

Pet Internet and Huggy Pajama: A Comparative Analysis of Design Issues



James K.S. Teh and Adrian David Cheok

Mixed Reality Lab, National University of Singapore, Singapore.

Abstract— Pet Internet is a system that allows human to touch ones pet remotely and for the touch to be reproduced on the pet. Also, human can see the movement of the pet reproduced on the physical pet doll avatar. The aim is to increase the feeling of physical presence between human and pet. Based on this system, Huggy Pajama is developed with a similar aim to connect humans remotely by providing an interface for physical interaction. This system aims to capture the meanings and intentions present in daily communication between co-located individuals, but lost in remote communication by voice and video.

In this paper, we give a short description of both systems and discuss the similarities and differences. This comparative evaluation highlights the different needs of remote physical interaction systems built for pets and humans.

Index Terms—Human-Animal, Human-Human, Interface Design, Haptic, Remote Communication

I. INTRODUCTION

In today's modern urban lifestyle and global 24/7 economy, working parents are constantly kept apart from their children at home by heavy over work and business trips. It is ironic that while the purpose of work is to enable parents to provide for their loved ones, they have to sacrifice too much time with their loved ones as a result. Children are left at home, while parents are constantly balancing between work and worrying about the well being of their children. The uncontrolled development of society due to this vicious cycle can result in feelings of isolation, loneliness and a lack of sense of value [1]. Communication via voice, video and text exist but such communication lacks the physical interaction which has been shown in previous research to be vital in effective communication [2]. Therefore there is a strong need for loved ones to constantly keep in touch, and express affections to one another.

In addition, a growing number of households are keeping pets. At the same time, cases of pets being abandoned with their owners citing a lack of time as a reason for their actions simply reflects a persistent problem in society. Along the same lines, there is a strong motivation for developing a system to help pet owners communicate with their pets in a manner which ensures that their care and presence contribute to the wellbeing of the

pet. Also, humans benefit from this exchange with pets as pets are one of the symbols of nature which bring non-mechanistic behaviors and warmth to our daily lives.

Although never intended to replace real physical hugging, we believe such systems would be of great benefit for times when the parent and child or owner and pet cannot be at the same place.

In this paper, we present a short overview of the Pet Internet [3] and Huggy Pajama systems [4]. Based on the experience of developing these novel physical interaction systems for very different end users, i.e. pets and humans, we discuss and evaluate both systems for their similarities and differences from the technical as well as end user viewpoint considerations.

Pet Internet is a novel physical interaction and symbiotic system between human and pet. It is a human-computer-pet interaction system that captures and reproduces human touch on the pet through a form of wearable pet jacket. At the same time, it also allows human to see the physical movement of the pet through a pet doll mounted on a mechanical table which tracks the movement of the real pet. Fig.1 depicts the general overview of the system. On one end, human touches the pet doll with embedded touch sensing circuitry, while on the other end, the pet wears a lightweight jacket with embedded vibrotactile actuators which reproduce touch at designated areas corresponding to the area of human touch on the doll.

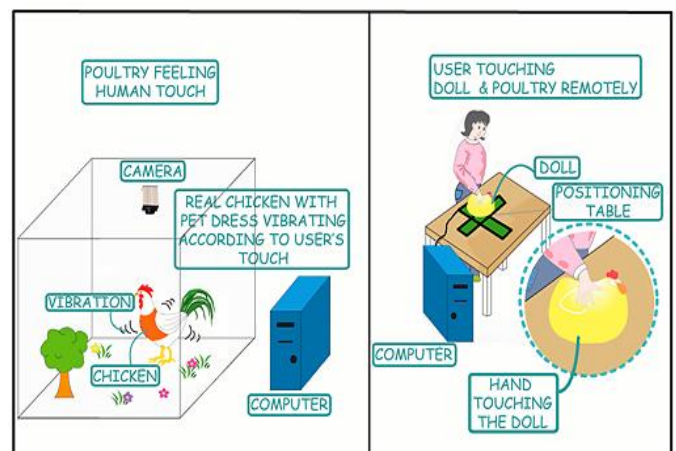


Fig. 1. Overview of Pet Internet. Office system is where the human touches a pet doll and see the physical movement of the pet. Backyard system is where the real pet is located. The pet wears a lightweight jacket which reproduces human touch on it through vibrotactile actuators.

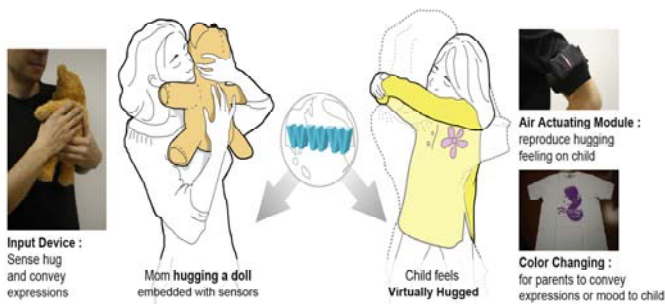


Fig. 2. Overview of Huggy Pajama. On the left side, we have an input device that acts as a cute interface that allows parents to hug their child and send mood expressions to them. On the right side, connected through the Internet, we have air actuating module and color cloth changing expressive interfaces to reproduce hug and connect parent and child.

Huggy Pajama is a remote and wearable human-computer-human interaction system that allows users to send and receive touch and hug interactions as well as communicate mood moods and expressions. Huggy Pajama consists of two physical entities. On one end, we have a novel hugging interface in the form of a small and mobile doll with embedded touch and pressure sensing circuits. It is connected via the Internet to a haptic wearable pajama with embedded air pockets, heating elements and color changing fabric. A general overview of the system is shown in Fig. 2.

TABLE 1: MODES OF INTERACTION FOR PET .INTERNET

Interactive Modes	Description
Remote touch	Transmit human touch on pet doll avatar to pet
Haptic pet jacket	Reproduce touch sensation on pet
Tangible feedback for human owners	Physical pet doll avatar mimics the movement of real pet

TABLE 2: MODES OF INTERACTION FOR HUGGY PAJAMA

Interactive Modes	Description
Remote touch and hug	Transmit touch and hug on doll to wearer of pajama
Haptic pajama	Reproduce hug sensation and warmth on wearer
Distance and emotion indication	Color changing clothes and accessories to indicate distance of separation between parent and child, and display emotional data

This pajama is able to simulate hugs to the wearer according to the inputs from the hugging interface, as well as generate warmth to accompany the hug, display fabric color changes according to distance of separation between parent and child, and display physical emoticons. Our system provides a semantically meaningful interface that can easily be understood by children and parents as a reproduction of hugging. Furthermore, hug sensation is produced in a calm and relaxing way through air, rather than through vibration or other mechanical means. We aim to have an “impedance matching” between the input (a soft, cute, calm touch sensing interface) and output (ambient, calm, cute, hugging output). The interactive modes for Pet.Internet and Huggy Pajama are summarized in TABLE 1 and TABLE 2 respectively.

1.1. Motivations

The main motivation for using touch and hug as part of communication is to support physical interaction in a way that current voice, video and textual communication cannot. In various psychological studies exploring touch, results show that touch is essentially not just important for complex sensory motor tasks, but offers a deeper neural sensation evoking for recognition and judgment. Such neurological consciousness aroused through available haptic information is important for humans to make decisions pertaining to their surrounding and interaction with others [5]. We have described further motivations that support the importance of touch and physical interaction in communication in our previous papers [3, 4]. Mainly, these arguments are from a neurological, psychological and social aspect. Therefore with Pet Internet and Huggy Pajama, we hope to further provide haptic communication for contact comfort, even though reproduced and via remote means, in an attempt to give more opportunities for owners and pets, as well as parents and children to show their love.

II. PRIOR ART

There are a number of works related to remote haptic systems in recent years. Here we highlight the works which are considered pioneers and have strong influence on the direction of this research area. Brave [6] presented InTouch, which is a system aimed at increasing the sense of two persons sharing the same physical space, albeit remotely. This work in turn supports the tangible user interface (TUI) concept as proposed by Ishii [7]. Both these works have set the stage for a proliferation of research projects on developing remote haptic systems.

Similarly, there are some previous works related to the area of hug interaction and communication between humans. The Hug [8], TapTap [9] and Hug Shirt [10] are some examples which were described in [4].

In contrast to these systems, one of the first examples of haptic remote communication between humans and pets, Pet.Internet developed a system for human owners to touch their poultry pet over the Internet and receive a tangible feedback in the form of a real, physical pet doll avatar which mimics the movement of the actual pet at a remote place. Building on the work done for Pet.Internet, Huggy Pajama places importance on building a real time touch and hug communication system with a

soft and mobile input interface, and a soft, calm and realistic touch and hug output, coupled with feedback for both users in both directions. The real time, instead of recorded or delayed feedback gives users assurances about the wellbeing of the other. In addition, the calm hug reproduction is important to create a comfortable feeling for users.

III. SYSTEM COMPARISONS

The Pet Internet and the Huggy Pajama systems are designed with the same common goal as stated in the previous section, but with different end users. Pet Internet is designed for humans to communicate with animals, and this presented a significant problem in finding common ground for both sides to understand the intention being communicated. On the other hand, Huggy Pajama builds on the work done in Pet Internet while also attempting to investigate effective ways for two remote persons to communicate their affection and intended mind. In the following, we compare the technical and design aspects of both systems.

3.1 Input module

In both the Pet Internet and Huggy Pajama, the inputs are designed to correspond and to map closely to the outputs. We have implemented a one-one mapping from input sensors to output actuators for both systems.

The Pet Internet project has a simple design for input touch sensing. Capacitive touch sensors are used and the touch sensing circuitry could detect the presence of a human touch nearby the capacitive electrodes. However, to maintain stable results, the touch sensing circuit can only detect two levels of touch, whether the touch is present or there is no touch. The circuit is not able to detect varying levels of touch force on the surface of the electrodes as the electrodes are mounted inside a hard doll casing. This is to fix the electrodes in place so as to create a stable capacitance field.

On the other hand, in Huggy Pajama, we implemented a touch sensing circuit based on force detected on the sensors. The main material used here is the Quantum Tunneling Composites (QTC) [11]. This design implementation is done because a simple on-off touch sensing circuit does not have the required fidelity to simulate and reproduce a realistic touch from one person to the other person. A lot of information in the touch (in terms of varying levels of force with time) is lost if the same on-off design used in Pet Internet is used in Huggy Pajama. Therefore, in order to capture the essence of a hugging action, detection of varying levels of force acting on the input device with respect to time is important.

Another aspect of the input design which is significantly different is the form factor of the input sensing device. For Pet Internet, a hard shell doll with a hollow body is used as the touch interface, with the touch sensing circuitry embedded inside it (Fig. 3). Also this body is mounted on a mechanical table for the purpose of replicating the movement of the real pet on the doll. Thus, the input device for Pet Internet does not have a soft feel, and is heavy and cumbersome due to the mechanical table.

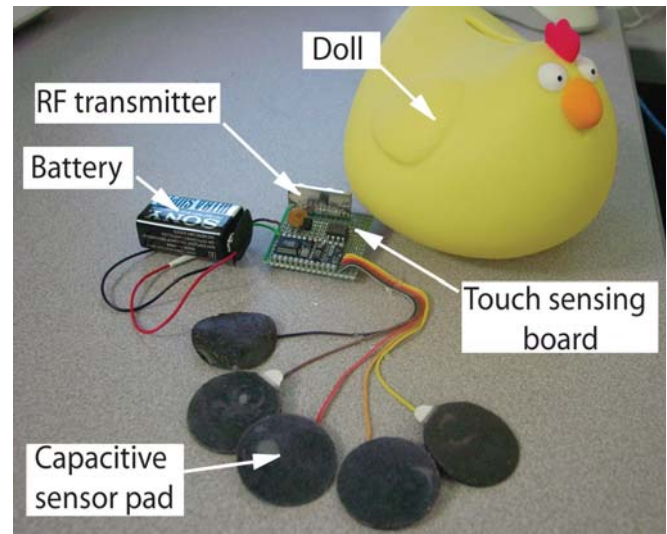


Fig. 3. Touch sensing circuit for Pet Internet. The sensor pads are positioned on the inside of the hollow body of the doll as well as the transmitter circuits and battery. (See Color Plate 15)

The input sensing device for Huggy Pajama received several important improvements over the Pet Internet interface. Fig. 4 shows the touch and hug sensing device for Huggy Pajama. As the end users are humans, the aesthetic design is shaped like a small doll with body and side arms to correspond to the human body where we want to reproduce the haptic sensation. The appearance of the input device is considered one very important point which affects the user experience in affective communication. Hence, we opt for a cute, simple and clean design, with rounded corners. The small size is also such that the device can be used as a mobile phone accessory, similar to a cute phone strap that is wildly popular in the Asia. Also, the doll has a semi-soft interface which gives user a nicer feeling while touching it.

3.2 Output module

The output module for Pet Internet is in the form of a light wearable jacket for the pet with embedded vibrating actuators (Fig. 5). In the design, the weight, size and shape of the wearable jacket are taken into consideration. We used a poultry pet (chicken) in the project, and since it has a relatively small size, this limits our design to include a few small vibrating motors targeted at specific areas of the body of the pet. In animal welfare, it is not necessary to know exactly what an animal is feeling, but the important thing is to know whether the animal feels good or bad [12]. Also, as an indication of the effect of touching poultry, a study by Jones [13] shows that poultry farmers could have more productive hens if they installed video screens showing chickens being stroked have positive effect from being touched. Therefore, our design needs to be as simple as possible to not burden the pet, and yet allow us to obtain a response from the pet. The vibrating motors are used as two-level on-off actuators so as to correspond to the function of the input. These simple to use and lightweight motors are suitable for the relatively small body of the pet compared to the human. Vibration can be experienced as diffused and unlocalized, and gives pet a distributed touch

sensation. Our related paper showed results of user studies conducted on the poultry, which showed positive effect and preference to experience the touch system [3].

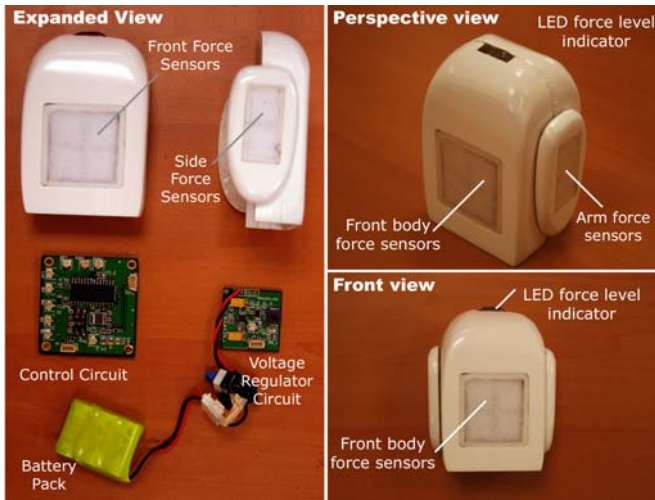


Fig. 4. Touch and hug sensing device for Huggy Pajama. The force sensors are covered with soft fabric which gives a nice touch feeling to the users. (See Color Plate 16)

In contrast, the output module for Huggy Pajama uses air actuators embedded in a wearable pajama to simulate hug on the body of the user. With air we can simulate different pressures acting on different parts of the body of the user in a calm and gradual manner. Thus the output module can be more precisely mapped to the touch or hug forces acting on the input device. The calm feeling produced by air actuators is important to create a comfortable feeling for users in emotional and affective communication, while vibration actually gives an intrusive and uncomfortable feeling, more suitable to arouse attention. The air actuators are developed in a modular manner, and embedded into the wearable pajama. Therefore we can easily change the size and shape of the actuators based on different body size and shape of the intended users. This feature is important as body sizes and shapes can vary greatly between children and adults.

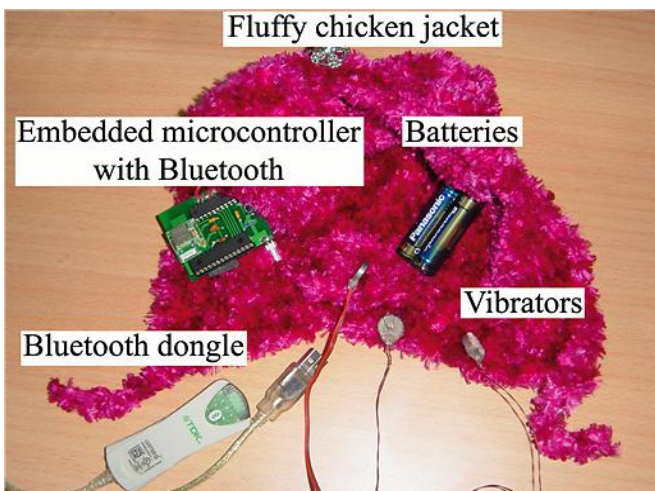


Fig. 5. Wearable pet jacket with embedded vibrating actuators

3.3 Communication and Feedback channels

The availability and type of feedback are important considerations for the design of remote communication systems. In daily conversations, we perceive facial cues and body gestures as important hints of the actual feeling of our counterpart. Similarly, in remote communication, we need special feedback cues give users a better sense of what the other person is feeling and also to find out if the intended message is successfully communicated.

In the Pet Internet project, we implemented a one-way touch communication where only the human users could touch the pet. This logical design stems from the inability of the poultry pet to touch. However, a feedback to the human user is still required in order to assure the human user that the pet is responding to one's touch. The feedback is implemented in the form of the pet doll following the movement of the real pet. The tracking is done at the location where the real pet is situated using a web camera. As such, users can see the real time movement of the actual pet reproduced on the pet doll. This type of feedback is suitable as it automatically obtains the input from the pet in the form of video camera images.

However, the usage scenario is different where both parties are human. In our daily lives, a hug given by one party is usually reciprocated by a similar hug from the other person, both happening simultaneously. Similarly, a remote hugging communication system should have a two-way hugging communication ability. In Huggy Pajama, we provide this two-way hugging functionality for real time hug interactions between the remote parties.

Besides that, Huggy Pajama has additional features which are aimed at allowing users to express their emotions and affections. Just as emoticons are useful in enhancing remote textual communication in online chatting, we believe that providing symbolic color changing patterns and designs can help remote persons to communicate their inner feelings more effectively. This design consideration also reflects the rich interactions that we have in our daily lives. For example, young children can have color changing emotion expressing teddy bears appearing as patterns on their clothes. As an example, a flower fashion accessory is designed for the young child in Fig. 6. This flower accessory thus becomes more than just an accessory; it is a connection point between parent and child. It allows the parent to relate his or her feelings to the child, and the child to see their feelings.



Fig. 6. Color changing flower pattern design as cute, emotional interfaces for Huggy Pajama.

3.4 Summary of Comparisons

In the previous sections, we have discussed and compared the different design considerations for the Pet Internet and the Huggy Pajama systems. Even though both systems are developed with almost the same motivations, the design considerations are different mainly because we are designing for different end users. TABLE 3 captures the essence of these design issues.

TABLE 3. COMPARISON OF DIFFERENT ASPECTS OF DESIGN FOR PET INTERNET AND HUGGY PAJAMA SYSTEMS.

Design Aspect	Pet Internet	Huggy Pajama
Input module	Simple on-off touch detection based on capacitive touch sensing.	Detects varying levels of force based on normal range of human touch and squeeze. Based on QTC touch sensing circuit.
Input module	Hard shell pet doll interface mounted on cumbersome mechanical table. Does not give a soft feeling and not very mobile. Doll has cute design and resembles pet animal.	Semi-soft doll interface, which is also small and lightweight for mobility. Has human shape like body and arms, and cutely designed. Can double up as a mobile phone accessory.
Output module	On-off vibrating actuators embedded in lightweight jacket suitable for small animal body. Vibration gives a distributed touch sensation and is not localized.	Air actuating output capable of producing a range of pressure on the human body. Gradual increase in pressure gives a calm feeling to wearer, not intrusive like sudden vibration. More localized feeling. Shape and size of actuation area can be customized for different body shapes and sizes.
Output module	Relatively simpler and fewer hardware circuit which makes it lighter and more suitable for pet to carry.	More complicated hardware which involves air pumps and pressure feedback circuits give more weight burden to user.
Communication channels	One way touch communication from human user to pet.	Two way touch and hug communication between both human users.
Feedback channels	Pet doll follows the movement of the real pet in real time. Human users can see this movement in their vicinity, and observe how the real pet reacts to their remote touching.	Color changing emotional and affective interface for richer interaction. This is also a two way communication and act to compliment the hug communication.

The main principle for Pet Internet is to maintain a simple design with minimal communication modes. The reason is that we must make the wearable jacket comfortable and lightweight for the pet without being encumbered with technology. This is to develop suitable and effective communication between humans and animals where a verbal language is not common, but interaction between human and animals usually involves touch as a medium of communication.

On the other hand, Huggy Pajama is developed to enhance remote communication between humans. It is based on the assumption that our daily interaction with one another is rich and involves multiple communication modes like voice, visual, gestures and facial cues. Therefore, a wide range of features aimed to reproduce more realistic hug and allow for emotional expression are implemented.

IV. CONCLUSION

In this paper, we have briefly described the novel systems for remote touching and hugging aimed at human-human as well as human-animal communication. The Pet Internet system is implemented first with the focus being to explore the method to capture and reproduce touch over the Internet. The next step of our research is then to investigate and propose a method for human-human remote communication using the sense of touch. This is significantly more complicated compared to the human-animal communication as daily human communication is filled with different types of information, some which are directly obvious while others are to be interpreted by the human cognitive ability. Therefore, in order to create a system which human users feel comfortable to use in remote communication, different aspects of human behavior, gestures and bodily cues have to be taken into account.

REFERENCES

- [1] P. Slater. *The Pursuit of Loneliness*. Beacon Press.
- [2] R. Bakeman and J. V. Brown. Early interaction: Consequences for social and mental development at three years. *Child Development*, vol.51, no.2, pp.37-447, June 1980.
- [3] S. P. Lee, A. D. Cheok, J. K. S. Teh, P. L. Goh, W. J. Chio, C. Wang and F. Farbiz. A mobile pet wearable computer and mixed reality system for human-poultry interaction through the Internet. *Personal Ubiquitous Computing*, vol.10, no.5, pp.301-317, July 2006.
- [4] J. K. S. Teh, A. D. Cheok, R. L. Peiris, Y. Choi, V. Thuong and S. Lai. Huggy Pajama: A Mobile Parent and Child Hugging Communication System. In *IDC '08: Proceedings of the 7th International Conference on Interaction Design and Children*, Chicago, USA, 2008. [Accepted, not yet published]
- [5] M. A. Heller, M. A. Heller and W. Schiff. *The Psychology of Touch*. Lawrence Erlbaum Associates, Hillsdale, New Jersey, 1991.
- [6] S. Brave and H. Ishii. A. Dahley. Tangible interfaces for remote collaboration and communication. In *Proceedings of the 1998 ACM Conference on Computer Supported Cooperative Work*, pp. 169-178, 1998.
- [7] H. Ishii and B. Ulmer. Tangible bits: towards seamless interfaces between people, bits and atoms, In *Proceedings of CHI '97*, pp.234-241, Atlanta, GA, USA, 1997.
- [8] F. Gemperle, C. DiSalvo, J. Forlizzi and W. Yonkers. The hug: a new form for communication. In *DUX '03: Proceedings of the 2003 conference on Designing for user experiences*, pp.1-4, ACM Press, New York, NY, USA, 2003.

- [9] L. Bonanni, C. Vaucelle, J. Lieberman and O. Zuckerman. Taptap: a haptic wearable for asynchronous distributed touch therapy. In *CHI '06: CHI '06 extended abstracts on Human factors in computing systems*, pp. 580-585, ACM Press, New York, NY, USA, 2006.
- [10] CuteCircuit. Hugshirt. [Online]. Available: <http://www.cutecircuit.com/now/projects/wearables/frhugs/>.
- [11] The Science of Quantum Tunnelling Composites [Online]. Available: <http://www.peratech.co.uk/science.htm>.
- [12] I.J.H. Duncan. Animal welfare defined in terms of feelings. *Acta Agricola Scandinavia*, Sect. A, Anim Sci 27, pp.29-25, 1996.
- [13] R.Jones, C. Larkens and B. Hughes. Approach/avoidance responses of domestic chicks to familiar and unfamiliar video images of biological neutral stimuli. *Appl. Anim. Behav. Sci* 48, pp.81-98, 1996.

accomplishments, commitment to society and potential to contribute to shaping the future of the world.

He is Editor/Associate Editor of the following academic journals: Transactions on Edutainment (Springer), ACM Computers in Entertainment, Advances in Human Computer Interaction, International Journal of Arts and Technology (IJART), Journal of Recent Patents on Computer Science, The Open Electrical and Electronic Engineering Journal, International Journal of Entertainment Technology and Management (JEntTM), Virtual Reality (Springer-Verlag), International Journal of Virtual Reality, and The Journal of Virtual Reality and Broadcasting.



James K. S. Teh, who was born in Johor, Malaysia, is a PhD candidate at the Electrical and Computer Engineering Department, National University of Singapore. He obtained his Bachelor of Computer Engineering degree at the same university in 2005. The current focus of his research thesis is in the area of remote affective communication and haptic interaction. He has previously worked as an intern in the Technology Growth Center, NBC Universal in Los Angeles, USA

and as a research intern in the C&C Innovation Research Lab, NEC in Nara, Japan. He has published his work in the Personal and Ubiquitous Computing Journal, Computer-Human Interaction (CHI) conference and International Symposium on Mixed and Augmented Reality (ISMAR) conference.



Adrian David Cheok, who was born and raised in Adelaide Australia, graduated from the University of Adelaide with a Bachelor of Engineering (Electrical and Electronic) with First Class Honors in 1992 and an Engineering PhD in 1998.

He is Director of the Mixed Reality Lab, National University of Singapore. He is Associate Professor in the Department of Electrical and Computer Engineering. He became Full Professor in Keio University, Graduate

School of Media Design from April 2008. He has previously worked in real-time systems, soft computing, and embedded computing in Mitsubishi Electric Research Labs (Osaka, Japan). He has been working on research covering mixed reality, human-computer interfaces, wearable computers and ubiquitous computing, fuzzy systems, embedded systems, power electronics. He has successfully obtained funding for externally funded projects in the area of wearable computers and mixed reality from Nike, National Oilwell Varco, Defense Science Technology Agency, Ministry of Communications and Arts, National Arts Council, Singapore Science Center, Hougang Primary School. The research output has included numerous high quality academic journal papers, research awards, keynote speeches, international exhibitions, numerous government demonstrations including to the President and Deputy Prime Minister of Singapore, broadcast television worldwide broadcasts on his research (such as CNN/CNBC/ABC/ Discovery /National Geographic etc.), and hundreds of international press media articles.

In the Mixed Reality Lab, he leads a team of over 20 researchers and students. He has been a keynote and invited speaker at numerous international conferences and events. He was invited to exhibit for two years in the Ars Electronica Museum of the Future, launching in the Ars Electronica Festival 2003. His works "Human Pacman", "Magic Land", and "Metazoa Ludens", were each selected as one of the worlds top inventions by Wired and invited to be exhibited in Wired NextFest 2005 and 2007. He was awarded the Hitachi Fellowship 2003, the A-STAR Young Scientist of the Year Award 2003, and the SCS Singapore Young Professional of the Year Award 2004. In 2004 he was invited to be the Singapore representative of the United Nations body IFIP SG 16 on Entertainment Computing and the founding and present Chairman of the Singapore Computer Society Special Interest Group on Entertainment Computing. Also in 2004, he was awarded an Associate of the Arts award by the Minister for Information, Communications and the Arts, Singapore. He was awarded as Fellow in Education, World Technology Network in 2004. In 2005 he was awarded a Microsoft Research Award for Gaming and Graphics. He was awarded Young Global Leader 2008 by the World Economic Forum. This honour is bestowed each year by the World Economic Forum to recognize and acknowledge the top young leaders from around the world for the professional