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A Brief Mathematical Approximation for Information Processing of Sound and Space for Deaf and Hearing People

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Abstract: *Considering a hybrid system where discrete (physical) and continuous (biological) variables are present constantly as inputs of sensory information of sound and space, an adaptive controller device needs to measure the given variables in order to achieve a specific performance of processing as an output of information and decidability. This measurement process of the adaptive controller can be resumed as the adjustment of the environmental data through an index of performances defined by each biological organism as an optimization of a given task.*

A mathematical framework was developed to conduct the pathways related to uncertainty caused by the continuous variables presence within the biological similar system.

Keywords: *Deaf and hearing people; agent-based systems; complex adaptive systems; hybrid probabilistic systems; control theory; biological systems; sound and space processing.*

1. INTRODUCTION

In order to perform an information processing in biological similar systems, the input and output of information processing constitutes an activity execution, understood here as the productivity effect, of which a machine or organism based system can perform. The term biological similar systems are used in this research to identify systems where biological patterns such as memory and adaptation are constant keys for system organization [1,2]. In this sense, also environmental conditions play an important role in the system input and output of information [1].

In examining the effects of sensory input of information processing towards physical expression of sound and space, some specific differences are defined in terms of how much sound or space can an organism detect within the environment. Those observations in order to design a computational formula that could resembles an organism processing of sound and space should be able to use not only discrete variables [1], but mainly continuous or discrete-continuous variables since basically the sensory and mental organization of information achieve a higher dimensional property of reality in a way it is not possible to identify the same physical properties of sound and space with sensory properties of detecting this information or the mental architecture of mind itself for each of individuals of same specie or different ones. Understanding this limit as a particular function for each type of organism, to uncover the definition of how an organism process this type of information can lead as well to the possibility of design soundness equations [1,2] and also tools for discretization of events in high dimensional orders that could be used as a mathematics of computing.

Considering this type of system as a nonlinear information processing, the system's productivity performances [3] are dependent of an adaptive controller as well as this device (agent), might be defined in terms of source of information (completeness), time and the agent's cognitive domain, considering for it features like memory and decision making triggers [1,2,3,4,5].

Despite of production with discrete variables present also a performance range [4,6], many types of production involving cognitive aspects lead to a higher level of performance range, constituting a labor system (activity execution) where continuous variables are created as a default pattern regarding of how to perform a given task [5]. This non-discrete form of productivity might reach commonly, due to cognitive nature, a probability distribution composed of discrete and continuous forms of information and its processing [3]. For this type of hybrid modelling, statistical analysis to evaluate a performance index gives a distinct elucidation of how the system works for the discrete events. In the other hand, if agent's forms of processing information (continuous variable presence) consists an inherent part of production, statistical methods (a priori data prediction or historical causality) can find a deadlock in determining how an agent or a group of agents might give a better performance comparing each other, since the nature of this variable in many cases can't be predicted previously if the algorithm of this processing is defined in a wide range of performances. In this sense, productivity elements such as time and resources (sensory/brain patterns), for example, are defined by the form of processing of the agents that produce, and likewise, the resources will be needed to the extent to the possibility to optimize the continuous variables of the system, and for this case, the cognitive dimension of agents. Following this path, discrete and continuous variables are inputs in the state of correlation with the agent and its processing mode, and not an impartial relation to the agent's processing mode [7]. This brief description can be represented by figure 1, where information processing scheme is presented.

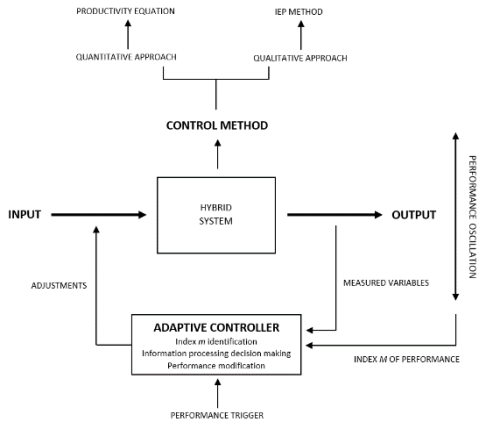

Figure 1: *Control method designed for a hybrid system in which agent-environment interactions achieve high level of complexity in adaptive forms of productivity [3].*

This whole control framework is a brief approximation of the possibility of creating an automated deaf sign language closed caption. This system would aim to detect and process patterns of space and sound in which, by mimicking the patterns of biological systems through equations, it would be possible to:

- Simultaneously and continuously (automated) translation from spoken language to sign language and vice versa;
- optimizing translation capacity between languages in relation to discourses and linguistic aspects based on space and sound similar to biological systems;
- optimizing the ability to translate oral languages in their textual form into the sign language space format for the broad and continuous discourses needed to read books and other written media;
- creation of automated translator incorporating sign languages in the world for spoken languages and sign languages among themselves;
- creation of automated educational programs targeting Portuguese as a second language for deaf people or teaching sign language to hearing people;
- possibility of automated interpreters for the entire public and private education network such as schools, colleges and universities;
- improved methods for professionalizing deaf people through spoken and sign language integrations.

2. INFORMATION AS THE MAIN COMPONENT OF PRODUCTIVITY FOR BIOLOGICAL SIMILAR SYSTEMS

It can be seen in human societies information processing skills that can be nurtured individually, culturally, academically, in labor activities and even scientifically. Considering the adaptive form of organization as the main effect for distinct outputs of information processing, a method that can describe the origin and performance of information processing for biological similar systems is important to bring in nowadays life, machine based systems that can simulate diversity in productivity of a given task. For that reason, an analysis of index of performance for productivity can be quite useful for optimization of various forms of cognitive processes concerning both machine systems or biological systems. And in the other hand, it can be notorious as an empirical prove of these statements that every individual develops its own performance of reasoning the world and other cognitive dimensional skill, thus improving the way of seeing the Universe phenomena [8]. Also for machine interactions with hybrid environment, the analogy of biological adaptation and memory plays a key role in the definition of the machine capability of interacting and pattern recognition, dealing with high level of uncertainty and the possibility of performing more complex reasoning operations [9,10,11].

Following the previous statements where hybrid environments have no defined methods of analysis and a mathematical framework for activity execution (workflows) whose systems are in adaptive mode and present constant nonlinear results of precision, considering for it inputs and outputs of information and processing, a mathematical framework is given by the equation of event i [3] as any event that considers information processing by an organism or machine giving P (precision/performance of system operations), can be defined by,

$$i = Prob(I^i).Prob\left(\frac{T}{I}\right) = m + i, \quad (1)$$

The mathematical modelling that describe information flows in this type of workflows can be defined as a probability event when from a given event i by the equation (1) of the interaction between given discrete information variables (I), individual experience I^i and defining the time T (discrete or continuous depending on the case) as a function of I for the execution of individual or group work/between agents/machines reaching a precision/performance (P). [3]

This represented formula for input and output of information and its processing (through other derivations) can handle specific factors in which cognitive process occur not considering for it if sensory, brain or mind domains of processing.

However, it is important to observe that a system that can detect pure data of environment patterns or the information as a whole and produce an output without any biological oriented patterns wont represent a biological system where sound and space

data are processed in a different physical and later mind oriented perspective.

To achieve a correspondence processing between machine and biological similar system, the organic property of processing (considered biological model investigated) must be recognized as one of the frameworks necessary for the machine information processing in order to reach similarity between both systems.

A particular path to reach systems similarity would be modifying machine discrete data input to a pattern where biological information processing is defined by a discrete/continuous phases of data source (hybrid), in terms of environment data detecting and later processing skills related to the desired organism's modelling.

2.1 Agent-based information processing within a biological similar system

As productivity equation (1) was defined for information processing events, one specific problem originated from biological aspects of organization is concerned to the natural pattern formation of biological organisms in terms of reducing high input of information to a lower pattern of complexity as it can be illustrated in the research of Liu et al [11].

For this approach, theory of information statements given by Shannon and Weaver (1998) [13] are very similar considering two dimensions of analysis, that is for machines and for organisms.

Also, considering sound and space patterns in nature, biological systems reflect partially this correspondence, also differing the inputs and outputs of this type of information and processing [5,10,11,12].

The productivity equation (1) [3] takes this statement as one main component of productivity in biological similar systems, since one main property of the event consists in biological orientation to discriminate patterns in deep level of complexity as found in Jacquemot*et al* [9]. For the simulation of this operation a mathematical framework is given generally to represent the initial condition of the phenomena.

Also one important aspect of information processing regarding sound and space is related to researches conducted with deaf impaired or deaf people [9,10,11,12]. These researches point out about the language divergence status of sign language or oral languages towards forms of processing skills or other related cognitive performances [2]. For this small research only one reference was added to illustrate this discussion, but this problem in a scientific point of view goes much further than a single reference.

This research will not opt to discuss if sign language or, the brain skill to process space in its details is similar to brain skills to process sound details. But it is very recommended to understand the mathematical aspect of information processing, to uncover brain performances towards sound and space sensory limits, brain limits and mind limits aspects including for this analysis all sorts of methodologies in the fields of theoretical and empirical knowledge [10,11,12].

2.2 Sound and space processing

Defined by equation $F_p(I) = Prob(P > I)$ from a discrete cumulative distribution function (CDF) perspective in which the discrete and probabilistic function is discrete by the presence of pre-defined data (sensory inputs), but with uncertain processing (brain inputs) and / or temporality (perception reasoning) that assume in an adaptive system the well-defined ad hoc mode of work and predictable [3,14]. This type of distribution associated with adaptive systems does not represent an entropy of information, in which it is not possible to reach accuracies close to 100%. The monotonically decreasing function is presented by the high probability of accurate execution and low presence of information that generates randomness in the system due biological property of constantly reorganizing information from the environment and from the own organism body, wherever it's biological condition (as it is precognized in one of the epistemological views of linguistics).

It is dependent on an ad hoc method (biological reorganizations) to achieve an accuracy of 100% or close. Consider for this accuracy and ad hoc model of processing as the individual organization of information in the search of more optimized ways to achieve higher standards of memory and processing skills such as communication and symbolic social reasoning.

Mathematically, it is not possible to obtain a CDF-like probability as described in last paragraph as a function of the organic or biological similar component of the system. Thus, the cumulative function of information as discrete values can of course be processed to the inverse of the manifestation itself in its physical nature or axiomatic origin of probabilities (a characteristic event of a non-adaptive system where $Prob(P < I)$). Precisely the propositions of biological order can establish a function between precision and information of the type $F(P) > F(I)$. Thus the probability of precision is strictly greater than that of information, the set of P contained in I being at the same time contained in another set of unknown dimension (of individual experience), such as, $\mathbb{P}\big((\infty, P]\big) \leq \mathbb{P}\big((-\infty, I]\big) \leq \mathbb{P}((-\infty, I^i])$, being I^i the experience accumulated by the individual, or in other words, the accumulated information of n events i, which confer to the biological potential the possibility that $\mathbb{P}((\infty, I^i] > P\big((-\infty, P]\big))$ [3]. A cumulative function in an adaptive system assumes the biological form of the individual and breaks the axiom of probabilities,

differentiating the axiom that applies to the physical world from the complex adaptive world.

2.3 Mathematical approximations

a) High accuracy workflow performances and inputs/outputs of information

Considering an information I and a biological processing I^iif $I^i > I$, for any I given to prevent oscillations on system resulting in $F_p(I) = Prob(P > I)$, thus the probability of precision is strictly greater than that of information, the set of P contained in I being at the same time contained in another set of unknown dimension (of individual experience $(I^i > I)$), which confer to the biological potential the possibility, $\mathbb{P}((\infty, I^i] > P\big((-\infty, P]\big))$.

To add biological properties in the complex adaptive system, learning process can be observed as a heuristic input and output of information of obscure probabilities. But for any given heuristic cognitive processing, weights can be strictly associated with organism search for environment patterns and previous memory experiences.

Considering short or long term memory, the processing skills if available and functional in its normal average towards population, that being a categorical class for deaf or hearing people, as organism limitations to process environment patterns fail, it leads to the inverse phenomena described at item b).

It is important to notice that categorical ways of processing information of biological system assume performances that can't be used as an universal input and output [9,10,11,12]. For this reason, any category must deal with specific index of performances considering for it the use of sound for spoken languages and space for sign languages.

b) Low accuracy workflow performances as the basis of information processing constrains

In the other hand if $I^i < I$, but present definition with limits of $\mathbb{P}\big((\infty, P]\big) \leq \mathbb{P}\big((-\infty, I]\big) \geq \mathbb{P}((-\infty, I^i])$, and cognitive system presents lower information processing skills, it can be written as,

$$F_p(I) = Prob(P < I) \therefore f^{'}(I) - f^{'}(P) = (I - P)f^{''}(I^i) > 0. \quad (2)$$

$$\text{Hence, } f^{'}(P) < f^{'}(I) \text{ [3].} \quad (3)$$

Thus, reducing time and pathways for reaching precision P of information given I.

As a complement of the workflow performances for both deaf and hearing people, there must be necessarily a constraint for both types of communication since sound and space physical aspects are processed specifically as inputs and outputs of information. This event has significant importance for social and mainly pedagogical approximations towards deaf people.

c) Time dependent performances

It is worth mentioning that in time dependent systems, regularity allows the continuous flow of information and possible interruptions caused by the exchange of information between distinct systems generates deceleration of subsequent processes. In other words, the frequency with which activities are performed are dependent on continuous flows to avoid saturation of the work steps that do not have their finalization in the appropriate time or with the desired performance. In large information flows, PDFs (probability density function) can be generated on account of chaotic profiles between time-controlled systems [15].

All items a, b and c are in connectivity to make a proper biological alike system for deaf and hearing people. It is suggested that neuroscience knowledge related to deaf biological aspects be evaluated together with the mathematical framework in order to obtain small completeness models of information processing.

3. CONCLUSIONS

A mathematical brief framework for information processing for sound and space was presented. Important derivations of the formula were roughly demonstrated for comparison of how a biological system can reduce environment complexity, making no difference between deaf or hearing people and its biological capacity of conducting such workflows.

However, it is suggested that a biological based system need to reproduce a biological sample performance regarding sound and space processing. For this point, deaf and hearing people might differ its sensory, brain and mind inputs or outputs of information processing due to empirical constraints that weight the probabilistic expressions.

This research suggests more studies for sound and space differences for brain and mind processing, as well sensory default pattern to detect this input information.

If confirmed that sound and space processing might differ for deaf and hearing people, it can also be of deep importance to deaf community since new technologies and studies can redesign new tool to estimate deaf learning skills, pedagogy methods, inclusion techniques in daily life or work places, and so on.

One important technology to obtain from this studies lies within the possibility of closed caption automation for sign language and spoken language, being this feature performed by artificial intelligence device that can transform sound into space patterns. This same schema can also be inverted resulting into

spoken language to sign language translations transforming space patterns into sound patterns of correspondence.

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