Explore Consumers' Requirements of Comfortable Chairs through Interactive Genetic Algorithm

Philip Hwang*, Yu-Hsuan Chang**, Jui-Ping Ma***

** National Taipei University of Technology, Taiwan, phwang@ntut.edu.tw*
*** National Taipei University of Technology, Taiwan, sharonchang0919@gmail.com*
**** National Taipei University of Technology, Taiwan, tima2007@gmail.com*

Abstract: In the research of Human Factors Engineering, comfort of seating is defined by scientific measurements such as pressure, force and Electromyography (EMG) signal. This paper proposed a method of exploring consumers' requirements of comfortable coffee chairs using Interactive Genetic Algorithm (IGA) processing where consumers evaluated their preferences. The research found some preferences coincided with Human Factors Engineering theory. On the contrary, some were opposite. Furthermore, there were preferences not addressed in theory of Human Factors Engineering. Hence, IGA would not only help to explore consumers' requirements, but also provide designers with further concern while designing comfortable coffee chairs.

Keywords: Interactive Genetic Algorithm (IGA), comfort, Human Factors Engineering

1. Introduction

All the time, comfort of seating is decided by theory of Human Factors Engineering on which designers develop chairs. However, there is no research about comfort of seating based on consumers' cognition. This research explored physical factors of comfort that affect consumers through Interactive Genetic Algorithm (IGA). This research focused on the chairs in the coffee shop. IGA is used to find the optimal solution in the evolutionary procedure, which is inspired by Darwin's evolution theory. Compared with Genetic Algorithm (GA), IGA adopts users' choices as fitness. Hence, IGA is suitable for the consumer-oriented product development. Furthermore, this research intended to distinguish definitions of comfort between consumers' cognition and theory of Human Factors Engineering.

2. Related Works

IGA has been applied to several fields where it considers human sensory perception, recognition ability, intuition, feeling and emotion. For example, Hua Zhu, Shangfei Wang, and Zhen Wang applied it to Emotional Music Generation, and users can get their satisfied emotional music through IGA, although they have no profound knowledge for composition [1]. Baker implemented a line drawing system based on the user's aesthetic criteria using IGA. The criteria of this system are attraction, amusement, control, and so on [2]. However, there is no research about comfort of seating applying IGA. The definition of comfortable chair in the respect of Human Factors Engineering theory includes soft cushions, armrests, backrest inclination and lumbar support [3-6]. In

Figure 1, it exp resses human require inclining backrests and armrests in the free time and that indeed increases comfort [3]. Furthermore, chairs with lumbar support reduce spine disc force compared with no lumbar support, and from the research done by B.J.G. Andersson and R. Ortengren, over 90 degree inclining backrests also cause less spine disc force (see Figure 2) [4, 5]. According to these definitions, this research started to set IGA to build the experiments.

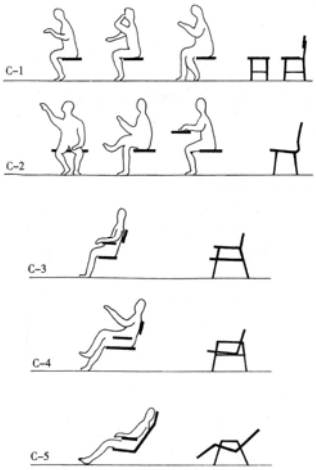


Figure.1 Human posture and types of chairs (Source: 梁啓凡: p285)

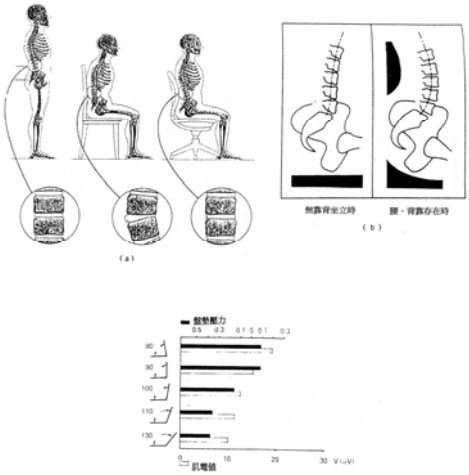


Figure.2 Top: Seating and lumbar support; Bottom: backrest inclination, spine disc force and EMG signal (Source: 張一岑: p243, p245)

3. Research Method

This research fo llowed the procedure of IGA. Setting t he parameters fo r IGA was first, and it followed by creating th e al gorithm an d t he IGA in terface. After building th e environment for e xperiments, corres pondents were invited to explore their requirements of comfortable chairs through executing IGA (see Figure 3).

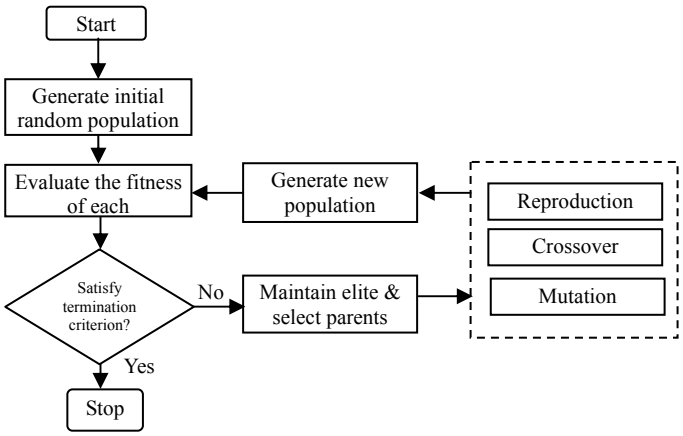


Figure.3 Flow chart of IGA process

Before starting IGA, in itially, it n eeds to identify th e at tributes for com fort o f seati ng. As th e definition of Human Fact ors En gineering theory desc ribed b efore, co mfort of seat ing i s a ffected by (1) t he l ength a nd t he slope of the backrest, (2) the height and the slope of the seat pan, and (3) the height and the slope of the armrest [3]. Consequently, the attributes of IGA were defined as backrest, seat pan, and armrest. All of them were listed with binary encoding separately in Table 1. IGA was crucially setting the p arameters wh ich were affected th e efficiency of the algorithm. Table 2 shows parameters adopted in the experiments.

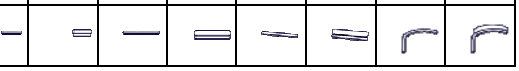
Attribute	Binary code & Image							
Backrest	000	001	010	011	100	101	110	111
								
Seat pan	00	01			10		11	
								
Armrest	000	001	010	011	100	101	110	111
								

Table.1 Attribute and binary code of IGA

Initial Population	Random, unrepeated
Size of Population	8
Number of Generation	10
Length of Chromosome	8
Selection Method	Roulette wheel selection & Elite strategy
Crossover Method	One-point crossover method
Crossover Rate	0.8
Mutation Method	Random
Mutation Rate	0.05
Fitness Function	Human
Scale of Fitness	Likert's Scale (1-7)

Table.2 Parameter setting for IGA

Based on the analysis about the issue of comfort, the hypothesis of this research was: chairs with armrest and soft cushions have better comfort. Additionally, the IGA interface (Figure. 4) was created using Borland C++ Builder. Thirty correspondents, ages from 23 to 35 were invited, including 19 males and 11 females. All of them had the habit of visiting coffee shops at last once per month. They came from a variety of backgrounds: sixteen from design field, five from market field, and nine from other fields such as Electrical and Mechanical Engineering (see Figure. 5). In the experiments, all correspondents evaluated each chair from 1 (most uncomfortable) to 7 (most comfortable) based on their experiences of comfort.

4. Research Findings

All correspondents successfully completed the IGA experiments, however, not all correspondents found their comfortable chair during the IGA procedure. Statistically, the rate of finding satisfied solution was about 60%. In other words, eighteen correspondents have chosen one chair they feel most comfortable in the interactive interface. However, in the failure case, three correspondents wanted the longer backrest which support the neck and head for rest out of the database. Both compositions of chairs in Figure 6 were the most popular in the experiments. Five evolved the left one and four evolved the right.

Figure.4 IGA interface

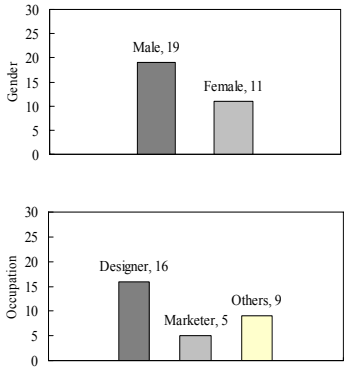


Figure.5 Correspondents for experiments

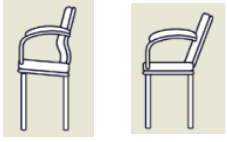


Figure.6 Two most popular chairs

4.1 Preference of Cushion

20 of 30 correspondents preferred chairs with completed soft cushions, which include soft backrests, soft seat pans, and soft armrests; the rest selections prefer at least one of them. This result coincided with the definition of comfortable chairs given by Human Factors Engineering theory [3]. However, a few of correspondents disliked cushions because of hygiene and heat.

4.2 Preference of Long Armrest and Curve Armrest

In the research of Human Factors Engineering, it dose not propose the length and the curve of armrests for a comfortable chair [4]. Otherwise, in this research, 18 correspondents preferred curve armrests and 28 correspondents preferred long ones. In the meanwhile, a few of correspondents (2 correspondents merely) disagreed with this. They believed short armrests leave more leg space and do not hit the desk.
Furthermore, all above research findings coincided with the hypothesis.

4.3 Uncertain & Special Preference

Several factors are not essential for seat comfort including lumbar support and seat pan slop. Approximately, half correspondents regarded lumbar support and the tilt of seat pan were comfortable. This finding does not agree with the research result of Human Factors Engineering study [6] completely, which emphasizes lumbar support reduces spine disc force. Likewise, several special requirements were proposed including higher backrests with head support or inclining backrest with lumbar support that did not exit in the database of experiments.

5. Result Analysis

Many correspondents were hesitated while facing many selections. On the other sides, if the correspondents are confident to what they prefer, it is easy to complete the matched solution. The more often correspondents visited coffee shops, the more precise decisions they made, and enhanced IGA to converge. This means experiences affect the consumers' requirements and preferences. Additionally, correspondents got semantics from the images shown in the IGA interface; consequently, the results of comfortable chairs depended on the correspondents' cognition. As the result findings shown above, (1) preferences of soft cushion coincided with the results of theory of Human Factors Engineering, and (2) this research showed lumbar support was not essential for coffee shop chairs. (3) This research also found correspondents preferred long armrests and curve armrests that were not mentioned in the filed of Human Factors Engineering. In conclusion, not all consumers were sensitive to comfort of seating, and it was encouraged to define their comfort through their cognition that was excluded in Human Factors Engineering theory.

6. References

[1] Hua Zhu, Shangfei Wang, Zhen Wang (2008), Emotional Music Generation Using Interactive Genetic Algorithm, *2008 International Conference on Computer Science and Software Engineering.*

[2] E. Baker and M. Seltzer (1994), Evolving line drawings, *in Proc. Graphics Interface, pp. 91–100.*

[3] 梁啓凡 (2000), 家具設計學, *中國輕工業出版社, 北京*

[4] 張一岑 (1997), 人因工程學, *揚智文化, 台北*

[5] B.J.G Andersson and R.Ortengren (1974), Lunbar disc pressure and myoelectric back muscle activity during sitting, study on an office chair, Scandinavian *J. Rehabilization Medicine, 3, pp.104-135.*

[6] Joyce Marilyn and U. Wallersteiner (1990) Ergonomics: Humanizing the Automated Office. S*outh Western Publishing Co., Cincinnati, OH 1990.*