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Yang Cai (Ed.)

Computing with Instinct

Rediscovering Artificial Intelligence

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Cover Photo. The autonomous vehicle was tested at Carnegie Mellon University, Pittsburgh campus, where the Instinctive Computing Workshop was held on June 9–10, 2009. The vehicle is designed to sense roads and avoid collisions instinctually.

Preface

Simplicity in nature is the ultimate sophistication. Honey bees are not able to play chess or solve the Tower of Hanoi puzzle; however, they do know how to build, defend, forage, navigate, and communicate for survival. They can even learn to recognize human letters independent of size, color, position, or font. Instinct is an inherited behavior that responds to particular environmental stimuli. In his book *On the Origin of Species*, Darwin pointed out that no complex instinct can possibly be produced through natural selection, except by the slow and gradual accumulation of numerous, slight, yet profitable, variations. Darwin also concluded that no one would dispute that instincts are of the highest importance to every animal species.

The world's magnificence has been enriched by the inner drive of instincts, perhaps the most profound drive of our everyday life. *Instinctive Computing* is a computational simulation of biological and cognitive instincts, which influence how we see, feel, appear, think, and act. If we want a computer to be genuinely secure, intelligent, and to interact naturally with us, we must give computers the ability to recognize, understand, and even to have primitive instincts.

We aim to understand the instinctive common sense of living creatures, including the specialties of individual species as well. Instinctual systems will learn from insects, marine life, animals, and children, to broaden and develop their essential primitive thinking. "Computing with instincts" must be conceived as a meta-program, not a violent attack on traditional artificial intelligence. Instead, this is an aggressive leap for a robust, earthy, and natural intelligence.

In the summer of 2009, the first Instinctive Computing Workshop (ICW 2009) was hosted at Carnegie Mellon University, Pittsburgh, USA, jointly sponsored by the National Science Foundation, Cylab, and Google. The two-day workshop aimed to explore the transformational developments in this area, including the building blocks for instinctive computing systems and potential applications in fields such as security, privacy, human–computer interaction, next-generation networks, and product design. The workshop was organized to engage in in-depth dialogue in a small group with multidisciplinary minds, returning to the origin of workshops to focus on ideas.

This book, *Computing with Instinct*, comprises the proceedings of ICW 2009. It is the first state-of-the-art book on this subject. This book consists of three parts: Instinctive Sensing, Communication, and Environments.

Part I. Instinctive Sensing. For many years, cyborg pioneer Warwick has explored neural behavior with bi-directional interactions between the brain and implanted devices, which he calls "Implantable Computing." In this book, Warwick and his colleagues present their new experiments with culturing biological neurons in vitro for the control of mobile robots. Inherent operating characteristics of the cultured neural network have been trained to enable the physical

robot body to respond to environmental stimuli such as collisions. The 100,000 biological neurons are grown and trained to act as the brain of an interactive real-world robot – thereby acting as hybrid instinctive computing elements. Studying such a system provides insights into the operation of biological neural structures; therefore, such research has immediate medical implications as well as enormous potential in computing and robotics. This keynote chapter provides an overview of the problem area, gives an idea of the breadth of present ongoing research, details the system architecture and, in particular, reports on the results of experiments with real-life robots. Warwick envisioned this as a new form of artificial intelligence.

Sound recognition is an invaluable primitive instinct for mammals. A recent archeological discovery suggested that, for over 120 million years, animals have developed an elaborated auditory system for survival. In the modern era, it is the most affordable diagnostic sensory channel for us, ranging from watermelon selection, car diagnosis to using a medical stethoscope. Cai and Pados explore an auditory vigilance algorithm for detecting background sounds such as explosion, gunshot, screaming, and human voices. They introduce a general algorithm for sound feature extraction, classification, and feedback. It is concluded that the new algorithm reaches a higher accuracy with available training data. This technology has potential in many broader applications of the sound recognition method, including video triage, healthcare, robotics, and security.

About half of our brain cells are devoted to visual cognition. A texture provides instinctual cues about the nature of the material, the border, and the distance. The visual perception of texture is key to interpreting object surfaces. In Vernhes and Whitmore's study, images of textured surfaces of prototype art objects are analyzed in order to identify the methods and the metrics that can accurately characterize slight changes in texture. Three main applications are illustrated: the effect of the conditions of illumination on perceived texture, the characterization of changes of objects due to degradation, and the quantification of the efficiency of the restoration.

Part II. Instinctive Communication. Visual abstraction enables us to survive in complex visual environments, augmenting critical features with minimal elements – words. Cai et al. explore the culture and esthetic impacts on visual abstraction. Based on everyday life experience and lab experiments, they found that the factors of culture, attention, purpose, and esthetics help reduce the visual communication workload to a minimum. These studies involve exploration into multi-resolution, symbol-number, semantic differentiation, analogical and cultural emblematization aspects of facial features.

To learn a genre is to learn the instinctual and cultural situations that support it. This dominant thinking overlooks critical aspects of genre that appear to be based in deep clusters within natural language lexicons that seem instinctual and cross-cultural. Hu et al. present a theory of lexical clusters associated with critical communication instincts. They then show how these instincts aggregate to support a substrate of conventional English writing genres. To test the cross-cultural validity of these clusters, they tested Chinese students in rural China

with limited training in native English writing and limited exposure to native English cultural situations.

Non-verbal communication such as gestures and facial expressions is a major part of fundamental interaction among people. Sonntag views intuition as instinctive dialog. To allow for an intuitive communication, multimodal task-based dialog must be employed. A concrete environment, where an intuition model extends a sensory-based modeling of instincts, can be used to assess the significance of intuition in multimodal dialog.

Part III. Instinctive Environments. Rapidly growing virtual world technologies permit collaboration in a distributed, virtual environment. In a real-world environment, distributed teams collaborate via face-to-face communication using social interactions, such as eye contact and gestures, which provide critical information and feedback to the human decision maker. The virtual environment presents unique challenges in this regard. Yvonne and Aguiar focus on how we evaluate human performance and various levels of expertise, strategies, and cognitive processes of decision makers within the virtual environment. Their exploitations include accurate and time-critical information flow, cognitive workload, and situational awareness among team members.

We are not living in the forest anymore. Modern living environments enable us to maximize comfort zones; however, they also introduce new problems associated with those artifacts. Garcia et al. study how to enable end-users to manage their preferences in personal environments. The system uses rules and modularizing agents, paying special attention to end-user programming issues and the natural hierarchies present in the environment.

Furthermore, O'Grady et al. propose an intelligent middleware framework as a means for harnessing the disparate data sources necessary for capturing and interpreting implicit interaction events.

The manifesto for ubiquitous computing was released in early 1990. Ten years later, ambient intelligence was envisioned. Today, how to implement networked intelligent artifacts remains an open issue. Human–computer interaction tries to combine psychology, computing, and design into a science. However, prevailing usability-centric studies have had little impact in real-world products or interactions. We need new genes, new dimensions, and new approaches. The goal of this book is to rethink the origin of human interactions, to define instinctual components, and to demonstrate the potential of such a new computing paradigm. We believe that "computing with instinct" is a solution for fundamental problems in ambient intelligence, such as situation awareness, understanding, learning, and simplicity.

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