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Computational Creativity

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ABSTRACT
Computational creativity is a newly emerging field within AI that focuses on the capacity of machines to both generate and evaluate novel outputs that would be considered creative. It is the philosophy, science, and engineering of computational systems which exhibit behaviors that unbiased observers would regard as creative. It is mainly concerned with building creative systems. It addresses processes that would be deemed creative if performed by a human. This paper provides an introduction to computational creativity.

KEYWORDS: *computational creativity, artificial creativity, mechanical creativity, creative computing, creative computation*

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INTRODUCTION

The recent years have witnessed advancements in systems that facilitate human or autonomous creation. New technologies, such as artificial intelligence (AI), are drastically changing the creative processes. Instead of just viewing computer as a creative collaborator assisting human creators, we can see it as a creative entity in its own right. In view of the limitation of human creativity resources, it is imperative to develop technologies for greater creativity. Such creative systems can be used for autonomous creative tasks, such as inventing mathematical theories, writing poems, painting pictures, and composing music.

Innovation is becoming accepted as central to competitiveness in today's world. Creativity is a fundamental ingredient for the completion of engineering design tasks. It is manifested in many ways, such as invention of new concepts and ideas or production of objects of art and music. Three different types of creativity have been identified: (1) Exploratory creativity, (2) Transformational creativity, (3) Combinational creativity.

CONCEPT OF COMPUTATIONAL CREATIVITY

Computational creativity (CC) (also known as artificial creativity or creative computation) is an emerging branch of artificial intelligence (AI) that places computers at the center of the creative process. It involves a generative step to produce many ideas and a selective step to determine the ones that are the best [1]. It is the generation of a product that is judged to be novel. Interaction between human and machine is based on the human cognitive process of creativity, as shown in Figure 1[2].

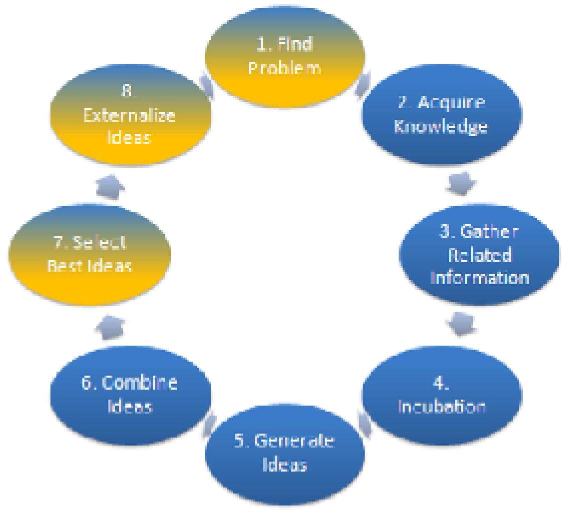

Figure1. Stages in the cognitive process of creativity [2].

As shown typically in Figure 2 [3], CC is a multidisciplinary area that embraces several fields of artificial intelligence, computer science, mathematics, literature, architecture, engineering , cognitive science, philosophy, and the arts. The goal of computational creativity is to model, simulate or replicate creativity using a computer [4].

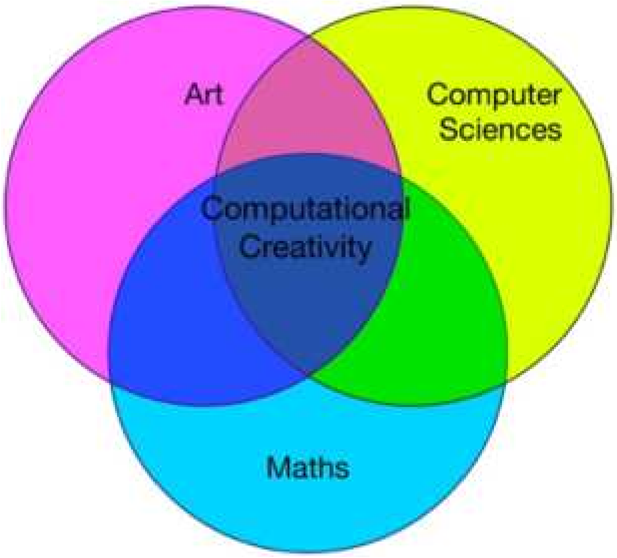

Figure2. Computational Creativity as a multidisciplinary field [3]

Computational creativity should be explored from four different perspectives, known as the four Ps: Person, Product, Process and Press [5,6]:

- **Person:** The individual agent or producer that is seen as creative. The Person approach is meant to discover what personality, emotional, and cognitive traits distinguish a more creative person from a less creative one.
- **Process:** What the creative individual does to be creative. The Process perspective includes any theory of how creative products are made.
- **Product:** What is produced as a result of the creative process. Generating creative products is an index of significant success for computational creativity. In other words, many evaluations in computational creativity focus on Product perspective, which is useful for systems that have the goal of producing something useful to humans.
- **Press:** The environment in which the creativity is situated. It is the surrounding culture which influences people, processes, and products and which determines if they creative or uncreative. The Press perspective focuses on what kind of social effect a product needs to have to be called creative.

These four perspectives are illustrated in Figure 3[7].

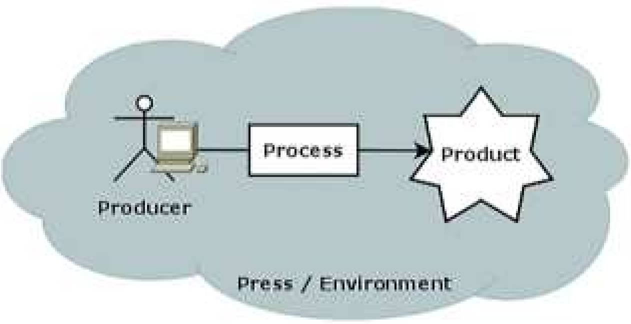

Figure3. How the four Ps fit together in creativity [5]

New technologies, such as machine learning and big data, are drastically changing the nature of CC. Learning is an important part of creativity. Human learning involves many behaviors, including memorization, comprehension, and generalization. It is expedient to look at how machine learning developed to suggest future directions for computational creativity research. Computational creativity techniques that use machine learning (ML) train and learn can be used to approximate the examples. ML has shown promise for many creative tasks such as music generation, image and painting generation, image style transfer, etc.

APPLICATIONS

The goal of computational creativity is to build systems that do things that are creative. CC has been developed for applications ranging from music to mathematics. Some computational creative machines include IBM's Watson and Deep Blue. Watson is a computational creativity machine that creates new stuff from its knowledge of existing stuff. Besides these, creative machines cover subjects like humor, poetry, games, music, design, code generation, and visual arts.

- **Music:** Computational creativity in the music domain has focused both on the generation of music for human musicians and generation of music for performance by computers. There is a large number dealing with the problem of automatic harmonization using several AI techniques. The harmonization problem is approached using a combination of neural networks and case-based reasoning. A robot can be used to create and play a multitude of orchestrated melodies.
- **Visual Arts:** Today, artists are extensively using technology to enhance their artistic expressions. Most work on visual creativity is conceptualized in terms of painting or drawing. Computational creativity in generating visual art has had some notable successes in the creation of representational art. The painter AARON is a robotic system that was developed by the artist and programmer Harold Cohen. Visual art AARON can pick up a paintbrush with its robotic arm, paint on canvas, and draw people.
- **Computer Games:** Games constitute the killer application for computational creativity. The integrating computational creativity philosophies and techniques into the game design process is a natural next step in the computational intelligence and games evolution. A newly emerging area of computational creativity is that of video games [8]. Chess has been a traditional challenge for AI. With the defeat of then-world chess champion Garry Kasparov to IBM's Deep Blue supercomputer in 1997, there is little controversy about the fact that the best programs outperform the best human players.
- **CC Exercises:** Promoting computational thinking is a priority in STEM and non-STEM disciplines. The goal of the Computational Creativity Exercises (CCEs) is to help students better learn course material and be able to apply their new knowledge and skills to complex, real-world problem-solving situations. Through computational creativity, students can leverage creative thinking skills to "unlock" their understanding of computational thinking. CCEs improve student learning and achievement [9].

Other areas of application of CC include robotics, education, information fusion systems, and culinary recipe.

BENEFITS AND CHALLENGES

Computational creativity research crosses several disciplinary boundaries across the arts, sciences, and engineering. It showcases ways of producing unpredictable behavior that goes beyond explicit program instructions, such as connectionist computation, evolutionary computing, emergence or the use of randomness [10]. A computational creativity system can test quadrillions of ideas at once without needing to invoke modularity as humans do.

Building creative software offers both a technical challenge and a social one. Creativity is very difficult and hard to define in objective terms. It seems mysterious to a lot of people. Even within computer science community, some are still skeptical about the creative potential of software. Detractors of computational creativity argue that it is impossible to simulate creative human thinking and reasoning in view of the fact that computers cannot be creative beyond what the programmer provides the system. Others hold the pervasive belief that to be creative requires having a special gift bestowed by a higher power. Creativity can be negative and it is not as always good. For example, an employee devices an effective way to steal from the employer [11].

Human creativity has been a compelling but elusive concept to study and formalize. Creativity is difficult to study because of its connections with poorly understood phenomena such as intuition, insight, genius studies, and brain processes. Evaluation of creative systems is a challenging problem in computational creativity.

CONCLUSION

Computational creativity is an emerging subfield of AI that places computers in the heart of the creative process. As a field of research, CC is a growing and thriving, and creative systems have been developed for many applications. As CC continues to grow in popularity, it is increasingly being taught in some form as a university-level course [12].

More information about CC can be found in the books in [13-15] and three specialized journals: *Creativity Research Journal*, *Journal of Creative Behavior,* and *International Journal of Design Creativity and Innovation.* The International Conference on Computational Creativity (ICCC) series, organized by the Association for Computational Creativity (http://computationalcreativity.net/home/) since 2010, is the only scientific conference that focuses on computational creativity alone [16].

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