggctaaactaaacttaacctgcgctttaaaagcgac aagctggtgg”. This coding can be presented as a digital hologram in an immense number of ways. We have chosen a simetric code of the form (-2, -1, 1, 2). Because each nucleotid (A, T, G, C) can take any numeric value we obtained 4! = 24 coding forms. An example of the coded hologram is given in Fig. 2. Together with the hologram a reconstruct is given, its noise factor and dominant reconstruct component.

combination(7/24) A= -2 T= -1 G= 2 C= 1

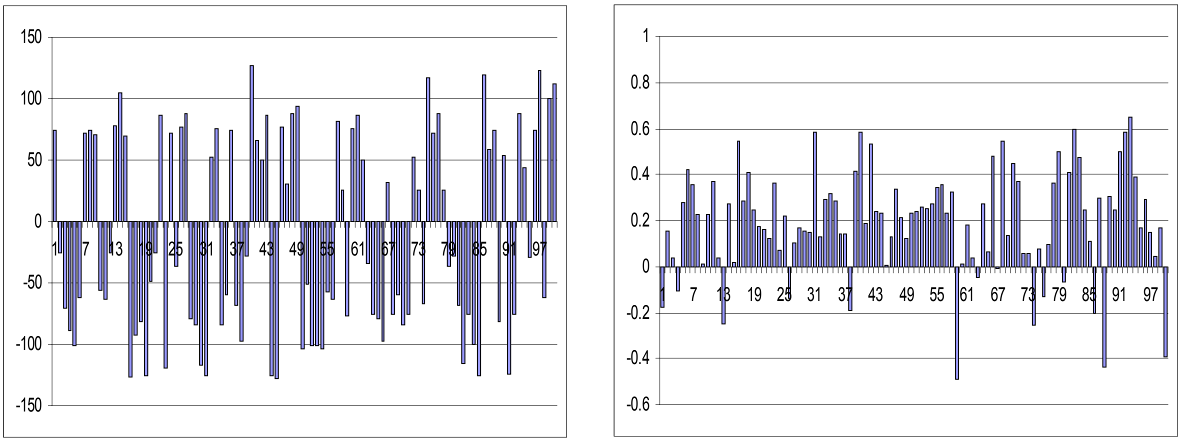


Hologram, left and reconstruct, right; noise measure is 0.341987; maximum = 1.000000 on position 51



Monohologram of the unit pulse from position 51, left and its reconstruct, right; noise measure is 0.081435

M



Hologram difference from above holograms, left; its reconstruct, right; noise measure is 0.251368 reconstruct maximum = 0.647019 at position 92

Fig.2 Escherichia coli DNA code combination 7/24 - possibilities for action coding

4. Short and long term memory, HOLA concept, discussion

The series of actions: raw data - reconstruct position 51 - reconstruct position 92 - can represent the so called short term memory, because it can be reconstructed by the process on the proper holosurface. The other memory surface spaces previously used can be reached by an associative or provocative input. In such a way a holographic engine can be designed based on holographic data processing similar to the Damasio's machine. Basic for such a machine is data flow from input - recognition of machine-process state to the output reaction to the stimuli. Holographic data processing for input and output receptors and action can be exchanged with associative data processing in order to obtain the necessary reaction speed. Damasio's machine exhibits recognition sequences in tens of seconds (1). Our opinion is that it can be made much quicker by means of the active memory data based on holographic data processing with the inclusion of associatively trained networks.

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