# Study on the Perceptual Intention Space Construction Model of Industrial Robots Based on 'User + Expert'

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**Abstract.** Nowadays, a new technological and industrial revolution is under gestation and the labor division as well as competition division is re-shaping. Meanwhile, the industrial robot has become the one contested by all high-end equipment field throughout the world. How to introduce emotion design into the robot will inevitably become a power weapon for robots shinning out in competition. Human beings have emotional appeals, and the emotional effect ignited based on product functional structure, material form, user aesthetic sense as well as experience, and the cross-over study among user emotional appeals, psychology, physiology and design will become front topics in the industrial design research field. No matter perceptual engineering or emotional design, they are mainly responsible for the scientific recognition and adoption of ambiguous perceptual or emotional factors appeared in the course of creation, which aim to try the utmost to solve the emotional problems via scientific approaches, and change the situation that people cannot scientifically as well as accurately deal with emotional problems based on the experience and feeling of designers. So, the primary problem to solve emotional recognition is how to scientifically and effectively construct the perceptual intention space of products. This paper carries out scientific research on the special filed industrial robot based on the research of constructing perceptual intention space, trying unremitt8ing efforts to know the most scientific and effective perceptual intention space. The model construction includes vocabulary acquisition, selection and establishment to determine the key elements of users and experts. The main task of perceptual vocabulary acquisition is to widely collect the perceptual intention of industrial robot purchasers and users and personal interview as well as questionnaire is adopted; the selection stage is to carry out hierarchical clustering and simplification of the vulgar, similar and opposite words and the KJ is adopted; the establishment stage is to refine and determine perceptual words based on experts counseling and refinement experiment (the experiment approach is to integrate the online questionnaire and field investigation), which cannot only help to have a good knowledge of the emotional appeals, perceptual intention vocabularies


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recognized by users but also make up for the inner voice of users. To conclude, this paper innovatively comes up with the idea of perceptual intention space construction model of industrial robots based on ‘users and experts’ appealing.

**Keywords:** Users · Experts · Industrial robot · Perceptual intention space

## 1 Introduction

Nowadays, a new round of scientific, technological and industrial revolution is brewing. A new trend appears to make manufacturing service-oriented and lead the upgrading of manufacturing. In developed countries like Europe and America, “reindustrialization” strategies are promoted, in an attempt to maintain leading advantages in technologies and industries, in order to take the lead in manufacturing. American President Obama has specially made four speeches over the past few years, highlighting that manufacturing should be revitalized. New plans have been declared in Germany, England, France and Japan to vigorously promote the vitalization of manufacturing (Zhou 2015). As mechanical products, industrial robots are generally considered as structural products, which have somewhat different requirements for “emotional quality” compared with ordinary consumer products. Design ideas have been persistently dominated by the “function first” concept. Research has primarily focused on “technologies” and “performances” of “items”, but attached inadequate attention to emotional experience of products and humanistic care. To solve the problem about single development of technologies based on functions, material functions will be inevitably separated from spiritual functions. As a consequence, modern society’s “reverse technological control”, “material and spiritual separation” have been caused, which isn’t in line with original intents of human beings (Xiao et al. 2014). As human beings appeal for emotions, it has become a cutting-edge topic of current studies on industrial design to carry out research on users’ emotional appeals in combination with psychology, physiology and design in light of interactions of functional structures of products and their material forms with users’ requirements for aesthetics and experiences, etc. However, emotions belong to psychological processes integrating multiple components, dimensions and levels. Covering knowledge about psychology, industrial design, engineering technologies, semiology, linguistics, aesthetics, sociology, computer technologies and ergonomics, emotional design of products have complicated, vague and variable characteristics that can be hardly controlled and grasped. As a result, it is highly difficult to perform emotional design of products and pertinent research (Lin 2012).

## 2 Research Background

Emotions have been usually neglected and suppressed for a long period in the field of science where rationality is the foremost. By the late 19th century, William James introduced emotional research into the field of psychology. Thereafter, emotional research had presented a relatively complete theoretical system for more than 100 years with the development of disciplines like physiology, cognitive science, behavioral science and sociology (Strongman 2006), gradually expanding form psychology to other fields, such as ergonomics (Vink 2005), engineering (Tractinsky et al. 2000) and computer science (Picard 2003). Although the research is still prosperous in this field home and abroad, neither specific definitions nor uniform names have formed up till now. For Asia, concept of "Kansei engineering" has been put forward in Japan, while "society of Kansei engineering" has been set up in both Japan and Korea. Currently, this wording is generally accepted by the academic circle of Europe (Yamamoto 1986). In spite of attaching great importance to Kansei science, "emotion" is a generally accepted wording (Luo and Pan 2007). Nevertheless, with an overview of much Chinese and foreign literature about emotional design, it may be discovered that Japanese theory of Kansei engineering and three-level theory put forward by an American professor known as Donald A Norman are the sole publicly acknowledged ones that can form a theoretical system at present (Ding et al. 2010).

The 1st International Conference on Design & Emotion convened in the Technische Universiteit Delft of Holland in 1999 and the founding of the "Society of International Design and Emotions" in the conference are hallmark events for research on emotional design as well. Dr. Desmet, from the Department of Industrial Design in the Technische Universiteit Delft, concentrates on research about emotional design and experience (Desmet et al. 2004). Proposing the concept of "product emotion", he has developed tools for measuring product emotions, including Emocards and PrEmo (Desmet 2003). Dr. Desmet has constructed a framework of product experiences with his colleagues, to explain users' all emotional responses in their interactions with products (Desmet and Hekkert 2007) and roles of products in emotional experiences (Demir and Desmet 2008). Considering that emotions are centers for human beings' quality of life (Desmet 2008), he has qualitatively and quantitatively conveyed relationships between evaluation and design projects. These research findings have provided theoretical foundations and technical support for research on emotional designs and measurements.

Regardless of "Kansei engineering" or "emotional design", research has been mainly conducted to examine those uncertain perceptual or emotional factors during human creations from the perspective of scientific cognition and applications, so as to solve material emotional problems of human beings by scientific means, thereby solving problems concerning emotional factors that can't be scientifically and accurately solved just based on designers' experiences and feelings. To deal with problems regarding emotional cognition, the foremost issue is how to scientifically and effectively construct perceptual image space for products.

## 3 Research Methods

By studying a great deal of literature, it may be discovered that research methods and key technologies for perceptual images of product design have been discussed in previous research on perceptual image space. Nevertheless, there is still space for further exploring the modes and routes for creating perceptual image space for products, including research about if it is proper and scientific to acquire perceptual vocabularies as well as multidimensional characteristics of perceptual image space. Perceptual vocabularies are critical premises for constructing perceptual image space of products. Accurate and scientific construction of perceptual image space of products is dependent upon if perceptual vocabularies are scientifically and rationally defined. In light of this problem, industrial robots are scientifically explored as a relatively special field, in an attempt to construct the most scientific and efficient perceptual image space for industrial robots. Such space may be constructed by gathering/selecting perceptual vocabularies, defining three stages, and two elements, including "users" and "experts".

### 3.1 Gathering Perceptual Vocabularies of Industrial Robots

In the process of gathering perceptual vocabularies, it is mainly necessary to extensively collect perceptual intentions of purchasers and users of industrial robots. In this study, information is collected by communication with users of industrial robots, personal interview and questionnaire survey as well as magazines, books and websites about industrial robots. In this way, 873 perceptual vocabularies are obtained at first, as shown in Fig. 1 as follows. In this stage, it is unnecessary to evaluate and deal with perceptual vocabularies in any ways. There is only a need to extensively collect adjectives related to feelings or cognitions presented by industrial products. The larger the scope, the wider the lexical coverage is. At last, perceptual vocabularies can be summarized and determined more scientifically.

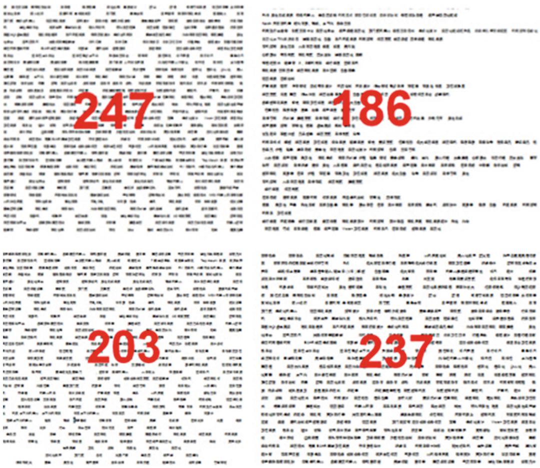


**Fig. 1.** Gathering perceptual vocabularies of industrial robots (independently drawn)

### 3.2 Selecting Perceptual Vocabularies of Industrial Robots

In the process of selecting perceptual vocabularies, the main tasks are manual hierarchical clustering and simplification of vague, similar vocabularies and antonyms by classification, KJ method, summary and combination of several methods. In this paper, a

7-person group is founded to simplify perceptual vocabularies, including a boss of a industrial robot manufacturers, a boss of an enterprise purchasing industrial robots, an operator of the enterprise purchasing industrial robots, two experienced industrial designers, a salesperson and an undergraduate majoring in statistics. The research process is shown in Fig. 2 as follows. The group for simplifying perceptual vocabularies eventually simplifies 874 perceptual vocabularies collected in the last stage into 72 vocabularies to make 36 pairs of adjectives by classification, KJ method, summary and combination of several methods, including modern-traditional, hospitable-indifferent, expensive-cheap, scientific-backward, popular-personalized, graceful-vulgar, bright-dark, concrete-abstract, generous-cautious, hard-soft, thin-thick, rhythmic-serene, streamlined-geometric, unique-ordinary, lively-rigid, coordinated-lofty, light-heavy, interesting-dull, complete-separated, concise-complex, leisure-work, durable-flimsy, young-old, emotional-rational, free-constrained, practical-ornamental, creative-imitative, opportunistic-pessimistic, handsome-manly, coordinated-lofty, kind-alienated.

**Fig. 2.** Selecting perceptual vocabularies of industrial robots (Self-portrait)

### 3.3 Defining Perceptual Vocabularies of Industrial Robots

Above 36 pairs of perceptual vocabularies are prepared into a questionnaire survey, to carry out an experiment with the participation of users in combination with expert consultation for the purpose of optimally extracting perceptual vocabularies. Concerning the experimental method, online survey questionnaire is integrated with the field survey questionnaire. Then, expert opinions are solicited. The online questionnaire survey is shown in Fig. 3 as follows.

This questionnaire survey is performed online and offline. In the online survey, the questionnaires are distributed by E-mail, QQ and WeChat. The offline field survey is conducted on users of industrial robots in areas like Shenzhen, Hefei, Wuhu and Ma On Shan, including Foxconn Technology Group, Anhui Jianghuai Automobile Co., Ltd, Chery Automobile Co., Ltd and Hualing Xingma Automobile (Group) Co., Ltd by anonymous answering. In completing the questionnaires, respondents shall fill up their age range and answer their familiarity with industrial robots. In the final online survey questionnaires, 1,382 people who are over 18 years old have known about industrial robots, so these questionnaires are valid. 300 questionnaires are distributed for the field survey, among which 249 valid questionnaires are recovered. The questionnaire surveys are summed up in Figs. 4 and 5 as follows.

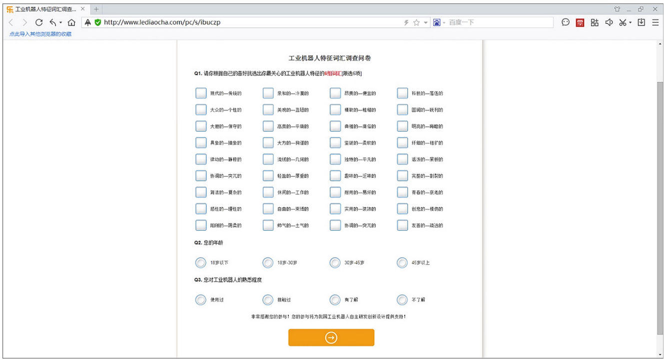


**Fig. 3.** Questionnaire survey of vocabularies on characteristics of industrial robots (Self-portrait)

An expert consultation meeting is convened in light of results of the questionnaire surveys and relevant problems. 3 experts of industrial design, 2 experts of industrial robot users (enterprises) and 2 experts of industrial robot manufacturers are invited to discuss and add perceptual vocabularies put forward by experts. At last, 6 pairs of perceptual vocabularies are defined, including friendly-hostile, safe-dangerous, modern-traditional, beautiful-ugly, exquisite-rough, durable-flimsy.

### 3.4 Constructing Perceptual Image Space of Industrial Robots

Created by American psychologists in the 20th century, semantic differential method is an empirical method used for investigating mentality of respondents. In fields of sociology and psychology, it is widely used for comparative research concerning differences of individuals and groups, people's attitudes toward things and their views. The experiments on semantic differential method are mainly carried out in the form of questionnaire survey.

**1st Stage of Experiment: Collecting and Selecting Samples of Industrial Robots.** At first, samples of industrial robots are collected. In this study, overall forms of industrial robots are explored, so pictures of the forms are collected from advertisements, magazines and exhibitions, etc. of industrial robots in market, so as to widely collect samples in different forms. In this way, research findings may be more significant and complete. After preliminarily selecting collected samples of industrial robots, 73 sampled products are left altogether. Once these 73 samples are confirmed by several people with pertinent design background, 37 samples in forms of cell phones are finally picked up. Next, 39 samples are grouped for treatment, in order to ease the burden of respondents. 30 majors of industrial design are invited from the East China University of Science and Technology and the Anhui University of Technology, including 10 postgraduates, 20 undergraduates, 15 males and females respectively. Respondents are asked to group 39 samples of industrial robots according to personal subjective feelings. After the number of the same grouping times is statistically

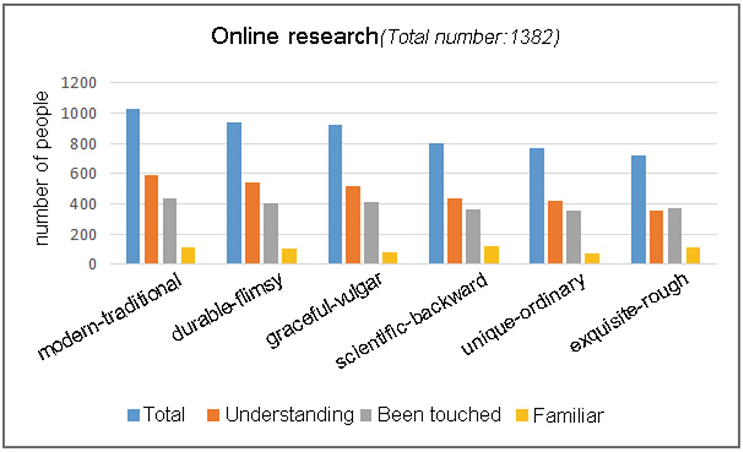


**Fig. 4.** Histogram statistics of online survey questionnaire (Self-portrait)

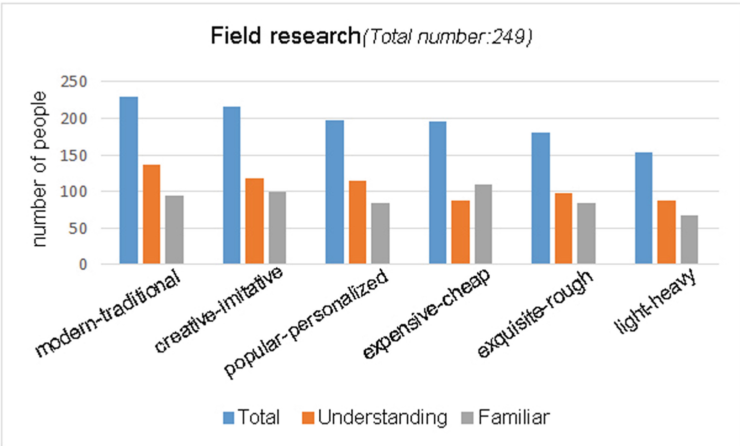


**Fig. 5.** Histogram statistics of field survey questionnaire (Self-portrait)

analyzed, $39 \times 39$ similarity matrix is listed to compare the frequency at which a sample appears in a group, namely degree of similarities. Subsequently, matrix data are input into the statistical software system, in order to perform analyses by multidimensional (2 to 6 dimensions) software system. Finally, the most representative 8 samples are obtained, as shown in Fig. 6.

**2nd Stage of Experiment: Evaluation of Perceptual Intentions.** In this stage, respondents are invited to take part in an experiment for evaluating images and semantics of 8 representative samples based on personal subjective feelings. A 7-scale attitude scale is set according to the scaling standard for semantic differential survey questionnaire. From the left to the right, 3 to −3 scores are granted for the scale.

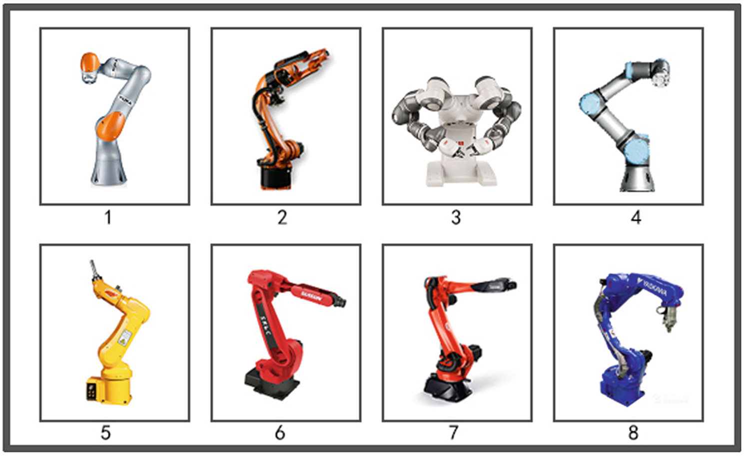


**Fig. 6.** Final samples of 8 most representative industrial robots (Self-portrait)

−3 means that the sample greatly deviates from the semantics, and 0 represents ordinary, while 3 indicates that the sample has pretty strong feelings represented by the image semantics. In this experiment, 40 respondents are randomly selected from users, including 23 skilled operators of industrial robots and 17 unskilled ones. Then, a questionnaire survey is carried out, and the mean of semantics is determined for the perceptual images as follows, as shown in Table 1.

**Table 1.** Evaluated mean of semantics for all images of representative samples (Self-portrait)

| semantic / samples | friendly-hostile | safe-dangerous | modern-traditional | beautiful-ugly | exquisite-rough | durable-flimsy |
|---|---|---|---|---|---|---|
| samples 1 | 0.956 | 0.861 | 0.648 | 0.982 | 1.014 | 0.246 |
| samples 2 | -0.154 | -0.537 | 0.366 | 0.54 | 0.219 | 0.137 |
| samples 3 | 1.5 | 0.915 | 0.874 | 1.694 | 0.89 | 0.313 |
| samples 4 | 0.426 | 0.114 | 0.3 | 0.373 | 0.389 | -0.314 |
| samples 5 | 0.561 | 0.12 | 0.564 | 0.494 | 0.675 | 0.518 |
| samples 6 | 0.13 | 0.264 | 0 | 0.252 | 0.421 | 0.451 |
| samples 7 | -0.239 | -0.158 | 0.4 | 0.377 | 0.3 | 0.199 |
| samples 8 | -0.853 | -0.316 | 0.117 | 0.1 | 0.198 | 0.466 |

## 4 Research Results

Based on above research, orders and total scores of perceptual characteristics of 8 sampled industrial robots are finally determined. It means the overall perceptual evaluation of a sample is decent when its total scores are lower. The sequence of sub-items also reflects friendliness, safety, modernity, aesthetics, exquisiteness and durability of samples, as shown in Table 2 as follows.

**Table 2.** Sequence of perceptual image space of industrial robots (Self-portrait)

| samples / semantic | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| friendliness | | 2 | 6 | 1 | 4 | 3 | 5 | 7 | 8 |
| safety | | 2 | 8 | 1 | 5 | 4 | 3 | 6 | 7 |
| modernity | | 2 | 4 | 1 | 6 | 3 | 8 | 5 | 7 |
| aesthetics | | 2 | 3 | 1 | 6 | 4 | 7 | 5 | 8 |
| exquisiteness | | 1 | 7 | 2 | 5 | 3 | 4 | 6 | 8 |
| durability | | 5 | 7 | 4 | 8 | 1 | 3 | 6 | 2 |
| total score | | 14 | 35 | 10 | 34 | 18 | 30 | 35 | 40 |

At last, perceptual image vocabularies that actually represent users' emotional needs and acknowledged by users are obtained. With the participation of experts, some perceptual vocabularies are beyond users' psychological expectations, but represent their potential emotional needs. This makes up previous failure to completely reflect users' thoughts by perceptual vocabularies in experiments on perceptual image cognitions and innovatively create a mode of "users + experts" for perceptual image space of industrial robots.

## 5 Conclusions and Prospect

In all stages where "users" and "experts" deeply get involved in the research from collection from selection and definition of perceptual vocabularies to the experiments for collecting/selecting sampled products of industrial robots and evaluation of emotional images, sequence of perceptual image space is eventually determined to construct a mode of "users + experts" for perceptual image space of industrial robots. This mode is somewhat creative, scientific and reasonable. Nonetheless, the perceptual image space constructed by this mode may be further optimized and deeply explored. Provided that current pictures of sampled industrial robots for experiments are replaced by physical objects, the research findings will be more reliable and scientific. In the mean time, numerous difficulties will be brought to experiments. Furthermore, industrial robots sampled for experiments may be developed into three-dimensional digital models with the same dimensions and experiments may be performed on virtual reality platforms. This will make the research findings more reliable and scientific while avoiding the difficulties for collecting physical samples of industrial robots.

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