Research on the Influence of Artificial Intelligence on Product Semantic Design

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Abstract: To apply the AI technology to product semantic design and build a designer model that matches users' mental through the application of technologies including big data, cloud computing and machine learning so that services provided for users can be transformed from reactive and passive ones to feed-forward and proactive ones. This paper illustrates the research framework of product semantic design, reviews the formation and development of the AI technology and proposes an AI-based method of research on product semantic design. The focus of the research will shift from the correspondence between a designer model and users' perception, cognition, meaning and behavior to the building of a designer model that directly interprets and simulates human intelligence through the application of AI so as to provide outstanding user experience tangibly and intangibly in the era of intelligence. By collaboratively extracting unstructured big and small data and directly translating them into a designer model that simulates human minds, the AI technology helps human users with their self-fulfillment and decision-making. AI has changed the subject-object relation between humans and the external world in product semantic design with the emergence of new ideas, thoughts, methods and evaluation criteria.

1. Introduction

Design pays attention to the relationship between man and technology in an effort to build their interface. The purpose of design is to provide quality experience for humans while they interact with external objects. With the technological advancement in recent years, the design methods have evolved. The object and scope of research are no longer confined to tangible products but instead extend to the medium that provides both "tangible" interactions and "intangible" information exchange. Also, new design concept emerged such as "experience design" and "service design". The fourth industrial revolution with the AI technology at its core occurred following the mechanical, electrical and digital revolutions after the concept of Germany's "Industry 4.0" and China' "Made in China 2025" were put forward in 2011 and 2014 respectively. The breakthrough of the three core technologies-cloud computing, big data and Deep Learning-indicated the beginning of the AI era. Ever since the modern design was born, the design methods and rules have kept evolving with the change of the context of times. In the 1920s and 30s, design gurus with the Bauhaus university explored the design laws and rules of tangible materials. In the AI era, the information technology has driven the need for a new generation of design methods and rules. How to design a product that combines tangible and intangible functions?

2. Product Semantic Design

Product semantics is a comprehensive study of the meaning and symbolic qualities of a product in the psychological context and social context where it is used. [1] In the field of industrial design, the development of product semantic design can be traced back to semiotics in the Bauhaus period and the study of design semiotics by the Ulm School of Design in Germany. In 1984, the concept of "product semantics" was first put forward by Krippendorf and Butter.[2]

As a methodology that combines the design theory with practice, product semantic design is an important tool to evaluate design outcomes. In the early days of raw material shortage and rigid hierarchy, designers engaged in arts-related work who would decorate ugly mechanical structures were referred to as stylists by Germans until the 1970s. After the concept of product semantics was proposed, the priority of design has reached beyond aesthetics and the logic of deign discourse gradually became clearer.[3]

2.1 Research Framework of Product Semantic Design

Morris divided semiotics into three parts, namely syntactics, semantics and pragmatics. The theoretical framework of product semantic design is based on the basic principles and methods of semiotics. Ferdinand de Saussure, the founder of semiotics, regarded "signifier" and "signified" as the two components of a sign, meaning the form of a sign and the concept it represents respectively. [4] The American psychologist James J. Gibson developed the key concept of affordance in his ecological theory of perception. Norman introduced the concept and interpreted it as the visual clue presented by the external environment to users.[5]Blumer set out three premises for his theory of symbolic interactionism: (1) humans act on the basis of the meanings that things have for them in their inner worlds; (2) meanings emerge from the social interactions between humans and things; (3) meanings are continuously recreated through interpreting processes while humans interact with things. [6] In the interaction between man and things, the senses of the body and mind and the interpretation of all things are the fundamental drive of human behaviors. The relationship between senses, meaning and actions has provided a logical argument for the design methods in the research framework of product semantic design (see figure 1). To ensure that users correctly manipulate and interpret the feedback while they interact with products, the design intent must be accurately perceived by them and translated into meanings that drive users to manipulate their actions on products. More research on meaning involves the "meaning-centered design method" [7] proposed by QI Jingyan in "Grand Interaction Design in Big Data Information Era" and the "meaningful interaction" by Delft scholar from Holland Välk.

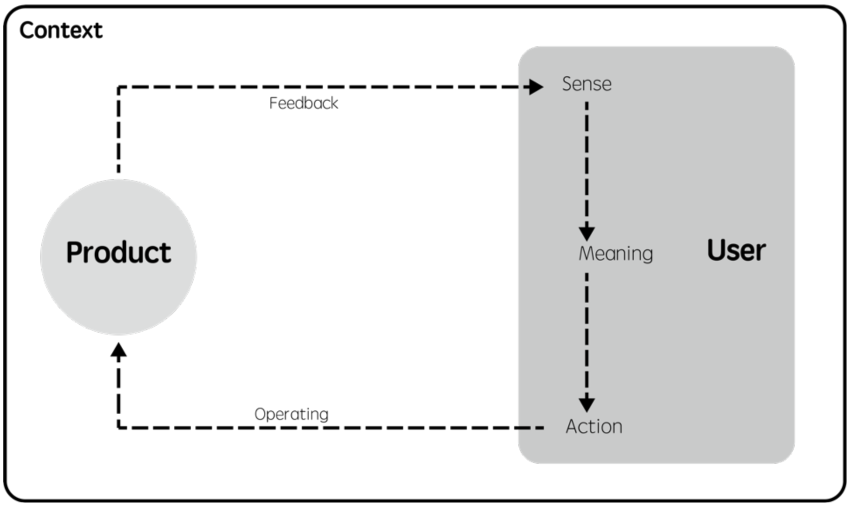

Fig.1 Product Semantic Design Method Research Framework

2.2 Product Semantic Design

2.2.1 Construction of Meaning from Senses

Senses are the response of people's sense organs to the external stimuli without their thinking or others' explanation, that is, vision, hearing, touch, taste and smell the combination of which is called "five senses". The American experimental psychologist Gibson proved Pierce's theory that senses are the psychological activity of people directly capturing information from the outside world without their psychological processing. After Gibson raised the core concept of affordance in his direct perception theory, Norman further interpreted it. According to Norman, sensory responses of organs can be attributed to affordance which serves as a thread that might connect humans and things. Senses are personal, which cannot be entered or copied by others; senses are developed upon a massive amount of subconscious details. People cannot sense things that are beyond their ability to perceive, which is also a corner stone of Kant' knowledge theory; the existence of senses is always believed in and it is meaningless to judge if the senses are right or wrong; senses occur at the moment, serving as a bond that connects humans and things. However, the sensory perception cannot directly drive humans to interact with things. The meaning constructed should be the medium instead.

Meaning is people's subjective interpretation of their senses. The interaction between man and things is a process that endows things with meaning. The varied meaning causes things to appear very differently to people. During interactions, people tend to subconsciously see things as what they expect to see. And expectations are generated by previous experiences accumulated and as a product of human culture and social education. Experiences are not causal links psychologically or physically but rather the conceptional links as a result of human acquisition in life. Take Ludwig Wittgenstein's duck-rabbit image, a classic illustration of the Gestalt psychology, as an example. People might see either a rabbit head or a duck head in the image. However, those who have never seen a duck or rabbit before won't see a duck or rabbit.

2.2.2 The Mapping from Meaning to Behavior

As the formation of things cannot be attributed to the physical causes, meaning cannot be directly translated and designed into product features. The translation of meaning cannot be separated from the perceivable physical carriers because meaning is the intrinsic premise of the interaction between humans and things. For example, when a user notices the physical image of a door handle, he or she will extract information stored by designers about how to hold or move the handle. The role of meaning is to transform this information into an action that moves the handle. Meaning is structured, which guides an individual's interpretation of his or her sense and logic behavior; meaning is constructed in a personal level, which cannot be shared with others even with the help of communication. Therefore, all the methodology to study users is meant to figure out a common meaning that are as close to real user groups as possible. Meaning not as a physical being emerges in the course of the interaction between man and things; it is plural rather than monotonous. The meaning generated by the interaction between man and things is shaped or broadened by different experiences. The mankind always acts upon the meaning they are faced with, and meaning provides designers with a logical cause and effect relation between external objects and human behavior. In the traditional product semantic design, the study of meaning bases its premise on the assumptions of user behaviors and screens the ways people interact with products via the reasonable construction of meaning.

2.2.3 Eliminating Invalid Meaning in a Context

Meaning is of practical significance only when placed in a context that corresponds to behavior. As stated above, the meaning of things to people is plural. People are only able to interpret characters in a context of a story. Things can be truly understood when placed in a proper context, so the interpretation of meaning must be contextual. A context is the prerequisite of correct acquisition of meaning. In design practices, the context limits the amount of meaning that may be relevant to the present. In semantics, the language structure of the sentence "A has the meaning B" avoids the ambiguity of meaning but blindly simplifies the meaning results.[3] Product semantic design logically interprets the relationship between man and products from the perspective of semantics and analyzes the dynamic relations between senses, meaning and actions to help designers anticipate the ideal interaction between humans and products. Furthermore, it enables the model of representation of designers to strike a balance between the model of materialization under the mapping technique and mindset model that reflects the users' vision.[9]

3. The Formation and Development of Artificial Intelligence

Artificial Intelligence or AI as it is often called is a comprehensive science subject that simulates, extends and broadens human intelligence with the help of computer algorithms. The study of AI can be traced back to humans' philosophical introspection of their own thoughts and feelings. The British mathematician A.M. Turing, known as the father of AI, introduced the Turing Test in his seminal paper "Computing Machinery and Intelligence" published in 1950 in Mind for determining whether or not a machine can think like a human being. In the Turing Test, the machines that are capable of simulating human cognition and communicating with other human beings without humans knowing it are considered to have human intelligence. In the Dartmouth College Artificial Intelligence Conference in 1956, John McCarthy first proposed the concept of "Artificial Intelligence". John McCarthy, together with Marvin Minsky, Allen Newell and Herbert Simon who also attended the conference, is credited for being the founder of AI. At first, AI was treated only as a branch of computer science. With the change of our times, it later became a techoscience subject involving a wide range of disciplines such as philosophy, mathematics, neurophysiology, psychology, cognitive science, systematology, cybernetics and computer science where natural science and social science converge.

Although philosophy and technology have different motives and paths, their ultimate purpose is to create a better life for human beings. From the perspective of technology, AI enables people to get to know the essence and laws of things in the field of technology as well as serves their real life with the application of its outcomes. From a philosophical point of view, AI is an embodiment of self-reflection and introspection of one's mentality, thoughts, state of living and way of life. [10] According to the Marxist philosophy with an emphasis on social practice, AI is a byproduct of human practice, which demonstrates the ability of the subject in practice to constantly innovate, make breakthroughs and go beyond oneself. It is also a practical tool for the subject in practice to act on the object in practice in today's technological context. Machines can only accept formal tasks and the semantics of machine instructions is given by humans. Thus, Searle believes that AI has a limited capacity and cannot exceed human intelligence. It can only get infinitely close to human intelligence. [11]

3.1 The Shift of the AI Research Paradigm

Since the 1980s, AI researches have come up with three paradigms of AI research on the basis of various disciplines: Symbolism, connectionism and actionism. Symbolism is based on mathematical logic in which the brain is reproduced through the representation of formal knowledge. In connectionism which is developed from bionics, the brain is constructed via the simulation of neural networks. In actionism which is built upon cybernetics, the brain is evolved into through the simulation of self-adaptive living mechanisms.

3.1.1 Symbolism

The symbolism in AI represented by Newell and Simon inherits and continues the modern Western philosophical thoughts and research methods of natural science. It had been considered to be the traditional paradigm of AI research based on the representation, reasoning and application of knowledge until 1980s. Symbolism believes that symbols are the basics of human intelligence and that the capability of storing and computing symbols is a prerequisite for machines to "think" like a human.

Mathematical logic is utilized to formalize the semantics of the external world; algorithms are developed to be executed by computers. Therefore, AI has a clear boundary. The boundary of the formalized semantics is the boundary of AI.[12]

3.1.2 Connectionism

The connectionist paradigm represented by Hopfield and Rumelhart was developed under the influence of bionics and neuroscience. Connectionism believes that neurons are the basic structural units of AI and the neural networks its basic structure. It is attempted that the models of neural networks and the brain are simulated via the study of neurons. Over the decades after the digital neural networks came into being in the 1950s, scientists devoted themselves to learning to utilize the "stacked layers" to control hundreds of millions of nodes of neural networks and their combinations that simulated human neurons. In 2006, Geoff Hinton proposed the concept of Deep Learning. [13] The advantage of Deep Learning lies in the mathematical optimization of the data of different layers of neural networks. In the meantime, the learning speed in stacking is accelerated. Deep Learning has been applied to AI products with unstructured data in facial recognition, audio processing and image processing. Examples include AlphaGo, the AI program that defeated the famous chess player Lee Sedol, social media platform Facebook and Google search engine.

3.1.3 Actionism

The behaviorism in AI represented by Brooks was mainly inspired by the theory of evolution and cybernetics. It is attempted that robots simulate the working principles, information theory and control theory of the human nervous systems to improve the thinking ability of machines. In the 1950s, Wiener and McCulloch among others proposed engineering cybernetics and biological cybernetics, using computers to simulate human behavior in the control process. The behaviorism believes the intelligence of machines lies in neither computing nor formalized description, but the direct responses of an intelligent body to the external world and the conversion of information of sensors. Therefore, Brooks doesn't think that the robot's ability to think is the premise of getting work done. Both the behaviorist and connectionist paradigms aim to solve technical problems in the study of AI and turn the focus from knowledge representation to the study of skills.[12]

4. The Application of AI in Product Semantic Design

Through the study of the complex human subjects, product semantic design and AI both empower external objects to be more capable of serving the human subjects. In the traditional and AI-applied product semantic design, the unstructured things that happened in the past are described and explained so that what lies ahead will be anticipated and controlled. The traditional product semantic design is a methodology of functionalism in the physical world, which studies how to build the appropriate mapping from human thinking to behavior, so that products can be correctly manipulated by users correctly and feedback accurately perceived. The AI technologies, notably cloud computing, big data and Deep Learning, has transformed the subject-object relationship between man and products where one party dominates over the other in the traditional product semantic design. A new type of subject-object relationship characterized by harmonious coexistence between man and products has taken shape, where a universal language is used.[14] The study of product semantic design has shifted its focus from the corresponding relations between senses, meaning and actions of human intelligence to how AI helps to obtain user data, how the senses of human intelligence are simulated by way of smart hardware like sensors and how to make computations and establish a model that matches users' mindset. The interaction paradigm between man and products has also evolved from reactive and passive services to feed-forward and proactive ones. Since the relation between the subject and object has changed in product semantic design in the AI context, products are no longer the mere physical carriers of the mapping of human consciousness. Instead, they may even be the cyborgs—bionic men—that imitate human minds by means of Deep Learning.

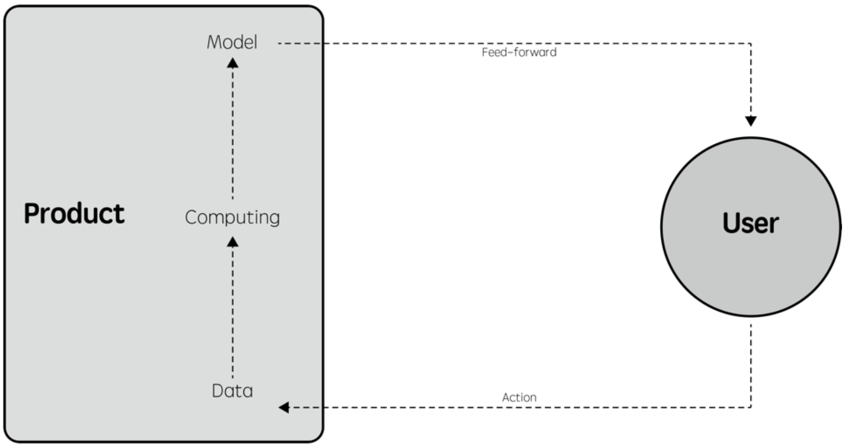

Fig.2 Artificial intelligence technology applied to product semantic design method research framework

4.1 Collaboratively Extracting the Big Data and Small Data

The user data is a group of data collected, organized, and abstracted from behavioral information such as users' social identity and habits of use. It is the prerequisite for drawing conclusions to user research and conducting creative design. In the early stage of product semantic design, traditional means of user research are employed including questionnaires, observations, interviews and focus groups to collect small unstructured data about users. Then designers with the help of empathy sort out the information and manually extract user data that reflect users' perception, cognition, meaning and their behavioral logic. When it comes to small data however, the volume and complexity of user data extracted are limited. Moreover, since data is collected from users who consciously express themselves or act, the true intentions may be hidden in their subconsciousness or concealed due to the external pressure. Last but not least, people have a limited capacity for sorting out and generalizing about the intrinsic relations and structures in the massive amount of user data.

With the penetration and development of Internet, Internet of Things and Internet of Everything, the computing methods in design such as App Cloud computing, pattern recognition and cloud computing have been employed to accurately dig out the big data of customer demands from which the information can be secured about the willingness, mentality and imagery of individuals or groups. The seas of unstructured data about users acting upon their products on a daily basis is collected too, which help to reflect the users' true intentions. Big Data by means of computer algorithms has powerful strengths in collecting, analyzing and reorganizing data. However, the individual emotions and motives behind the data cannot be identified. In the collection of small data, participates experience the design creations and services. Then, the small data converge into big data through the Internet of Everything.

4.2 Deep Learning Simulates Human Intelligence

Machine Learning helps to analyze seas of data by way of algorithms and constantly improves the performance of the machine itself to better identify and predict what is happening in the outside world. The development of cloud computing and big data has enabled more data to be secured to "train" machines. Deep Learning is a type of algorithms in Machine Learning relevant to deep neural networks. It excels in handling massive and disorganized user data and figuring out the inherent relations and structures of data. The purpose of product semantic design is to create the mapping between the physical signs of a product and the users' behavior. Thus, it has become one of the important design criteria whether or not the mapping can be perceived by users. Unlike the traditional product semantics that explores the mapping between human perception and machine thinking, Deep Learning based on the learning algorithms of deep neural networks simulates the layered way of information processing in the stacked and abstract layers of the human brain. Products with a Deep Learning capability will better correspond to human thinking.

In 2018, the MIT Design Lab and the German sports brand Puma jointly invented the Deep Learning Insoles, as shown in Figure 3. The Deep Learning Insole consists of a microbial layer, a circuit layer and an electronics and battery layer. Bacteria and media in the micro-cavities of the microbial layer sense the various chemical compounds present in the running sweat by detecting the change in pH and conductivity. The circuit layer records the biochemical information generated by the microbial layer and transmits it to the micro-controllers in the electronics and battery layer. The micro-controllers then digitalize the biochemical information and broadcast to a smart device. With the help of the Insole, the smart device can capture the digital data of motion, build up a personalized algorithm model, accurately predict the critical point of the user's fatigue and notify the user about it before it happens (see figure 4).

Fig.3 Deep Learning Insoles

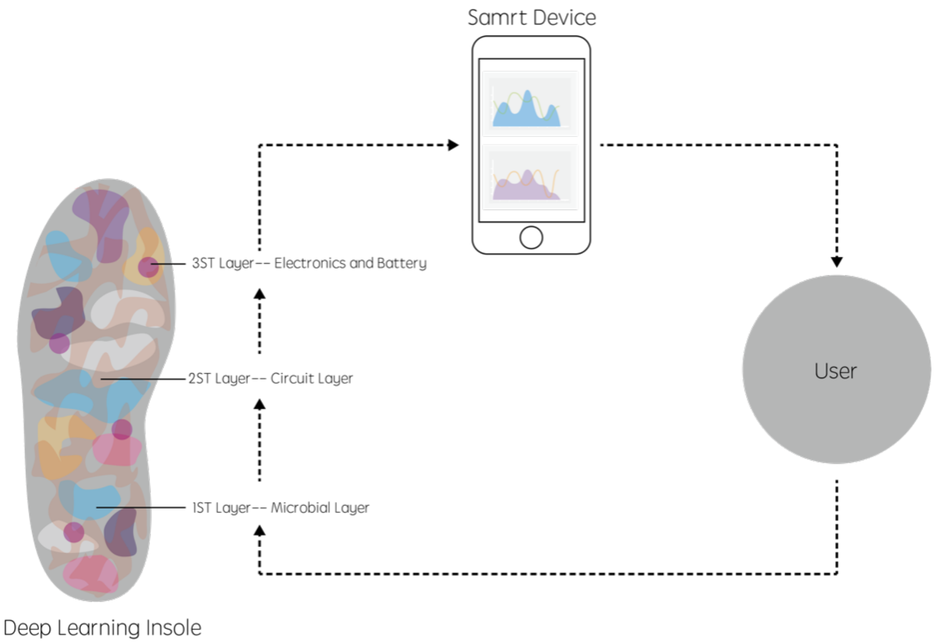

Fig.4 Deep Learning Insole Interaction System

5. Conclusion

In the world of information where all things are connected, every person is like a numerical figure in the vast seas of data. The connectivity of all things brings data providers together to be part of the "crowd innovation" in design. Everyone is a producer, disseminator and beneficiary of information, which enables the sustainable design concept of "all for design and design for all" to come true. The

AI technology has transformed the subject-object relation between humans and the external world in product semantic design, empowered products to simulate human thinking and truly assisted users in their self-fulfillment and decision making. The AI era is bound to witness more new ideas, thoughts, approaches and evaluation criteria in the realm of product semantic design.

Acknowledgments

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