Design a media art installation based on fuzzy controlling system

Zheng Wang1*, Zhenjiang Miao2

1 School of Architecture and Design, Beijing Jiaotong University, Shangyuancun 3, Beijing, China
2 School of Computer and Information Technology, Beijing Jiaotong University, Shangyuancun 3, Beijing, China

Received 11 March 2014, www.tsi.lv

Abstract

As an art installation showed at Houtan station of Shanghai Metro Line7 and 2010 Shanghai World Expo Museum, "smart suspension ball" system displayed the rational sense of form and order of the controlling. The article focused on how to use appropriate fuzzy strategy to make the movements of the art installation more accurate under detailed experimental data. Another point of the article is to consider how to make this art installation to be a product with network, being combined and modular after upgrading the hardware and software of the installation. The performance of this upgraded product will bring more beautiful visual effects of controlling and technique. It will also be a successful case of integrating of science and technology into product designing for development of creative industries in China.

Keywords: Digital Media Art, Fuzzy Controlling, Installation Design, Arduino

1 Introduction

In recent years, a number of digital art works more or less related with “controlling” theory showing in many international or domestic art exhibitions attracted much attention. The visual presentation of the works in common is to control a large number of simple geometry objects moved regularly and performed in a real space. Audiences may feel a strong sense of order spatial transformation from the work. The performed form of the art works implies a particular technology beauty. This kind of visual effect gives audiences an extremely rational aesthetic enjoy.

From a technical analysis, most of these art works used stepper motors to control objects in space for precise displacement. Special computer programs were also used to control multiple real objects shaping different visual effects. After recently years developing, this kind of “controlling” art works gradually becomes a popular trend in the creating of digital art. It not only subverts the concept that only monitor, projectors could belong to the final output media, but also enriches the ways of digital art works showing. Therefore, more and more digital interactive artists prefer to use such means of expression in their art works.

2 Creative idea and system components

As one of the representatives of digital art works showing rational aesthetics and order of controlling, “smart suspension ball” was originally designed for participating the 2009 Liverpool Biennial. The art installation was planned to place in the Mersey (a canal in Liverpool) side. When audiences went into the display area, the spherical objects in the glass tubes were triggered to move up and down by computer-controlled fans. The shapes made up by spherical objects symbolize waves of the ancient canal and cargo ships shipping in the busy waterway. The idea of the art work makes the residents left abandoned riverside gradually to replant recalls a better life when they lived in the Mersey surrounded communities.

FIGURE 1 Effect drawing of “Smart Suspension Ball” placed in the Mersey side of Liverpool

For some reasons, finally this art installation didn’t be showed in Liverpool. The creative idea was selected by Shanghai Shentong Metro Corporation Limited in 2010. The size of the art installation was re-adjusted to fit the metro station. It was also renamed to "Bright Wave" because the dancing spherical objects symbolize
Shanghai’s “urban pulse.” The total length of this digital art installation was more than 15meters and the height of each transparent tube was up to 2.5 meters. It was placed in the hall of main station of 2010 Shanghai World Expo metro Line7 (Houtan Station of Shanghai Metro Line 7).

In response to above ideas, the optimal display space for this creative product should be interior environments such as bars, cafes, clubhouse and other semi-public space. So, the product will be upgraded in several important aspects as follows:

1) The overall height of the glass tube in product is controlled in about 80cm. The sphere diameter will be no more than 4cm.
2) Unitization and modular design. Each spherical object in the tube of product is like a display pixel. User can set up a different number of units to constitute entities of varying resolution display system.
3) Limits the noise of industrial fans built inside the product under 35db or less.
4) Using an ultrasonic distance sensor (Sharp) to get the height data of each spherical object, which forms a closed loop control system. The new controlling system makes it possible to control the height of the spherical object more precisely and form them to be a shape.

3 Model of system

In a prototype of the product design, accuracy of experimental data depends on the level of craftsmanship in making. Different batches of materials such as the thickness of the wall of tube, the weight of the spherical objects or the voltage level of digital port on Arduino panel will have a direct impact on the movements of spherical objects. Therefore, it will be unavoidable to have some errors in the data of the system. Followed the laws of mechanics and based on fuzzy control theory under, we proposed a suspension control model.

First of all under physical laws, we will derive the relationship between the height of the spherical object and the wind force.

The cross-sectional area of the spherical object is

\[ \text{S}_{\text{ball}} = \pi R_{\text{ball}}^2 = 3.14 \times 0.001256 \text{ m}^2. \]  

(1)

As for the tube diameter is 0.04m, the wall is 0.0025m; as for the spherical object sphere diameter is 0.04m and a radius of 0.02m.

Thus, a formula of wind force the spherical object suffered can be derivate by Bernoulli equation:

\[ F_{\text{ball}} = \text{W}_{\text{ball}} \times S_{\text{ball}} = \frac{V_{\text{fan}}^2}{1600} \times 0.00125(k\text{N}) = \frac{V_{\text{fan}}^2}{1600} \times 1.256(\text{N}), \]  

(2)

where \( V_{\text{fan}} \) means industrial fan wind speed, velocity near fans approximately \( V_{\text{fan}} = 2.2m / s \), while another outlet of tube (about 0.8 meters away from the fan) winds \( V_{\text{fan}} = 1.8m / s \), show wind speed and the distance from the outlet on.

\[ v_{\text{fan}} = f(D_{\text{fan}}) = kD_{\text{fan}} + C, \]  

(3)
Here $D_{\text{ball}}$ represents the distance from the bottom of the tube to the bottom of the spherical object. By the
\[
\begin{align*}
2.2 &= k + 0.1 + C \\
1.8 &= k + 2.2 + C
\end{align*}
\Rightarrow k = -0.1905, C = 2.219,
\]
\[
V_{\text{sat}} = f(D_{\text{sat}}) = k - 0.1905D_{\text{sat}} + 2.219.
\tag{4}
\]
Therefore, by the formula (1) to (3) can be obtained
\[
F_{\text{fan}} = \frac{(-0.1905D_{\text{sat}} + 2.219)^2}{1600} - 0.000028D_{\text{sat}} + 0.0039(N).
\tag{5}
\]
On this basis, the experimental observation will focus on the relationship between the height of the spherical object and the speed of the wind.

3.1 DETECTION OF SUSPENDED HEIGHT

According to the product used in the sphere diameter, tube diameter sizes, the actual height of the sphere from the target height is divided into nine levels: -0.3 m, -0.2 m, -0.1 m, -0.04 m, 0 m, 0.04 m, 0.1 m, 0.2 m, 0.3 m and the distance fuzzy language to describe size: ultra low(HN4), very low(HN3), lower(HN2), slightly lower(HN1), middle(H0), slightly higher(HP1), higher(HP2), very high(HP3), ultra high(HP4), as shown below.

<table>
<thead>
<tr>
<th>TABLE 2 Fuzzy function of fans speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{\text{sat}}$</td>
</tr>
<tr>
<td>$F_{\text{fan}}$</td>
</tr>
</tbody>
</table>

3.3 FUZZY CONTROL STRATEGY

1) If the ball is close to the target position “ultra low” (HN4), the wind should be “ultra strong” (FP4).
2) If the ball is close to the target position “very low” (HN3), the wind should be “very strong” (FP3).
3) If the ball is close to the target position “lower” (HN2), the wind should be “strong” (FP2).
4) If the ball is close to the target position “slightly lower” (HN1), the wind should be “slightly stronger” (FP1).
5) If the ball from the middle of the target location (H0), the wind should be in middle (F0).
6) If the ball is close to the target position “slightly higher” (HP1), the wind should be “slightly weak” (FN1).
7) If the ball is close to the target position “higher” (HP2), the wind should be “weak” (FN2).
8) If the ball is close to the target position “very high” (HP3), the wind should be “very weak” (FN3).
9) If the ball is close to the target position “ultra high” (HP4), the wind should be “ultra weak” (FN4).

3.4 FUZZY MATRIX

\[
R = (HN4 \rightarrow FP4) \cup (HN3 \rightarrow FP3) \cup (HN3 \rightarrow FP3) \cup (HN2 \rightarrow FP2) \cup (HN1 \rightarrow FP1) \cup (H0 \rightarrow F0) \cup (HP1 \rightarrow FN1) \cup (HP2 \rightarrow FN2) \cup (HP3 \rightarrow FN3) \cup (HP4 \rightarrow FN4) = \left\{ \begin{array}{ll}
\text{(HN4 \land FP4)} & \text{\lor (HN3 \land FP3) \lor (HN3 \land FP3) \lor (HN2 \land FP2) \lor (HN1 \land FP1) \lor (H0 \land F0) \lor (HP1 \land FN1) \lor (HP2 \land FN2) \lor (HP3 \land FN3) \lor (HP4 \land FN4)}
\end{array} \right. \tag{6}
\]
By the (6) finally get fuzzy control strategy matrix,
3 Software Design

Programming language of System Control module of the software uses Java-core Processing language. The flow chart is as follows.

\[
\begin{bmatrix}
1 & 0.5 & 0.2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.5 & 1 & 0.4 & 0.2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.4 & 0.4 & 1 & 0.2 & 0.1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0.5 & 1 & 0.2 & 0.2 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0.2 & 0.5 & 1 & 0.5 & 0.2 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0.2 & 0.2 & 1 & 0.5 & 0.2 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0.2 & 0.5 & 1 & 0.5 & 0.4 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0.4 & 0.5 & 1 & 0.5 & 0.2 & 0.4 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.4 & 0.4 & 0.2 & 0.5 & 1 \\
\end{bmatrix}
\]

(7)

4 Industrial Design

"Smart suspension ball" unit consists of four transparent tubes with a hexagonal base composition. Each height of the sphere object can be controlled independently, when a user uses a plurality of unit combination, the spherical objects in the tubes formed by program control in different spatial pattern. Here is some ideas using bionic to design the figure of the base part: on the one hand the base need a large enough area to enhance the stability of the monomer product; on the other hands, analogue cellular shape achieved by the combined overall shape of a plurality of units coordinated.

5 Conclusions

First of all, "smart suspension ball" is an innovative product with creative art and humanities works. In the second, the product combined the fuzzy control system design for the technical means. Finally, it also represents domestic design and creation of art works changing from the traditional manual way to the mode of workshop in a modern high-tech means. Meanwhile, making the physical objects as an interactive elements into interaction, means that not only tech disciplines but the visual communication, industrial modelling, sculpture, landscape and even construction and other visual arts, public art are also incorporated into the interactive art. More materials inclusiveness, diversity and technical means manifestation makes digital interactive art goes toward to a comprehensive direction.
Acknowledgments

This project is supported by School of Computer and Information Technology, Beijing Jiaotong University and Fine Art College, Shanghai University. I have to acknowledge assistance and encouragement from Virtual Lab of Fine Art College, Shanghai University, special work by Jiakang Ji, Dayi Zhu and Zhimin Zhang.

References


Authors

Zheng Wang, born in July 11, 1978, Nanjing, China

Current position, grades: Postdoctor in school of computer and information technology of Beijing Jiaotong University, Doctor of Art and Design, vice professor in Beijing Jiaotong University
University studies: Art and Design(doctor degree) in Fine Art College of Shanghai University
Scientific interest: Interactive Art, Digital Art
Publications: 2 Patents, 3 books, 8 papers
Experience: Wang Zheng was researching in digital interactive art. He focused on natural interaction and how to use automatic control theory in art work creation. His art work and installation had been displayed on many galleries, museums and exhibitions.

Zhenjiang Miao, born on 1965, Beijing, China

Current position, grades: professor in school of computer and information technology of Beijing Jiaotong University
University studies: school of computer and information technology of Beijing Jiaotong University
Scientific interest: machine visual and virtual reality
Publications: more than 100 papers
Experience: Miao Zhenjiang was researching in HCI and machine vision. He used to work in France and Canada. From 2004 he came back to Beijing Jiaotong University to be a professor in school of computer and information technology.