Chapter 2
Review

Abstract One of the first challenges researchers in artificial intelligence (AI) tried to conquer was programming a computer to play chess that could compete on the same level as humans. It took almost 50 years but once achieved, they had to find other ways of proving the value of AI. Of particular interest was the idea or concept of programmable general intelligence that the human brain possessed. Naturally, other sub-fields spawned and looked into different aspects of general intelligence that were hoped would come together synergetically. Popular culture embraced AI with its utopian and dystopian ideas of highly advanced machines and robots working for, but usually eventually against, their human creators. Expectations therefore grew and AI researchers found themselves struggling to keep up and find funding for their proposals. Computational creativity, among other sub-fields of AI such as artificial life, artificial consciousness and machine ethics even made us question what it means to be human. In this chapter, we briefly review the path AI has taken, the factors that may have influenced it and the importance of advances in computational creativity in the second millennium.

Keywords Computational creativity · Artificial intelligence · Chess · Science-fiction · Approach · Technique · Brain

Sternberg and Kaufman (2010) offer a good coverage of the concept and theories of creativity across various disciplines (primarily psychology) but these are not particularly relevant here. The *concept* of creativity with regard to artificial intelligence (AI) , however, is pertinent. It was mentioned in the proposal that lead to the famous 1956 Dartmouth Summer School often remembered as the birth of the field (Boden 2009). Even so, the field was in its infancy back then and challenges specific to creativity as opposed to the 'mere' mechanization of tasks requiring human intelligence were generally unheard of (McCorduck 2004; Levy 2006; Ekbia 2008; Warwick 2011). Put simply, getting a computer to play *good* even though bland chess was enough of a challenge then than trying to make it play good and *creatively*, e.g. in a way that would surprise even the most stylistic human grandmasters such as the late Mikhail Tal. Analogously, generating a relatively simple

A. Iqbal et al., *The Digital Synaptic Neural Substrate*,
SpringerBriefs in Cognitive Computation, DOI 10.1007/978-3-319-28079-0_2

painting was enough of a computational challenge than creating a masterpiece (Cohen 1999).

With the defeat of then-world chess champion Garry Kasparov to IBM's Deep Blue supercomputer in 1997 (Newborn 1997) and the general successes of AI in many small but significant ways in other fields (e.g. medical diagnosis, law, stock trading), demand and expectations from machines grew. Even with the resounding success of computer chess today such as computer programs running on smartphones that play at the grandmaster level and computers being indispensable in the training of human grandmasters, some experts still wonder, *where is it going?*[1] The many popular science-fiction films such as *Colossus*: *The Forbin Project* (Sargent 1970), *Blade Runner* (Scott 1982), *Terminator 2* (Cameron 1991), *The Matrix* (Wachowski and Wachowski 1999) and *A.I.* (Spielberg 2001) depicting intelligent and lifelike machines may also have had an influence on societal expectations from the field, regardless of their generally dystopian outlook.

These productions are becoming more common and are dealing with even more sophisticated issues related to AI such as human-machine social interaction in the film, *Her* (Jonze 2013; Saunders et al. 2013) and the transcendence of genuine human existence into the digital domain such as in the motion picture, *Transcendence* (Pfister 2014). Computational creativity therefore began to receive more serious attention from academia at the turn of the second millennium (Colton and Steel 1999; Buchanan 2001) perhaps to address some of these expectations and new challenges, in particular those related to the burgeoning Internet (Battelle 2006). While most applications in this area are generally small and task-specific as is also the case with traditional AI, others are far more ambitious and aim to replicate the workings of the entire human brain.

These would include projects that hope to 'give rise' to creativity and perhaps even what is known as the technological 'singularity' (Holmes 1996; Seung 2012; Kurzweil 2012). This is when AI supposedly will overtake human intelligence and radically alter the world we live in. Even an attempt to mimic the functioning of a cat's brain (Ananthanarayanan et al. 2009) was mired in controversy about its actual performance (Shachtman 2009) so we can be fairly skeptical. There are also approaches that lie somewhere between traditional AI and computational creativity such as IBM's *Watson* supercomputer which is apparently capable of extracting information and determining proper context; in English, at least. In short, it can 'read' and answer questions meaningfully (Chandrasekar 2014). However, it cannot create any novel content of its own, such as producing a book like this.

In principle, many of the fundamental approaches or techniques[2] that have been developed in AI such as artificial neural networks, genetic algorithms and evolutionary computation (McCulloch and Pitts 1943; Box 1957; Fraser and Burnell

[1]Kasparov, G. Personal Communication (with main author). 25 April 2014.

[2]This is what makes them *fundamental*, i.e. they work to a reasonable extent and have had demonstrable applications beyond a single domain or task. Note that being *task*-specific is even more constrained than domain-specific. There is also the 'no free lunch theorem' to consider.

1970; Back et al. 1997) can and have been applied to varying degrees in computationally creative systems (Abe et al. 2006; Terai and Nakagawa 2009; Correia et al. 2013; Machado and Amaro 2013). Such systems may also take the approach of combining information or knowledge from within the same domain using mathematical logic, statistical modeling or some form of machine learning, which is also used in mainstream AI (Cope 2005; Eigenfeldt and Pasquier 2013). A tempting idea is for a computationally creative system to also learn from its own 'experience', much like humans are thought to do (Iqbal 2011; Grace et al. 2013).

However, the methods these systems use tend to be domain or task-specific as well. There is nothing inherently wrong with this if the system performs well but it is certainly not any kind of *general* intelligence or 'creativity machine' that the human brain is; some brains more so than others.

In summary, the arsenal of approaches and techniques available in mainstream AI have trickled down to computational creativity and given rise to new types of applications that apply them somewhat; examples include those that generate creative objects, and assess beauty or 'interestingness' (Iqbal et al. 2012; Pérez and Ortiz 2013). At the same time, computational creativity researchers have found new ways to adapt mathematical logic and existing AI to suit their purposes. However, we could not find any approach documented in the literature that was able to successfully integrate discrete information from two or more unrelated domains so as to produce viable creative output in either one of the original sources. This is different from producing simultaneous outputs in more than one domain based on a particular set of inputs and with the help of an AI engine (Benghi and Ronchie 2013). The successful integration of discrete information from multiple, unrelated domains for computational creativity purposes may be important if one subscribes to the notion that creativity in a particular domain can be borne out of 'inspiration' obtained from more than one domain.

Take, for example, a musical piece composed that the composer says was inspired by the photo or memory of a beautiful companion. Whether or not such information in the brain is aggregated through systematicity (Phillips 2014; Clement and Gentner 1991) is presently unproven and therefore not assumed to be something our approach should be based on. So is codification of context-specific, high-level concepts really necessary for this or do low-level 'mindless' mathematical interactions suffice? The process of biological evolution is said to be a mindless and semantic-independent one that actually produces minds and even 'free will' (Dennett 1996)[3] even though there is much debate regarding the nature of the latter, particularly in association with the notion of 'consciousness' (Chalmers 1995; Harris 2012).[4] This is worth noting because consciousness and free will are often held by many as prerequisites to creativity.

The idea held by many dualists is that 'genuine' (and general) creativity cannot be described in terms of a computable, and hence fundamentally mathematical or

[3]Dennett, D.C. Personal Communication (with main author). 27 August 2012.

[4]Chalmers, D.J. Personal Communication (with main author). 17 November 2012.

algorithmic, process. In the specific case of chess problems there has never, to our knowledge, been an approach to automatic composition that relied on a 'creative process' that was independent of human involvement and that could also, in principle, be applied to other areas. Iqbal (2008, Sect. 2.4) provides a more detailed review of the main approaches in this regard that have been used in the past.

In the following chapter, we nevertheless present our novel approach to computational creativity as applied to chess problems. We have intentionally left out the numerous other techniques in AI and computational creativity to compare against to retain focus on the main subject matter of this book and more importantly, because they are fundamentally different to the one we propose even though they may be applicable to the same problem discussed. Ours, however, not only works given the aforementioned problem of quality automatic chess problem composition but is also scalable, in principle, to other domains. We therefore present our research in the practical spirit of fundamental science in that if something can be shown to work—even in a limited domain initially—*why* it works is of secondary importance. In fact, we readily concede there are open questions of this nature which are briefly discussed in Chap. 6.

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http://www.springer.com/978-3-319-28078-3

The Digital Synaptic Neural Substrate
A New Approach to Computational Creativity
Iqbal, A.; Guid, M.; Colton, S.; Krivec, J.; Azman, S.; Haghighi, B.
2016, XV, 119 p. 13 illus., 4 illus. in color., Softcover
ISBN: 978-3-319-28078-3