A Study on the Emotional Design Method for Industrial Robots

Wangqun Xiao, Xuejie Wang*

Academy of Art and Design, Anhui University of Technology, Ma’anshan243002, China

Abstract

In view of the relatively special field of industrial robots, a set of new design methods for industrial robots is constructed through emotional words, sample selection, questionnaire survey test and eye movement experiment. A study on the scientific recognition and the application of those elusive sensibility factors or perceptual factors in the process of human’s creation aims to solve the perceptual problems endowed to materials by human through scientific means and to change the situation where previous designers are unable to deal with emotional problems scientifically and exactly only by the reference to experience and feelings.

Keywords: Industrial Design, Industrial Robots, Emotional Design, Method

1. GENERAL INSTRUCTIONS

The first modern industrial robot was born in the United States in 1954, designed by George Devol with electronic programmable schemes (Liu, 2012). General Motors Corporation took the lead to put industrial robots into production in 1962. In the 1980s, the high development of automation and the integration of the world’s industrial technology have promoted faster progress of industrial robots (Sun and Luo, 2012). Industrial robots have made significant contributions for the improvement of the life quality of the global community. Especially, the newly available multi-freedom collaboration industrial robots have reflected the care of robots to humans and emotional qualities. Incorporating emotional design concept into product design has become an inevitable trend for the future development of industrial robots and also a focus in the research field of industrial robots.

2. SIMPLE ANALYSIS ON THE RESEARCH SITUATION OF PERCEPTUAL DESIGN

Kansei engineering, or known as perceptual engineering was first put forward by Japanese scholars and gradually developed in Japan, South Korea, Europe and the United States. Khalid and other scholars (Khalid, 2004) have proposed the general factors for the design of future electronic equipment based on semantic difference scale evaluation. Petiot and other scholars (Petiot and Grognal, 2002) have established a corresponding perception model with the use of multidimensional scaling (MDS), generalized regression neural network and fuzzy adaptive resonance theory. Ishardita (Ishardita et al., 2015) has made an analysis and a study on the classification of perceptual words by using factor analysis and semantic difference analysis with the application of Kansei engineering and Kano Model. Kuang (Kuang and Jiang, 2009) has set up a quantitative model for the product perceptual image and the design parameters through the cluster analysis method and the regression analysis method. Chinese scholars including Liu Wei (Liu, 2011), Wang Zhen-ya (Wang, 2011) and Song Jia-lin (Song, 2013) have established a Kansei engineering model for the design of engineering machinery products. Jiao Guang-xia (Jiao, 2010) has collected physiological and psychological response data and put forward a type of implementation method process model for Kansei engineering. Su Jian-ning (Su et al., 2013) has studied perceptual image, design pattern, design elements and other key technologies and methods. In addition to Kansei engineering, Europe and the United States have integrated emotional factors into product design for research and triggered a boom of product’s emotional design, often called as perceptual design. Whether it is Kansei Engineering or perceptual design, the main research contents are focused on the scientific recognition and the application of those elusive perceptual factors or emotional factors in the process of human’s creation, and its purpose is to solve the perceptual problems endowed to materials by human through scientific means and to change the situation where previous designers are unable to deal with perceptual problems scientifically and exactly only by the reference to experience and feelings. To facilitate a uniform presentation, the research into Kansei engineering and perceptual design” in the discipline of industrial design is called perceptual design in this paper.
3. A STUDY ON EMOTIONAL DESIGN METHOD FOR INDUSTRIAL ROBOTS

3.1 Selection of Perceptual Words and Test Samples

Samples of industrial robots are collected through a wide survey, and 10 industrial robot samples are selected in the end as research objects through a clustering analysis on perceptual research, as indicated in Figure 1. For the 10 pieces of industrial robot product samples, emotional words are collected according to the robot module, function, structure, shape, color, man-machine, environment and material by taking a brainstorming experiment and referring to the new product introduction, advertising on the magazines related to this product and other related news and reports. Then, the experiment results are selected and picked out in view of the results obtained from the brainstorming experiment and the characteristics of industrial robots.

![Figure 1. 10 Industrial Robot Product Samples](image)

3.2 Questionnaire Survey Experiment

A total of 413 people are involved in the questionnaire survey. 297 questionnaire responses received are valid, except that 31 respondents are under the age of 18 and 85 respondents have no idea about industrial robots. Table 1 demonstrates the data concerning the top 10 groups of the perceptual word survey questions among the 297 valid samples. In terms of all the respondents’ choices of design factors in the process of designing industrial robots, safety and function are selected far more frequent than the other design factors. The approximate ranking is as follows: security > function > structure > operation > working efficiency > form > materials > process > interface > color > decoration > area. Among them, the frequency that operation and working efficiency are selected is close, and the frequency decoration and regional choice are picked is similar. Based on the results above, safety and function should be first considered in the process of designing industrial robots.

<table>
<thead>
<tr>
<th>Perceptual Words Survey Data Table</th>
<th>complicated</th>
<th>simple</th>
<th>understood</th>
<th>technological</th>
<th>murderous</th>
<th>delicate</th>
<th>indifferent</th>
<th>amiable</th>
<th>dangerous</th>
<th>reliable</th>
<th>rough</th>
<th>exquisite</th>
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<td>176</td>
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<td>193</td>
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<td>256</td>
<td>102</td>
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<td>109</td>
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<td>125</td>
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<td>145</td>
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<td>100</td>
<td>89</td>
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</table>
3.3 Eye Movement Experiment

3.3.1 Eye Movement Experiment Design

The instrument adopted in the experiment is head-mounted glass eye trackers produced by Germany SMI Company that was founded in 1991. According to the characteristics requirements of the eye movement experiment, the experimental materials must be first handled to avoid that distraction items (such as location, color, background, type, size, etc.) exert an influence on the experiment results. Diagram used for experiment is illustrated in Figure 2. This experiment has invited 20 subjects, including 12 males and 8 females. They are the graduate and undergraduate students of East China University of Science and Technology, major in disciplines related to design and robots, and possess higher aesthetic appreciation abilities and a proficiency degree of industrial robots, which is advantageous to the experimental research.

![Figure 2. Diagram Used for Experiment](image)

The experimental design scheme is as follows. The first step is to invite participants into the lab, make them get familiar with the laboratory environment, the study experimental requirements and matters needing attention; the second step is to calibrate the eye movement for each participant, keep him or her in a stable status (preventing calibration failure) and to prepare materials for the experiment; the third step is to place 10 industrial robot product samples on the computer screen (in full-screen status) and to make the participants observe the pictures. The presenting time of the pictures is 20 s. Through the experiment, the tester collects the heat map of fixation point, fixation duration, fixation times, lost time, etc., of each tested person; the fourth step is to handle and analyze data.

3.3.2 Eye Movement Experiment Results

This paper mainly adopts the perceptual quantification technique to carry out the quantification collection of an optimal scheme of industrial robot product samples. The optimal scheme is obtained through the eye movement results and the comparison of AOI (areas of interest) data, and the process of data analysis uses EXCEL and SPSS software. A total of 20 eye movement video files in the format of AVI and 20 IDF eye movement data files are acquired from the above experiment. In light of the experiment data file, AOI area map is carried out first for these 10 samples, as demonstrated in Figure 3.

![Figure 3. AOI Drawing Diagram](image)
As seen from Figure 3, the AOI area is the area which distinguishes 10 samples on the screen with a broken line or a rectangle tool. Each AOI area is covered in each case, and the color needs to be distinguished. A total of 10 AOI areas are redrawn according to the number of cases. After finishing drawing the AOI areas, the fixation heat map, the scanning path, the dynamic KPI, the AOI sequence diagram and the linear figure of each sample are collected. An analysis and a summary of experimental data are carried out for data indicator within AOI area and the guided event data according to dynamic KPI.

3.4 Experiment Result Analysis

According to the analysis on the 20 experimental samples, excluding the invalid eye movement (reflective eye movement, vision loss, and non-AOI area vision), EXCEL and SPSS are applied for data recording and statistics to obtain the fixation time, the average fixation time, and the sum of saccade time in the AOI area. One table, such as Table 2, is selected to illustrate the experimental results.

<table>
<thead>
<tr>
<th>AOI area</th>
<th>AO1</th>
<th>AO2</th>
<th>AO3</th>
<th>AO4</th>
<th>AO5</th>
<th>AO6</th>
<th>AO7</th>
<th>AO8</th>
<th>AO9</th>
<th>AO10</th>
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<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>sum of fixation and saccade times (ms)</td>
<td>2184.5</td>
<td>2147.6</td>
<td>2320.8</td>
<td>516.0</td>
<td>1557.9</td>
<td>1760.7</td>
<td>1654.6</td>
<td>2648.7</td>
<td>1328.4</td>
<td>2014.8</td>
</tr>
<tr>
<td>Total value</td>
<td>17432.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Table 2 Measured Data Statistical Table for Eye Movement of Industrial Robot Product Samples

Based on the data in the table, it is clear that the average fixation time of the 20 subjects concerning the 10 industrial robot product samples is 5.5, 2.8, 6.2, 2.6, 2.7, 3.8, 3.5, 5.6, 3.5, and 2.9, respectively. The average fixation time (unit of ms) is 407.8, 312.8, 470.2, 292.5, 305.0, 358.1, 328.8, 448.4, 346.9, and 319.8, respectively, and the sum of the average fixation time and saccade time (ms) is 1654.6, 1686.7, 1848.4, 1848.4, 1848.4, 1901.0, 1901.0, 1901.0, 1901.0, and 1901.0, respectively. In view of the above data concerning the fixation time, Sample 3 > Sample 8 > Sample 1; as far as the average fixation time is concerned, Sample 3 > Sample 8 > Sample 1. In terms of the terms of the average fixation time and the saccadic time, Sample 3 > Sample 8 > Sample 1. Data results of the three samples are the same as the experimental hypothesis. On basis of eye movement psychology and cognitive psychology, the longer the subjects observe a certain area, the more they are interested in this area, the more details of this area need to be identified and felt by the testers. Besides, according to the experimental results, the testers have showed greater interests in Sample 1, 3, and 8, and the images of industrial robots similar to Sample 1, 3, and 8 should be explored and designed.

4. CONCLUDING REMARKS

The perceptual design method for industrial robots is explored by means of actual cases to bring a scientific and reasonable basis and support for the innovation, the evaluation and the decision-making of design, so as to promote a creative design mode of the designer by way of subjective feelings and to combine materials with sensibility in the creative design mode. However, the method can also be considered for further optimization and
in-depth study. For example, the product sample of industrial robot at the experimental stage can be replaced with real objects from current pictures, which will make the results more reliable and scientific, but also can bring difficulties to the experiment. With the use of the current computer’s three-dimensional modeling technology and virtual reality technology, the experimental industrial robot product sample is established into a 3D digital model of the same size and the experiment is completed on a virtually real platform, which will avoid the difficulty of industrial robot product samples at the time of strengthening the reliability and the scientificity of research results.

REFERENCES