TURNING RUST INTO GOLD:
AN ANCIENT ARTIFACT AS AN INTERACTIVE ARTWORK

Chun-Ko Hsieh[1,3], Xin Tong[2], Yi-Ping Hung[1], Chia-Ping Chen[1], Liang-Chun Lin[1], I-Ling Liu[3],
Meng-Chieh Yu[1], Chu-Song Chen[1], Jiaping Wang[2]

[1] Graduate Institute of Networking and Multimedia, National Taiwan University, Taiwan
[2] Microsoft Research Asia, Beijing, China
[3] National Palace Museum, Taiwan
kenneth@npm.gov.tw; xtong@microsoft.com; hung@csie.ntu.edu.tw, cpchen@iis.sinica.edu.tw;
r96922003@ntu.edu.tw; iliu@npm.gov.tw; d95944008@ntu.edu.tw; song@iis.sinica.edu.tw;
jiapw@microsoft.com

ABSTRACT

Turning Rust into Gold is inspired by a Chinese antique *Mao-Kung Ting* (cauldron) treasured by the National Palace Museum in Taiwan. Having a five-hundred-character inscription cast inside, and its weathered appearance made the Mao-Kung very unique. Motivated by revealing the great nature of the artifact and interpreting it into a meaningful narrative, we have proposed an interactive multimedia system that facilitates effective communication between museum audiences and the *Mao-Kung Ting*. Three technologies have been implemented to emphasize the weathered appearance of the bronze. De-/weathering simulation techniques have been deployed to revive the bronze to its original shiny gold color; while breath-based biofeedback and haptic technology have been utilized as user interfaces to trigger the de-weathering process of the *Mao-Kung Ting*. Also, the interactive scenarios have been designed with the Chinese cultural context and philosophy *Qi*, enabling users more easily fall into the Chinese civilization. The paper aims to present the development of the artwork *Turing Rust into Gold*, in order to further contribute to the feasibility of incorporating new media art in a historical museum context, and bring a new horizon in the museum sector.

Keywords— de-/weathering simulation, breathing-based biofeedback, haptic technology, new media art, museum

1. INTRODUCTION

Museums have mission to share their treasures with the public, and to enrich people's lives with intellectual, aesthetic, spiritual, and enchanting experiences. With that spirit, the research team has explored innovative applications of interactive multimedia technologies to interpret an invaluable ancient artifact as an interactive artwork.

The artifact Mao-Kung Ting has been selected, as it is a ritual bronze vessel dating back to 800 B.C. and well-known for its length of inscription on the interior, the longest inscription so far discovered. The five hundred characters cast on the ancient bronze are the precursors of modern Chinese characters. However, the Mao-Kung Ting has been weathered for approximately three thousands years, the original shiny gold color of its appearance has become rusty and the inscription is too blurred to be read by the general public.

With an attempt to integrate modern technologies and aesthetic design to reveal the unique features of the Mao-Kung Ting, three core technologies, de-/weathering simulation, UWB breathing detection and haptic technology have been implemented in the installation. The interaction scenarios have been designed for two stages. At the first stage, this installation interprets the changes in the appearance of the Mao-Kung bronze cauldron as a metaphor for travel through time. It also uses a person's breath as a metaphor for Chinese philosophy "*Qi*", the bridge connecting humans and the heavens in the universe. The breath of life touches off the process of de-/weathering to the Mao-Kung Ting (cauldron), taking the user through the course of thousands of years in Chinese history. In the second stage, while the user breathes regularly and vitality is filled, he/she would touch the Mao-Kung Ting in cyberspace via haptic technology, feeling how the energies of life that turn rust into gold is prevailing in the universe (Fig.1).

Figure1: The child was touching the virtual *Mao-Kung Ting* in cyberspace, and watching with surprise as its appearance turned to gold.

The paper is organized as follows. In Section 2, related works are provided to discuss the core technologies applied in the installation. Then, the design concepts are presented in Section 3, while the system architecture is detailed in Section 4. Next, the processes of the implementation are described in Section 5, followed by the conclusion in Section 6.

2. RELATED WORK

2.1. Interactive Art

To date, thanks to the continuous evolution of technology, Interactive Art has become popular in New Media Art. The integration of art and technology creates a whole new sensational experience for audiences [1]. Two-way communication is the key feature of Interactive art, which not only allows users to input their information, but also provides responses for users with the output of results. Meanwhile, approaches and regulations of output can be adjusted according to continuous changes [2]. Jeng claims to have applied a Human-centered Interaction Model to examine the state of interaction in cognitive, physical and virtual spaces. (1) In cognitive space, people will act after perception. (2) In physical space, events will be triggered while users manipulate interfaces. (3) In virtual space, virtual interactive models are triggered by interactive events, and provide feedback to users via digital interfaces [3].

Recently, some new media artists have started to create their artworks with cultural elements. Some might be inspired by physical outlook of cultural artifacts, such as the artwork *Media Device for Hand Scroll*; the others might be inspired by the intangible cultural philosophies or stories, such as *Shan-Shui-Hua*. The following are brief discussions to do with these projects. *Media Device for Hand Scroll* presents the main feature of traditional hand scroll painting through the mechanical scroll and digital image projected on the continuous roll of paper [4]. The artwork recreates the sensational experience of appreciating a scroll like an ancient, but discovering the continuous narrative in the digital flow. Moreover, the artwork *Shan-Shui-Hua* is recreated in the format of a video-painting to explore the creation concept of Western and Asian aesthetics [5]. Inspired by the Chinese landscape painting (Shan-Shui-Hua), the artist used the media to discuss the space and perspective of the painting through Chinese philosophy.

2.2 De-/weathering Simulation

The original appearance of the bronze *Mao-King Ting* was in its shiny gold color. However, the bronze has been weathered for approximately three thousands years, and its appearance has become rusty. In order to reconstruct the brand new 3D model of Mao-King Ting, the team had applied the de-/weathering simulation technique [6]. In previous studies, an approach of modeling real-life changes of appearance by recording time-variant surface colors and BRDFs (Bidirectional Reflectance Distribution Functions) of the material for a period of time is considered to be data-driven[7, 8].

Figure2. Weathered appearance manifold: "Modeling the time-variant surface appearance of a material from data captured at a single instant in time."[Wang et al. 2006]

Although the techniques are more physically accurate, they require a long period of time to capture the spatial variations of the materials. Therefore, the team has switched to another visual simulation technique "appearance manifolds" for modeling the time-variant surface appearance of a material from data captured at a single instant in time[6] (Fig.2).The technique can infer spatial and temporal appearances of weathering process at different times.

2.3 Breath-based Biofeedback

At present, many techniques are available for detecting respiration status, for example: Optoelectronic Plethysmography, Ultra Wide Band, Respiratory Inductive Plethysmography, or Heart Rate Variability. Optoelectronic Plethysmography (OEP) is an optical movement detecting system, which measures the variety of thoracic and abdominal breathing volume [9]. Heart Rate Variability (HRV) can drive the respiration status [10]. Respiratory Inductive Plethysmography (RIP), a traditional breathing detection method, utilizes the stretch sensor to detect

respiration status of users. Among these techniques, Ultra Wide Band (UWB) is the most appropriate in a museum setting, as it is non-invasive, it does not require attaching a device to the body. The UWB detector can remotely measure the heart activities and respiration of users [11]. Table 1 shows the comparison of these respiration detection methods.

Table 1. Comparison of Respiration Detection Methods

	UWB	HRV	RIP	OEP
Attached to body	Non-invasive	Attached to skin	Attached to body	Attached markers
Accuracy	Medium	Medium	Medium	High
Limits	Less mobility	Detector attached to fingers	Detector attached to body	Least mobility

3. DESIGN CONCEPTS

Design concepts can be discussed from three perspectives: object itself, user interface, and the interactive environment. The interactive installation has been designed in alignment with the nature of the object and human nature.

3.1. The object Itself

Interpretation is imperative to transfer material culture into historical or philosophical narratives, which are readable by the general public. As Pearce states [12], "objects as social ideas, frozen thoughts and feelings, all of which have been created deliberately by our society and the individuals in order to give themselves the chance of living what is locally considered to be a decent life, and which will then help to convey this idea of decency to the next generation of children." What the quotation makes clear is that the interactive scenario should be designed with the aim of interpretation of the object. The object "Mao-kung Ting" is a 2800- year-old ritual bronze vessel that was used at the ancestral temple of the court. The 500 characters cast inside the vessel form the longest inscription found in the Chou periods. The inscription, which can be divided into seven sections, describe how King Hsüan of the Chou came to the throne and was anxious to see the country thrive, so he charged his uncle, the Duke of Mao, with governing the domestic and external affairs of state, and to do so conscientiously and selflessly. The inscription goes on to state that the King then presented the Duke with official vestments and gifts, and the bronze vessel was cast in order to record the honor given to the Duke for his descendants[13].

3.2. User Interface

3.2.1 Metaphor for Time

Generally, people understand the world through the basic five senses, sight, smell, taste, touch, and hearing. However, humans do not have a specific sensory system governing the perception of time. This point is relevant to the Mao-Kung Ting as it has been weathered for nearly three thousand years and its appearance has become rusty. It is hard for museum visitors to comprehend that its original appearance was golden. It is for this reason that the de-weathering process of the Mao-Kung Ting has been employed as a metaphor for time. By witnessing the changing appearance of the Mao-Kung Ting, people can gain a perception of long Chinese history.

3.2.2 Metaphor for Qi

In traditional Chinese culture, "Qi" refers to energy flow, sustaining living beings in the world. Also in Chinese Classics, the concept of Qi has two main meanings: 1) the air we breathe in and out; 2) intellectual spirits that are fulfilled in our bodies. These two meanings of "Qi" are well known by Chinese people [14]. Legend has it that a number of ancient Chinese people practiced Qi to empower themselves in martial arts performance. Masters of martial arts could even gain incredible strength to achieve extraordinary things, such as breaking rocks, moving objects by their mind, or formulating sword-like power to defeat enemies. Today Qi in the form of martial arts has become popular theme in many novels, television series, video games or films, such as the movie *Kung Fu Panda*. In the spirit of elaborating the interesting Chinese philosophy Qi for modern people, human breathing has been designed as the metaphor for Qi.

3.3. Interactive Environment

Inspired by the unique features of the *Mao-Kung Ting*, the installation has been designed with an immersing and interactive environment with a Chinese cultural atmosphere. The contextual environment has been decorated with multi-layered veils projected with flowing images related to the story of Mao-Kung Ting, implying the endless Chinese civilization in the universe. Furthermore, the physical environment has been designed as the mysterious universe, giving a sense of crossing thousands of years, and millions of miles to the Western Chou (800 B.C.), when the Mao-Kung Ting was just cast in its mint condition. The environment also symbolizes communication with Heaven, which does not weary of caring for Chinese people and protect them for good. We may say that the Mao-Kung Ting carries this ancient Chinese belief and will be implicitly

conveyed to audiences through the immersing Chinese cultural environment (Fig.3)

Figure3: The immersing environment designed with artistic atmosphere and Chinese cultural elements.

In brief, the interaction scenarios of the artwork have been designed in two stages. In the first stage, users are required to adjust their breathing frequency with the tempo of the de-/weathered Mao-Kung Ting, so that they may perceive the long Chinese history via the changing appearance of the Mao-Kung Ting. In the second stage, users who have accumulated energy from the breathing practice in the previous stage will gain the inconceivable power to turn the rusty Mao-Kung Ting into its golden form through touch. The haptic technology enables Qi to be seamlessly transformed into the virtual world.

4. SYSTEM ARCHITECTURE

The architecture consists of a detection module and a display module. In the detection module, the main component is the Mao-Kung Ting-shaped chair embedded with a UWB breath sensor and pressure sensors inside. While the user sits on the chair, the pressure sensors will sense the weight of body, and the UWB breath sensor will start to detect the breathing of user. In display module, the primary display and the secondary display are the main components shown in Figure 4. The 47-inch touch screen TV has been implemented as the primary display to precisely convey the main message. On the other hand, the secondary display comprises a large projection area made up of multi-layered veils and a Mao-Kung Ting-shaped chair. The images projected on the multi-layered veils are corresponded relatively to the main message displayed on the touch screen TV. Meanwhile, the LEDs embedded in the feet of chair will emit lighting which corresponds to the breathing frequency of the user in real-time.

Figure4. The installation has a primary display and a secondary display.

5. IMPLEMENTATION

The implementation of the artwork was completed in four main phases: 1) De-/weathering Simulation 2) Breath Detection Setup 3) Application of haptic Technology 4) Immersing Environment Construction.

5.1. De-/weathering Simulation

To simulate the de-/weathering process of the Mao-Kung Ting, a weathered bronze sample was prepared, and its BRDF (Bidirectional Reflectance Distribution Functions) were captured at a single instant in time. The bronze sample with spatial variations corresponding to varying degrees of weathering can be further analyzed to obtain spatial and temporal appearance properties for synthesizing the weathering process of the Mao-Kung Ting. In the beginning, the linear light source device was utilized to capture spatially-variant BRDF from each surface point on the flat bronze sample (Fig. 5)[15]. Then the sample analysis was performed to acquire the degree map of the Mao-Kung Ting model. Next, a time-variant appearance sequence was generated to respond to the breathing of users. The degree values in the de-/weathering frame can be linearly decreased when the system receives a stable breathing signal from the user. On the other hand, the degree values will be increased in response to irregular inhalation and exhalation.
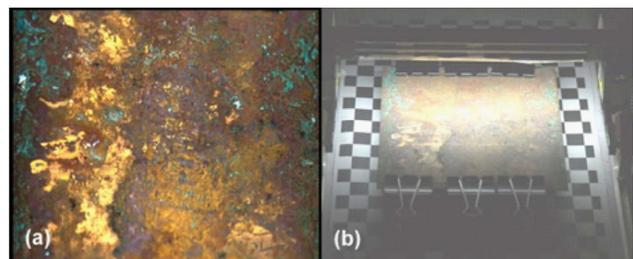

Figure5. (a) The weathered bronze sample. (b) The spatial-variant BRDF data capturing device.

5.2. Breathing Detection Setup

UWB (Ultra Wide Band) breath detector has been installed underneath the arm of chair to detect the user's real-time breathing. The invisible transformation of "Qi" (breathing) is meticulously detected and shown on the Mao-kung Ting through its varying degrees of weathered appearance. According to different breathing signals, the system will operate in four different configurations. 1) Initial status of the system: while no one sits on the chair, the Mao-Kung Ting would appear in its neutral state, which is between the weathered and de-weathered appearance 2) Regular breathing signal input: the Mao-Kung Ting would appear more in its original mint state. 3) Irregular breathing signal input: the Mao-Kung Ting would appear more in its weathered state. 4) Without any further breathing signals: as the user leaves the chair, the system will return to its initial setting.

5.3. Application of Haptic Technology

Haptic user interfaces provide an exciting opportunity to develop multisensory feedback and communication systems that present data with an intuitive approach[16]. In supporting two-way communication between humans in the physical world and the virtual Mao-Kung Ting in the digital world, the 47-inch touch screen has been implemented as the haptic user interface in this installation. The haptic interface recognizes and responds to two main manipulation gestures- click and drag (Fig 6).

While the users click the virtual Mao-Kung Ting with their fingers, the color of the touched point will change from rusty to golden, and gradually spread out on its surface. In addition, while the user drags the virtual Mao-Kung Ting, the object will be moved or rotated. In line with the interaction scenario, Qi of users has magically flowed into the digital world through their fingers and changed the ancient artifact dramatically. The visual effects enhance users' perception towards the properties of the Mao-Kung Ting, such as its shape and color. Hence, sensory information from the kinesthetic receptors enables users to cognitively appreciate the Mao-Kung Ting.

Figure6. The user clicks the surface of the virtual Mao-Kung Ting (left); the user rotates the object to its inside (right).

5.4. Immersing Environment Construction

The immersing environment changes actively to correspond with interaction from the user via the multimedia content of the secondary display. The content was produced to emphasize the unique features of the Mao-Kung Ting-its long existence and five hundreds Chinese characters cast inside.

Before the user sits on the Mao-Kung Ting-shaped chair, the primary screen will play the brief story of the Mao-Kung Ting to entice users to approach. Once the user sits on the chair, the interactive scenarios will be initiated. In the first scenario "Breath between the Past and Present", the multilayered veils will be projected with a universal scene, giving the user a sense of crossing the time and space in Chinese history (Fig.7).

Figure7. The multi-layered veils have been projected with a universal scene, giving the user a sense of crossing the time and space in Chinese history.

At the same time, the LEDs embedded in the feet of the Mao-Kung Ting-shaped chair will emit light according to the inhalations of the user. On the other hand, the light will extinguish when the user exhales. In the second scenario *Turning Rust into Gold*, as Qi of the user flows into the Mao-Kung Ting, the object will be revived in its energetic status. As the result, the ancient Chinese characters inside the vessel will start floating on the multi-layered veils. Dynamic changes on the scene make users more aware that the Mao-Kung Ting also carries the important Chinese heritage -words. In addition, the audio and visual effects have been designed to stimulate multi-sensory experiences for users in this immersing and interactive environment, so that people may more easily fall into the Chinese cultural context (Fig.8). In the end of the interaction, the primary display will play a short film to emphasize the significance of the *Mao-kung Ting*.

Figure8. The floating Chinese characters created in the immersing Chinese cultural context.

6. CONCLUSION

Turning Rust into Gold has creatively incorporated new media technologies with the precious state vessel Mao-Kung Ting, facilitating communication between modern people and the ancient artifact through the Chinese philosophical concept of "Qi" transformed as the energy of breath and touch. In addition, the immersing and contextual environment of the Chinese aesthetic atmosphere has indeed created the sensational experience of crossing time and space through Chinese civilization. The artwork has been exhibited in a festival for ten days. It has been observed that the strong haptic exchange had reinforced people' perception towards the unique feature of the Mao-Kung Ting, and further provoked their curiosity about the solemn state vessel. The artwork contributes to the feasibility of integrating new media art in a historical museum context, providing visitors new approaches and perspectives to appreciate ancient artifacts.

7. ACKNOWLEDGEMENTS

8. REFERENCES

[1] R. Dannenberg and J. Bates, "A Model for Interactive Art," *Proc. the 5th Biennial Symposium for Arts & Technology* 1995, pp. 103-111.

[2] S. Wilson, "The Aesthetics and Practice, Designing Interactive Computer Events," 1993.

[3] T. Jeng, et al., "Interaction and Social Isuues in a Human-Centered Reactive Environment," *Proc. the 7th International Conference on CAADRIA*, 2002, pp. 285-292.

[4] N. Y., et al., "Media Device for Hand Scroll," *Proc. ACM SIGGRAPH ASIA 2008 Art Gallery, Emerging Technologies*, 2008.

[5] C. BOLEWSKI, "Shan-Shui-Hua," *Proc. ACM SIGGRAPH ASIA 2008 Art Gallery, Emerging Technologies*, 2008.

[6] J. Wang, et al., "Appearance Manifolds for Modeling Time-Variant Appearance of Materials," *ACM Transaction on Graphics*, vol. 25, 2006.

[7] A.S. Georghiades, et al., "Observing and transferring material histories," *Tech. Rep*, 2005, pp. 1329.

[8] J. Gu, et al., "Time-varying surface appearance: Acquisition, modeling and rendering," *ACM Transaction on Graphics* vol. 25, no. 3, 2006.

[9] M.-C. Yu, et al, "Multimedia Feedback for Improving Breathing Habit," *Proc. 1st IEEE International Conference on Ubi-media Computing* 2008.

[10] D. Hoyer, et al., "Nonlinear analysis of heart rate and respiratory dynamics," *IEEE Eng Med Biol Mag.*, vol. 16, no. 1, 1997.

[11] I.Y. Immoreev, "Practical Application of Ultra-Wideband Radars," *Proc. Ultrawideband and Ultrashort Impulse Signals*, 2006.

[12] S.M. Pearce, *On Collecting: an investigation into collecting in the European Tradition*, Routledge, 1995.

[13] National Palace Museum, 2010.DOI=http://www.npm.gov.tw.

[14] C.-W. Cheng, "The Daoist and the Primitive Mind," *Chinese Studies*, vol. 19, no. 2, 2001.

[15] A. Gardner, et al., "Linear light source reflectometry," *ACM Trans Graph*, vol. 22, no. 3, 2003, pp. 749-758.

[16] K.S. HALE and K.M. STANNEY, "Deriving haptic design guidelines from human physiological, psychophysical, and neurological foundations," *IEEE Computer Graphics and Applications*, vol. 24, no. 2, 2004, pp. 33-39.