Neurocomputing 74 (2010) 121–128

Contents lists available at ScienceDirect

Neurocomputing

journal homepage: www.elsevier.com/locate/neucom

The Ouroboros Model in the light of venerable criteria

Knud Thomsen *

Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland

ARTICLE INFO

Available online 25 June 2010

Keywords:
Algorithm
Schema
Iterative data processing
Consistency
Consumption analysis
Self-reference

ABSTRACT

The Ouroboros Model is a new conceptual proposal for an algorithmic structure for efficient data processing in living beings as well as for artificial agents. Its central feature is a general repetitive loop, where one iteration cycle sets the stage for the next. A monitoring process called "consumption analysis" yields valuable feedback for the optimum allocation of attention and resources, including the selective establishment of useful new memory entries.

In this paper, it will be tried to show that the Ouroboros Model offers much promise to understand "whole brain" function, and that it fares well in the light of criteria for general artificial intelligence set forth over time.

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1. Introduction

The Ouroboros Model proposes a general algorithmic layout for efficient self-steered data processing in agents [1]. A research proposal is formulated starting from the hypothesis that the processes in the Ouroboros Model describe the whole brain function in living beings and that the very same structures are essential for artificial general intelligence [2].

This is work in progress; it aims at understanding general intelligence, and even consciousness in the end, starting from a new perspective and following a top-down engineering approach.

In this note, first a conceptual design is outlined devising the algorithmic structure of the Ouroboros Model. The focus lies on the flow of data processing in rather broad terms and not on exact formalization and neither on low level feature extraction, on grounding, embodiment or physical action.

In any case, before investing a lot of effort into scrutinizing detailed implications of this proposal, it seems prudent to take a step back and have a coarse look on its principal compliance with lists of requirements distilled from the work of fifty years on artificial intelligent systems by some of the foremost experts [3]. This is done in the second part of the paper.

A truly fundamental requirement for consistency, most notably consistency between experience, action and perception, lies at the heart of the Ouroboros Model [2,4,5]. As a direct consequence, the proposed algorithm funnels all unfolding activity of an agent repeatedly through one stage, where overall consistency of all current activity is checked. The end of one processing cycle is at the same time the beginning of the next iteration, while its results provide the new basis: the snake of data-processing devours its tail.

2. General layout in four steps

2.1. Basic loop

A principal activity cycle is identified; starting with a simple example of sensory perception, the following succession of steps can be outlined:

… anticipation,
perception,
evaluation,
anticipation …

The identified data processing steps, i.e. sub-processes, are itemized and briefly discussed below. They are linked into a full circle as shown in Fig. 1.

2.1.1. Start

This is the almost an arbitrary entry point in the perpetual flow of the proposed data-collection and data-evaluation processes: a novel episode commences with little heritage from previous activity.

2.1.2. Get data

In this example, first perceptional data arrive as an input.

* Corresponding author. Tel.: +41 56 310 4210; fax: +41 56 310 3131.
E-mail address: knud.thomsen@psi.ch

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doi:10.1016/j.neucom.2009.10.031

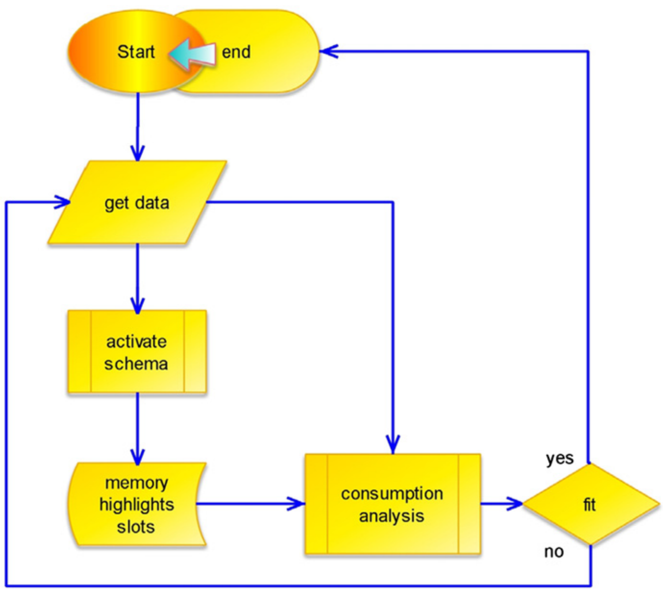

Fig. 1. Basic loop structure of the Ouroboros Model.

2.1.3. Activate schema

Schemata are searched in parallel; the one with the strongest bottom-up activation sharing similar features is activated.

2.1.4. Memory highlights slots

Each of the features making up the selected schema are marked as relevant, and they are activated to some extent; this biases all features belonging to this schema also when they are not part of the current input, i.e. empty slots are thus pointed out.

2.1.5. Consumption analysis

This is the distinguished recurrent point at the core of the main cyclic process constituting the Ouroboros Model.

A comparison of the demanded attributes of the activated schema with the actually available features will often lead to satisfactory correspondence; the current cycle is thus concluded without gaps, and a new processing round can start.

If the achieved fit is not sufficient, e.g. slots are left unfilled, follow-up action is triggered. In the outlined most simple example, more data are searched for, guided by expectations in the form of the biased empty slots.

2.1.6. End/new start

In the example of Fig. 1 a (preliminary) end is reached when good agreement between expectations and data is detected, e.g. an object is recognized; a new episode can start.

The current emphasis on data processing leads to the neglect of any other, in particular bodily, action—even if movements often are of highest importance to living creatures. Obviously, the information that expectations based on experience are in accord with current sensory data is useful for any living being as well as artificial agent; no need for action is signaled then. In case some discrepancy is detected, it might often be wise to collect further data as a first step.

Recently, in a state of the art model of image interpretation the substantial advantage of combining a bottom-up and a top-down pass into a cycle has been demonstrated [6].

2.2. Extended loop

The basic loop of Fig. 1 does not offer much room for sophisticated data processing or possibilities for growth. At the very minimum provisions for applying different memories and a learning mechanism to establish new ones has to be included.

If the first selected schema does not lead to any satisfactory fit, another script, one that was disregarded first, has to be tried. In case no preexisting schema can accommodate the sensory data well enough, a new data structure is generated, such, that at least during the next encounter of a similar situation, relevant memories can be brought to bear.

The basic loop can easily be extended with flexible schema selection and memory capabilities as indicated in Fig. 2. The most notable addition is a "reset" process. Consumption analysis in most cases will not deliver a clear cut yes/no decision. The range of achieved correspondence can vary from very bad to (better than) perfect.

2.2.1. Reset

If nothing fits ("impasse"), a "reset" is triggered and the cycle starts anew, this time with another schema and avoiding the first one. The assignment ("consumption") of the available sensory input data is investigated with respect to a second schema, while the originally selected one is bypassed and muted. Reciprocal inhibitory links between schemata in Fig. 2 indicate a winner take all competition between possibly applicable schemata; at the same level only one can be active at a given time.

Assuming for the time being, a static scene as the source of input, never-ending minor discrepancies also will eventually cause a reset—another schema will be tried after a number of unsuccessful iterations. In the last chapter, it will be suggested how this threshold can itself be determined in an adaptive way as a result of feedback in the context of relevant experience.

Even if no mismatch is detected, when repeating the loop too often without much new input, a timeout will cause the switching

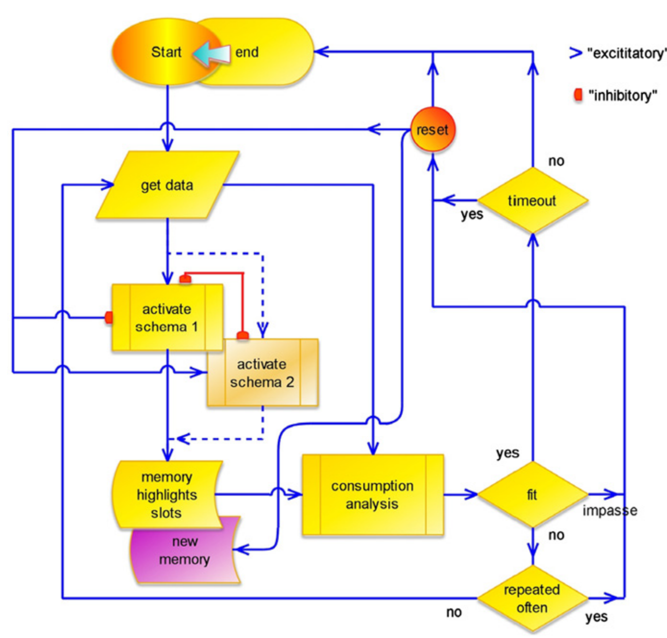

Fig. 2. Basic loop augmented with mechanisms for flexible schema selection and the recording of likely useful new memories. Although connections are marked "excitatory" and "inhibitory", no direct correspondence to nervous structures is intended at the moment; "excitatory" simply stands for a link activating the receiving entity, and "inhibitory" means that arriving activation dampens or prohibits activity of the terminal process.

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