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Cognitive Computation on Connectionist Causal Representations

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 19(0)

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Publication Date
1997

Peer reviewed

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Introduction

Connectionist networks do not use symbolic structures explicitly. Thus, they call for a new definition of the goal of computation and an appropriate representation to carry it out. This abstract reports on an unstructural approach, in which causally constructed representations are used in cognitive computation that is defined below.

Cognitive Computation

We believe that our study of cognitive computation should start with a black-box approach.

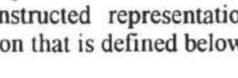

Figure 1: A black-box model of computation.

In the model, u_n is an input vector, y_n is an output vector, and x_n is the state vector. Inputs and outputs represent elements at a conceptual level (e.g., words in natural language). If the model has all necessary computational power, how can we define the goal of computation ?

Most tasks of cognitive modeling can be defined as the sequence-mapping problem (SMP), shown in Figure 2.

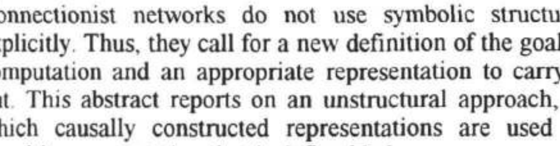

Figure 2: Cognitive computation as SMP.

In the problem, $u_1\, u_2 \ldots u_k$ is an input sequence, $y_1\, y_2 \ldots y_l$ is an output sequence, and $l > k$. The model must produce a sequence $y_{k+1} \ldots y_l$ that is an answer for the input sequence. It is assumed that $y_1 \ldots y_k$ is the same as $u_1 \ldots u_k$, and $x_1\, x_2 \ldots x_l$ is associated with the computation.

It has been shown (Pozarlik, 1995a, 1995b) that connectionist models can solve SMP owing to parallel processing. More precisely, they can produce any finite output sequence for any finite input sequence without a necessity of using any intermediate state.

Causal Representation

In the sequence $x_1\, x_2 \ldots x_l$, each state must encode a causal relation between past and future states (it is a necessary condition). It does not imply structured representations. Thus, the states can be described by sets of microfeatures (unstructured representation) as follows:

$$x_n = \alpha(u_n) \cup \beta(u_n) \cap [x_{n-1} \cup \gamma(x_{n-1})] \qquad (1)$$

where $\alpha(.)$, $\beta(.)$, and $\gamma(.)$ are functions: $\alpha(u_n)$ defines microfeatures specific for u_n; $\beta(u_n)$ defines how information propagates to x_n from previous states; $\gamma(x_{n-1})$ defines how x_{n-1} actively determines x_n. Microfeatures have no semantic meanings. States are interpreted as distributed patterns of activity in connectionist networks and state transitions from x_{n-1} to x_n are modeled by a pattern association mechanism or fuzzy set relation. Outputs are defined by specific microfeatures. Causal construction of representations is an alternative for constituent construction (Butler, 1991).

Conclusions

The defined computation is called cognitive, because it is natural for cognitive processes (e.g., language processing). It is carried out with causally constructed representations, not structure encoding representations. It exploits a pattern association mechanism and inherits its properties. An implementation of the computation may be found in some connectionist models (e.g., St. John & McClelland, 1990).

References

Butler, K. (1991). Towards a connectionist cognitive architecture. *Mind & Language*, 6(3), 253-272.

Pozarlik, R. (1995a). An unstructured representation for subsymbolic computation, *Proceedings of the Third World Congress of Neural Networks* (pp. 309-312). Hillsdale, NJ: Lawrence Erlbaum Associates.

Pozarlik, R. (1995b). An unstructural approach to natural language processing in neural networks (Tech. Rep. ICT-48-95). Doctoral dissertation. Institute of Engineering Cybernetics, Technical University of Wroclaw.

St. John, M.F. & McClelland, J.L. (1990). Learning and applying contextual constraints in sentence comprehension. *Artificial Intelligence*, 46(1-2), 217-257.