# Chapter 1
# Introduction

*It is the speed of electric involvement that creates the integral whole of both private and public awareness. We live today in the Age of Information and of Communication because electric media instantly and constantly create a total field of interacting events in which all men participate.*
*Marshall McLuhan, Understanding Media, 1964*

Over the past few decades there has been a revolution in computing and communication. Machines that once occupied whole rooms have moved to the desktop, the lap and palm, and into clothing itself. Stand-alone systems are now networked with each other and a wide range of different devices across vast distances. One of the consequences of this revolution is an explosion in Interactive Media technologies. Interactive Media is one of the main developments that emerged as a product of the technological, intellectual, and cultural innovations of the late twentieth century.

Interactive Media means much more than the convergence of telecommunications, traditional media, and computing. Using Marshall McLuhan's definition of media as an "extension of man", new media includes all the various forms in which we as humans can extend our senses and brains into the world. It includes new technologies that allow us to facilitate this new communication, and to create natural and humanistic ways of interfacing with machines, as well as other people remotely over large distances using the full range of human gestures such as touch, sight, sound, and even smell. Thus, new media includes new ways of communication between people, between cultures and races, between humans and machines, and between machines and machines. The vision of new media is that it will bring about radical developments in every aspect of human lives in the form of new kinds of symbioses between humans and computers, new ways of communication between people, and new forms of social organization and interaction. It will drive a revolution in finance, communications, manufacturing, business, government administration, societal infrastructure, entertainment, training and education.

In order for businesses and countries to flourish commercially and culturally in the new millennium, it is necessary for them to understand and foster growth of Interactive Media technologies, and open-minded creative experimentations.

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In this book, we will look at a blue sky research perspective on the field of interactive media for entertainment computing. Entertainment as an end-product is amusing; as a tool it is powerful. The power of entertainment stretches far beyond venues for amusement [21]. Entertainment is a key driver for development of technology. It is able to excite, motivate, satiate, communicate and inspire. With powerful functionality of entertainment, it is being applied to all aspects of life from learning, training, designing, communicating and collaborating everywhere. Therefore, there has been a lot of recent research put in the entertainment industry and it has grown dramatically as a topic of research interest. The book explores the future of entertainment technologies and aims to describe quantum step research. It hopes to inform and inspire readers to create their own radical inventions and innovations which are not incremental, but breakthrough ideas and non-obvious solutions. One of the main explorations in this book will be to examine how new forms of computer interaction can lead to radical new forms of technology and art for entertainment computing.

To make breakthrough ideas in entertainment computing we can draw upon the methods developed at places such as Xerox PARC, Disney Imagineering, and the MIT Media Lab, and by visionary individuals in computer interaction such as Douglas Engelbart, Alan Kay, Jaron Lanier, and Hiroshi Ishii (to name just a few).

The seminal works done by these pioneers were all achieved with small teams of "Imagineers" of multi-disciplinary teams of computer scientists, electrical engineers and product designers together with graphic designers, artists, and cognitive psychologists. The work can be termed "Imagineering", or the imaginative application of engineering sciences. Imagineering involves three main strands of work:

- Imaginative envisioning – the projections and viewpoints of artists and designers;
- Future-casting – extrapolation of recent and present technological developments, making imaginative but credible ("do-able") scenarios, and simulating the future;
- Creative engineering – new product design, prototyping, and demonstration work of engineers, computer scientists, and designers.

In this book, we will focus on two major strands of new interaction design and their effects on entertainment technology and art. These are the related research areas of embodied media and mixed reality. It is therefore useful to outline and introduce these research topics below.

## 1.1 Introduction to Embodied Media

Ubiquitous human media foresees that the future of human–computer interaction will lie in an interface to computing that appears throughout our physical space and time. Thus, humans as physical beings now actually become situated inside the computational world. Extending HCI through concepts of phenomenology and defining the main theoretical roots of both tangible and social computing, Paul Dourish defined a new field of embodied media [8].

Embodied media is a next generation interactive media and computing paradigm that involves the elements of ubiquitous computing, perceptual user interfaces, tangible interfaces and interaction, as well as computer supported collaborative work and social computing. The thesis of embodied media is that all these interactive elements have a common foundation, and that this foundation is the notion of "embodiment". By embodiment, we mean the way that physical and social phenomena unfold in real time and real space as a part of the world in which we are situated, right alongside and around us. Thus, it brings the opportunity of placing computation and interaction through and with the environment, as well as incorporating the sociological organization of interactive behavior.

Important research paradigms that incorporate embodied media can be said to be Weiser's ubiquitous computing, Ishii's tangible bits or "things that think", and Suchman's sociological reasoning to problems of interaction. This sociological reasoning recognizes that the systems we use are embedded in systems of social meaning, fluid and negotiated between us and the other people around us. By incorporating understandings of how social practice emerges, we can build systems that fit more easily into the ways in which we work.

Weiser's [24] philosophy of ubiquitous computing derived from the observations that the most successful technologies are those which recede into the background, and become an unnoticed feature of the world we live in, and secondly, from the observation that computing power is becoming so small and so cheap that it is now really possible to embed computing devices in almost every object and every facet of our physical environment. Weiser saw from these two observations that this would allow computation to be embedded and recede into the environment, allowing new possibilities and completely new uses of computing. Essentially, the environment becomes a distributed computer and responds to people's needs and actions in a contextual manner.

Ishii's [11] vision of tangible bits or "things that think" has its origins in Weiser's work in terms of embedding computing in the environment, but has led to a distinct development because Ishii observed that we operate in two different worlds. These two worlds are the computational world and the world of physical reality. Ishii termed these two worlds the world of "bits" and the world of "atoms". Through tangible bits, Ishii has set out to bring these two worlds together, and allow the computational world to engage and employ our physical and tactile skills which we are intimately familiar with.

It can be seen that ubiquitous computing deals with computing in the environment and with activities that take place in the context of the environment. Also tangible interaction deals with using the physical world and objects and physical space manipulation to interact with the digital world. They are related by sharing the viewpoint that interaction with computers should exploit our natural familiarity with the physical environment and physical objects, and to tie the interaction with computers with physical activities in such a manner that the computer is embedded in the activity. In this way, the environment and physical objects become the interface.

Another research paradigm which is incorporated into the idea of embodied media is social computing, or the study of context in which interaction with compu-

tation occurs. The important work of Suchman [22] on this topic draws on ethnomethodology to analyze interaction and social conduct. In ethnomethodology, social conduct is an improvised affair which is real-time and nonlinear. This perspective argues that the context in which interaction takes place is what allows people to find it meaningful. Experimental investigations have found that people's interaction with technology does not follow formal theoretical abstracts but is improvised in real-time.

These research visions have a central strand that deals with the role of context in interaction. The role of context is seen in the spatial and temporal context found in ubiquitous computing, the physical context found in tangible computing, and the social, cultural, organizational, and interactive context found in social computing. Thus, all are mutually dependent on the concept of embodiment, or a presence and interaction in the world in terms of real-time and real-space. Hence, they define the concept of embodied media.

For example, ubiquitous and tangible computing is the idea of the computer being embedded in our environment, in objects, and in the background. Thus the interaction is embodied in the physical environment, rather than on abstract representations on a computer system. Similarly, social computing places the real-time and real-space activities of humans as social beings, or embodied actions, at primary importance. Embodied media ties all these ideas together, as a single research vision. Furthermore, embodied media foresees that the future of human–computer interaction will lie in an interface to computing that appears throughout our physical space and time. Thus, humans as physical beings now actually become situated inside the digital media.

Through embodied media, new computer and cybernetic systems will improve our lives and create new and seemingly amazing possibilities in human society. We can foresee a future where, instead of humans needing to adapt themselves to computers and electronic systems, computers interact with people in a totally natural and human-like manner to make life easier.

Embodied computing in the context of entertainment and communication systems can use mixed reality to allow the concepts of ubiquitous computing, tangible interaction, and social computing to be concretely implemented. Thus, the concepts of mixed reality are briefly introduced below.

## 1.2 Introduction to Mixed Reality

Mixed reality [2] (the fusion of augmented and virtual reality) is a technology that allows the digital world to be extended into the user's physical world. Unlike virtual reality in which the user is immersed in an artificial world, mixed reality operates in the user's real world. This is made possible through the use of head-mounted displays where the user's real-world view can be overlaid with 3D computer graphics, text, video, audio and speech.

Mixed reality can be used to develop an almost magical environment where the virtual world, such as 3D computer graphics images and animations, is merged with

the real world as seamlessly as possible in real time. For example, architects could work on a realistic virtual 3D model on their desk, and then enter the model together to explore the inside of the virtual buildings; surgeons could "see" the inside of a patients body before operating; children could see animals from exotic lands, and play with them in their real physical space; people could play games with each other together with virtual characters or creatures that appear in their real environment. In the military, there are vast applications of mixed reality in battlefield visualization, simulation, and training, soldier information systems, maintenance, and security.

Hence mixed reality can become a highly important component of future computing systems. It will allow humans to interact with each other in ways that now can only be imagined, and will allow humans to interact with computers in a way that goes beyond the desktop computers we have now.

Mixed reality allows tangible interaction with 3D virtual objects. For example, by moving a physical object, or marker, one can move and interact with virtual objects as if they were real objects in our physical world. Thus, a form of tangible interaction between the physical and digital world is achieved. Later in this book, a tutorial-like chapter on developing simple marker based mixed reality systems will be introduced.

Entertainment art and technology developments using embodied media and mixed reality opens up exciting new opportunities in the areas of computer graphics and human–computer interface development. We can expect applications in a great variety of areas such as education, architecture, military, medicine, training, sports, computer games, tourism, video conferencing, entertainment, and human welfare.

Using our technology, the following entertainment and communication scenarios are possible:

| | |
|---|---|
| Holo-phone technology | While making a telephone call, the person who you are speaking to transfigures in front of you like the way Princess Lea appeared in holographic form in Star Wars. |
| 3D books | For example, on Ancient Greece, where you can read a real book, and then see 3D figures of Greek mythical figures on the actual pages, moving and gesturing. Then you can "fly" into the book and experience what the Ancient world felt like. |
| Sports training | For example, watching a famous ice skater appear on actual ice, and to be able to "freeze" the skater in her actions so that you can look at key aspects in 3D. |
| Training simulators | The use of mixed reality greatly enhances training realism in training-simulators. In particular, the technology can be implemented on military combat-platforms (tanks, helicopters, armored fighting vehicles, etc.) to provide combat simulation when the platforms are operating in real-terrain environment. Computer-generated objects (obstacles and enemy combatants) are superimposed onto the real terrain to provide simulated combat. |

| | |
|---|---|
| Computer games | For example, where 3D figures move around in your actual physical world, just like the holographic chess game in Star Wars. Furthermore, imagine computer games where your friends in 3D form appear in the game, for example, a football game together. |
| Live virtual tours | For example, imagine walking on a guided tour of the real New York Metropolitan Museum of Art in the privacy of your home without having to go to New York. You can see it floor by floor and item by item just like on a real visit. |
| Medical collaboration | For example, a group of doctors sitting around a boardroom in Athens watching "live" or "recorded" a complex heart surgery conducted at the Baltimore Heart Center. Unlike watching a screen, you can choose to observe the operation in 3D from any angle. Unlike other technology, you can observe the patient from the inside using 3D captured data. |
| Architecture | For example, converting an architectural drawing and having it appear in 3D form right on your desktop. You can see the 3D building appearing in 3D in your real world, and then "fly" into the inside of the building and explore it floor by floor. Interior decoration can become so much more realistic and exciting when you can conduct a real 3D renovation. |
| Education | Books will take on a new meaning. Imagine reading "Alice in Wonderland" and having Alice chase the rabbit right before your eyes on the table. |
| Training | Throw away your Tai Chi textbook. Instead, follow your Kungfu Master in live 3D as she shows you how to do the Tai Chi in front of you. |
| Entertainment | Why go to London and watch Tom Jones perform at the London Palladium when you can watch Tom Jones "live" in 3D form right in your living room? Or the same technology could allow Tom Jones and a recreated late Elvis Presley perform together. |

In addition to embodied and mixed reality, in terms of the important effects of interaction technology on entertainment, some of the main aspects we should consider are that computers and other devices are being networked together, supporting new forms of face-to-face and remote collaboration. Wearable and mobile devices are being developed that enable humans interact with each other, digital data and with their wide-space physical surroundings in a new futuristic manner. Perception and sensing technologies are being developed that allow the overlay of virtual imagery on the real world, so that both virtual and real can be seen at the same time to enable remote collaboration and play. These computing technologies are increasingly being used to support new forms of entertainment. Thus we should examine and consider entertainment as a strong form of communication, which can be enhanced

using novel communication media. Instead of communication of raw information, for entertainment purposes we can expand our focus to communication of feelings and affect. Thus we should consider the novel aspects of feeling communication systems and how they can be used for entertainment computing systems, and this will be discussed in the next section.

## 1.3 Feeling Communication

Communication is one of the most fundamental needs and desires of most organisms, especially humans. Media has made advances in many ways in our networked age, for example, allowing communication over long distances including sound, voice, and text. The advent of the Internet, broadband, virtual worlds, and mobile devices allows remote communication through screens (providing audio/visual communication), even while on the move; however, we can have a lack of understanding of real feelings between the sender and the receiver. As described in previous research [19], the metaphor of communicating through a screen or window limits the sense of immersion and limits the ability for humans to communicate effectively. In traditional human communications, body gestures and touch [4] can sometimes more deeply explain the intended mind and provide intrinsic information, which makes for a more rich communication exchange. Furthermore, we often communicate emotionally using all the senses simultaneously, including sight, touch, sound, but also through taste and smell, such as sharing a meal together or cooking for a partner. We thus need to create fundamentally new forms of media to connect humans in the physical world and through the virtual world, not just in the transmission of information and verbal communication, but through meaning and nonverbal communication to increase the sense of telepresence using all the senses. This will allow more opportunities for people to make meaningful exchanges using media in both the physical and virtual world.

Feeling communication focuses on emotional communication that can deeply send our feelings and emotions to others. In other words, feeling communication does not only convey raw data or information, but also our deep feelings, intentions, expressions and culture. This will revolutionize the present digital communications and enhance social, business, and entertainment communication. We thus will examine various forms of feeling communication for that can create new forms of entertainment computing.

There will be various novel research trends and standards from the study of feeling communication. At the fundamental level, we need to develop new theoretical models of communication that unleash the potential for innovation in co-space communication from physical media through the virtual world. Human communication habits and preferences are continuously changing and evolving. A contemporary model includes the role of media and user context and provides for a model that recognizes the more complex context of the communication process and the possibilities of new media being truly extensions of man. Researchers need to go beyond this approach and focuses on human emotions, feelings, and nonverbal language

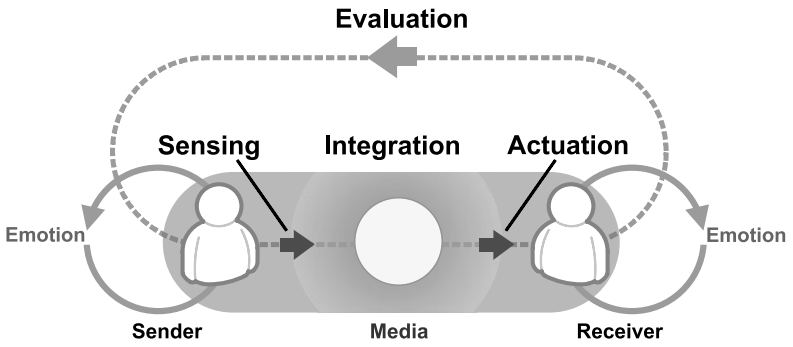


**Fig. 1.1** Feeling communications

as key components in the communication process. Recent studies have helped illustrate that human senses are more acute and versatile than expected. For example, the studies show subjects using the sense of smell to determine the emotions of another person in much the same way as ants use pheromones [5]. This type of research is just beginning to unfold new mysteries of human perception and mind, which shows the potential for a new and more meaningful sense of presence with these new media technologies. Aside from the need for a new model of communication, we also look to improve the nature of human-to-human communication and entertainment, particularly through the co-space of physical and virtual world. The highly connected nature of people using the Internet also leads to our disconnectedness in physical social spaces, providing weaker links to general society and in some cases reducing the community and social aspects of life. We can improve this situation with corresponding new forms of entertainment and communication.

The main components in the design of feeling communication and entertainment systems are described below and summarized in Fig. 1.1.

Sensing This interaction is between the sender, the sender's environment and the media. The sensors can detect five sensory cues from the sender and her environment. An example is that the various sensors in the smart media can measure the sender's behaviors, intentions, and emotional changes.

Actuation This interaction is between the media and the receiver. The actuator can actuate certain sensory cues, which can represent the emotion or feeling of the sender, according the transmitted parameters. Following the example above, the smart media can make various visual, auditory, tangible, smell and taste expressions on it such that the receiver could also understand the meaning of those expressions.

Integration This interaction is between the sender and the receiver. This interaction needs the integration of human emotions and various expressions to understand the sender's and receiver's messages and emotional state.

To develop such a feeling communication and entertainment system, there are fundamental, theoretical issues that must be addressed, and a there is a need to refine the theory and provide insightful experimental results, user experience, and

usability studies. Hence, the research issues which need to be examined through a combination of engineering, social science, and human computer interface studies include the following:

### *1.3.1 Emotional Communication and Entertainment Using Multi-sensory Media*

In the world of co-space, physical presence takes a major role and it should dive into a new dimension of cutting edge technologies offering improvements to ordinary day-to-day feelings and experiences. We can use new technologies related to multimodal sensing and actuation to give the user more definition in their experience in the co-space environment. Visual, Auditory, Haptic, (Olfactory) Smell, and (Gustatory) Taste are the five sensors that humans use for environmental sensing, and emotional feeling communication. In addition to traditional communication through telephone and video-conferencing, the use of haptics, smell, and taste communication will enable a new paradigm of communication and have great research potential. Research into taste and smell communication has just begun to be explored in the field of human–computer interaction [3]. It is a field which still presents great technical challenges leading to early technical breakthrough results. We need to make use of these two senses for feeling communication media in combination with touch, sight, and sound, and enable users to utilize new media for conveying a sense of emotion. We can identify two main components in taste and smell communication: sensing and actuation.

Sensing of smell and taste is still in its early stages; researches have been conducted in the field, yielding promising results such as NASA JPL's electronic nose that uses 16 polymer sensors. Present research (Table 1.1) uses primary theories, for example, when a substance such as stray molecules from methane is absorbed into these films, the films expand slightly and there is a change in how much electricity they conduct. For actuation (Table 1.2), smell can be printed either in a 2D paper or in a 3D object using individually identified molecular components. It is possible to transmit smells and tastes over a distance, where it requires the exact composition of percentages to be transmitted.

The sensing of taste too takes a similar approach to the sensing of smell. There are five basic tastes a human perceives: sweetness, bitterness, sourness, saltiness, and umami. It is believed that these five tastes in various combinations make up different kinds of tastes that the human feels. Similarly, research in this field has come up with various solutions to identify taste such as those summarized in Table 1.3. Most of the current researches focus on a particular problem such as food quality control or beverage identification, etc., resulting in a limited range or number of chemicals to be identified. But for a next generation sensor, the contexts of use will include applications such as high fidelity human communication in which it is a great technical challenge to build a more general sensor that responds to a wide variety of tastes. Therefore, a new kind of taste sensor that uses an array of higher

**Table 1.1** Smell sensing

| Present state-of-the-art | Description | Next steps |
|---|---|---|
| JPL's ENose by NASA research and Electronic nose research at IIT [20] | Uses a collection of 16 different polymer films. These films are specially designed to conduct electricity. The sensor array "sniffs" the vapors from a sample and provides a set of measurements, pattern recognized with stored patterns for known materials | Develop systems to use a large collection of different polymer films to increase the sensing resolution. Also Frequency variation of a quartz oscillator can be used to accurately decide the different polymer types (a better way of identifying the polymers). The overall smell sensing subsection should be a very small-scale smell module which can be easily fit into a mobile phone |
| Electronic Nose Prometheus by Alpha M.O.S. [17] | The PROMETHEUS is the world's first odor and VOC analyzer that combines a highly sensitive fingerprint mass spectrometer | |

**Table 1.2** Smell actuation

| Present state-of-the-art | Description | Next steps |
|---|---|---|
| Energi Print [9] | Energi Print has developed, in conjunction with international ink manufacturer Flint Ink, a genuine litho-varnish that has fragrance encapsulated within the varnish. It can print 10 different fragrances of flowers and plants | Develop a small-scale smell actuator or printer that can be used to actuate a vast variety of smells. The actuator could be electrical or chemical and perhaps inserted into the nose. Or the smell can be printed either in a 2D paper or in a 3D object using individually identified polymer components. Edible paper can be used where there is a need for smell and taste to be printed, and fragrance ink can be used for smell printing. Furthermore, develop a new kind of printer which is capable of printing graphics, taste and smell into edible paper, and which uses edible inks for smell and graphic printing |
| Olfactory display at ATR [25] | This work is more of a related work as it did not look at synthesizing the odor itself, however, it provided a very interesting method for a smell actuation interface which could be used with smell actuation systems, an olfactory display that does not require the user to attach anything on the face. The system works by projecting a clump of scented air from a location near the user's nose through free air. The system also aims to display a scent to the restricted space around a specific user's nose, rather than scattering scented air by simply diffusing it into the atmosphere. To implement the concept, the researchers used an "air cannon" that generates toroidal vortices of the scented air | |

**Table 1.3** Taste sensing

| Present state-of-the-art | Description | Next steps |
|---|---|---|
| Electronic Tongue of the St. Petersburg University [23] | It uses an array of non-specific chemical sensor arrays to detect the taste of various liquids. The sensor module, hardware for A/D conversion and a PC for data processing are being used | Develop systems to use a large collection of different polymer films to increase the sensing resolution. Also Frequency variation of a quartz oscillator can be used to accurately decide the different polymer types (a better way of identifying the polymers). The overall smell sensing subsection should be a very small-scale smell module which can be easily fit into a mobile phone. Quantum steps in developing a taste sensor that is both miniature and of higher resolution to determine almost any taste are needed. The current status of research does not focus so much on the mobility of such a taste sensor. Research into developing a non-specific sensor array on a silicon wafer that could efficiently determine the composition of the chemicals to determine the taste |
| Electronic Tongue of the Cardiff University's School of Engineering [6] | It has an array of 5 chemical sensors to detect the 5 basic tastes. It has a 3 tier system similar to the one from the St. Petersburg University | |

**Table 1.4** Taste actuation

| Present state-of-the-art | Description | Next steps |
|---|---|---|
| Chef Cantu's Canon Inkjet taste printer at the Chicago Restaurant [13] | This is a normal inkjet color printer that has been modified for taste printing with different edible ink cartridges on edible paper | Focus on miniaturizing the taste actuation process with a much higher precision and accuracy. New actuation media which could be direct electrical, or via liquid or edible paper media need to be invented. We can envision a taste sensor and taste printer that is attached to a mobile communication device that enables us unlimited seamless taste communication that would enhance our feeling communication |
| Food simulator at Tsukuba University [12] | The food simulator is a haptic device that simulates and actuates a biting force, while presenting auditory and chemical display at the same time. The device can present both food texture as well as chemical taste. The food simulator operates by generating a force on the user's teeth as an indication of food texture. Although the work was focussed on the haptic sensation of food rather than taste actuation, it can be combined with future taste actuation systems | |

number of non-specific chemical sensors for a wide range of taste sensing should be developed. Thus, to add to this technical challenge is the immense effort to increase the resolution and the speed of response. In addition, such a device should be as small as possible to be easily integrated with a mobile communication device. For taste actuation also, the same principles can be applied. By identifying the chemicals that contribute to the five different tastes, we can mix and match them to produce the desired taste. As some research indicates, common printer technology can be used to print the tastes on edible paper (Table 1.4). The technical challenge here too remains in the miniaturization of such a device where careful research and design has to be spent on engineering such a device to suite the requirements such as the resolution of the sensed taste and also the speedy printing.

## 1.4 Social and Physical Entertainment

We have introduced the important paradigms of embodied media coupled with mixed reality, and the changing form of network communication for feeling communication and entertainment. We will now discuss in more detail some introductory concepts about why such techniques are important for the future generations of entertainment computing, especially to form social and physical connections through entertainment.

In pre-computer age, games were designed and played out in the physical world with the use of real world properties, such as physical objects, our sense of space, and spatial relations. Interactions in pre-computer games consisted of two elements: human-to-physical world interaction and human-to-human interaction. Nowadays, computer games have become a dominating form of entertainment due to their higher level of attractiveness to game players. There are some superior advantages which make computer games more popular than traditional games. Firstly, they attract people by creating the illusion of being immersed into imaginative virtual world with computer graphics and sound [1]. Secondly, the goals of computer games are typically more interactive than those of traditional games, which brings players stronger desire to win the game. Thirdly, usually designed with the optimal level of information complexity, computer games can easily provoke players' curiosity. Consequently, computer games intrinsically motivate players by bringing them more fantasy, challenge and curiosity, which are the three main elements contributing to the fun in games [14]. Finally, compared with many traditional games, computer games are also easier to play at any individual's preferred location and time. Thus, today's mainstream entertainment revolves around interactivity. People today enjoy entertainment they can control, and experience in which they are fully involved [26].

However, there is still a big gap to achieve physicality, mobility, tangible, social and physical interaction for people's entertainment. The development of computer games has often decreased their physical activities and social interactions. Computer games focus user's attention mainly on the computer screen or 2D/3D virtual environments, and players are bounded to the use of keyboards, joysticks, and the

mouse while gaming. Although Nintendo Wii has been a breakthrough in terms of adding a more natural physical action to the video game play, the users are still basically standing or sitting in a spot and are focussed on a television screen. Thus in general, physical and social interaction is constrained, and natural interactions such as gestures, body language and movement, gaze, and physical awareness are lost [15].

Social interaction is critical as people not only want computer entertainment; they want to enjoy it together with family and friends. As shown in a survey [11], one of the top reasons why game players like to play games is that game playing is a social activity people can enjoy with family and friends. With advancement in networking technology, social gaming has gained popularity since the introduction of networked games [11]. Networked games overcame the barrier of distance, enabling real people play against each other over large areas. After all, there is no opponent like a live opponent since no computer model will rival the richness of human interaction [9]. According to a recent study by Nezlek [18], enjoyable and responsive interactions increase life satisfaction scores among people. However, a network game has a big deficiency because people cannot have physical interactions among each other. Natural interactions such as behavioral engagement and cognitive states are lost during entertaining. Addressing this problem, growing trends of nowadays games are trying to fill this gap by bringing more physical movements and social interactions into games while still utilizing the benefit of computing and graphical systems. In the commercial gaming area, the stunning success of the Nintendo Wii over the more technically advanced Sony Playstation and Microsoft Xbox has shown the general popularity of social and physical entertainment.

In future research systems, it seems that tangible mixed reality gaming has assumed a prominent role in fusing the exciting interactive features of computer gaming with the real physical world. An addition to the traditional paradigm offered by combining real and virtual worlds in entertainment is the notion of the social experience. Most of today's computer entertainment titles are multi-playing and draw their attraction between human competition and cooperation. However, since there are limitations of traditional human–computer interface, social interaction is still not an integral part of the entertainment experience. For example, with a traditional game, players cannot interact with each other in a natural affective fashion, but communicate each other through a computer screen or microphone. And also all actions they play on each other are implemented by keyboard or mouse, or joy-controller. Natural human interactions such as gestures, physical movement, tangible touch, gaze and eye contact, and communication such as with smell are lost in the game. The social experience is not just about providing multi-player experiences where the user's can compete and collaborate with each other, but also have to further augment the strong emotional involvement among the players by introducing direct social face-to-face and feeling communications as well as new interfaces between the players and the virtual domain.

In the subsequent parts of the book, some blue sky research examples of mixed reality entertainment which give players more compelling experiences of physical, virtual and social interactions in the future of entertainment systems will be pre-

sented. In order to regain natural interactions, mixed reality technology and feeling communication have great potential for promoting social and physical interactions in entertainment. Such systems are a novel form of entertainment that anchors on physicality, mobility, tangible, social and emotional interaction, and ubiquitous computing. With these systems, there are three main features: Firstly, the players physically and immersively role-play in the game, playing as if a fantasy computer digital world has merged with the real physical world. Secondly, users can move about freely in the real world, whilst maintaining seamless networked social and emotional contact with human players in both the real and virtual world. Thirdly, such systems also explore novel tangible aspects of physical movement and perception, both on the player's environment and on the interaction with the digital world.

Physical interaction allows a psychological advantage in that players immerse themselves from the real world to virtual world effectively. Players should keep a mental model of the action in real world when they jump into the virtual environment. Physical interaction thus should be a fundamental element for the next generation entertainment. Together with the highly dynamic nature of computer simulations, the upcoming use of the multi-sensual presentation capabilities of entertainment technology has the potential to provide much more inversive and richer gaming situations than those of the present gaming systems.

With social and physical interactive paradigms, the new hybrid application will open a new page for computer entertainment. In subsequent chapters, we will discuss these ideas, systems, and projects in detail in terms of their motivations and requirements of the particular application domain, their system description and design decisions, as well as their future impacts on the human social and physical entertainment field.

In Chap. 2, Human Pacman, based on the original Pacman video game, is an outdoor gaming system where players take the role of Pacman and Ghost physically, and interact in a physical–virtual environment through custom-built wearable computers. Human Pacman emphasizes the importance of physical activities and human–human relationship in a future entertainment system.

The Human Pacman is an example of augmented reality entertainment, where the virtual world is embedded in the physical world, whereas in Chap. 3 we examine augmented virtuality entertainment, where the physical world is captured and embedded in the virtual world. The described 3D-live system is used for making an interactive theater that combines the live human capture, spatial sound, augmented reality, human-oriented interaction, and ambient intelligence technologies. Users can interact tangibly with their or their friends' 3D live avatars, which leads to a special kind of self-reflection and offers a new form of human interaction.

Interactive media should be aimed to enhance not only human-to-human communication, but also human-to-animal communication. Thus in Chap. 4, a new type of inter-species media interaction is described, which allows human users to interact and play with their small pet friends (in this case, hamsters) remotely via the Internet through a mixed reality based game system. The system called "Metazoa

Ludens" is an example of mixed reality entertainment computing, forming a new kind of human-to-animal communication.

Entertainment is a form of empathetic communication, and it can also be used to enhance warm communication between humans and animals. Being a cross-section of haptics, cybernetics, tangible interaction and remote communication, Poultry Internet described in Chap. 5 is a human–computer–pet interaction system that transfers the human contact through the Internet to the pet, and simultaneously transfers the pet's motion in real time with a physical dolls movement. This system emphasizes and enhances the human–pet relationship which is under-estimated severely in our modern society.

Another positive advantage of entertainment computing is to enhance communication of young and elderly, especially in our modern world with rapidly aging population. To enhance inter-generation relationship between the elderly and young, Chap. 6 presents the Age Invaders project. Like Human Pacman which brings standard computer games into the real world, Age Invaders requires and encourages physical body movements rather than constraining the user in front of computer for many hours. More importantly, the game offers adaptable game parameters to suit the simultaneous gaming of elderly and young so that they can play harmoniously together. This unique feature of Age Invaders helps to strengthen the intergenerational bond significantly and promotes mental and physical activity through mixed reality entertainment.

With more and more time being spend in the virtual world, we are often isolating ourselves from the real world where actual physical touch is very important as a communication means. Touch is able to signal deeper meanings than words alone, and is an essential non-verbal and non-logical communication. Entertainment and play can enhance non-verbal and indirect communication. In Chap. 7, a novel wearable system aimed at promoting physical interaction in remote communication between parent and child is discussed. The system "Huggy Pajama" enables parents and children to hug one another through a hugging interface device and a wearable, hug reproducing pajama connected through the Internet.

Another positive use of entertainment computing is to promote deep culture by creating new forms of entertainment media which combine traditional culture with modern entertainment media. Young people often prefer new entertainment and social media, and this we can allow them to explore culture through a novel merging of traditional cultures and literature with recent media literacy. New forms of cultural computing systems are thus presented in Chap. 8.

Entertainment can be a great tool to promote happiness and comfort in all ages and cultures, and this can be aided by the soft power of cuteness. Chapter 9 describes the importance of cute or kawaii culture in entertainment, popular culture, and interactive media. Cuteness in interactive systems is a relatively new development, yet has its roots in the aesthetics of many historical and cultural elements. We provide an in depth look at the role of cuteness in interactive systems by beginning with a history. We particularly focus on the Japanese culture of kawaii which has made a large impact around the world, especially in entertainment, fashion, and animation. We then take the approach of defining cuteness in contemporary popular

perception. This knowledge provides for the possibility to create a cute filter which can transform inputs and automatically create more cute outputs. The development of cute social computing and entertainment projects are discussed as well.

In our busy urban lives, we need to have short bursts of fun to relieve stress no matter where we are. Entertainment includes "fun" in our everyday life activities, from meeting friends to relaxing at hot spas. Everyday artifacts can become entertaining media if these artifacts and environment are designed to be responsive. Chapter 10 discusses the researches of entertaining artifacts to share how to design responsive artifacts for entertaining experience in our everyday life.

Chapter 11 describes a new form of combining physical and virtual entertainment on the tabletop. The video game industry is constantly searching for new ways to convert non-players into dedicated gamers. Despite the growing popularity of computer-based video games, people still love to play traditional board games, such as Risk, Monopoly, and Trivial Pursuit. Both video and board games have their strengths and weaknesses, and an intriguing conclusion is to merge both worlds. We believe that a tabletop form-factor provides an ideal interface for digital board games. The design and implementation of tabletop games will be influenced by the hardware platforms, form factors, sensing technologies, as well as input techniques and devices that are available and chosen. This chapter describes the most recent tabletop hardware technologies that have been used by tabletop researchers and practitioners, discusses a set of new experimental tabletop games and presents ten useful evaluation heuristics for tabletop game design.

## 1.5 Conclusion

It has been argued that entertainment is a key driver for development of technology, and it is proposed to use embodied interaction between humans and computation both socially and physically, with the aim of novel interactive computer mixed reality entertainment. Social and physical interactive paradigms for mixed reality involve the elements of ubiquitous computing, tangible interfaces and interaction, as well as social computing. They bring the opportunity of interaction and entertainment through and with the environment, rather than only on a desktop computer with keyboard and mouse, in addition to incorporating the sociological organization of interactive behavior and a deeper feeling communication. Thus, with social and physical interactive paradigms, people can easily play and entertain with each other and computers within the real and virtual world. Essentially, humans as physical beings now actually become situated inside the computational world.

The background of social and physical interactive paradigms was discussed, and in the later sections of this book, more detailed research and analysis will be shown, where the users have interactions both socially and physically by computing within the physical environment. Moreover, these activities take place in the context of the environment. Using 3D graphical objects, tangible interaction, and 3D sound, ubiquitous computing allows the manipulation of objects in physical space to interact

with digital information. For these systems, the computer is embedded in the activity in such a way that the user interacts with the environment, and physical objects themselves become the interface.

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