Artificial meta-system transition to clarify useful novelty control.

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Abstract

The research on useful novelty control is a research on artificiality, self-organizing rationality, useful novelty, creativity, innovation and artifacts. The research is an analytical investigation of how artificiality is in control. Three system transitions are suggested to understand the control: higher-level cognition is an aggregation of a lower-level cognition and can itself be an aggregation to a phenomenal cognition. Each cognitive level the autonomy and capacity of the virtuality increases: lower-level will virtualize to concepts, the higher-level will adapt the concepts, the phenomenal-level experiences the concepts. The virtuality has a clear evolutionary advantage but there is a catch, it can be destroyed in a blink. Sustainability is reached when virtuality links to physical properties, and externalized to the physical world. The virtuality becomes even more fit when it is embedded in artifacts. Artifacts seem to have their own evolution and become a second example for the HL-architecture. Two possible natural implementations of the HL-architecture are recognized and will be used in the defense of this research.

1 Introduction

Simon on "The sciences of the artificial" uses the term artificial as "man-made, as opposition to natural" [Simon, 1969, p 4]. This paper contributes to the research, by investigating how a conceptual abstract world can natural exist in a physical world. It is an attempt to understand how "representing abstract" can have evolutionary roots. By assuming "default" cognitive categorizations, merely by mapping of environmentally "fit" configurations [Heylighen, 1994]. A concept as "stones are hard" should get abstracted in a self-organizing way, by a basic or lower-level (LL-)cognition. Some living systems have evolved into a goal directed approach to fitness. Leading to a problem solving system that can categorize the patterns context-depending. The goal directedness, problem solving and context-dependency are new control structures next to the categorization. They form the architecture to deal with complexity. Related is Hollands view on Complex Adaptive Systems (CAS) [Holland, 1995]. His CAS model contains four properties and three mechanisms. The properties are: aggregation, nonlinearity, flows and diversity. CAS-mechanism includes: tags, internal model and building blocks. The CAS scheme does not look complete, like the absence of "bootstrapping". By evolution the environment becomes filled with systems capable of adapting. The fittest living systems would evolve fit architecture. Using Turchin meta system transition [Turchin, 1977] the artificiality can be divided in three transitions. Each level can overcome the weakness of that level by an aggregation. The first level is well known both natural (Pavlov kind of conditioning) and artificial (machine learning techniques). The bottleneck of the LL-cognition is context-dependency and dealing with novelty. The second level is the investigation at hand; many researchers are working on higher-level (HL-)architecture in different settings. Two questions that need answers are: How can such architecture be evolutionarily natural? What are the necessary and sufficient conditions for such architecture?

In the next chapter the cognitive levels will get outlined to clarify HL-architecture and its limits. The architecture outlines how an adaptation process between virtual concepts and physical properties can exist. While the whole investigation was based on living systems it can be applied to artifacts as well. Artifacts are primary created to extent and expand human capabilities, but seem to have an evolution of their own. The interplay between science & technology is again an adaptation process between virtual concepts and physical properties. The last chapter will look at two possible natural implementations of HL-architecture. It may well illustrate how natural virtuality actually is.

2 Three levels of cognition

The first and most important aspect of the cognitive space is information. After analysis, there seem to be three systems transitions. Each meta-level is created by aggregation of several similar systems. The virtuality becomes stronger after each transition and each level a new aspect is introduced. The LL-cognition will form the basis; it will be the building blocks for artificiality. The higher-level will add adaptability by creating architecture to manipulate information. The effect of HL-cognition creates two important changes. The information becomes the controller and it creates artifacts. For example, notice a child does not have a similar attention span than an adult. We learn how to be more in control by creating several cognitive tools for it. So we learn to create control architectures: no hard-coded architecture (like the HL) can be found. The new feature of the phenomenal-level can be in general described as meta-experiencing to overcome the bottleneck of the higher-level: clarity.

2.1 From lower-level to higher-level

The LL-cognition is the reality getting "virtualized" to information. By conditioning (or so-called training) distinct features get extract out of the environment. The adaptation of LL-cognition will lead to self-organization of patterns that can represent the features of the reality relevant to the conditioning. Some researchers are using architectures to make more dynamic or context depending categories. Such architectures are however a new level of control. During the research, the suspicion arose that one fittest architecture exist to deal with the problem. For example the architecture of "Animat Brain" is based on motivation, environment and memory [Red'ko, 2006]. It seems several different disciplines are emerging to a similar structure as all are dealing with a same problem to control highly adaptability. In this paper the focus is on the necessary and sufficient conditions, the structures that build the architecture are neglected for now.

2.2 Higher-level cognition

The current HL-architecture has been growing from its first implementation attempt [Kiemen, 2003]. The architecture exists out of specific evaluation models, based on recursively pattern matching or "tuning to context". The recursion is not straightforward but passes a working memory. Every pattern match happens in one context, but the raw information itself has several contexts. Each type of match ends up in the same working memory pool, it can have influence for the other evaluations. The latest version of the architecture exists out of four evaluation models. Each does simple matching:

- **external:** Tuning the stimuli to structures of the Long Term Memory.
- **internal:** Matching concepts in the working memory with conceptual similar patterns.
- **directional:** The information flow in the working memory can contain motivational concepts, they can be pinpointed and use to direct/control/filter the flow.
- **adaptational:** Matching the current experience with past experiences.

The HL-cognition can be split up to an evaluation level and a behavior level. The behavior level is a minor transition, created by speeding up the four interacting evaluation models. To understand very specific each evaluation we do need to account every previous evaluation step. In pervious paper [Kiemen, 2006] the example of recognizing a face did require several modules on the evaluation level. By neglecting the few evaluations the perception becomes a pure "external issue" on the behavior level. For the behavior, thoughts may linger and dwell. For example traveling does only require periodic attention; between those attention moments we can dwell on issues not at all related to the traveling.

On the behavior level we distinguish two types of learning (or more general adaptational processes). There can be a virtual concept that needs to get tried out; this has been called behavior mastery. Reflection will work the other way around: several physical examples can get abstracted to a virtual concept. The two types of adaptation are related to a specific pattern of the evaluation level. With reflection the motivational focus is on adapting the internal and the external is neglected. For the behavior mastery it is the other way around: adapting the external and the internal gets neglected. It is as such a recursive bootstrapping system more generally knows as a constructive learning behavior.

2.3 CAS and RRC

While the evaluation seems to relate to CAS, the behavior level needs a more specific scheme. The framework explored by Ezhkova [Ezhkova, 2002] can help for the behavior. She suggests a framework of Relativity, Rationality & Clarity (RCC) and "tuning to context" as a mechanism. It is clear that the RRC scheme is a specialization of CAS and a complex system by its own [Ezhkova, 2004]. The CAS properties are applicable to the evaluation level: The flow of the evaluations leads to a diversity of exploring information. The aggregation between the models (by interaction) enforced selection on the exploration. The information itself is the key to control. As such some information can radically change the process of evaluation, producing a nonlinear behavior. The RRC properties are more related to the behavior level. By the structure of the architecture the relativity is inherent to the system. By pinpointing one concept property (virtual or physical) to learn its relation to the other type (physical or virtual) the concept becomes rationally expanded. The self-organization is related to the useful novelty produced by the interplay of the learning types that can only occur when a particular knowledge is clear (reached a certain distinguishability). The aspect clarity touches the limits of a single HL-cognition system as the process requires vast amount of experience, learning, and again experience (to increase the trust of learned relations).

2.4 Higher-Level aggregation

Information is for HL-cognition more than "virtualizing reality" it becomes clearly the output of a tagging mechanism. The difference between the tags and the relations such tags implies, will be the difference between information and knowledge. The externalizing process [Clark and Chalmers, 1998] allows putting information back into the environment, making information explicit, while knowledge only stays in the head. For example a story is composed out of words. The words are information but the story is knowledge. The words are defined, but the story can be interpretated. Notice when people perceive a word it becomes knowledge as people immediately start linking all the connections that word implies. The transformation from information to knowledge is in the HL-architecture a natural consequence of the internal evaluation. The externalizing used to put information back in the environment is a door to open aggregation (via language) between HL-cognitive systems.

The process of internalizing and externalizing the information is a specific case of the behavior mastery (internalizing) and reflection (externalizing). The whole external and internal world seems to be reversed. The internal world will be the trustful world now, as it is build up by experience. The (explicit) information on the other hand is more doubtful; it has to fit the internal world. In relation to clarity notice how useful novelty increases by the interaction: By externalizing new ways to express thought can occur; this is reflection. Internalizing can leads to new knowledge by interpretation of the information and creating new links; this is behavior mastery. What has been a system for learning on the higher-level is been used at the phenomenal-level to capture attention. As such going from adaptational processes to stimulating clarity can be reached.

2.5 A guess on next transition

As clarity becomes the bottleneck for HL-cognition, the fittest aggregation will enhance the control of clarity on the next level. The interaction between many HL-cognition already helps but how does it become fittest and how can it be explained on the basic level? Lets use reflect. In the low-level no architecture can be found, it is the capacity added to the system to have more control. So it would be reasonable to find a new feature for the next-level. As each level requires another mindset, it may simply be our lack of knowledge that makes the problem.

There are experiments on our visual perception that may bring solace. Gestalt psychology shows us how we experience clearly and holistically. The classic example is to show us a picture with not enough distinguishability to recognize it. The picture becomes sharper and after recognition even the less clear pictures can be recognized. The experiment shows how to enforce clarity. So what exactly is new to the artificiality? It seems the new feature could be called meta-experiencing. Experiencing is a basic neural feature, but experiencing the experience would mean experiencing the working memory flow, so it is on top of the HL-cognition.

Another way to find more understanding is to look at the literature on consciousness to find any clue. As the literature is large, it can only be briefly touched. The literature can be divided in action and phenomenal consciousness. With a basic understanding, action consciousness seems related to rationality, a feature of the HL-cognition. The definition of phenomenal is: perceptible by the senses or through immediate experience. One quote about phenomenality does seem very similar to the problem at hand: "Why should physical processing give rise to a rich inner life at all?" [Chalmers, 1995]. As such it seems appropriate to reefer to the next-level as the phenomenal-level.

3 Artifacts

Artifacts will be defined as those virtual-concepts that are externalized. Such artifacts can be symbolical or useful. Symbols will be weak as an entity: a culture is needed to give meaning to the symbol. When enough information is externalized it can be more sustainable. Still as with the burning of the Alexandria library many narratives may have been lost forever. The useful artifacts seem more robust to cultural change as the competing culture can make use of such artifacts. This type of artifact has a clear evolutionary sustainability.

3.1 Useful artifacts

The useful artifacts will evolve from basic tools into technology. Mokyr describes a historical narrative on technology [Mokyr, 1990], the stories clearly illustrate technological evolution. In later work Mokyr describes useful knowledge as well [Mokyr, 2002]. With technology also science comes into play. Let us clarify with a [Mokyr, 1990, p 167] on how Gille sees the distinction between science versus technology:

> Gille [Gille, 1978, p 1112], who has examined the nexus closely, suggests a distinction based on purpose: science aims at comprehension, whereas technology aim at utilization.

For the research on artificial, one specific trait in Mokyrs work is most important. Science has been wrong many times. A famous example is the alchemic dream to transmute lead into gold. Another example would be the redundant concept 'aether' as medium for radio. Some concepts were wrong, but other defines our current reality. Latour throws light on how science in action really works [Latour, 1987]. For this paper, the failures in science can be seen as virtual-concept that never got linked to reality. They got irrelevant after another theory does links back to reality (in the examples it was nuclear physics and wave theory). In many cases no conceptual difference is seen between the social context or the physical environment. In one of Latours examples a labor representant and a nuclear physician are seen as a same kind of mediator. The first person mediates the labors will to the management. The second person mediates the physical laws to his fellow researchers.

To ensure the innovation is rational, a strict definition of innovation is used: Novelty will be innovation when it leads to adaptation of the social context or the physical environment. By this definition, potential innovations (that did not come to production) are no innovations, but merely novelties. Also technology will be used on a particular way, where social structures will be seen as technology. By these definitions the interplay of science and technology can become more useful. Science behaves similarly to reflection (creating virtual concepts of physical properties). Technology can be seen as behavior mastery (creating physical properties of a virtual concept).

3.2 Artifacts and cognitive levels

Practical artifacts become advanced. Simon described in a later revision [Simon, 1996] symbolic systems or rational artifacts like computers and humans. Although both may be rational artifacts it are humans who self-organize rationality, while computers are just extending human reasoning. Extending humans is the primary goal of artifacts. The first sustainable artifacts where symbolic, used to stimulate cultural (and religious) experience. When the virtual concept does not get linked back to physical reality, it leads to rhetoric, not rationality. Rhetoric is useful for the phenomenal-level; those artifacts are the easiest and most powerful at start.

Rationally expanding concepts (pinpointed virtual or physical to learn the other type part) is an intense process. The subset of useful knowledge has gained power only recently. Mokyr describes how just before the industrial revolution the need to write down book on technology occurred. From both Mokyrs and Latours work it becomes clear how important technology is to science. By technology we can truly understand the nature of the world and as such reinforce the science. With computers, artifacts have reached LL-cognition (self-organizing patterns). Regardless of the fact that humans are the medium for science & technology the artifact doe seem to follow a similar evolutionary process. However the artifacts are only at the first stage of artificial levels.

3.3 Artifacts and clarity

The interplay of how science and technology define each other, has of course influenced our own research on the cognitive levels. Currently, computers aid in rationalizing LL-cognition. The higher-level and the phenomenal-level are currently virtual concepts without physical properties. The stories on scientific failure show maturity comes from linking new concepts to physical properties. So how can we learn the physical properties of higher-level or phenomenal-level? For the HL-cognition we can search and implement the architecture. The phenomenal-level needs to be approached differently. A promising approach is cyborg technology. For example the sensory substitutability brings a conflict with our experience of consciousness: It makes consciousness less physical than expected. Maybe the concept of consciousness is as unlikely as the concept of 'aether'. Another example is to see cyborg technology as natural phenomenon [Clark, 2003; 1996]. Most people wouldnt call cyborgs natural, but would call consciousness natural not artificial. More related to this paper the approach is to treat the interface as a complex fractal design and the illusions as a nesting of contexts [Vrobel, 2006] that could link back to the behavior of the HL-architecture.

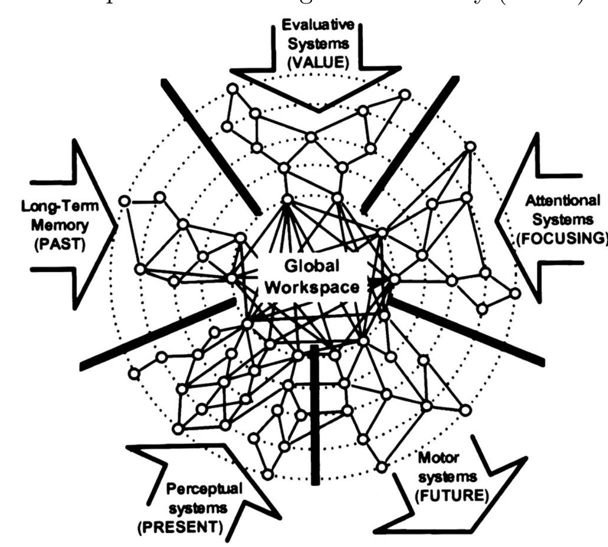
4 Natural implementation

Two empirical implementations have been recognized as a HL-architecture. Both very different from each other, but both created to solve the same problem: to increase useful novelty. Both models are analytical descriptions of natural phenomena. The first implementation is found in the brain. This may be expected as HL-cognition was of course focusing on the behavior producing creativity. Human behavior has been a case study in the research. The second implementation is created by Latour on his study of how science & technology works. For both implementations it is interesting how well they match the architecture.

4.1 Global workspace

The region in our brain known as "workspace" has as much a theoretical as empirical research on it, and several parts of the cortex are involved. In a recent hypothesis of the global workspace (fig.1) we see a remarkable similarity with our theoretical model. Only one extra entry is recognized: the motor system. The other entries could be related as follows:

- internal → Evaluative Systems (VALUE)
- external → Perceptual Systems (PRESENT)
- directional → Attentional Systems (FOCUSING)
- adaptational → Long Term Memory (PAST)



Global workspace [Dehaene *et al.*, 1998]

In respect to the specific context a living system needs to deal with motion, a specific evaluation module for it would be logical. The diagram talks about entries not evaluators. The term evaluation has been used in a programming modeling way. However the interpretation of the underlying system may be very different and it is expected to be so in the case of a neural network. In case of neurons the largest part of the evaluation may be realized by (simultaneous) firing of neurons.

4.2 Useful artifacts

The relation between HL-architecture and useful artifacts leads to science as "reflection" and technology as "behavior mastery". As such technology & science have been related to the behavior level of HL-cognition. Bruno Latour as an anthropologist on science has come up with a model (fig.2) to understand how science (and technology) leads to innovation. The examples used to construct the model are very depending on the social structure of the West. If we look at the historical analyses of Mokyr about innovation in China around1400 [Mokyr, 1990], we understand how the bureaucracy can be the medium for transition. It should be clear that the two social contexts are radically different, Latours model being general enough, should hold for both social contexts.

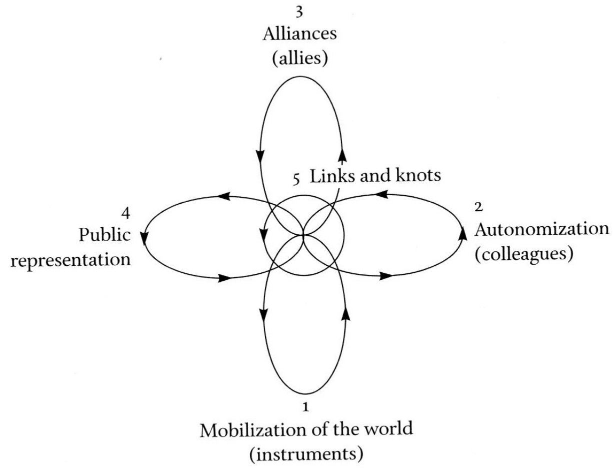
The model contains five loops. The "links and knots" is the place for feedback, what is similar to the working memory in the previous scheme. So again a remarkable similarity is found. Let us give some more information on the terms used.

- internal → 1 Mobilization of the world (instruments)
  What is called the "Mobilization of the world" is to bring the world to workable environment for the research (tools to measure, frames to apply, etc.); this is the internal-context as it makes linking to other bodies of knowledge possible.

- external → 4 Public representation
  The public representation is exactly what it means. Some research (for example cloning) has known much resistance. Other work, like the Internet, has known a social adaptation so intensively that much research has started asking questions about it. As such the public representation is an external factor that has a big impact on which science & technology get realized.

- directional → 3 Aliances (allies)
  The "Alliances" is what provides the system with the required goods (funding, data, raw material, etc.) to produce the research: funding institutes, political policy, venture capitalists, etc. It defines means for work and therefore it is the directional-context.

- adaptational → 2 Autonomization (colleagues)
  The "Autonomization" is the colleagues (peers) who do similar research and use frames to communicate about the research (and if possible automate it). As such the autonomization creates vast amounts of experience; it is the adaptational-context.



Innovation diagram [Latour, 1999, p 100]

5 Conclusion

To clarify cognition, three levels were suggested, based on evolutionary fitness applied to cybernetic & system thinking. LL-cognition self-organizes to patterns and the fittest aggregation leads to HL-architecture. HL-cognition self-organizes to rationality and its fittest aggregation leads to phenomenal cognition. The focus of this paper is on the HL-cognition. The higher-level has a minor transition between the evaluation level and the behavior level. The evaluation level can be related to CAS and the behavior level can be related to RRC. The aggregation to the phenomenal-level has been explained in more detail to understand the (seemingly) reversed adaptation process: "own knowledge" becomes more reliable than "other people's information". The self-organizing rationality becomes more sustainable by embedding concepts in artifacts. Useful artifacts have reached the LL-cognition, but more interesting is how it extends cognition. Evolutionarily, the artifacts stimulating phenomenal concepts are older than useful artifacts. Several investigations can be done from the current point: falsifying the relation between HL-architecture and the natural implementation; simulating in more detail the HL-architecture; even practical applications like using the HL-architecture for innovation management.

At the moment the research brings us some questions on the evolution of artificiality. The rules of the artificial world seem to behave very differently from the physical world and are as such counter intuitive. It all becomes more investigatable once another HL-architecture exists to compare with. Both the living systems and the artifacts seem to have that similar pattern (HL-architecture). In the physical world it is complicated, as the living system produces the artifacts, the relation is entwined and bootstrapping. Notice such increase in complication is true for all sciences, it is the difference between theoretical and operational research. The artificiality seems to be natural: an evolutionary fit feature. So-called intelligence seems to arise from the adaptation power, optimized by each transition. Each transition does require a new mindset to work in. In relation to meta-system transition it is expected to have other mind sets for investigating each level.

While the primary goal of the research is to bring clarity, it is of course the dream to create intelligent artifacts. With the findings of the HL-architecture to explain technological & scientifical innovation, a radical change of mind is needed to stay in-line with the findings: The artificial transition may be more present than acknowledged. Two questions seem to arise. Can useful technology with HL-architecture be created or even phenomenal artifacts? With respect to the transition can there be a meta-level above phenomenal cognition?

For the first question, the problem with the HL-architecture is that it needs complex environment to operate. As many IT systems try to minimize the complexity a lot of work has to go to increase the complexity. For innovation management the primacy seems to exist, but the control becomes more delicate. At least a constructive answer can be given; this is not so evident for the second question. The rationalization of the phenomenal-level is even far off, so we enter pure speculation now. To find a meta-level above phenomenal cognition, one needs to know the limits of the phenomenal-level. The only reasonable limit left seems to be the limit of our imagination. The only recognized pattern over all transitions so far it the aggregation of the sub-level systems to the meta-level. As such it seems a diversity of phenomenal systems are needed to aggregate to a meta-level. It may be clear the current environment has but a small diversity in phenomenology: by the different cultures. We dont even have a clue what a radically different phenomenal entity would mean.

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