Cognition, Cognitics, and Team Action – Five Theses for a Better World

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Abstract. In order to reap the benefits of novel definitions and metrics, as well as to boost the development of intelligent autonomous systems, consider a shift of attention from AI to cognition. Mankind has gained a decisive advantage in the race for survival, and people's satisfaction with their lives has started a dramatic growth in scope, when their cognitive abilities, cognition, appeared and started to develop. Five theses about cognition are summarized below: cognition to know the world, to explore and perceive, to model; cognition for defining alternative worlds and possible futures, visions, for anti-causality; cognition for effective control; cognitics for a large scale, technical deployment of cognition; and social cognitics, a foundation for team action and increased momentum for change. The five theses can be seen both as paths towards better insights in human and social nature and also as a roadmap for simultaneous and iterative processes capable to freely foster a better future for individuals and society.

Keywords: cognition; modeling and vision; anticausality and freedom; cognitics; team action; learning

1 Introduction

The purpose of this position paper is to strongly call for a merge : for closing the current gaps remaining between, on one side, say AI, numerous, traditional, informal concepts, generally developed in the field of intelligent autonomous systems, and, on the other side, say cognition, formal notions defined for the domain of cognitive systems, with artificial or biological implementations, along with specific metrics. In the former context, a lot has been made (e.g. [1]), yet intelligence cannot be quantitatively estimated there. In the latter context, formal definitions and metrics are well established, yet these research results remain too little widespread still. The conjecture is that this merge can be accelerated by shifting attention to the field of cognition, along with extensions for including automated deployment and possibly addressing multi-agent, multi-

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pp. 33-41

scale cooperation, sometimes involving integral, holistic structures or on the contrary more elementary, subsystem levels.

Already, cognition has been essential for humans.

Obviously humans have gained an amount of power to change things in the world that is enormous, larger than ever before demonstrated by biological beings, reaching the limits where major traditional, natural equilibriums and assets on Planet Earth can be affected: climate, resources, pollution, as well as order.

It is striking to notice that humans have made a critical difference in evolution, relatively to other biological entities, with the relative size of their brains (e.g. [2]).

The key ability that the brain supports is cognition; ultimately, this is the faculty to take the good decisions, to deliver the right information. And as a result of the huge effect of cognition as mentioned above, it is crucial today to better study how it develops, and possibly to technically increase its deployment.

Cognition has allowed humans to unfold as they did. In recent millennia, centuries, and in fact, in large proportions, especially in recent years, cognition has allowed the fantastic development of science and technology that everyone can witness.

Of utmost importance, on the limits of the cognitive world, information is really the closest notion that has been clearly defined and given a metric system, with the well-known [bit] unit. This was a prerequisite for the mastery of communications and coding.

It is strange to notice though, that cognition did not yet really reflect on itself, with a degree of attention similar to what has been directed toward human environment and applications!

The present paper, on the contrary, focuses on the concept of cognition, and develops 5 theses about it. The goal is mostly to call for the due attention onto this domain, and incidentally also to support related recent proposals (e.g. [3-4]), that have not been exploited enough yet in regard of potential benefits for humans: better insights in human and social nature; and a roadmap for simultaneous and iterative processes capable to freely fostering a better future for individuals and society.

The sequel of the paper is organized in five other sections. The first ones follow three phases of information flows in cognitive domain, and then it focuses on artificial paths for boosting capabilities, and finally shows how collective embedding is powerful. Concretely, Section 2 discusses how cognition is critical to know the world, to explore and perceive, and to model; Section 3 indicates that cognition can be viewed as a resource capable of defining alternative worlds and possible futures, visions, thus triggering anti-causality; Section 4 indicates that cognition is also effective in ensuring control; in Section 5, automation, by targeting cognitive processes, i.e. "cognitics", can trigger a very large scale, technical deployment of cognition for the benefit of mankind; and as a last thesis, in Section 6, by extending cognition to a social scope, more complex structures appear, such as groups (e.g. teams), capable yet of higher degrees of action and momentum for change.

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pp. 33-41

2 Cognition to perceive, explore and model the world

Modeling is, more or less dynamically, at the core of cognitive processes, i. e. of cognition. Let us first see whether innate or acquired resources are at hand. Then modeling is addressed again. Finally, it is shown how models can be updated and refined, as a result of exploration, perception and experience.

2.1 Innate or acquired resources

How do humans (and machines) know something? Where does cognition start? It mainly appears two very different types of phenomena: the ones where innate ("pre-wired") capabilities prevail, and the other ones, where learning is the core mechanism for reaching cognitive maturity.

As an example for the first case, consider in biology the behavior of cuckoos, those birds that lay their eggs in the nests of birds of other species. The newborn birds have no contacts with their previous generations, yet know precisely how to proceed according to traditions; they grow experts without learning.

By contrast, humans take about two decades to reach cognitive maturity, i.e. to reach levels of expertise compatible with most professional requirements.

In fact even in the latter case, innate components are numerous, essentially encoded in genetic heritage (DNA).

The situation is similar for artifacts: some are designed and produced with a definite cognitive profile, while others may evolve in time, according to experience, supervised or not.

2.2 Modeling

Cognition may tackle purely immaterial domains, possibly receiving input information, processing internal information and possibly delivering output information as well, for example as typical programs do in ICT contexts.

Cognition typically implies immaterial entities, information, knowledge, yet it also requires an engine to run the latter. Cognitive processes must be implemented on a physical structure, such as a neuron, a brain or a computer to name a few.

As the etymology of the French word for "knowledge" ("connaissance") states it, cognition is capable to let reality be born again, to be duplicated or essentially replaced: with knowledge, for similar pieces of information as input, a similar output information is delivered by the cognitive system, as a possible alternative for reality.

Cognition can often operate if the goal is clearly defined. For this specific goal (e.g. the strategy for successful species survival in the case of cuckoos; or the delivery of banknotes at an Automatic Teller Machine) a simple representation, i.e. by definition a model, typically involving a process with perception of very limited aspects of reality can prove satisfactory for launching appropriate action (re. Fig 1).

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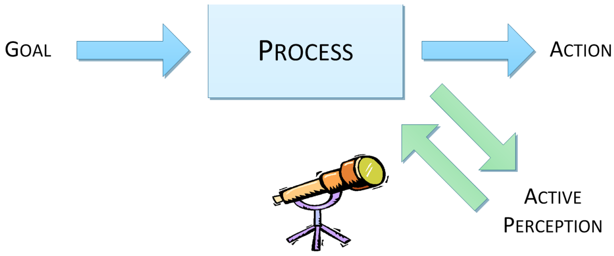

Fig. 1. In cognition, backtracking is the rule. From the selected goal, specifications are derived, which then lead the cognitive process, and in particular an active perception ("exploration") faculty capable of acquiring the experience necessary for action and possibly later improvements.

In terms of replicating reality, things are very much contrasted. Experience shows that for simple input information, as typically required in the usual models introduced in the previous paragraph, real-world input transducers, sensors, can often be designed with success. But of course if the goal is to have an exhaustive representation of reality in cognitive world, a complete replication, then complexity explodes; infinite amounts of information would be required.

2.3 Exploring the world , refining and updating models

As shown above, some innate capabilities are always required, as well as a physical infrastructure for implementing cognition. Now for a world where many unforeseen changes may occur, especially in more complex situations, cognition is necessary, whereby goals and processes may dynamically evolve (re. Fig. 2).

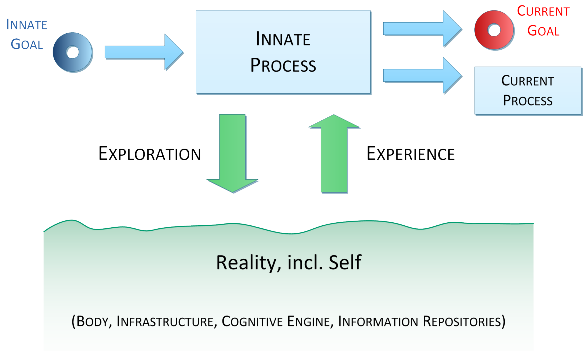

Fig. 2. Current goals and processes may result from exploration performed and/or experience acquired by an agent running a given cognitive process in a certain domain of reality. Initial goals and processes are innate (or "wired").

3 Cognition to define alternative worlds and possible futures, visions, triggering anti-causality

As already stated, cognition is not bound to address only models of physical reality, even though it remains necessarily implemented on real-world, physical infrastructure.

Therefore cognition has the extraordinary capability to define alternative conceptual worlds, assumptions, possible futures.

A special attention should be given here to "visions", those immaterial constructs, models, capable to inspire and trigger the autonomous action of cognitive systems, typically humans today.

Thus the model item that is proposed here for effective results both in technical and in human sciences, is the one of anti-causality. For example it is a call for paper, including topics to be addressed, information about location and date, at some point in time, somewhere in the future, that actually triggers the necessary, successive, preliminary, preparative and deployment actions (re. " D Day", and "consequent" "D-7", "D-100", etc. ancillary, anterior, planning dates).

Such a case for anti-causality illustrates very well how freedom may exist. Kant had a similar approach, in deriving cognitive processes typical of freedom from a transcendental rational source rather than from the perceived reality (e.g. [5]).

4 Cognition for effective control

Cognition contributes to effective control in a variety of ways, including capabilities in perception, modeling, decision-making, and concretization.

Consider the basic case of a controlling system (C) driving a controlled system (S) towards a goal, a reference state.

Control can often be done "open-loop", i.e. as a sequence of commands defined a priori, without reference to real-time situation. This is already cognition, in its basic capability to deliver the relevant information.

When unforeseen, significant disturbances may occur, it is useful to upgrade the solution. "Closed-loop" control is a more elaborated approach, whereby corrective actions are generated not only as a function of goal (e.g. reference values) but also of the perceived effects due to those disturbances, should they happen.

In this latter case, dynamics are crucial. A certain ratio of agility of the controlling system, C, with respect to the agility of the controlled system, S, is critical for ensuring success. Cognition again may be useful here, in possibly anticipating actions, thereby improving delays and agility, as well as in providing additional open-loop components, on the basis of more sophisticated models.

Especially when the relative agility of C degrades, cognition may also contribute, as will be discussed below, in introducing "social" solutions, that is multi-agent architectures and hierarchies, occasional autonomy.

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5 Automated cognition – Cognitics for large scale deployment

For ages, cognition has been mostly performed by humans, even though domestic animals have also sometimes contributed in some limited niches.

Nowadays, digital systems, in particular computers, service-oriented communication networks, smart systems or robots appear as effective artificial cognitive systems (ACS).

Such capabilities for automated cognition, cognitics, allow for drastic changes in people's life.

Things happen as if a much larger number of human workers were available for service. Well-known examples already include the ones of bank tellers, or ticket selling clerks, who not only have been replaced by machines in most cases, but for whom a much more convenient alternative has been provided in terms of number of points of access and of opening hours for service.

Progress in cognition and cognitics has the potential of further deployment to levels hard to underestimate, for the requirements in natural resources are very small for ACS as compared to human needs in comparable case.

Moreover, as can be seen for example in transportation, and in optical perception, the capabilities of artificial systems, when technologically developed with a clear goal, can largely exceed human capabilities. For cognitics, this is no exception.

In the case of transportation, the human leg has been augmented beyond all reasonable comparison by the invention of motorcycles, boats, trucks, trains, planes or rockets for example; or exo-skeletons. The human eye not only often benefits from glasses, but also possibly from many technological complements, binoculars, microscopes, scanners and space telescopes; not only in visible range but also e.g. for infrared signals, X-rays, ultrasonic waves or gamma signal.

Consider a few examples in cognitive domain, already today: which human brain can successfully compete with ACS for automatic, Google-typed searches, for the arithmetic expertise of mere pocket calculators, for chess-playing, SLAM capabilities, the capacity and fidelity of large capacity data repositories, or the accurate estimation of permanence (quantitative perception of time)?

Learning is already common, for example in the simple behavior of erase and "undo" keys, or for more complex cases as the cache-memory mechanism of computers, or even more so in the background indexing to support content-based addressing (thus effectively turning ordinary storage into associative memories).

In particular, an interesting direction for further, general learning, might benefit from the paradigm already present in LZW encoding [6, 7]: elementary inputs are gradually replaced by larger, integrative items, whenever possible, as experience is gained in the cognitive domain under consideration.

In the field of cognition, let us insist though on the fact that intelligence and learning are not always required, nor even useful per se. Best benefits always

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result from expert performance, and whenever all learning phases can be spared to get the appropriate expertise levels (re. DNA or electronic duplication for example), this is an advantage.

6 Social cognition for team forming, and achieving more benefits, common a well as individual

As a final thesis here for the importance of cognition, and cognitics, and the relevance of focusing more future efforts in this direction, consider the principle of consolidating the contributions of multiple, individual ACS's into a novel, common, meta-level, self-coordinated ACS, a "group" (e.g. [3, 4], and Fig. 3).

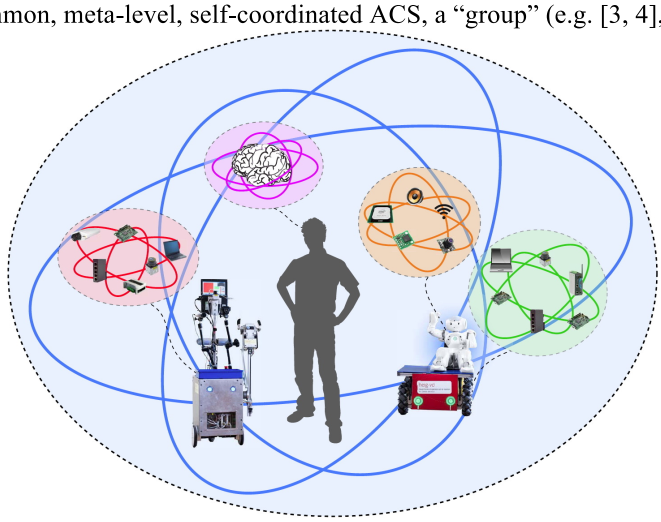

Fig. 3. Five examples of collective cognitive systems, at two scale levels: within overall, social group (blue color), and within 4 individual agents: a human, and three robots, including a humanoid (red color for RH-Y, magenta for the human, orange for Aldebran's NAO, and green for OP-Y) . In the case of the human, only the mental network of cognitive subsystems is represented.

Like for 2 systems cooperatively carrying a heavy object, or aligning posts, or like in older times, numerous mathematicians working as a team for actuarial work in insurance companies, stepping up in meta-levels allows for more actions and benefits.

Among new problems appearing in such a context, we notably find the relationships across different levels, e.g. between an individual member of a group, and the group as a whole; of the conflict management when an individual ACS is simultaneously a member of multiple groups, different in culture (scope, shared values, etc.).

A peculiar, somewhat mysterious property arising from groups is the fact that only at a single level, they can be physically defined, in the real-world; then implicitly, all the other levels are de facto described. E.g. if individuals are physically identified, de facto this is the group; the latter consists in a nil addition, in physical terms to the described individuals. Reciprocally, if a system, or a group, are physically described, implicitly their subsystems, or the members of the group, all consist in a nil addition, in physical terms, to the group description. A member cannot meet the group as such; and if a partial view is considered sufficient, than meeting another member validly means meeting the group. Similarly, it is hard to distinguish common and individual benefits. In cognitive terms though, typically, these difficulties do not seem to apply as strongly. Modeling allows, on one hand, for giving a cognitive existence to all elements, at all levels; and on the other hand, modeling also allows for possibly providing the simplifications with respect to the real, physical world, as necessary, in order to reach the goal.

To better succeed in this evolution towards social ACS's, some further progress in science and engineering is required for social technologies and cognition.

7 Conclusion

Mankind has gained a decisive advantage in the race for survival, and people's satisfaction with their lives has started a dramatic growth in scope, when their cognitive abilities, cognition, appeared and started to develop. Five theses about cognition are summarized below: cognition to know the world, to explore and perceive, to model; cognition for defining alternative worlds and possible futures, visions, for anti-causality; cognition for effective control; cognitics for a large scale, technical deployment of cognition; and social cognitics, a foundation for team action and increased momentum for change. The five theses can be seen both as paths towards better insights in human and social nature and also as a roadmap for simultaneous and iterative processes capable to freely foster a better future for individuals and society.

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