

# Synergy Between Human Creativity and Computing Technologies

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## Abstract

The study of human creativity has never been stopped. Nowadays, although various kinds of computing technologies, such as online courses, research tools, virtualising applications, and professional applications, have been widely used to serve human creativity, the contradiction between the subjectivity of human creativity and the objectivity of computing technologies still cannot be reconciled very well. As the relationships between human creativity and computing technologies are being pushed forward, more possibilities have been explored, such as digital creativity and computational creativity. Within digital creativity, artists can have deeper cooperation with technologists. Some artists even could work with technology by themselves. By creating from the perspective of technology, more creative ideas may be discovered. Computational creativity is devoted to facilitating human creativity by imitating human creativity. Based on the great computing power, it aims to generate new ideas that we humans may not be able to come up with. However, due to the deep utilisation in creativity fields, computing technologies have been influenced dramatically by the elements of creativity. People have started to consider what else computing technologies could do for human creativity. Therefore, the concept of creative computing that requires computing itself to be creative has been proposed to serve human creativity better. Within this paper, various synergy possibilities between human creativity and computing technologies are discussed thoroughly for the improvement of human creativity.

**Keywords:** human creativity; computing technology; digital creativity; computational creativity; creative computing

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## 1. Introduction

Human creativity needs to be improved. Due to its great creation power, the study of human creativity has never been stopped. The temptation can be traced back to the Greek age. The great philosopher Plato's belief was that since artists cannot understand where their inspirations originate, they must originate outside the artists' minds and be given by the Greek Goddess Muses [1]. When people started to wonder if IQ could represent the whole human intelligence, the creative part of the human mind began to receive attention. The study of creativity has been one of the main directions in the psychology field, and a great number of research results have been generated [2]. Nowadays, as the competition of contemporary society becomes extremely intense, the requirements for creative people or creativity have never been so urgent [3]. Both individuals and organisations are seeking valuable methods to improve creativity [4]. It has even influenced nation-wide policies. In China, a strategy known as innovation 2.0 was proposed to facilitate people's creativity and innovation during the information age and knowledge society. "Creativity" and "innovation" have been hot topics not only in China but also around the world. For example, the first theme of the G20 Hangzhou Summit is "innovation", that is, how to innovate for the world economy [5].

Various computing technologies have been utilised to facilitate human creativity. Due to the fast development, a variety of computing technologies have been widely used in different fields. The creativity field also benefits greatly from the utilisation of computing technologies. For example, as a large amount of knowledge about creativity has been generated, much of them are used to form online courses to help train people's creativity. With the rise of cognitive psychology, bio-technologies like FMRI and EEG have started to play an important role in the understanding of creativity. Photoshop is the most well-known application for art. Its most important function is the virtualisation of materials. Furthermore, as creativity

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is closely related to divergent thinking, many mind mapping tools have been developed. Nowadays, we have entered into the era of a so-called new generation of information technology. Various new types of technology have drawn much attention, such as social networks, mobile Internet, cloud computing, big data, artificial intelligence, and virtual reality. The key question is what else creative people can do with these new technologies. One of the surprising things is the cooperation between human creativity and computing technologies, including digital creativity and computational creativity. Within digital creativity, computing technologies are not used as facilitating tools but as artistic materials for the creation of digital works of art. The core computing technology of computational creativity is artificial intelligence. It aims to generate a kind of machine creativity by imitating human creativity.

However, there is always a contradiction between creativity and computing. Although human creativity has been studied for a long time, there are many mysteries within it, such as vagueness and uncertainties [6]. However, computing technologies follow very strict algorithms and instructions. No matter how close computing technologies can get to human creativity, even imitating human creativity, the contradiction between the subjectivity of human creativity and the objectivity of computing technologies still cannot be tackled very well. However, as people continuously push the boundaries between human creativity and computing technologies because of the ever-evolving nature of computing technologies themselves, a new type of computing known as creative computing has been proposed to reconcile the contradiction and serve human creativity better.

Creative computing aims to improve human creativity by computing in creative ways. If the summarisation of creativity knowledge can be deemed as “making the subjective become objective”, at the same time, we should also consider how to “make the objective become subjective”, that is, to make computing itself creative and to serve human creativity better. It is believed that, due to the pervasive utilisation of computing technologies in creative fields, the creative elements start to infiltrate into various aspects of computing. For example, inspired by the expressiveness of artistic work, a field that known as creative coding starts to focus on generating something expressive, instead of creating something functional. By doing so, it aims to help people explore the mysteries of human creativity from a new point of view. Meanwhile, with the help of powerful computing capability and a massive amount of data, creative computing approaches may be able to find something surprising for facilitating human creativity.

In order to explore the synergy possibilities between human creativity and computing technologies comprehensively, this paper is divided into three essential parts. In Section II, various common computing technologies used for facilitating human creativity are summarised. The cooperation between computing technologies and human creativity is described in Section III, demonstrating a more active role of computing technology to human creativity. In Section IV, as computing technologies are being influenced dramatically by the creative elements of creativity field, a new relationship between creativity and computing, creative computing, is discussed thoroughly.

## **2. Common Computing Technologies for Human Creativity**

### *2.1. Online Courses*

As mentioned before, human creativity has been studied for a long time. A great number of results on explaining creativity have been generated. Based on these research efforts, many organisations or individuals have developed many training courses including techniques or methods that could trigger people’s creative thinking [7-8]. A very famous and typical instance is the lateral thinking proposed by French psychologist Edward De Bono. Instead of vertical thinking, he focuses on stimulating people’s creative thinking by promoting lateral thinking/horizontal thinking, encouraging people to “think outside the box” [9]. Several techniques, methods, and even games to facilitate people’s creative thinking have been created by De Bono, such as his masterpiece known as Six Thinking Hats. Each hat has its own colour and represents a different approach to thinking. For example, the white hat encourages people to only think about what information is available for the problem solving. The red hat lets people focus on their intuitive thinking about something [10]. By using different colour hats, people will be triggered to use different thinking styles, which is good for creativity.

With the fast development and pervasive utilisation of Internet technologies, besides some portal websites built for creativity training organisations and institutes as a kind of information exchange platform for people who want to be creative, a new type of learning has been generated known as e-learning, in which “e” stands for “electronic” [11]. It focuses on how to leverage the digital contents and materials online for a more efficient study. For example, Effective Thinking Course is one of the online creativity training courses certified by De Bono. One of the most important advantages is, based on the considerable amount of materials online; there could be three modules, 36-hour courses, and 219 training exercises for training people’s creative thinking [12]. Bono’s creativity courses have been widely applied in various big organisations like Microsoft, IBM, and Panasonic. Universities, colleges, and schools across the world also benefit from his works on creativity.

## 2.2. Research Tools

The study of human creativity can never be separated from the study of the human mind. Therefore, creativity is always one of the main topics within the realm of psychology. One direction is the discussion between creativity and intelligence. Another direction that is worthy to mention is the study of the close relationship between creativity and thinking. Various types of thinking have been associated with creativity. One of the most famous is divergent thinking, which aims to generate creative ideas by exploring as many potential solutions as possible [13]. It is often used in conjunction with convergent thinking, which is to derive correct and well-established answers for a question [14]. By using divergent and convergent thinking together, a more comprehensive creative solution may be formed. Another one is known as analogical thinking. Within the domain of artistic fields, like poetry, the creation power of metaphor and analogy have drawn much attention. By studying linguistic creativity, a fascinating language phenomenon has been found. Techniques like metaphor and especially analogy can always trigger artists' creativity by introducing new perspectives of seeing things.

As computing technologies (e.g., FMRI and EEG) start to be applied widely in psychology [15-17], it is possible for more psychological phenomena to be studied, which finally leads to the rising of cognitive science. The physical or biological part of human creativity can be studied. It is possible to show how people's brains work when they think creatively. It has been discovered that the right hemisphere of the human brain seems more "creative" than the left hemisphere, as it is associated with artistic work (e.g., painting and music). The default network, which is formed by the interactions of various regions between the left and right hemisphere, is found closely correlated to people's creative thinking [18]. During modes like this, it is more possible for remote neurons to be connected. Creative ideas may be generated from this kind of unexpected connections of neurons. Sometimes, it will trigger the sudden insight of people, which is one of the most mysterious phenomena of human creativity. Accordingly, it is much easier for people to achieve the default mode network through brain activities like daydreaming or mind wandering [19]. Furthermore, through the utilisation of computing technologies, more perspectives of human creativity can be studied, such as brain waves. It has been found that some certain brain waves (e.g., alpha wave and gamma wave) could, to some extent, indicate people's creative thinking processes [16-20]. It could be predicted that more research results on the unconscious parts of human creativity could be generated with the increasingly deeper utilisation of computing technologies within the psychology field.

## 2.3. Virtualising Applications

Among all kinds of computing technologies used in the creativity field, one particular type is the virtualising applications, whose main function is to virtualise tools or materials that are used to create something. One of the most outstanding advantages of these virtualising applications is to provide an unlimited platform for people to create without worrying about things like canvases (e.g., Photoshop [21]), musical instruments (e.g., MuseScore [22-23]), etc. The Guardian once selected the top 50 apps for creative minds [24]. Magic Piano is one of them, and it can allow people to learn how to play music on a virtual piano. By operating on mobile devices like smartphones or tablets, the Magic Piano can enable people to compose music almost anytime and at any place. By providing a simple and easy interaction, it can allow a musician, student, or even a lover of music to create his or her own piece of music. By doing so, the virtualising applications are able to support people's creativity.

## 2.4. Professional Applications

In addition to the applications that are specialised in virtualisation, there are also some applications that are developed more specifically for stimulating people's creative ideas. For example, applications with the function of mind mapping are among the popular ones. They are specialised in facilitating divergent thinking for people to generate creative ideas. Many applications have been developed, such as MindManager [25] and MindGenius [26], whose primary purpose is to visualise ideas and help people connect them creatively. Similar to mind mapping applications, there are also many others for creativity with different functions like brainstorming. Moreover, various complicated platforms have also been developed with the aim to generate more comprehensive creative solutions for people to be creative. For example, Goldfire Innovator is a knowledge management platform dedicated to facilitating professional people to be increasingly and sustainably productive [27]. Using DFSS (Design for Six Sigma) as the core idea and TRIZ (Theory of Inventive Problem Solving)/ARIZ (Algorithm for Inventive-Problem Solving) as tools, based on more than 9000 scientific principles from various disciplines and interactions with more than 70 patent pools, the Goldfire Innovator could provide a powerful and convenient innovation platform that can synchronise with the world.

# 3. The Cooperation Between Computing Technologies and Human Creativity

## 3.1. Digital Creativity

In recent years, as the possibilities between human creativity and computing technologies are being explored, a new trend

known as digital creativity has started to draw people's attention. The primary purpose of digital creativity is to use computing technologies to create digital works of art, such as digital art installations. By doing so, artists have found a new approach to doing art. A good practitioner is known as DevArt (art made with code) [28]. It is a project commissioned by Google dedicated to pushing the possibilities between creativity and computing by creating various kinds of digital art installations, which have been displayed in an exhibition named "Digital Revolution" in Barbican, London [29]. During the project, artists can work closely together with technologists. Some artists are even able to use technology by themselves. Therefore, different thinking styles can be interacted with deeply. Something overlooked or unthinkable before may be generated for the creation of artwork.

For example, one of the main functions of art is the representation of feelings. With the help of computing technologies, people's emotions can be shown in an interesting way. The Wishing Wall [30] is one of the typical art installations of digital creativity that can enable people to turn their wishes into beautiful butterflies. When someone catches a butterfly, the carried wish can also be released immediately. Even more interesting is that the installation can use different categories of butterflies to represent different wishes according to different emotions (see Figure 1).



Figure 1. Wishing wall ([http://blog.sina.com.cn/s/blog\\_779c9ed40102v3k7.html](http://blog.sina.com.cn/s/blog_779c9ed40102v3k7.html))

As new types of computing technologies are being applied in creativity fields, there are more options for artists to create. Another digital art installation worthy to mention is known as "Les métamorphoses de Mr. Kalia [31]". This is the most popular digital art installation of the Digital Revolution exhibition. Surprisingly, it was made by two French artists. A kind of motion tracking device was used in this installation to track users' movements and, interestingly, turn them into beautiful animations (see Figure 2). However, the animations are not just generated randomly but with artistic meanings of exploring and revealing the beauty of human body transformation. Therefore, it can be seen that technology has been used not only as a tool but also as a kind of perspective for creation. The next question is how far can computing technologies go to facilitate human creativity?



Figure 2. Les métamorphoses de Mr. Kalia ([http://blog.sina.com.cn/s/blog\\_779c9ed40102v3k7.html](http://blog.sina.com.cn/s/blog_779c9ed40102v3k7.html))

### 3.2. Computational Creativity

Another new concept about human creativity and computing technologies is computational creativity. Differing from digital creativity, the approach of computational creativity is to achieve creativity through computation. Inspired by the ideas of

artificial intelligence, it aims to achieve machine creativity by imitating human creativity [32]. As mentioned before, human creativity has been studied for a long time. Many results have been generated, such as the creative process that includes the four stages of preparation, incubation, illumination, and verification [33-34]. By simulating processes like this, the computing system, like a famous system named Experiments in Musical Intelligence (EMI), is able to compose music in the style of Bach [34].

Nowadays, due to their great creation power, many technologies of AI have also started to consider making contributions to the creativity world. One of the typical examples is IBM Watson. After its first appearance in the quiz show Jeopardy!, Watson has been successfully applied in various fields, especially finance and medicine. In recent years, IBM has also tried to explore Watson's ability in creativity fields like fashion. One of the most surprising cases is the cognitive dress or dress of AI worn by the famous Chinese singer Chris Lee for the 11<sup>th</sup> anniversary of the fashion magazine VOGUE [35] (see Figure 3). The dress was made by the cooperation between IBM Watson and the Chinese designer Huishan Zhang. Watson's task was the intelligent data analysis and precise definition of the fashion image for Chris Lee. A considerable amount of data including texts, images, and videos was analysed by Watson to "know" essential information like what is the popular colour during those days, what are the features of Chris Lee's image, and even what are fans' expectations of Chris Lee. The designer was influenced and inspired dramatically by the facilitation of Watson.

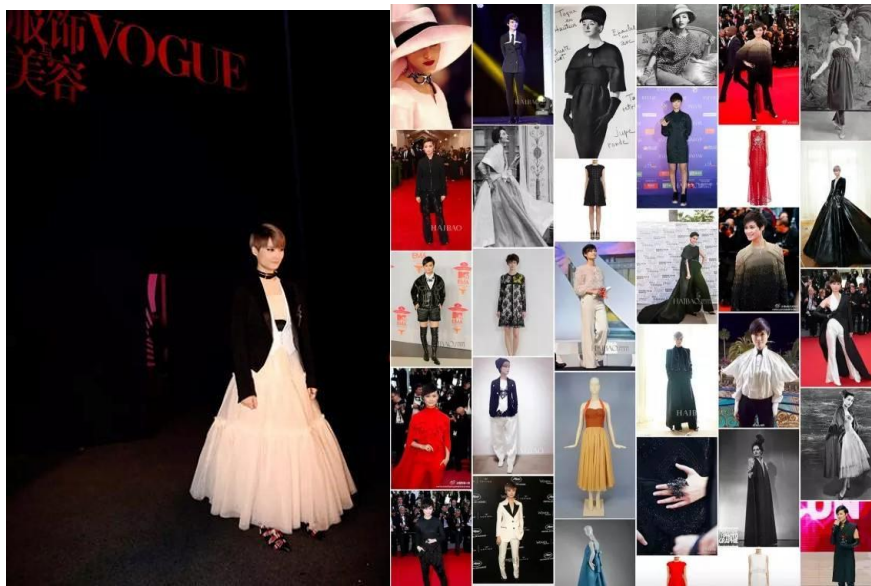


Figure 3. Cognitive dress ([http://www.sohu.com/a/118535173\\_505837](http://www.sohu.com/a/118535173_505837))

Due to Watson's great success in fashion, the exploration of art with Watson has been one of the main topics within IBM [36]. Another interesting project known as Hidden Portraits was undertaken by 15 artists with the assistance of Watson. By analysing vast amounts of data, Watson's job was to discover the unseen insights of some world's most influential figures, such as Charles Darwin, Eleanor Roosevelt, Nikola Tesla, and Paul Rand [37]. Then, the provocative findings generated from writings, letters, speeches, sketches, photos, handwritten notes, and even music were interpreted by the artists for the creation of the portrait (see Figure 4). By doing so, this project not only used data to discover and illuminate the unknown essence of the notable individuals, but also explored machines' ability of finding something hidden in familiarity to help people's creation.

#### 4. Creative Computing Technologies for Human Creativity

Although digital creativity and computational creativity have explored new approaches to facilitating human creativity, due to the fast development and pervasive utilisation, what else computing technologies could do to meet the increasingly complicated societal requirements is always the key question. With the increasingly deeper cooperation between artists and technologists, not only will there be more technology options for artists to create, but also the creativity of technologists can be stimulated. Under the dramatic influence from artistic fields, what if computing technologies could go further and be creative to serve human creativity better? This is why the concept of creative computing has been proposed [38].

Creative computing aims to facilitate human creativity by computing in creative ways [39]. Instead of giving people the "right" answer, creative computing is devoted to generating "wrong" answers, which could be deliberately unexpected but

meaningfully provocative for people's creative thinking. For example, if somebody inputs the word "Toad" into a creative computing system, instead of getting a similar word like "Frog", he/she may receive a surprising word like "Heqet", who is the Egyptian goddess of fertility and may be able to lead the user into the Egyptian world. By doing so, people's fixed pattern of thinking may be broken for creative thinking.



Figure 4. Hidden portrait of Charles Darwin (<https://www.ibm.com/watson/artwithwatson/charles-darwin.html>)

It is crucial to differentiate creative computing from computational creativity [40]. The former requires computing itself to be creative. However, the latter aims to imitate human creativity and does not require computing itself to be creative [41]. Take Chris Lee's cognitive dress as an example. Watson may know what people expected from her through intelligent data analysis. However, what if there was something amazing for Chris Lee that the public could not imagine? Although it was easier for the designer and Chris Lee to break their old styles and create something new. However, through creative computing, the new, surprising, and useful results may be able to help people see the unseen and think the unthinkable.

The core idea of creative computing is to "unite and conquer" [38], also known as knowledge combination. It aims to unite various kinds of knowledge from diverse kinds of disciplines to conquer problems within the computing field. People need new perspectives to find the creative ways of performing computing. New perspectives come from new knowledge [42]. Moreover, creative computing particularly focuses on the knowledge that is not conventionally associated with computing like physics or mathematics. It pays more attention to the knowledge that seems more "remote" to computing, such as art or philosophy. It is believed that the more disparate the knowledge is, the newer the perspective will be. With a new point of view, there may be more possibilities for computing to be creative.

However, "computing" is a very general concept that can be understood through various aspects. Microscopically, it can be understood as any activity that uses computers. It includes developing hardware and software and using computers to manage and process information, communicate, and even entertain. Macroscopically, the study of computing can include disciplines like computer engineering, software engineering, computer science, information systems, and information technology. Therefore, the understanding of creative computing also depends on how to comprehend the meaning of "computing". Inspired by the 4P's model of creativity (i.e., creative product, creative press, creative person, and creative process) [43], three approaches for computing in creative ways have been summarised as follows:

#### 4.1. Creative Computing Product

Illuminated by the ideas of creative product, one of the main topics of creative computing is to study the computing product with creative qualities and outcomes. One of the most essential features of creative computing product is the creative instructions/algorithms that can generate unexpected but valuable results for stimulating people's creativity. Furthermore, compared with hardware and web products, for now, creative computing pays more attention to software products, for there are more flexibilities of software. Due to the fast development of hardware and web, a kind of well-developed infrastructure has been prepared for the development of creative software.

One of the typical computing products of creative computing is known as Deviator (see Figure 5), for it is based on the concept of Deviation, also known as the Latin word Clinamen. The concept comes from a discipline known as pataphysics. According to the ideas of knowledge combination, creative computing is particularly devoted to utilising knowledge from other fields to tackle problems within the computing field, especially knowledge that is different from computing. Pataphysics, a kind of philosophy, has received much attention within the realm of creative computing. It is deemed as the science of imaginary solutions and laws governing exceptions, and it was proposed by French writer Alfred Jarry [44]. Based on his writing experiences, various kinds of operations were summarised for stimulating people's creative thinking, including Clinamen.



Figure 5. Deviator

The operation of Clinamen stands for deviating from a conventional way of thinking (see Figure 6). Originally, the idea behind Clinamen is the unpredictable swerve of atoms. It is believed that just because of this kind of deviation, there can be a world with great diversity. A technique is also known as the deviation is widely applied in artistic fields. The Great Wave off Kanagawa was painted by the Japanese artist Katsushika Hokusai by using this technique. Hokusai painted a series of paintings describing the 36 views of Mount Fuji. Each painting was made by unpredictably changing a bit of the previous one. Because of the gradually and deliberately deviation, he finally created the well-known masterpiece. Due to its great creation power, Jarry embodied it as a concept of pataphysics “Clinamen” to trigger people's creative thinking. Specifically, if people often think of “B” from “A”, the deviation operation aims to help people come up with “B'” from “A”. Like the example mentioned before, instead of getting the word “Frog” from “Toad” like people may be used to, the user may receive the word “Hequet” from an application of creative computing and enter a totally different world where creativity may lay in the way (see Figure 6).

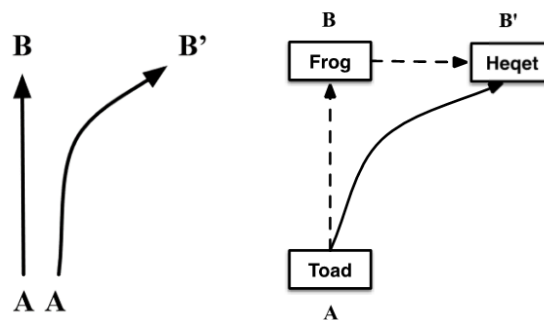


Figure 6. Clinamen

The next key question would be how to fuse the ideas of Clinamen/Deviation into the development of Deviator. As mentioned before, the creative instructions or algorithms are essential to creative computing products. Therefore, how to compose the deviation algorithms for Deviator is the core task. To embody the ideas of deviation further, we need the aid of ambiguity, which is the hallmark of creativity. According to the various studies of human creativity, it has been found that people with creative minds possess some properties in common. The tolerance of ambiguity is one of them, which could help people connect seemingly unrelated phenomena and generate new ideas or alternatives. It is also widely used in the realm of linguistic creativity [45], such as cliché. “An apple a day keeps the doctor away” is a very famous cliché, in which the apple is not just a kind of fruit, but also connected to health or healthy living approaches. Therefore, ambiguity offers the

perfect approach for people to deviate from one perspective to another. To begin with, Deviator starts from the utilisation of text ambiguity. There are various kinds of phenomena that could generate text ambiguity, such as polysemy, compound, and cross-culture, which are associated with the nine deviation functions of Deviator correspondingly (see Figure 5).

Take the function of PolysemyDeviation as an example. It is common that one word could contain multiple meanings. Like the word “Bridge”, it can be understood as “span”, “circuit”, “nosepiece”, and “deck” simultaneously (see Figure 7). Although the different meanings contain something in common, there are still differences among them, which could just be utilised to lead people to see things in different ways. For example, if a user enters the word “Bridge”, conventionally, he/she might get the word “Waterloo” that may remind the user of the Waterloo Bridge or an American drama film tells the story of a dancer and an army captain who meet by chance on the Waterloo Bridge. However, what if people’s minds could creatively deviate to different things through the multiple meanings? For example, if the word “Bridge” is deviated to the word “Deck”, the results might be able to lead people to think of something previously unthinkable, such as a historic deck boat in America (see Figure 8).

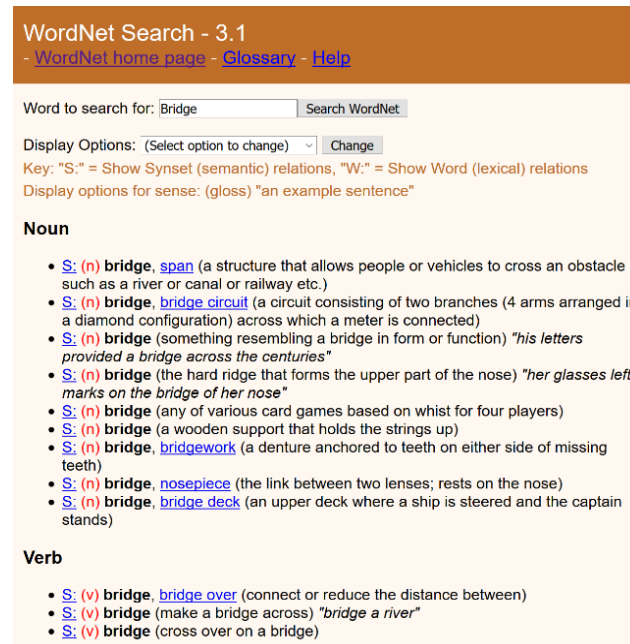


Figure 7. Multiple meanings of word “Bridge”

## 4.2. Creative Environment for Computing Product

The creative environment is another hot topic within the realm of creative computing. Besides the creative computing products, there are also countless common computing products applied in various domains. It is well-known that a good working environment like Google is beneficial to the people who want to be creative and productive. Similarly, with a creative environment, it is also possible for the common computing products to be creative. For now, two possible perspectives have been summarised as follows:

### 4.2.1. From the Perspective of Input and Output

Generally speaking, any computing product is like a black box. With the input, there would be the output processed by the computing instructions/algorithms. Therefore, the first perspective of creating a creative environment for common computing products is through the manipulation of the input and output. Take the output as an example. Nowadays, a new type of search known as Universal Search has drawn much attention from big search engine companies like Google and Baidu. The most important feature of this type of search is integrating search results from different fields into one web page. By doing so, various kinds of resources including webpages, news, images, and videos could be effectively integrated for better user experiences, which offer a perfect solution for the creative integration of the output. For example, if a user inputs the word “iPhone”, the word “iPad” may be one of the outputs. Instead of vertically following the ideas of “iPhone”, a common computing system with the creative integration rules might horizontally deviate the output “iPad” to the word “PDA”, and the user’s attention might be changed from the world of Apple to the domain of PDA (Personal Digital Assistant) (see Figure 9).

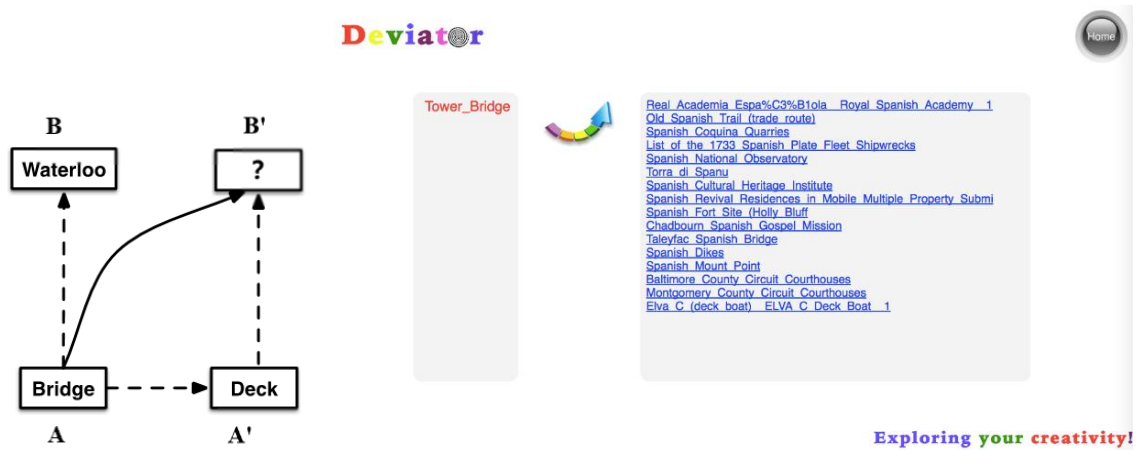


Figure 8. Polysamy deviation

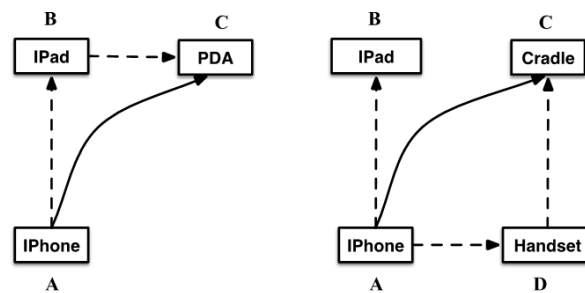


Figure 9. Creative manipulation of input and output

Besides the output, the input also could be creatively manipulated for stimulating people's creativity. Among various potential solutions, the plug-in is one of the most promising ones. A computing product like software always contains various APIs (Application Programming Interface) that could enable the extensions of functions. According to the corresponding regulations, the plug-in containing the rules of creativity, like deviation, may be able to add creative elements into the common computing product for the improvement of human creativity. For example, if a user inputs the word "iPhone", a common computing system might output the word "IPad". If a common application with a creative plug-in could creatively manipulate the input, like deviate the input "iPhone" to the word "Handset", the word "Cradle" might be one of the outputs. By doing so, the user's point of view on iPhone may be changed to a kind of cradle (see Figure 9).

#### 4.2.2 From the Perspective of Middleware

Various facilitations for human creativity can be either simple or complicated. They can either rely on a single program or count on a collection of applications. As mentioned before, the computing technologies nowadays are unprecedentedly abundant, and how to make the fullest utilisation of them has been one of the key concerns. The crucial feature of middleware is the facilitation for the interoperation between different or disparate applications that may be distributed on different machines. Therefore, creative middleware that can supply a good platform for uniting various applications to facilitate human creativity should be studied. Furthermore, with the fast development of IOT (Internet of Things) technologies, it is believed that more types of computing products can be connected creatively for stimulating people's creativity.

#### 4.3. Creative Development of Computing Product

This perspective is illuminated by the creative process of the 4P's model of creativity. It demonstrates that the development process of a computing product is also an essential part of creative computing. The influencing factors of the creative development of computing products include both the activities and people.

In terms of the aspect of activity, two issues are particularly considered in the realm of creative computing. The first one is the research methods for creative computing. As creative computing is a new research field, appropriate research methods may be very helpful to facilitate its development. Furthermore, creative rules or methods are particularly needed for the

creative development of computing products. It is even suggested that the development of computing products should be like the creation of works of art. The second one is the available technologies for creative computing. Technologies nowadays are extremely abundant and diverse. It is unnecessary to construct creative computing entirely from scratch. Therefore, the selection of appropriate technologies, such as Semantic Web, to develop creative computing is necessary.

In terms of the aspect of people, in order to perform creative computing, the associated developing people are also required to be creative. For developers of creative computing, in order to facilitate other people's creativity, they should be creative in the first place. Therefore, how to foster creativity for people like designers and developers is concerned. There is no doubt that a good collaboration can make the best use of knowledge, which is just one of the unique features of creative computing. Furthermore, the developers of creative computing can come from different fields. There may be even artists like musicians studied in the realm of creative computing. Therefore, how to deeply collaborate with them is also studied. After all, the knowledge combination in creative computing is about not only reading papers but also talking with creative people.

## 5. Conclusions

Nowadays, human creativity needs to be improved to meet the increasingly complicated requirements of modern society. Computing technology has been the faithful servant for the world's development, and creativity fields also benefit significantly from it. Various kinds of computing technologies have been explored to facilitate human creativity in different aspects. Due to the fast development of Internet technologies, a new type of learning has been proposed, which offers the initial solutions for technologies to facilitate human creativity. Then, as more types of computing technologies have been generated, more forms have been leveraged in creativity fields, like virtualising applications. Until the era of the so-called new generation of information technologies, computing technologies not only could be utilised as a kind of artistic materials but also could be used to imitate human creativity. Furthermore, as the creativity elements impact computing technologies greatly, people begin to wonder if computing technologies themselves could be creative to serve human creativity better. It is believed that more creation power of computing technologies can be released through this way. There may be more synergy possibilities between human creativity and computing technologies waiting to be discovered.

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