An Attempt to Generalize AI Part 17: What I'm Thinking

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This is the seventeenth in a series of articles attempting an overview of how minds may work and how similar systems could be implemented in computers. The cognitive model and approach to artificial intelligence uses a probabilistic hierarchy based on *patterns*. A pattern has a specification describing a set, or population, of *pattern instances*, distributed throughout a hierarchy containing the pattern instances of all the patterns. The hierarchical model is actually used to plan the system's actions, and this implies that what people regard as the "self" is really an object in the hierarchical model. The hierarchy needs to be relevant, with pattern instances that are useful being featured in the hierarchy, and used as a basis for exploratory extension of the hierarchy, while less useful pattern instances are removed, so that the hierarchy "grows" into high-relevancy regions, and this is achieved by an *exploratory relevance process*. This uses a back-propagation *relevance measurement process* which assigns relevance values to pattern instances. Relevance can also be provided by *reflexive outputs*: special outputs that are made in the same way as normal outputs, but which alter the hierarchical model. This article will be less formal and structured than previous articles. The cognitive model, as described so far, presents issues regarding its future development, and I wanted to give an idea of my thoughts on some of them. Some of my thinking on these issues is not fully developed, or very well-defined, and I did not want this to get in the way of being able to give some idea of what my views are. In this article, I will therefore, informally, say what I am thinking about various issues regarding the cognitive model.

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List of Abbreviations

AI	artificial intelligence
BERP	basic, exploratory relevance process
ERP	exploratory relevance process
RMP	relevance measurement process

1 Introduction

This article is the seventeenth in a series intended to develop a model of human cognition which could be used for producing artificial intelligence (AI). For anyone who has not read all the previous articles to date, I suggest reading *An Attempt to Generalize AI – Part 15: A Complete Description*, available at http://www.paul-almond.com/AI15.pdf.[1] This article is an ideal starting point, because it gives a complete description of the cognitive model that has been developed so far.

The previous articles have been used to develop a model of cognition, and approach to AI, and discuss some general philosophical issues relating to this.

The cognitive model involves a hierarchy based on *patterns*, which are sets of *pattern instances*.[2] The system is not there just to model the world: It needs to plan actions. Planning is provided by the *action selection process*, which involves using the modeling system to model the system itself to plan its behavior.[3]

The view of planning of actions taken in this series has implications for our view of the "self".[4] In this view, there is no separate system, outside the hierarchical model, that is planning all the actions. Planning is something that is done mainly within the model. The system has no special "self-modeling" process. Instead, what we think of as the "self" is part of the model within the hierarchy, generated in much the same way as the parts of

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[1] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc.

[2] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.10-31.
Almond, P., 2010. *An Attempt to Generalize AI - Part 1: The Modeling System*. [Online] paul-almond.com. http://www.paul-almond.com/AI01.pdf or http://www.paul-almond.com/AI01.doc.
Almond, P., 2010. *An Attempt to Generalize AI - Part 5: A Completely Probabilistic Hierarchy*. [Online] paul-almond.com. http://www.paul-almond.com/AI05.pdf or http://www.paul-almond.com/AI05.doc. pp.8-29. (Part 5 supersedes the description in Part 1, which referred to the (now obsolete) concept of "fixing".

[3] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.32-41.
Almond, P., 2010. *An Attempt to Generalize AI - Part 2: Planning and Actions*. [Online] paul-almond.com. http://www.paul-almond.com/AI02.pdf or http://www.paul-almond.com/AI02.doc.

[4] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.53-56.
Almond, P., 2010. *An Attempt to Generalize AI - Part 2: Planning and Actions*. [Online] paul-almond.com. http://www.paul-almond.com/AI02.pdf or http://www.paul-almond.com/AI02.doc. pp.23-24.

the model that deal with any other aspects of reality. A view of cognition in which the "self" is part of the model has been described by Thomas Metzinger.[5]

The hierarchy needs to be *relevant*, which means including the pattern instances that represent those features of the world which are most useful in planning actions and excluding others. This requires a way of measuring the relevance of pattern instances, and this is provided by the relevance measurement process (RMP).[6] The RMP starts with particular pattern instances, used in the action selection process and corresponding to future inputs, being assigned relevance and this relevance is then back-propagated so that other pattern instances are assigned relevance. The relevance values are used in a *basic, exploratory relevance process* (BERP), which involves continual removal of low-relevance pattern instances while the hierarchy is extended from the pattern instances that remain.[7] "Forgetting" – the removal of obsolete pattern instances – is also provided by the BERP.[8]

There are various ways in which the sophistication of the BERP might be increased, giving an improved exploratory relevance process (ERP).[9]

Relevance can also be provided by *reflexive outputs*: special outputs which, while made in the same way as other outputs, are directed inwards, acting on the hierarchy itself.[10]

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[5] Metzinger, T. (2003). *Being No One: The Self-Model Theory of Subjectivity*. Cambridge, MA: MIT Press. Metzinger, T. (2009). *The EGO Tunnel: The Science of the Mind and the Myth of the Self*. New York: Basic Books.

[6] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.53-56.
Almond, P., 2010. *An Attempt to Generalize AI - Part 6: Measuring Relevance*. [Online] paul-almond.com. http://www.paul-almond.com/AI06.pdf or http://www.paul-almond.com/AI06.doc.

[7] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.57-64.
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[8] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.77-85.
Almond, P., 2010. *An Attempt to Generalize AI – Part 8: Forgetting as Part of the Exploratory Relevance Process*. [Online] paul-almond.com. http://www.paul-almond.com/AI08.pdf or http://www.paul-almond.com/AI08.doc.

[9] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.70-76.
Almond, P., 2010. *An Attempt to Generalize AI - Part 9: Improving the Exploratory Relevance Process*. [Online] paul-almond.com. http://www.paul-almond.com/AI09.pdf or http://www.paul-almond.com/AI09.doc.

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[10] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.85-90.
Almond, P., 2010. *An Attempt to Generalize AI - Part 13: Reflexive Outputs*. [Online] paul-almond.com. http://www.paul-almond.com/AI13.pdf or http://www.paul-almond.com/AI13.doc.

2 Various Issues

2.1 Ontology

Is the existing ontology (patterns and pattern instances) general enough?[11] Can we think of some feature of reality that could not be represented in the model?

How should the pattern specification be represented? In previous articles, the construction specification has been viewed as a computer program, capable of examining the "wiring" of the hierarchy and setting up pattern instances.[12] (Variations of this may include existing pattern instances in a pattern to some degree, rather than setting them up.[13]) This issue needs consideration. The method of representing pattern specifications that is used must allow a reasonable chance of generating viable patterns, either randomly, or by random variation of existing ones in a Darwinian process. Existing work on simulation of Darwinian evolution may be relevant here. Maybe it would make sense to talk to someone with experience in evolution of computer programs or similar information processing systems?

Not much is being asked of a pattern specification: It is intended to use the hierarchy that is already there and would be a small amount of complexity built on top of it.

Is there any way of reducing the pattern specifications so that everything becomes basic components, rather than having this hierarchy and the pattern specifications existing "outside" it, encoded in a more complicated way?

2.2 Action Selection Process

The action selection process is needed to start the system off and establish a history of improving behavior.[14] Is the required behavior accessible? Would it be possible and

[11] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.10-31.
[12] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.16-19.
[13] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.91-94.
[14] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.32-41.

desirable to "come in higher up" in some way, so that the action selection process involves manipulating pattern instances above the bottom level of the hierarchy?[15]

Could there be some way of back-propagating through the hierarchy to get the required behavior?[16]

2.3 Exploratory Relevance Process (ERP)

The exploratory relevance process (ERP) attempts to grow the hierarchy into relevant "regions".[17] There may be some structures that appear repeatedly in a relevant hierarchy, and use of these structures might make such a process faster. Could anything like this be needed?[18] It should be noted that the hierarchy will tend to guide its own development to some degree: A high level pattern instance, persisting in the hierarchy with high relevance, will tend to dictate the relevance of lower-level pattern instances, so the pattern instances already in the hierarchy will tend to impose a structure on future growth. We might generalize this. Rather than just thinking of reusing structures, we might say that the high relevance parts of the hierarchy will have patterns that could be exploited in future growth of the hierarchy. Whether some method of more explicitly doing this is required is debatable. There is one reason for thinking it may be: The ERP, like Darwinian evolution, has a short-term view. A pattern instance may have low relevance and be removed, even though, if it were allowed to remain, other pattern instances might be added later that cause it to have high relevance.

All of this suggests the idea of maybe applying something like the hierarchy to the hierarchy itself and its distribution of relevance values. Another possible solution could be reflexive outputs: if they could be made practical in a deep way, they would actually fulfill the role of a more sophisticated system capable of exploiting previous patterns.[19]

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[15] This idea was previously mentioned in Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.40-41.

[16] and if I knew the answer I would not be *speculating* here.

[17] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.57-64.

[18] I have been thinking about the idea of explicitly allowing reuse of structure for a while now, but thought about more after Dr Georges Otte kindly sent me a copy of Mansour, H., 1983. *A Structural Approach to Analogy*. [Online] DSpace@MIT. Available at: http://hdl.handle.net/1721.1/5657. Although this paper dates back to 1983, it does make a good point about reuse of structure. We *need* that: The issue here is how *explicitly* we need it. Sometimes, seeing something even peripherally related can make you think a bit.

[19] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.85-90.

The hierarchy has been described up to now as if it were some kind of "mass of probabilities" describing all possible futures, but there will clearly need to be some "splitting" in the hierarchy. Some pattern instances will need to be used to represent particular sets of possible futures. The ERP should deal with all this: Relevant pattern instances are encouraged in the hierarchy, and ones corresponding to specific, relevant possible futures would be relevant. This raises the issue, though, of whether the system could progress more rapidly if there were some kind of explicit "group splitting process", so that a group of pattern instances could somehow be split, en masse, to represent two possible futures. If this were done there would probably also be some "group combination process".

2.4 Reflexive Outputs

Reflexive outputs are made in the same way as conventional outputs and can be used to control the structure of the actual hierarchy.[20]

Why should we need reflexive outputs if there is a working ERP? The issues of reusing structure, exploiting patterns in the hierarchy and the short-sightedness of the ERP, just discussed in 2.3, are possible answers. Reflexive outputs might deal with these issues by allowing the system to use its own learning ability to learn how to manage itself. The system's own sophistication can be used to increase its sophistication. This seems a powerful argument for reflexive outputs *if* they can be got working.

Reflexive outputs should not replace the ERP: If we did that, we would have an overworked process for ensuring relevance. Instead, I imagine reflexive outputs working with the ERP: The ERP would give the "baseline" behavior of the system, and reflexive outputs would intervene to modify the system on top of this – pulling it away from this baseline – causing pattern instances to be added where the ERP would not have added them, or causing them to be removed where the ERP has added them.

One way of implementing reflexive outputs might be for each reflexive output to be associated with a specific pattern. When activated, the reflexive output might "boost" the relevance of any pattern instances of that pattern. Clearly, this could not be done for all patterns: Different patterns might be tried. The emphasis would probably be on patterns that tend to have high-level pattern instances, or patterns with pattern instances that tend to interact directly with pattern instances of patterns already associated with reflexive outputs. A similar kind of mechanism might be used to *reduce* relevance.

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[20] Almond, P., 2010. *An Attempt to Generalize AI - Part 15: A Complete Description*. [Online] paul-almond.com. http://www.paul-almond.com/AI15.pdf or http://www.paul-almond.com/AI15.doc. pp.85-90.

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Almond, P., 2010. *An Attempt to Generalize AI - Part 3: Forgetting*. [Online] paul-almond.com. Available at: http://www.paul-almond.com/AI03.pdf or http://www.paul-almond.com/AI03.doc [Accessed 7 August 2010].

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Almond, P., 2010. *An Attempt to Generalize AI - Part 12: Pattern Relevance*. [Online] paul-almond.com. Available at: http://www.paul-almond.com/AI12.pdf or http://www.paul-almond.com/AI12.doc [Accessed 7 August 2010].

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