Introspective Learning, Reasoning, and Decision Making in NARS*

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https://phillyagiteam.github.io/Website/

Abstract. The reasoning-learning mechanism of the AGI system NARS can be used to learn the beliefs and skills about the system itself.

This work-in-progress paper reports our recent work on the basis of our previous publications [1–3].

NARS (Non-Axiomatic Reasoning System) is a project that is moving toward Artificial General Intelligence (AGI) via an unified approach, that is, to mainly depend on a single reasoning-learning mechanism for various cognitive functions.

NARS is based on the theory that intelligence is the capability for an adaptive system to work with insufficient knowledge and resources. The system has to depend on its past experience to make predictions about a future that is different from, though still similar to, the past, in various aspects, as well as to use its bounded time and space supply to meet the unbounded demands.

NARS is designed as a reasoning system, though it is fundamentally different from the conventional reasoning systems where the canonical type of inference is to prove theorems according to axioms. There are multiple types of inference in NARS, including Deduction, Inductions, Abduction, Revision, Choice, Comparison, Analogy, etc., where various forms of uncertainty (randomness, fuzziness, ignorance, inconsistency, incompleteness, etc.) are inevitable.

NARS uses a term-oriented formal language to uniformly represent all types of knowledge, such as declarative, episodic, and procedural. A term gets its meaning by identifying a relatively significant ingredient or pattern in the system's experience, and relating it to those of the other terms. Besides abstract concepts, terms also represent perceived regularities, executable operations, and desired goals. Compound terms can be composed recursively from other terms.

The inference tasks for NARS include experience summarizing, question answering, and goal achieving. The system normally processes a large number of tasks in a time-sharing manner, and gives each an adjustable priority. Though the basic inference steps are predetermined by the rules, the actual process for a task to be handled is determined, in every moment, by many historical and contextual factors in a way that can be neither predicted nor repeated accurately.

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In the current open-source implementation of NARS[1], an internal sensorimotor mechanism is being developed. It serves as an addition to the existing sensorimotor mechanism that is concerned about external events and operations. The basic components of this inner-oriented mechanism are mental operations that are triggered by certain conditions within the system, and produce events entering the system's inner experience.

One group of mental operations mainly provides self-awareness, such as the recent major internal events regarding concept activation, inference step, anticipation, busyness and satisfaction value, etc. They can be triggered by factors outside the system's experience, and consequently bring them into the system's attention. For example, if a new event greatly contradicts the system's anticipation, a "surprise" event will be triggered, and if the current situation is very different from the system's desires, an "unsatisfied" event will occur.

Another group of mental operations realizes self-control, such as by reallocating the system's computational resources. For instance, the system can deliberately increase the resource budget for a task, even though it only corresponds to a weak input signal; it can also explicitly disqualify the confidence of a belief, when it has reason to doubt the credibility of its source. These operations supplement and override the automatic inference processes that run "uncounsciously", that is, without going into the system's experience as events to be explicitly expressed in the system's inner language, to be processed by the inference mechanism.

The system's reasoning-learning activities connect the above "internal stimuli" and "internal responses". For instance, the temporal induction rule can selectively create implication statements between events, including mental operations, to form beliefs with low confidence values. These can be interpreted as "hypothesis" about the preconditions and consequences of the mental operations involved, and will be used to produce anticipations about the future. With the coming of new experience, some beliefs will be strengthened and remembered, while some others will be weakened and forgotten.

Such a mechanism allows for a preliminary form of self-consciousness in NARS by being aware of what it is thinking, as well as being able to partially control what it wants to think and how to think.

References

1. Wang, P.: Rigid Flexibility: The Logic of Intelligence. Springer, Dordrecht (2006)
2. Wang, P., Li, X., Hammer, P.: Self-awareness and self-control in NARS. In: Proceedings of the Tenth Conference on Artificial General Intelligence. pp. 33–43 (2017)
3. Wang, P., Li, X., Hammer, P.: Self in NARS, an AGI system. Frontiers in Robotics and AI **5**, 20 (2018), https://www.frontiersin.org/article/10.3389/frobt.2018.00020

[1] http://opennars.org/