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Product Fitness Design Based on Head and Facial Anthropometry Knowledge Management Systems

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Abstract
Human head facial surface changes are rich. However when designing a product to interact with people, fitness is a question that has to be considered. The accurate measurement of the size and shape of the human head and face is the key to creating a suitable product. The three-dimensional scanning method solves many problems encountered by the traditional measurement method to obtain the rich head and facial knowledge. We use the knowledge of the head and face to build the knowledge management system, thus guiding the design practice.
Keywords: human factors, ergonomics, industry design, knowledge management systems

1. Introduction

The relationship between industrial products and the user's body relates to fitness, which is a topic that continues to be explored and updated in the design field. The human body is the standard for human beings to make tools and construct the world, and becomes the power source of product design. The theory of the ancient Chinese that man is an integral part of nature reveals the harmonious relationship among man, products, and environment. In ancient Rome, Vitruvits argues that eurythmy is beauty and fitness in the adjustments of the members(Vitruvits,2017). Industry utilizes anthropometric size for a long history. Traditionally, anthropometric measures have been collected with tape measures and calipers, and are referenced to coordinate systems dependent upon anatomical landmark locations (Whitestone,1993). Henry Dreyfess, one of the first generation of postwar industrial designers, began to measure people's sizes. Its purpose was to produce comfortable products and improve the usability of products, so as to increase the appeal to consumers. It can be said that to design the form of the product, one should measure the size first.

With modern development and the advancement of technology, the concept of fitness has widely existed in the process of industrial product design, and has been constantly integrated into new meanings. It is vividly reflected in the change of the industrial design standpoint. Industrial design has long been developed, and has formed numerous morphological views, such as "form follows function," "form follows sale," and "form follows passion." There different understandings of the product form according to the political, economic, and cultural factors at different historical stages. It is becoming apparent that the ideal product is not necessarily that which is the most beautiful. In many cases, the form of the ideal product will be the most comprehensible and usable. The form of the product represents the design goals, and a number of limitations after the integrated consideration of the size and shape of the body are ultimately validated by the target market. "Form follows body" becomes the practical requirement of industrial design.

Currently, the concept of fitness design is based on human psychology, physiology, and physical structure, including research on the relationship between people and products to achieve a symbiotic state. Fitness is not the property of the product itself. However, according to the product function and the used scene, the designer gives the product and the user a kind of harmony relationship. The fitness design ensures people use the product in a health, comfortable, and efficient manner. In the process of product design, it is essential to coordinate the relationship between the body knowledge and the product's form.

The limitations of human ability and the need for entertainment require people to wear such instruments as masks, helmets, earphones, and virtual reality glasses. The product that fits the head and facial form has extremely high ergonomics requirements. The importance of the shape of the head and face to the product fitness is self-evident, improper product fit will damage the perfect realization of product functions. For example, if the helmet shake easily, it is not good for action, and could cause easy fatigue or even injury (Parkinson & Hike, 2003). It also has been shown that even a small air leak in the facemask can drastically reduce the efficiency of drug delivery (Amirav & Newhouse, 2008). The lack of virtual reality glasses fitness will make a gap between the face and the device, which leads to the light leakage problem, so that the product can not bring the quality immersive experience to the users.

The head and face contains a large number of measurement dimensions, and their surface changes are rich. It is important to know both the sizes and shapes of the head and face, which are not isolated values, but need to represent the space relationship (Stewart, 2017). Body measurement in the field of product design is a necessary method to make products fit the user size and shape of the body. In the past, they mainly rely on conventional instruments to measure the parts of head and face, and then identify the overall rich surface shapes depends on the eyes, experience and repeated correction. This will lead to long design cycles, poor variety of adaptability, and low precision. These problems are mainly due to a lack of human basic parameters. Industrial design has

become too complex for intuitive methods, with more design methods relying on scientific methods (Cross, 2001). Product design must find more scientific design methods to build comprehensive human data, information, and knowledge systems to enhance the design theory.

Facing the size dilemma in industrial design practice, the three-dimensional scanning measurement was revolutionary applied to anthropometry, to help designers obtain accurate measurement of head and facial size and shape, to establish head and facial databases. Compared with the traditional manual measurement methods, three-dimensional scanning measurement technology is faster and obtain more rich and accurate data. Because the size of the data automatically extracted by the computer, there is no subjective error caused by human factors. From one-dimensional to three-dimensional, and manual to automated, the continuous development of human measurement methods, greatly improve the ability to solve various fitness problems in product design.

Several researchers pioneered fitness design research based on the variability in body size and shape of human head and face (Liu, 2008; Ellena, 2016; Li, 2016). There are two main issues when designing a product to achieve fit: First, three-dimensional scanning data of the human body is integrated to form information and ultimately knowledge. We use the knowledge of the head and face to build the knowledge management system, thus guiding the design practice. Second, there is a lack of a commonly accepted framework for fitness research in the design process. Incorporating principles, practices, and procedures, we propose and develop a fitness methodology for the designers.

2. The head and facial knowledge management systems

A commonly held view with sundry minor variants is that data are raw numbers and facts, information is processed data, and knowledge is authenticated information (Vance 1997). The human size, shape, and body, after three-dimensional scanning produce, correspond to data, information, and knowledge (Figure 1). The human size date will be organized and structured into human shape information, and then integrated and extracted into human body knowledge. From data to information and ultimately knowledge, it is the process of adding special purpose and meaning to the previous stage. There has been a growing interest in treating knowledge as a significant organizational resource. Consistent with interest in organizational knowledge and knowledge management, researchers have begun promoting a class of information systems, referred to as knowledge management systems (Alavi, 2001).

The objective of introducing three-dimensional scanning into knowledge management systems is to support the creation, transfer, and application of knowledge in the process of design. It is intended to make it easy for designers to work with anthropometric data. Combined with three-dimensional scanning measurement technology and the new visual output platform of the knowledge management system, the way human body data is displayed has undergone tremendous changes. The size changes from flat and boring figures to stereoscopic and visual images. The three-dimensional model of the product is imported into the knowledge management system for fitness analysis. Therefore, it is easy to determine if the product fit the human body, so that the designer can modify the design model in real time. This establishes a direct mapping between the three-dimensional scanning data and the product form parameters. It provides context in which designers can understand and evaluate the effect between product design and head and facial characteristics. The design process has been changed in such a way that the designer only has to input the minimum and essential data to design a new product.

As the size of the population varies greatly from country to country, a few three-dimensional measurement database such as CAESAR, Size UK and Size China were built by different countries. The purpose of these databases are different. Some focus on the size of the entire body, while others focus on parts of the body. For example, we are building the Chinese head and facial database, which only focuses on the size of the head and face (Figure 2). In the initial stage, the database incorporates 300 Chinese head and facial models using three-dimensional scanning technology. After statistical analysis, the date, information, and knowledge of Chinese head and face is demonstrated on the knowledge management system.

3. Application of head and facial knowledge management systems in the product fitness design

In the product design process, the knowledge management system enable designers to analyze the combination of different specialized knowledge and the creation of new knowledge. For example, designers can use the platform to retrieve human-related features and statistical values, understand the data measurement methods, view and download the complete three-dimensional data, and collect and share information. The product design was driven by three-dimensional human knowledge reflects the user-centered design concept. The fitness design procedure includes three methods:

3.1 Match the size data

Three-dimensional human body scanning can build multi-parameter databases and enable the diversity of adaptive data types. Given the complexity in design, we need to understand which size determines the product

form. According to the needs of the design project, a large amount of human size will be condensed into the least amount of data, product dimension should match these data. It can completely reflect the body's original information characteristics and reduce the workload.

To make respirators and masks that cover the mouth and nose of the users, it is impossible to make the accurate three-dimensional shape with a small amount of one-dimensional measurement data (Lee et al., 2013). The biggest problem is that human mouth and nose data is seriously lacking. Rapid and accurate measurement of human data is critical to the production of excellent and cost-effective ergonomics products. But as a result of the preservation of the three-dimensional scanning images, it is convenient to retrieve the original data and measure new projects relating to shapes, angles, and relational data points. By converting these measurements into the design features of respirators and masks, it ensured that users could wear products with optimal contact and have an enjoyable wearing experience.

3.2 Organize shape information

The utility of raw body scan data is limited, we should make greater use of the shape information. In the process of body scanning, it formed a large number of three-dimensional point cloud data, constituting the body's curvature, surface and volume information. This made the designer's understanding of the human body more real and comprehensive. And it provides a solid foundation for product designers to grasp the surface changes.

In the process of designing protective or wearable equipment, one of the main requirements of a protective bicycle helmet is to provide and maintain adequate fitness and coverage to the head(Thai et al., 2015). The fitness design between the user and product can ensure the user's security during the shock. In order to fit the helmet form with the human head, the point cloud data of the target area can be extracted from the head and facial knowledge management system, and the offset surface can be calculated and generated. On this basis, considering factors such as ventilation and aesthetics, the surface of the helmet can be designed. The design process is based entirely on the observation of people's habits and the study of the physical structure, rather than the imagination of angles and curves.

3.3 Extract body knowledge

Human physical dimensions vary considerably with age, gender, race group, and so on. We can obtain a lot of data and information by scans, correlation analysis was then used to assess the relationships between the study variables. Most consumer products, such as masks and intelligent glasses, still need mass production, requiring designers to consider the user as a large number of users and adopt a few types of models to make the product service the majority of the population. Some statistical body shape categories can be built to predict how to arrange production. For a single individual in a group, it may not be the most comfortable, but it can satisfy the majority of the users.

When designing ear related products, because ears continue to grow with age, it is recommended that using different dimensions for people at their different ages. There are significant statistical variations between ear shapes of Koreans and Caucasians. It found that Koreans males have bigger ears while Westerner females have bigger ears, and their ears belong to different categories (Jung, 2003). It is this knowledge that informs designers to make a significant difference in size and shape when designing ear related products. It is not appropriate to use measurements of one place to design for the other market. These methods are based on mastering the body knowledge accurately, and during the design period, it will generate some new knowledge that can be incorporated into the knowledge management systems.

4. Conclusion

Fierce market competition, along with the improvement of people's economic level, results in increasing quality requirements of the products. In addition, fitness becomes a very important consideration for the consumer to buy products. Products that fit the user's body, such as smart glasses, sunglasses, masks, and headphones, specifically their size and shape, directly affect the realization of product features and user experience. Perfect product form is not just based on pure aesthetic performance, but also should be coordinated with the user body, product function and external environment. The development of design connotation is also becoming more extensive. Through the knowledge management systems, the designers acquire more detailed data, information, and knowledge of the human body to change existing situations into preferred ones. It significantly improves the fitness of product design, and better explains the user-centered design concept to meet people's health needs.

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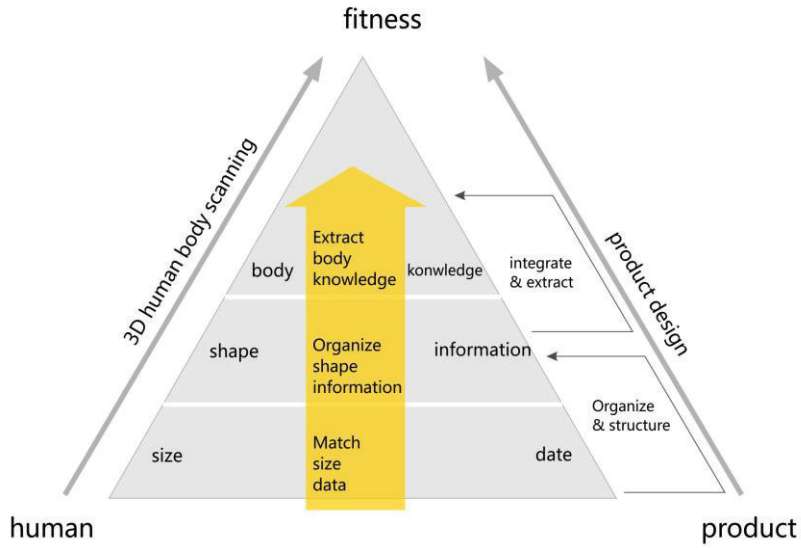

Figure 1. The fitness design procedures

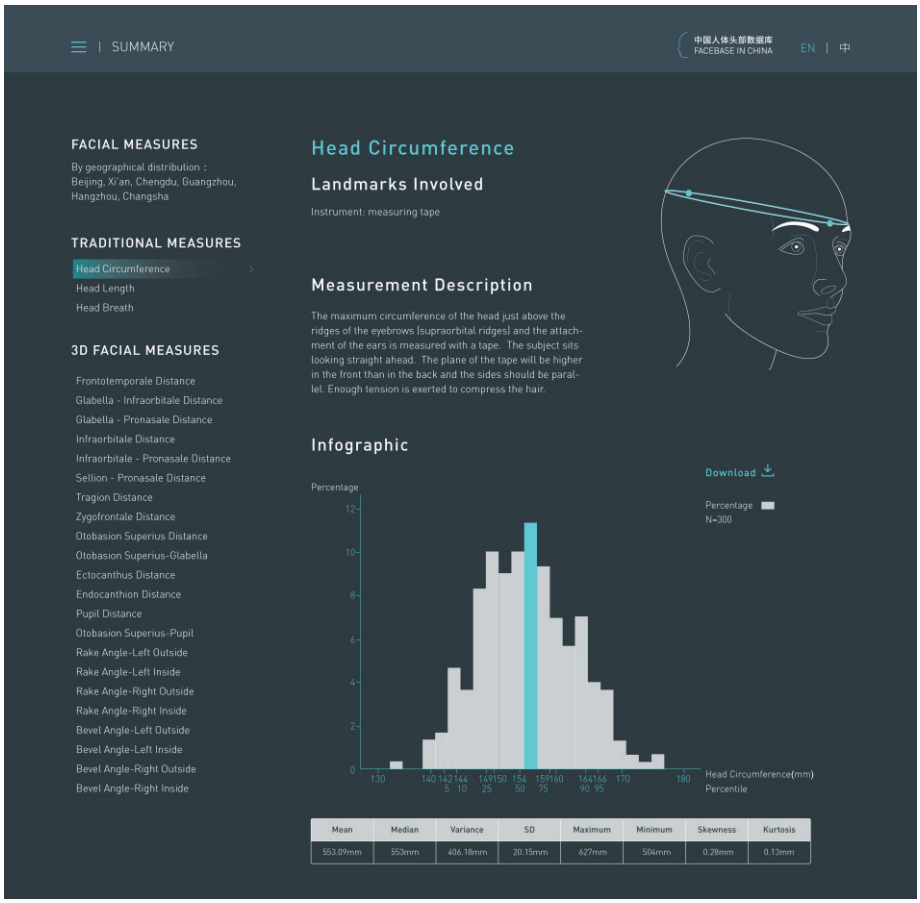

Figure 2. Head and facial knowledge management system