Tāotiè: Design and Implementation of a Bronze-Relic Inspired Sentimental Robot

Zhihao Yao[1*] , Mingyue Gao[2*], Shuqin Li[3], Haipeng Mi[4†]

Abstract— This on-going work attempts to create a sentimental robot namely Tāotiè, which is inspired by ancient Chinese bronze-relics. With a unique design of facial patterns and a combination mechanism, Tāotiè robot can represent up to twenty-seven different animal faces by rotation and alignment. Tāotiè robot conveys a unique sentiment inherited from ancient relics, encouraging visitors to empathize with ancient people.

I. INTRODUCTION

In the emerging research area of sentimental robot design, researchers have adopted different technologies to enable emotional expressions of a robot. [1] Facial expressions are widely used from humanoid robots to various wheel robots with a screen face on their heads [2]. However, either realistic facial expressions of humanoid robots or cartoon style facial expressions on screens can convey very limited emotions compared to human's rich sentimental sense.

On the other hand, we found that some ancient artifact has unique sentiments. For example, totem poles of American Indians have special designed human faces or animal faces. [3] And bronze wares of ancient China have unique patterns of animal faces. We can even feel the empathy with ancient people via such special designed ancient artifacts.

This paper presents Tāotiè robot(See Fig. 1), which is a sentimental robot inspired by ancient Chinese bronze-relics. Tāotiè robot has a two level totem-pole-like structure. Each level has three layers of concentric rotatory facial feature rings, presenting horns, eyes and mouths separately. With a unique combination mechanism, Tāotiè robot can form different animal-face pattern expressions, encouraging a unique empathy with ancient people.

II. SENTIMENTS OF BRONZE-RELIC PATTERNS

Ancient Chinese bronzes can be traced back to Shang Dynasty (around 1600 BC) or even earlier. These bronze relics convey unique sentiments by their animal face patterns. A typical animal face pattern of a bronze relic usually consists of horns, eyes, and mouth. Yun-lei (cloud and thunder) vein and swirl vein are commonly used for decoration.

*Zhihao Yao and Mingyue Gao contributed equally to this study.

†Haipeng Mi denotes the corresponding author.

[1] yaozh18@mails.tsinghua.edu.cn

[2] gaomy20@mails.tsinghua.edu.cn

[3] lisq19@mails.tsinghua.edu.cn

[4] haipeng.mi@acm.org

All authors are with Academy of Arts & Design, Tsinghua University, Beijing, China

Fig. 1.   From left to right, there are the Tāotiè robot, the pattern details and mechanical structure.

A. Animal-Face Patterns

In ancient China, the bronze wares with animal-face patterns were used for sacrificial rituals. The animal face patterns evolved with the change of dynasties. Later patterns on bronzes were highlighted and exaggerated, expressing ferociousness and power. [4]

Among lots of different animal face patterns, the gulosity (or Tāotiè in Chinese) pattern is well-known in China. The mythical animal Tāotiè is dipicted as a massive-eating and treasure-keeping beast according to ancient Chinese myths. It is generally accpeted that the Tāotiè patterns could arouse people's reverence and piety sentiments.

Fig. 2.   The animal-face pattern (right) on a bronze ware (left).

B. Combination Mechanism

From the perspective of ancient creators, the animals' facial features were extracted and combined to generate new types of facial patterns. Bronze relic patterns reflect the unique cognition of nature of ancient Chinese people. This combination mechanism of facial features is a representative cultural characteristics of ancient Chinese bronzes.

C. Historical and Cultural Value

As the most important type of culture relics of China, bronze wares reflect a tremendous historical and cultural value. Even after thousands of years, people could still get connected by the empathy with their ancestors. The animal-face patterns reflect the life scenes of the ancestors at that time, which could arouse sentimental resonance beyond time and space.

III. DESIGN

Tāotiè robot is designed as a totem-pole-like structure with two levels. Each level has an independent facial expression gadget. Each gadget has three rotatory concentric rings representing different facial features - horns, eyesand mouth. The gadget presents different facial expression sentiments with different combinations of those facial features.
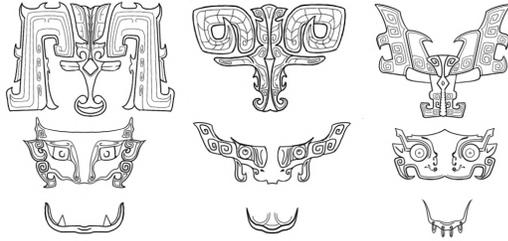

Fig. 3. Design of facial features: horn (top), eyes (middle) and mouth (bottom)

A. Pattern Design

Learned from bronze wares, we found there were lots of animals used to create facial patterns with the Yun-lei vein and swirl vein. Thus, as regards the horns, we selected three animals, which are ox, sheep, and dragon, to extract their horn features based on relevant bronze ware patterns.

Similarly, we have selected three types of eyes representation, which are in the shape of square, sharp and round.As to the mouth, based on the cognition of modern people, we designed the mouths, consistent with three animals.

B. Permutation of Patterns

Inspired by the ancient creation of new animal-face patterns, the three facial features adopt a special combination mechanism to form different facial expressions. For each feature ring, three different feature patterns are placed 120° apart from each other. So when the ring rotates every 120°, the according facial feature will change to another one. According to the permutation calculation, Tāotiè robot can demonstrate up to twenty-seven different animal faces.

Fig. 4. Three different animal face examples from twenty-seven possible patterns.

IV. IMPLEMENTATION

A. Mechanical Structure

The Tāotiè robot consists of a central pillar and two facial expression gadgets. Each gadget has three concentric rings. All the rings are connected to the central pillar with a specially designed bearing mechanism.

- Horn-ring: the outer ring, carrying three horns of different shapes. The horn-ring is connected to the central pillar via a reinforced ribs.
- Eyes-ring: the middle ring, carrying three eyes patterns. Every pair of eyeballs can move forward and backward to simulate prominent eyes.
- Mouth-ring: the inner ring, carrying three mouth patterns. Mouth component has a tiny linear motor installed inside, enabling open and close of the mouth to simulate activities like talking.
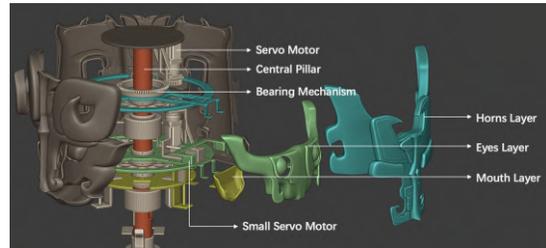

Fig. 5. Mechanical structure of a facial expression gadget.

The mechanical structure of the Tāotiè robot follows the principle of central symmetry. These symmetry patterns conform to the traditional oriental aesthetics.

B. Hardware Design

Tāotiè robot has dozens of actuators to support its movement. Six servo motors respectively control the upper and lower three-layer structure, which enables the independent rotation of each layer. As for the eyes ring, each of 12 small servos controls one eye, which realizes the left and right rotation of the eyes. Six rails, attached to the eye platform, move the eyeball back and forth. The eyes can also change various colors with six LED light bars.

One STM32 MCU is adopted to control the movement of each component. Several hardware interfaces were reserved for more interaction.

V. INTERACTION

The Tāotiè robot was displayed as Fig.1. A standing cushion is set in front of the robot. A pressure sensor under the cushion detects users' stepping-on and triggers the robot to perform a face-changing. Pattern rings then rotate randomly, forming a new animal face pattern. The simple interaction mechanism renders a mysterious atmosphere and brings an ancient sentiment to the user.

VI. CONCLUSION AND FUTURE WORK

Inspired by ancient Chinese bronzes, this paper proposes a sentimental robot, Tāotiè. We endow the Tāotiè robot with the same animal-face patterns on ancient bronze relics, which completes the sentimental transfer.

REFERENCES

[1] Gockley, R., Bruce, A., Forlizzi, J., Michalowski, M., Mundell, A., Rosenthal, S., ... & Wang, J. (2005, August). Designing robots for long-term social interaction. In 2005 IEEE/RSJ International Conference on Intelligent Robots and Systems (pp. 1338-1343). IEEE.

[2] Kalegina, A., Schroeder, G., Allchin, A., Berlin, K., & Cakmak, M. (2018, February). Characterizing the design space of rendered robot faces. In Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction (pp. 96-104).

[3] Jonaitis, A. (1989). Totem Poles and the Indian New Deal. Canadian Journal of Native Studies, 9(2), 237-52.

[4] Li, S. (2011). Chinese Bronze Ware. Cambridge University Press(pp. 40-62).