CHAPTER 6

Discussion and the next steps
6.1 Discussion

This thesis proposes a new perspective on Artificial Intelligence and science in general. Instead of regarding the scientific endeavor as an analytic process, a generative and more active stance is proposed. The tools developed in science can be used to study intelligence in machines, but this intelligence needs more than being analytic. It requires an active machinery with possibilities to scaffold its internal (mental) structures.

In the first chapter of the thesis, the abstract machinery required for the automated creation of models is investigated. It is argued that most, if not all, of science could be extended with a generative perspective for a better understanding of the research topics. The analytic stance is not discarded, but can be used to study generative processes in general. The abstract machinery for the creation of models (and machine intelligence) forms the basis of Generative AI. Although the concept of Generative AI, and generative science in general, is not new, this chapter pushes the generative stance onto the center stage of its investigations. Disciplines other than AI, such as quantum mechanics, sociology, neurology, biology, and philosophy are investigated in order to describe the generative abstract machinery required for the scaffolding of mental structures. The metaphors of Generative AI are created from a bottom-up perspective, which is in concordance with the abstract machine itself. The abstract machine is recursive and applied to the development of neural structures in the hominid brain for demonstrative purposes. The last section formalizes the abstract machine.

The next chapters put the theory to the test. Previous research is treated using the new perspective developed in the first chapter. The second chapter deals with the use of evolutionary algorithms with a human giving feedback. The human acts as a fitness function. This requires that the internal mechanisms of the evolutionary algorithm have to be adjusted to the intelligent fitness function. The discussion of the previous research shows that the evolutionary mechanisms have a strong relation with Generative AI, and that many parts of the abstract machinery of Generative AI are available in contemporary research.

Chapter three discusses the foundations of modern computations. Although the chapter does not develop the abstract machine, it does demonstrate that Generative AI is ready for the revolution in computing which has recently started to drip from the academic world into the public: massively parallel computing. Most contemporary AI
algorithms are not ready to make good use of computers with hundreds to thousands of computing cores, but for Generative AI this development is very welcome. In Generative AI there are many parallel processes, which can easily be distributed amongst parallel computers using embarrassingly parallel computing.

The next chapter shows a complete implementation of the abstract machine developed in chapter one. A neural network, based on the primate visual cortex, is applied to the problem of handwriting recognition. There are several iterative procedures at work, such as the generation of examples by humans, which are used by machine learning algorithms to generate more examples which are then sorted out by humans. Circadian rhythms, where the machine learning is trained every night, produce these examples for the human sorting machine. Once a reasonable amount (two or more) of examples is generated, the model of the visual cortex is applied. The results are very good. With this cycle of the implemented abstract machinery a search engine is developed, which forms the next level of information processing. Although this 'next' level cannot (at the moment of writing) be used by machines, there is no reason to believe that this is theoretically impossible.

The last chapter applies the developed abstract machinery to a world-wide research initiative, called ROBOCUP@HOME. The metaphor developed in the first chapter is also applicable to the coordination of research. The metaphor of Generative AI is a useful tool to steer the development and to get a better grip on the research of the initiative. It is argued that it is possible to have standardized testing or benchmark procedures where the instances of tests change on a regular basis. The goal of the @HOME competition is the creation of a fully fledged personal assistant to be used in daily life. Since this is not (yet) possible the metaphor of sorting machines and generators can be used to incrementally improve the intelligent machines and to move into the direction of artificial personal assistants.

6.2 The next steps

Generative science and generative artificial intelligence are two concepts that might seem far fetched. The proposed methods are not traditional. The point of view on the matters of intelligence and science in general is new. The proposed methods imply that a wealth of computational power is needed if the program is to succeed at all. At the moment of writing this computational power is slowly seeping into academia around
the world. Many universities possess a high performance computer cluster. Some institutes have the luxury of an even bigger machine such as the Blue Gene \(^1\). History has taught us that this computational power will become available to the general public within a decade or so. This enormous amount of computing power will transform society in many ways. It does not matter whether the computing power arrives in the form of cloud computing, quantum computing or any other form. But it will come.

Those humans who are ready to seize the power of these computing environments will probably be the ones with more success than others. It might be difficult to see how to make good use of this computing power. This book discusses an algorithm tuned to multi-core and distributed computing. This book proposes a general methodology to tap into this ever growing power of computing. It discusses a framework of thinking which is not very common. But a new framework is needed. The old paradigms where solving toy problems on single-core computers was the way to perform science did not perform as predicted in fields with complex real world problems, such as robotics or handwriting recognition. It is for this reason that scientists in many fields of artificial intelligence know that another methodology is needed. It is no longer the question whether another way of working is needed. The question is: What is the new paradigm that will get AI out of the local optima it finds itself in?

The next steps involve the application of this framework. The ideas of dynamical systems theory has already been applied successfully in other disciplines. Now it is time to apply generative AI (GAI) to the problem of the creation of intelligent machines. Applying GAI does not require many changes. Probably existing research programs can incorporate GAI principles at any time. The biggest hurdle will be in the minds of the scientists themselves. If scientist do not accept a new perspective on their research, then machines will not become as intelligent as many hope. Although the theory of GAI might not be the one that brings us intelligent machines, it is a new way of looking at the same materials. A new point of view, especially one that might work, is always worth investigating.

The next steps are not written in this book. This book can only hope to serve as a generator of ideas. In the best case the book installed a generator in the mind of the reader and the reader will generate ideas about GAI. Perhaps the reader will even install GAI generators in the minds of others. It is up to the sorting mechanisms, such as the scientific community, whether the ideas of GAI are good enough to overcome the

\(^1\)http://en.wikipedia.org/wiki/Blue_Gene
problems of contemporary artificial intelligence. Since the principles of GAI only require a different way of looking at the problems AI face, it would be a small investment to acquire a potentially large gain.