

Preface

Why Does Computing Matter to Creativity?

This book, *Computers and Creativity*, examines how computers are changing our understanding of creativity in humans and machines. It contains chapters from twenty-five leading researchers in this field, on topics ranging from machine-assisted art creation, music composition and performance to formal theories of creativity and the emergence of novelty in natural and artificial systems. Before introducing these contributions we thought it useful to reflect on why we feel this book is both timely and important.

In just a single generation, computers and information technologies have brought about seismic changes in the way we communicate, interact, learn and think. Yet while these technologies are now well integrated into the fabric of modern society, their operation, design, and potential is understood by relatively few people. This limited appreciation of computing might explain why there remains a general reluctance to see its practice as something creative, and computers as machines that present a radical new potential for extending our own creativity.

Whilst general society may not think of computing as being a creative enterprise, we find ourselves in a world where we are now dependent on computers in almost every aspect of contemporary culture. Computers have become an extension of ourselves and how we communicate and think, even changing the way we think. They form a complex network of dependencies around us, and are constantly and rapidly developing, ever expanding in their role as a dynamic cultural and creative partner.

However the majority of traditional computing education and training has struggled to keep abreast of these changes. In September 2011, Google chairman Eric Schmidt criticised UK education, claiming: “Your IT curriculum focuses on teaching how to use software, but gives no insight into how it’s made. That is just throwing away your great computing heritage.” Art and Science need to be brought back together if we are to better tackle the challenges this rich entanglement with technology brings. And that doesn’t just go for art either, to be a successful sociologist,

journalist or social entrepreneur, for example, a deeper understand of computing as a creative discipline is becoming increasingly indispensable.

Creativity is critical for our ability to function and change as a society. Yet until recently, the practice of computing has not formally situated itself around the exploration of creative artistic ideas. Rather it has been taught in the main from a scientific and engineering perspective, using data structures (how to represent data) and algorithms (how to process or manipulate data) to directly solve problems. One of the great challenges for computing is to achieve a fuller understanding of process and representations which are beyond those that are easily computable or even fully comprehensible by humans. Necessarily, human design of software requires reducing difficult and complex concepts to far simpler abstractions that can be practically implemented, in some cases even ignoring those aspects of a phenomena that are too complex to express directly in a program. One way to overcome this limitation is to design programs that are capable of initiating their own creativity – to increase their complexity and discover ways of interacting independently of human design. Yet people don't naturally think of creative expression in terms of formal algorithms, leading to a perceived gap between natural creative human expression and computation.

Despite these difficulties, a field known as “creative coding” has emerged as an artistic practice of rising popularity. Here, software is considered a medium for creative expression, and the field has been enthusiastically embraced by many artists, designers and musicians. Software undergoes development at a pace and complexity that far exceeds all prior tools humans have developed, so these practitioners see the computer as something more than a benign tool such as a chisel or paintbrush. However, many artists find their artistic expression limited by a lack of knowledge in how to program *creatively*. While social and information networks allow easy access to a vast repository of resources and examples, what is often missing is a cogent technical, historical and philosophical foundation that allows practitioners to understand the “how and why” of developing creativity with computers. We hope this book makes important contributions by engaging with these foundational issues.

It is our belief that we now need to embrace and support the new forms of creativity made possible by technology across all forms of human endeavour. This creativity is important because it provides opportunities that have not been previously available, and are necessary if we are to address the complex challenges we face in our increasingly technology-dependent world.

Many excellent titles that look at creativity in general already exist.¹ Similarly, many works on the technical or didactic aspects of creative coding can be found, and are becoming standard in many university computing and design departments. However, due to a growing interest in appreciating computing as a creative discipline, and as a means of exploring creativity in new ways, the time is right for an edited collection that explores the varied relationships between computers and creativity. This book differentiates itself from general books on creativity or artis-

¹ Here we would suggest titles such as the *Handbook of Creativity* (edited by Robert J. Sternberg, Cambridge UP, 1999) and Margaret Boden's *The Creative Mind: Myths & Mechanisms* (2nd edition, Routledge, London, 2004) as titles preliminary to the material in this book.

tic coding because it focusses on the role of computers and computation in defining, augmenting and developing creativity within the context of artistic practice. Furthermore, it examines the impact of computation on the creative process and presents theories on the origins and frameworks of all creative processes – in human, nature, and machine.

Many of the book's authors come from an interdisciplinary background. Indeed, the origins of this book arose from a 2009 seminar on interdisciplinary creativity organised by the editors (McCormack and d'Inverno) and Professor Margaret Boden (University of Sussex), held at Schloss Dagstuhl – Leibniz-Zentrum für Informatik in Germany (<http://www.dagstuhl.de/09291>). Participants included artists, designers, architects, musicians, computer scientists, philosophers, cognitive scientists and engineers. With such diversity you might wonder what, if anything, was able to be understood and discussed beyond the traditional interdisciplinary boundaries and misinterpretations. It turned out that everyone passionately supported the view that computers have a substantial role to play in developing new forms of creativity, and the value of better understanding creativity from computational models in all its varied guises.

This book will appeal to anyone who is interested in understanding why computers matter to creativity and creative artistic practice. It is a proudly interdisciplinary collection that is suited to both those with a technical or scientific background along with anyone from the arts interested in ways technology can extend their creative practice. Each chapter arose in response to group discussions at the Dagstuhl seminar, and has undergone extensive review and development over a sustained period since, leading to what we hope will be a seminal volume on this topic that will remain relevant for many years to come.

Summary of Contributions

The book is divided into four sections: Art, Music, Theory and an Epilogue. However, as we have tried to make each chapter self-contained, the reader may read chapters in any order if they wish.

Part I, *Art*, addresses the long-standing question of machine creativity: can we build a machine that is capable of making art? And not just art, but good or even great art. Art that is exhibited in major art museums, prized and respected for its creative brilliance. Since the earliest days of computing, the idea of a machine being independently creative has been challenged. As Ada Lovelace famously claimed, a computer cannot be an artist because a computer cannot *originate* anything. All the machine does is what it is told to do, so how can a machine be independently creative?

Of course these arguments are closely tied to the history of Artificial Intelligence (AI), a research effort now more than sixty years old. The most famous and celebrated example of a “creative painting machine” is the *AARON* system of Harold Cohen. Cohen's initial investigations followed the “GOFAI” (Good Old-Fashioned

Artificial Intelligence) approach to automated painting, but over its forty year history has developed considerably, producing an impressive oeuvre of paintings in collaboration with its creator. Cohen remains reluctant to ascribe independent creativity to AARON and sees the software as an extension of his artistic process rather than an independent, autonomous creative entity (he also acts as a curator and filter, carefully selecting specific images from AARON's prolific output).

Simon Colton's *Painting Fool* (Chapter 1) is the 21st-century continuation of research pioneered with AARON. Colton's bold and ambitious goal is to build a computer painter recognised in its own right as an independent artist. He deftly uses a diverse array of methods from contemporary AI, and anticipates the use of many more if he is to achieve his goal. Like Cohen, this ambitious agenda may require a lifetime's work, and also similarly, Colton is not deterred by this prospect. His chapter also addresses a number of criticisms and philosophical issues raised in both the idea of creating a computer artist, and the exhibition and appreciation of paintings made by a machine.

The chapter by Jon McCormack takes a very different approach to the problem of machine creativity. He sees the processes of biological evolution as a creative algorithm that is eminently capable of being adapted by artists to allow a machine to originate new things. Importantly, these "new things" (behaviours, artefacts) were not explicitly stated by the programmer in authoring the program. Using ideas drawn from biological ecosystems, he illustrates the creative potential of biological processes to enable new kinds of machine creativity. Here the computer is able to discover new artistic behaviours that were not explicitly programmed in by the creator, illustrating one way in which Lady Lovelace's enduring criticism can be challenged.

Pioneering artist Frieder Nake has been working with computational art since the 1960s. Nake frames creativity as a "US American invention" and through a series of vignettes examines the processes of developing creative works from the earliest days of digital computer art. As one of the first artists to create work with computers, Nake is uniquely placed to appreciate and reflect on over 40 years of endeavour in this field. His evaluation of the work of Georg Nees, A. Michael Noll, Vera Molnar, Charles Csurí, Manfred Mohr, Harold Cohen and even himself is fascinating.

Both Nake and Cohen are highly sceptical about machines ever being autonomously creative, and this is explored in the final chapter of this section: a discussion on machine creativity and evaluation between Nake, Cohen and a number of other Dagstuhl participants. These informal, and sometimes frank discussions reveal the complexities and diversity of opinion on the possibility of developing machines capable of independent artistic creativity that resonates with human artists. This chapter has been included for both its insights and its historical significance in documenting a rare discussion between several of computer art's most experienced and significant practitioners.

Part II, *Music*, deals with issues related to computers, music and creativity. A major challenge for machine creativity is in musical improvisation: real time, live interaction between human and non-human performers. This not only sets challenges for efficiency and on-the-fly decision making, but also in articulating what encompasses musically meaningful interactions between players. The chapter by

François Pachet draws on the concept of “virtuosity” as an alternative way of understanding the challenge of improvisation. Pachet aims to create a computational musician who, in its improvisational skill, would be as good as the best bebop jazz musicians. He describes in detail the construction of a system that is capable of competently improvising with, and challenging, professional jazz musicians. Many think of AI’s most public successes as game playing (such as Deep Blue’s defeat of world chess champion Garry Kasparov in 1997) or mathematical problem solving, but as demonstrated by a number of authors in this book, intelligent musical interaction with computers is now a real possibility.

The goal of musically meaningful interaction between human and machine performers is the basis of what has become known as “Live Algorithms”. The chapter by Tim Blackwell, Oliver Bown and Michael Young summarises a series of frameworks for human-machine interaction and improvisation inspired by the Live Algorithms model. The authors detail the kinds of interactions necessary for musically meaningful exchanges to occur and document some recent projects and research in this area.

The idea of a computer as “creative partner” is a major topic of this book. In combination, how can humans and computers expand our creative consciousness? The chapter by Daniel Jones, Andrew Brown and Mark d’Inverno details how computational tools extend and modify creative practice: challenging old assumptions and opening up new ways to simply “be creative”.

Rather than looking for a general theory of human creativity through the work of others, researcher and musician Palle Dahlstedt introspected deeply about his own creative processes. This has led to his theory of how materials, tools and ideas all interact and affect the creative process in complex, layered networks of possibility. While the theory comes from a musical understanding, it is broadly applicable to any creative discipline based around computers and software.

Many artists working with computers do so at the level of writing their own code. Coding is a unique form of artistic endeavour, which is often poorly understood as it lacks the extensive mainstream critical analysis and heritage found in more traditional art practices. Alex McLean and Geraint Wiggins – both coders and composers – examine the special relationship between a computational artist and their programming environment. Borrowing the art idea of the bricolage, they examine how perceptions affect the creative process when working with code. It is interesting to compare the use of feedback processes discussed by McLean & Wiggins, Dahlstedt, Jones, Brown & d’Inverno in relation to the current design of creative software, which often does little to facilitate or enhance the types of feedback emphasised as crucial by these authors.

Personal- and practice-based understandings of creativity are contextualised next in Part III, *Theory*. As discussed in Part I, for any machine to be creative it is argued that it must have some way of evaluating what it is doing. Philip Galanter undertakes an extensive survey of methods used in computational aesthetic evaluation: considered a first step in designing machines that are able to produce aesthetically interesting output. Although the chapter focuses primarily on visual aesthetics, the techniques can be applied more broadly, and Galanter’s chapter provides a distinc-

tive and comprehensive survey for researchers entering this challenging field. Similarly, Juan Romero and colleagues look at perceptual issues in aesthetic judgement and discuss how a machine might take advantage of things like psychological models of creativity. Both these chapters provide a much-needed overview of the field that has previously been lacking.

While the computer has brought new creative possibilities for artists, designers and performers, computer science has challenged traditional definitions of creativity itself. Over the last two decades, Jürgen Schmidhuber has developed a formal theory of creative behaviour, one that he claims explains a wide variety of creative phenomena including science, art, music and humour. Schmidhuber sees creativity as the ability of an agent to create data that through learning becomes subjectively more compressible. What humans term “interesting” is a pattern (image, sculpture, poem, joke, etc.) that challenges our compression algorithm to discover new regularities from it. Similarly, the chapter by Alan Dorin and Kevin B. Korb challenges the long-held definition of creativity that relies on a concept of appropriateness or value. Dorin and Korb define a creative system as one that can consistently produce novel patterns, irrespective of their value. These definitions appear to accommodate a number of criticisms levelled at previous definitions of creativity. For example, that some discovery may lie dormant for decades or centuries before its “value” is recognised, or that aesthetic appreciation is a truly subjective thing. It is interesting to read these theories in light of the dialogue of Chapter 4.

A different approach is taken by Oliver Bown, who distinguishes two fundamentally different kinds of creativity: generative and adaptive. The main distinction is the teleology of each – generative creativity is not goal-directed, adaptive creativity is. Bown also looks at the role of social processes in determining creativity often (mistakenly) ascribed exclusively to individuals.

Finally Peter Cariani presents his theory of emergent creativity, which like Schmidhuber, he has been working on for over two decades. Cariani shows how new informational primitives arise in natural systems and presents a detailed and ambitious framework for developing creatively emergent artificial systems.

Throughout this book you will find many different definitions of creativity and opinions of what (if any) level of autonomy and creativity might be possible in a machine. For example, Nakano and, to an extent, Pachet downplay the importance of creativity in individuals. In Pachet’s case, he demonstrates a system that can competently improvise with professional jazz musicians to illustrate how virtuosity, rather than creativity, is the predominate factor in musical improvisation. In a sense Pachet (a jazz musician himself) has been able to begin “reverse engineering” the complex motifs employed by famous jazz musicians such as Charlie Parker and Dizzy Gillespie. His challenge is to compute the “99% explainable stuff” of jazz music and make serious inroads into the “1% magic” that we might intuitively call human creativity. Computer scientists such as Schmidhuber see the way forward in terms of formal, computable definitions, since in theory they can be implemented and verified practically on a computer. Of course, any formal model of creativity requires abstractions away from the complexity of real human creative practice, so any such model could never fully represent it. Conceivably, neuroscience will

eventually provide a full understanding of the mechanisms of human creativity, potentially overcoming current difficulties in validating computer models of human creative processes.

To conclude the book, Part IV, *Epilogue*, contains a short chapter that poses questions that were raised while editing this volume. As is often the case with new and emerging research fields, we are left with many more questions than answers and here what we consider the twenty-one most interesting and critical questions that this book has inspired are summarised. Competently answering these questions will take decades of research and investigation, the results easily filling many more volumes like this.

Whatever your views on creativity are, and whether you think a machine is capable of it or not, this book presents many new and inspiring ideas – wonderfully written and passionately argued – about how computers are changing what we can imagine and create, and how we might shape things in the future. We hope you enjoy reading *Computers and Creativity* as much as we have enjoyed producing and editing it.

Jon McCormack and Mark d'Inverno
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