Aesthetical Concept for Human-Computer Interaction Using Fuzzy Knowledge Base Clustering

M. Reza Mashinchi
Faculty of Computer Science & Information Systems
University of Teknologi Malaysia,
Johor, Malaysia
r_mashinchi@yahoo.com

M. Hadi Mashinchi
Faculty of Computer Science & Information Systems
University of Teknologi Malaysia,
Johor, Malaysia
h_mashinchi@yahoo.com

Ali Selamat
Faculty of Computer Science & Information Systems
University of Teknologi Malaysia,
Johor, Malaysia
aselamat@fsksm.utm.my

Abstract **-** This paper attempts to reduce the complexity of aesthetical conceptual system rule base by using fuzzy clustering method to make our decision making nearer to human computer interaction ideals by using the concept of similarity. Where we have a rule base of our aesthetical concept called *Aesthetical Fuzzy Rule Base (AFRB)* we have numbers of aesthetical concept rules. To make our *AFRB* more usable and preparing it for better interaction with human, it must be clustered, whereas we are dealing in our interaction with computer by uncertainties of aesthetical semantics. Finally, we will show an appropriate clustering called fuzzy clustering by reasoning for our AFRB.

Keywords: Aesthetic, fuzzy clustering, HCI

1 Introduction

Dynamic advances in technology have revolutionalized the way that people now interact with computers [10]. In parallel with these technical advances our understanding of human computer interaction (HCI) has also progressed phenomenally over the past 20 years. Reasearch in all aspects of HCI has extended our understanding of what it means to interact with technology and how to put this undersranding to practical use in the design and evaluation of products [10]. Therefore HCI is one of the most rapidly develoaping subject in computer science. What was a fascinating research subject is now recognized as a vital component of successful computer applications. Consequently it has appeared in related fields such as knowledge understanding and representation for better interaction. Therefore the problem formation and solving, understanding human requests in natural language, machine learning and other urgent problems of computer simulation that are needed for better interaction, are appeared in understanding the entire diversity of human knowledge. For all these it is needed an appropriate tool for processing. One of the important dimensions of human knowledge is aesthetic cognition ability that he is strongly surrounded by it [11]. The role of aesthetics in human affairs has been widely documented [9], and throughout the centuries human is trying to know aesthetic cognition and its rules, and so the philosophers have pondered over the questions related to it [10]. Careful application of aesthetic concepts can aid acceptability, motivation, learnability, comprehensibility and productivity [5]. But due to vagueness of aesthetic, processing of this concept and consequently decision making based on aesthetical cognition model, becomes difficult and it is more complex and vague when there is huge number of data and rules which are gathered as a rule base. Therefore, we need to cluster our aesthetical rules to obtain more usability that is also a key concept of HCI. This is concerned with making our aesthetical conceptual system safe and easy to use [10]. To this end, one of the mathematical disciplines which can be used is fuzzy logic. It gives us the possibility of organizing our views on this matter due to its flexible capability of managing uncertainty [5, 1]. We will use fuzzy clustering to make our decision making nearer to HCI ideals by using the concept of similarity that is the essential component of any form of clustering that helps us navigate through data space and form clusters [8]. As we mentioned the vagueness nature of aesthetic, we always scale it by using linguistic variables in our expressions. Fuzzy logic is one of the appropriate tools to process linguistic variables. We will show our clustering by a diagram as a graphical representation.

The aim of this paper is to use fuzzy clustering as a mathematical tool on aesthetical fuzzy rule base to have better usability and optimized reasoning. This approach makes better occasion for

aesthetical decision making, in consequence of reaching to the ideals of HCI.

2 Human Computer Interaction

A good HCI depends on HCI designers. Design teams have to have a wide range of knowledge about both of human and technology and to know how they are related to each other. For this reason, HCI is multidisciplinary. The goals of HCI are to produce usable and safe systems, as well as functional systems [10]. These goals can be summarized as *"to develop or improve the safety, utility, effectiveness, efficiency, and usability of systems that include computers"* [10]. The promotion of safety in relation to computer systems is the major importance in the design of safety-critical systems. *Utility* refers to the functionality of a system or, in other words, the things that it can do. Improving *effectiveness* and *efficiency* are self-evident and universal objectives. *Usability* that is a key concept in HCI, is concerned with making systems easy to learn and easy to use. And finally for the term *system*; it derives from systems theory and it refers not only to the software and hardware but also to the whole environment –be it an organization of people at work, at home or engaged in leisure pursuits – that uses of it affected by the computer technology in question.

In order to produce computer systems with good usability HCI specialists strive to [8]:

- *Understand* the factors (such as psychological, ergonomic, organizational and social factors) that determine how people operate and make use of computer technology effectively, and to translate that understand to into the
- *Development* of tools and techniques to help designers ensure that computer systems are suitable for the activities for witch people will use them, in order to
- *Achieve* efficient, effective and safe interaction both in terms of individual human-computer interaction and group interactions.

2.1 Artificial intelligence and HCI

Artificial intelligence (AI) is concerned with the design of intelligent computer programs which simulate different aspects of intelligent human behavior [11]. In particular, the focus has been on representing knowledge structures that are utilized in human problem solving. AI knowledge and methods, such as the use of production rules, have been applied to HCI to in connection with the development of tutoring and expert systems with intelligent user interfaces [10]. However, the relationship of AI to HCI is mostly concerned with user's needs when they interact with an intelligent interface. These include, for example the use of intelligent agents to support users' navigation and reduce menial tasks that many users faced when using computer systems and it is a recent challenge in hypermedia and multimedia developments. Figure 1 shows the main topics that make up the discipline of HCI. Different kinds of applications are needed for different purposes and also care is needed to divide the tasks between human and computer system, and making sure that those activities that are creative and non-routine are allocated to people and those that are repetitive and routine are given to computer system. It is necessary to know about the range of possibilities offered by computer hardware and software so that knowledge about humans can be mapped on to the technology appropriately. Therefore, knowledge of human psychological and physiological abilities, and more important still, their limitation is important. As it has shown in Figure 1 there are some involved knowing about such things as human information processing, language, communication, interaction.

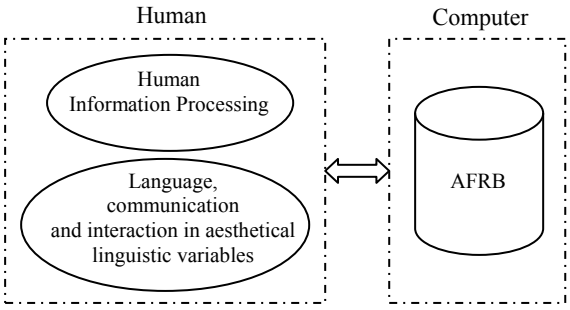

Figure 1: Human Computer Interaction diagram

2.2 HCI and Mental Models

The concept of mental model has manifested itself in psychological theorizing and HCI research in a multitude of ways. It is difficult to provide definitive description, because different assumptions and constraints are brought on the different phenomena it has been used to explain. A mental model represents the relative positions of a set of objects in an analogical manner that parallels the structure of the state of objects in the world [10]. It is very important to have a flexible model whenever It is very useful to have a large set of scripts to deal with typical every day situations such as aesthetical semantics. Furthermore, we can make inferences in those complex situations, predict related future states and comprehend situations that we have never personally experienced. Mental model is an alternative, but related, theoretical concepts, witch has been developed to account for these more dynamic aspects of cognitive activity. Mental models are assumed to be constructed dynamically, by activating stored schema, as creations of the moment.
In the best case, interaction between human and computer is when computer thinking like human. People should not have to change radically "fit in

with the system", the systems should be designed to much their requirements [10]. Therefore for this purpose we have to know if a program is thinking as human, and so consequently to know how human think. Therefore, we must concentrate on human brain action. There are two ways [11]:

- Idiotropically
- Psychological experience

If we accurate theories about our mental, then we will be able to program it [13]. Knowledge is more than a static encoding of facts; it also includes the ability to use those facts in interacting with world. The basic premise of our system is that knowledge if something is the ability to form a mental model that accurately represent the thing as well as the action that can be performed by it and on it. Then by testing actions by model, our system can predict what is likely to happen in the real world. In this paper that we are going to show safety of a system by doing clustering on it, we are assumed on human mental model for aesthetical conception showed in Figure 2, where we have [5]:

- *RW*; The Real World
- *AW*; The Abstracted World
- *GA*; Guessed Aesthetic

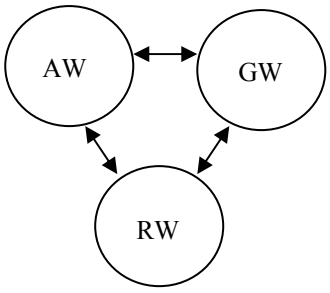

Figure 2: Aesthetic Model Process

2.3 Uncertainty and HCI

The uncertainty, called randomness, is discussed in Probability. It is over 300 years since probability was thought about [12]. However, the uncertainty with regards to our subjectivity has not been distinguished from randomness until recently. Uncertainty is fuzziness for witch fuzzy theory is formalized. It has been more than 30 years since it was theorized [12]. Fuzzy theory has had a great impact on our life because it makes us notice the existence of uncertainty. Human communication involves uncertainties. Even misunderstanding that is one consequence of uncertainty, is useful for creative works. Because of this flexibility, we can understand each other. Uncertainty plays a key role in allowance, open-mindedness, flexibility and interaction among human being. Furthermore, it is form advantages of uncertainty that rough, incomplete, or inconsistent statements can be accepted as they are. An uncertainty-free society would loose its humanity and creativity, and whereas our computers are coming in the center of our society that w have more interaction with them nowadays. We can relax in our interaction with computers when we leave the world of zero and one for the see of uncertainty, because we are human [11].

3 Fuzzy expert system

Fuzzy expert system is a system that uses a collection of membership functions and fuzzy rules for reasoning and processing of data, instead of Boolean logic[11]. The goal of the expert system [6] is to employ human knowledge and experience in the field where conventional technologies do not apply. The process of uncertainty is, therefore, a crucial step to the expert system. From this observation, we see that the expert system needs fuzzy theory and fuzzy theory needs the expert system for its most important applications. Fuzzy inference is absolutely appropriate for the frame works of the fuzzy expert system [11] specially when we process on aesthetical uncertainty for HCI. Usually rules of fuzzy expert systems are in this simple case [11]:

If X is low and Y is high, then Z is average. (1)

Where, *X* and *Y* are input variables and *Z* is output variable. It is called *Rule Base* to collection of rules that is used in fuzzy expert system. In the *antecedent* section it will be defined how much degrees are predictable with rules and in the *conclusion* section it will be defined with membership function for each output variables.

Reasoning in the fuzzy expert systems usually done through four stages [11, 14]:

- Fuzzification
- Inference
- Composition
- defuzzification

Although as it is seen in some papers it can be shown as following sections [11, 14]:

- Fuzzifier
- Fuzzy inference system
- Fuzzy rule base
- Defuzzifier

In this division Composition stage is getting to be under step of fuzzy conclusion and step 2 and 3 are in direct interactive with each other. In generally, input data that are importing to fuzzy and output that system gives, have to be *crisp*.

3.1 Aesthetic Fuzzy Rule Base

In computer science that we are trying to transfer human conceptions as the symbol of ability to

systems as a least ideal, but we see that in reality we are faced with a lot of problems that we should first clarify and solve them. Understanding data, revealing underlying phenomena, and visualizing major tendencies are major undertakings pursued in system modeling [15]. The informal linguistic information that the software engineer deal with is not simply supplemental information that can be ignored because automated tools does not use it rather, this information is fundamental. If we are to use these informal information in design recovery tools, we must propose a form for it [7]. Data collection anytime and everywhere has become the reality of our lives. In real life human is surrounded by a one called aesthetic that is influence on every part and detail of human decisions. However, due to vagueness of aesthetic, it is still not processed well from scientists but its influence is remained as before. As we usually expressing our feeling by linguistic variables, so it can be infinite amount of variables. In the real life our mind which is our prototype, he is faced to all these variables and able to process all so simple. Moreover, mostly his decisions on these variables are enough safe, although some times it makes some misunderstanding and fault decision due to vague of these aesthetical variables. One approach for making safe the decision on a huge number of data is clustering. Clustering is a methodology and a remarkably rich conceptual and algorithmic framework for data analysis and interpretation [15]. Incase of two valued and classical logic clustering, we use zero and one that consequently would be appeared in its related table index by a two valued. But, due to vagueness of aesthetic that we have always overlapping of meanings within its values it is more realistic and appropriate to cluster it by fuzzy clustering, where there is a base full of aesthetical data that we call it *Aesthetic Fuzzy Rule Base (AFRB)*, for further information refer to [5]. In general, fuzzy rule bases are an approximate representation of some interesting system. As such they could potentially be used for indexing and searching candidate solutions in case-based reasoning (CBR) system in a variety of application areas [3]. By assuming AFRB, we can have the radar diagram for its clustering as in Figure 3. Each $X_1, X_2, \ldots, X_n$ and $a_1, a_2, \ldots, a_n$ are aesthetical variables and its related believing degrees. By this clustering understanding of Aesthetic and further decision making and consequently its interaction will be more safe, and it would be easier to extracting and access to data sets and less run time for decision making, so it can cover the keys of HCI. Aesthetical linguistic X is concerned to object S by its believing degree value (where S is a label of sub cluster), or in vice-versa; aesthetical object S is concerned to aesthetic via aesthetical linguistic a. Moreover, due to operating at the level of linguistic rulebase, rather than a defuzzified reasoning surface, thus belongs to computing-with-words (CW) [4] paradigm. We use these aesthetical linguistics as propositions in Natural Language (NL) as Initial Data Set (IDS). In CW, a granule g which is denotation of a word w is viewed as a fuzzy constraint on a variable. A pivotal role in CW is played by fuzzy constraint propagation from premises to conclusions [4]. As a simple example consider the propositions:

$$P1 = Ast\ x_1\ is\ almost\ Ast\ x_2 \qquad (2)$$
$$P2 = Ast\ x_2\ is\ almost\ Y \qquad (3)$$

In this case, the word *"is almost"* is playing the role of fuzzy constraints. If the query is, *"How much Ast x_1 looks like (or belongs to) Y?"* (where Y is name of cluster), an answer yielded by fuzzy constraint propagation might be expressed as P_3, where:

$$P_3 = Ast\ x_1\ is\ not\ so\ different\ from\ Y. \qquad (4)$$

And so by propagating fuzzy constraints and using its linguictical similarities we would be able to complete our clustering.

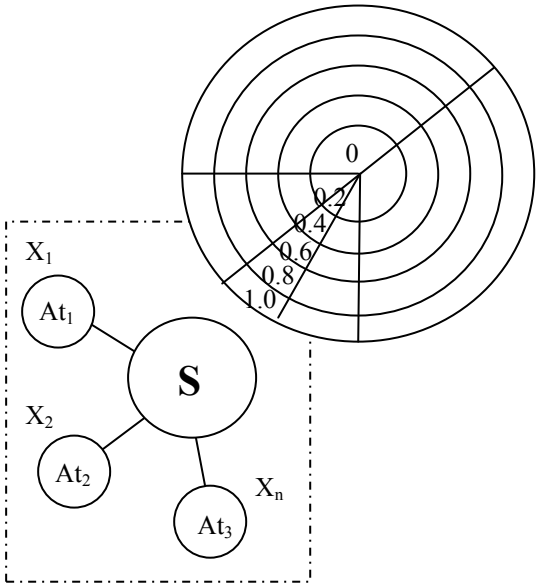

Figure 3: Radar diagram on AFRB

4 Conclusions

The main purpose of this note is to draw attention to the interaction of human and computer where there is aesthetical conception relation between them. To make nearer our system as assumed AFRB to the ideal of HCI we tried to cluster AFRB it by fuzzy clustering. We used also CW that its role model is human mind to make complete our clustering by fuzzy constraint propagation and using linguistic similarities.

References

[1] Mashinchi, M.R., "On Aesthetic Cognition and Its Implementation in Computer Systems," Proceedings of the Conference on Computer Science and Information Technology, Yerevan, Armenia, pp.260-265, 2005

[2] David Chek Ling Ngo, Lian Seng Teo, Gohn G. Byrne, "A Mathematical Theory of Interface Aesthetics," Visual Mathematics, 2000, preprint.

[3] Hui Li, Scott Dick, "A similarity measure for fuzzy rulebases based on linguistic gradients," Information Science 176, pp. 2960-2987, 2005.

[4] Lotfi A. Zadeh, "Fuzzy Logic = Computing with Words," IEEE Transaction in Fuzzy Systems, VOL 4, NO. 2, pp. 103-111, May, 1996.

[5] Mashinchi, M.R., "Implementation of Aesthetic Cognition in Computer Systems," Advances in Fuzzy Mathematics (AFM), Research India publications, Vol. 1, NO. 1, pp. 5-5, March 2006.

[6] Phylyshin, Zenon W., "What the mind's eye tell to mind's brain: a critique of mental imagery," Psychological Bulletin 8o, 1-24, 1973.

[7] Ted J Biggerstaff, "Design Recovery for Maintenance and Reuse," IEEE Computer, pp. 36-49, July, 1989.

[8] Ahmadi, B., "Truth and Beauty, Lectures on the Philosophy of Art," 3rd edition, Nashr-e Markaz, Tehran, (in Persian), 1996.

[9] Birkhoff G. D., "Aesthetic Measure," Harvard University Press, Cambridge, May, 1933

[10] Jenny Preece with Yvonne Rogers, Helen Sharp, David Benyon, Simon Holland, Tom Carey, "Human-Computer Interaction," Open University, Addison-Wesley, England.

[11] Mashinchi, M.R., "Developing Models for Aesthetic Knowledge Processing," Master thesis, State Engineering University of Armenia, Yerevan, Armenia, June 2006.

[12] Mukaidono, Masao, "fuzzy logic for beginners," World Scientific Publishing Co. Pte. Ltd., 2001.

[13] Stuart Russell, Peter Norving, "Artificial Intelligence: A Modern Approach," Soft-Cover, ISBN: 0130803022, Publisher: Pearson US Imports & PHIPEs, 2002.

[14] Safyan P., "Philosophical Foundation of Fuzzy Logic," Master thesis for philosophy with minor in logic, Isphahan University, Faculty of Literature and Humanities, Department of Philosophy, Isfahan University, Iran, 2004.

[15] Witold Pedricz, "Knowledge-based Clustering," Wiley and Sons, Inc, ISBN: 0-471-46966-1, John New York, 2005.