Clothing and Artificial Intelligence—Taking ECG Clothing as an Example

Yuhan Yang

Faculty of Innovation and Design, City University of Macau, Macau, China

***Abstract:** With the continuous development of artificial intelligence, big data and other technologies, producers in the clothing industry are no longer satisfied with designing and creating clothing that is only used for wear. Consumers are also more inclined to purchase functional clothing. The article mainly analyzes the background and current situation of today's smart wearable industry, analyzes the future application scenarios of smart wearable devices and clothing and their role in the era of Internet of Everything, and explores the internal and external value of smart wearable devices. We use ECG clothing as a specific case to analyze its effect on consumers and different groups of people. At the same time, the direction and trend of the future development of smart wearable devices and smart clothing under the premise of the rapid development of technology in various fields is proposed. It is proposed that the design of smart wearable devices and smart clothing in the future will be based on the linkage between technologies and disciplines in multiple fields, to be people-oriented.*

***Keywords:** artificial intelligence; big data; smart wearable devices; smart clothing; electrocardiographic clothing; development trends*

1. Background and Current Situation of Smart Wearable Devices

With the rapid development of electronic information technology and communication technology, the network era has gradually shifted from the Internet era to the mobile network era, and then evolved into the Internet of Things era [1]. With the advent of the Internet of Things era and the gradual maturity of technologies in various fields, people are increasingly pursuing more fashionable, fast, convenient, intelligent and humanized functional product assistance. And with the development of informatization and industrialization, technologies in more and more fields are being applied to smart wearable devices and smart clothing. Modern smart wearable devices and smart clothing are developing in the direction of more diversified functions, health and comfort, diversified technology, and more innovative smart materials.

1.1 Definition of smart wearable devices and smart clothing

Wearable devices are also called wearable computing devices, and there is currently no unified conceptual definition [2]. The MIT Media Lab defines wearable computing devices as computer technology that combines multimedia and wireless communication to connect personal area network functions and detect specific input or output devices such as jewelry, glasses, or clothing that do not highlight the sense of foreign bodies. Situations may become personal smart assistants, and then become tools for users to process information while traveling.

Wearable devices can be understood as devices that are based on the natural abilities of the human body and use computer technology to implement corresponding business functions. The natural abilities of the human body refer to the innate abilities of the human body, such as hands-on ability, walking ability, language ability, eye movement ability, heart pulse beating ability, brain nerve thinking ability, etc. The computer technology here refers to the ability to pass through the human body based on human body abilities or environmental abilities. Built-in sensors, integrated chips, etc. realize corresponding information intelligent interaction functions.

To put it simply, smart clothing combines clothing with technologies in various fields to create clothing that people need and that can meet people's needs in all aspects. It has the characteristics of multi-disciplinary and multi-field technology intersection. It is the result of the combination of electronic information technology, human-computer interaction technology, biochemical technology, bionic technology, exoskeleton robot technology, and nanotechnology. It can realize information perception,

calculation and communication, etc. Function, on the premise of ensuring the wearing performance of the clothing, it provides users with intelligent analysis, decision support and feedback control [3].

1.2 Classification of smart wearable devices

The smart wearable device industry is divided into commercial consumer-grade and professional medical-grade devices based on application fields. Commercial consumer-grade equipment can be divided into bracelets, watches, glasses, clothing, etc. according to product form; professional medical-grade equipment can be divided into monitoring and treatment-type medical equipment, which are mostly used in hospitals and other medical institutions (Figure 1).
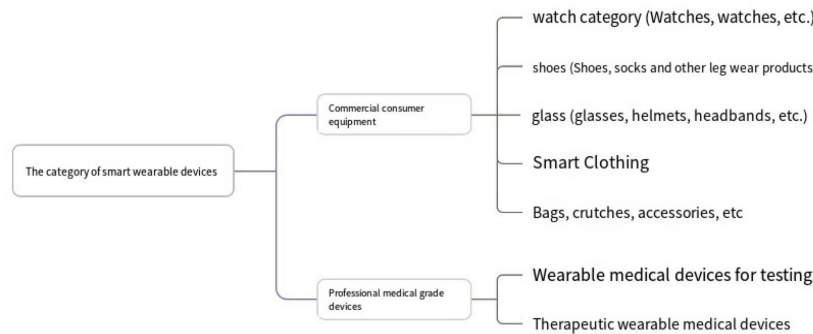

Figure 1: Classification of smart wearable devices

1.3 Characteristics of smart wearable devices

In summary, smart wearable devices have the following four points:

1) Smart wearable devices are portable: Mobility means that users can wear the device in any state, regardless of time, space, or physical status. Making the application of smart wearable devices more extensive and flexible.

2) Smart wearable devices are sustainable: Sustainability refers to the application time of smart wearable devices and the continuity in data analysis and monitoring. The devices can accumulate data for a long time to form periodic data analysis reports.

3) Smart wearable devices have sensorability: Sensibility means that the lowest technical principle of smart wearable devices is biosensing technology, and biosensors can sense physiological signals of the human body.

4) Smart wearable devices have data detectability: Data detectability means that the value of the wearable device itself is not great. The key lies in the data it obtains and the services it provides, such as health data heart rate, blood pressure, etc.

1.4 Different needs of different groups of people for smart wearable devices

Smart wearable devices are mainly divided into consumer-grade smart wearable devices and medical-grade smart wearable devices. Consumer-grade smart wearable devices are mainly aimed at the general population and achieve users' self-health management and health improvement through sports monitoring, muscle relaxation, rehabilitation and physical therapy. Representative products include health watches, wearable massagers, smart wristbands and other common products. products, as well as various non-mainstream product forms such as smart clothing, school bags, shoes and socks; and medical-grade smart wearable devices mainly serve patients with various diseases, providing monitoring and prevention for patients with specific diseases and treatment for patients with chronic diseases. Guidance, representative products include blood pressure monitors, blood glucose meters, blood lipid detectors, wearable heart rate defibrillators, etc. The 2021 smart wearable device industry white paper summarizes the consumption intensity of wearable devices among households with different monthly incomes, different interest groups, and different age groups (Figure 2).

	Family monthly income					Interested groups					age						
	3000 Yuan to Under	3000-5000 yuan	5000-9999 yuan	10000-19999 yuan	20000 Yuan and to falling-rising tone	Sport expert	science and technology Geek	hard core player	film and television Drama fans	attach importance to health	18-24	25-29	30-34	35-39	40-44	45-49	50 With falling-rising tone
smart bracelet	77	98	113	120	110	103	127	124	121	101	122	114	109	103	85	55	41
Smartwatch	80	100	110	117	108	102	123	120	119	101	118	114	110	104	89	57	42
Smart headphones	75	99	113	119	114	103	127	126	123	103	124	116	107	101	82	52	41
Smart glasses	68	95	115	122	127	98	136	139	132	100	131	115	108	99	75	47	35
Intelligent clothing	73	82	106	124	173	117	147	172	135	102	150	106	93	93	78	53	38
Smart accessories	68	83	113	127	166	113	143	170	134	106	146	113	100	89	73	42	35
I haven't heard of it	150	101	74	56	83	94	39	48	55	97	52	66	74	91	131	210	253

Figure 2: Consumer market research on smart wearable products in 2021

2. Case analysis of smart wearable devices - taking ECG clothing as an example

From the development of ECG clothing to its current appearance, there are four factors driving its development: science and technology, economy, society and consumers. First of all, from the perspective of science and technology, the emergence of artificial intelligence, big data technology, new materials and wearable technology have become one of the factors promoting the birth of electrocardiographic clothing. Secondly, various traditional industries are seeking integration in many aspects, gradually launching products and transforming and upgrading the industry. At the same time, they are seeking products with higher added value, which is also driving the emergence of ECG clothing. Third, in the world today, cardiovascular and cerebrovascular diseases are sudden and have extremely high mortality rates, which are extremely threatening to human health. In addition, the aging problem in society is serious, which is also a factor that promotes the emergence of electrocardiographic clothing. Finally, with the improvement of people's living standards and quality, consumers are paying more attention to the quality of life and pursuing a healthy life. This factor also prompted the advent of Xidian clothing.

2.1 Development background and process of ECG clothing

The emergence of electrocardiographic clothing did not appear suddenly, but also went through a long process. In 1984, Italian physicist Calo Matteucci discovered that the beating of the heart changes with electric current, which laid the foundation for the first complete human electrocardiogram recorded by Dutch professor Einthoven in 1902. It took 54 years from the ECG machine to the ECG monitor and then to the Holter ECG machine (Figure 3). Then innovating and upgrading wearable ECG products, however, it took a long time to combine wearable ECG products with clothing (Figure 4).
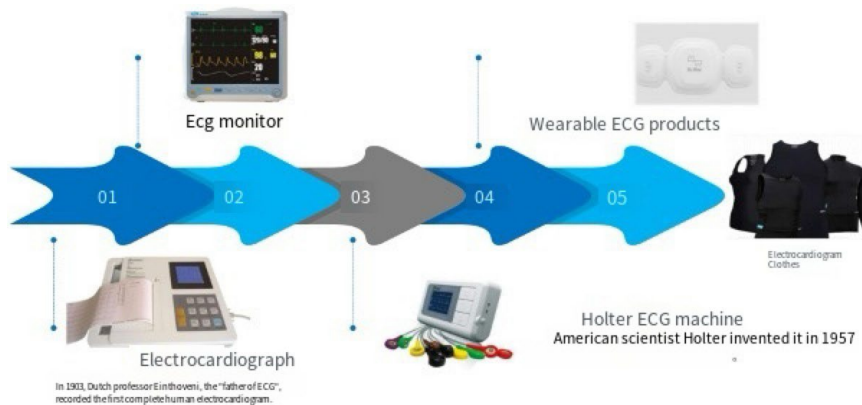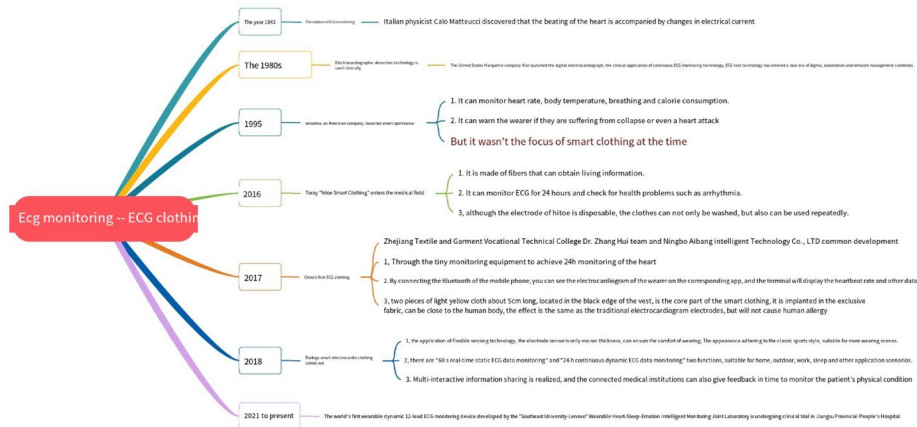

Figure 3: Development of ECG products

Figure 4: Development of ECG clothing

2.2 Design of ECG clothing

During the production process of ECG clothing, it is necessary to intersperse conductive metal yarn or sew conductive yarn to achieve information transmission. The information is transmitted to the APP in the electronic device through the ECG host computer, and is not subject to time and space conditions. monitor. The overall design needs to be easy to disassemble, easy to clean, practical and beautiful. The designed electrocardiographic clothing can satisfy popular consumption only if it is lightweight and reasonably priced. The operation process of the ECG clothing system is shown in Figure 5 [4]. The ECG clothing is made of metal yarn (metal thread that can be sewn), ECG host (receiving and analyzing information), ECG wristband (collecting information), connectors and other materials.

In the design process, the following principles are mainly followed: when combining electronic devices with clothing, they must be concealed, safe, rational, and comfortable; when combining electronic devices and clothing with clothing, they must be firm and cannot be loose, and electronic devices must not be loosened. The components are installed in parts that interfere with human body movements and hinder people's normal life. At the same time, they cannot interfere with others.
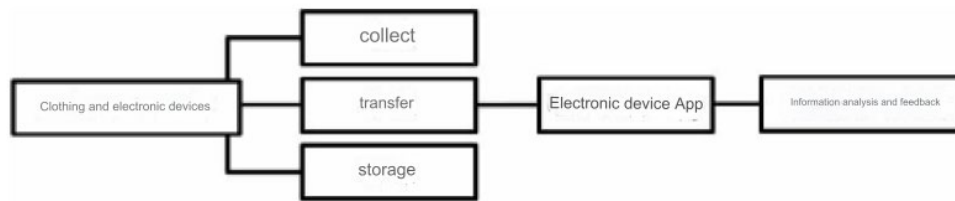

Figure 5: ECG clothing system operation flow chart

2.3 The role of electrocardiographic clothing

1) Health monitoring

The incidence of heart diseases such as myocardial infarction and heart failure is relatively high. Cardiovascular disease is one of the main killers that threatens human health. With ECG clothing that can monitor heart rate in real time, such diseases can be treated in advance to a large extent.

2) Sports monitoring

ECG clothing can monitor heart rate when people are exercising. By analyzing the collected exercise data, exercise plans can be formulated based on heart rate changes to achieve better exercise effects and avoid excessive exercise.

3. Summary of smart clothing development trends

3.1 Problems with smart clothing

Although smart clothing has come out now, the following five problems have been exposed in the development process of smart clothing (Figure 6):

1) Safety issues: Since smart clothing is equipped with electronic components, leakage and radiation problems may occur in some cases. Secondly, some warm and heated clothing may cause safety hazards such as excessive temperature and burning of the human body. Finally, because smart clothing needs to be connected through mobile phone Bluetooth to upload data to the APP, there are technically problems such as information leakage.

2) Practical performance issues: More and more smart fibers and components are added to clothes, but few can maintain human body comfort and washing resistance. At the same time, some intelligent elements are overused, product functions are exaggerated and cannot guarantee the comfort of heat, humidity, and poor internal and external environments.

3) Process integration issues: It is difficult to combine intelligent components to achieve perfect functions and beautiful appearance while maintaining human comfort.

4) Energy conservation and environmental protection issues: Some smart components have high cost, high power consumption, and need to be charged at any time, which will cause a waste of resources. At the same time, some components have short lifespans, are not reusable and may cause environmental pollution.

5) Material selection issues: Some materials have a short lifespan and low practicality, and some materials are hard and cannot meet human comfort issues.
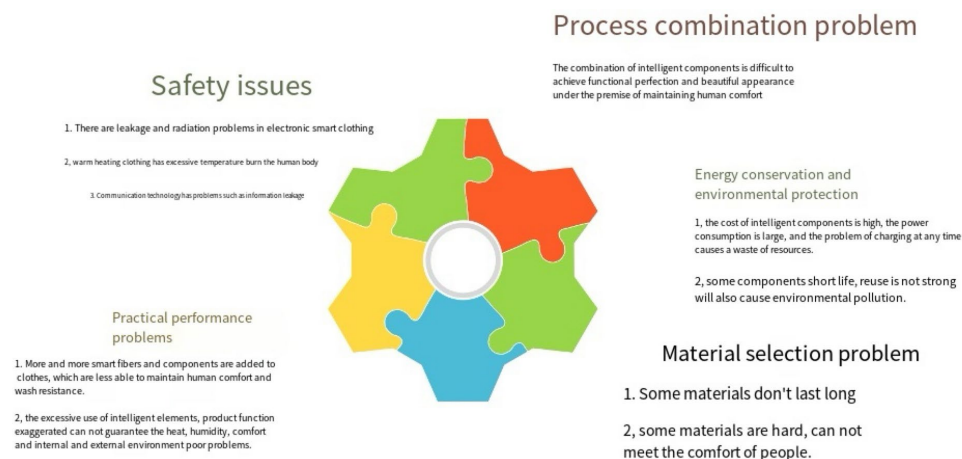

Figure 6: Problems with smart clothing

3.2 The future development direction of smart clothing

According to big data, smart safety clothing already accounts for 83% of the market [5]. The development direction of smart clothing embedded in the future will be divided into four directions based on the cross-integration of technologies in various fields: physical sign detection direction, safety protection direction, thermal comfort improvement direction and intelligent change direction.

1) Physical sign detection direction: perform health monitoring such as heart rate, electrocardiogram, blood oxygen, body fat, respiration, and pulse. For the elderly or users with diseases, it can help monitor health data at any time, provide dietary suggestions, and has the functions of health care, prevention and disease prevention and treatment (Figure 7).

Figure 7: Lenovo SmartVest smart ECG clothing

2) Safety protection direction: The targeted groups are mainly children, the elderly, disabled people and practitioners in some special industries. Users are provided with safety protection according to specific requirements (Figure 8) [6].
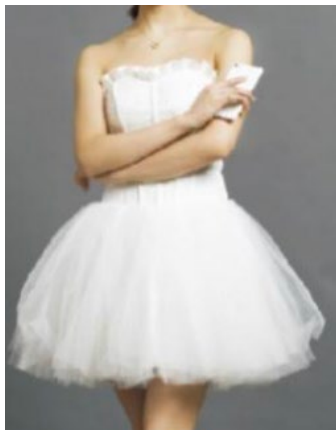

Figure 8: Positioning anti-wolf gown designed and researched by Professor Shen Lei of Jiangnan University

3) Thermal comfort improvement direction: Thermal comfort improvement direction mainly includes constant-temperature clothing made of new materials such as graphene, including heating physiotherapy thermal clothing, "air-conditioning clothing", color-changing clothing, etc. Among them, heating physiotherapy clothing is mainly aimed at users in cold weather. It can maintain a constant temperature in winter and hot summer, achieving warmth in winter and coolness in summer. This type of clothing can also achieve physical therapy effects on the basis of keeping warm, such as promoting blood circulation, metabolism, etc. (Figure 9) [7].

Figure 9: Smart thermostatic clothing

4) Intelligent changing direction: Smart clothing with intelligent changing direction is mainly

combined with certain behaviors in life to free up hands, facilitate people's lives, or bring a unique way of life experience or increase interest (Figure 10).

Figure 10: Smart light-emitting color-changing clothing

4. Conclusion

Smart clothing stands out from many smart wearable products, which shows that it is the focus of research and development in domestic and foreign markets. However, smart clothing like ECG clothing has been around for several years but has not yet been popularized by all people, indicating that there are still many shortcomings in its development. After solving the related issues such as safety, reliability, wearability and environmental protection, only by improving the aesthetic issues can it be more easily accepted by the public. Solving these problems cannot be achieved overnight, and the development of smart clothing still has a long way to go.

References

[1] Guo Rui, "Development Status and Market Analysis of Electronic Intelligent Clothing" [J]. Guangxi Textile Technology, 2010.

[2] He Jiaqi, Gong Zihan, Lu Lu, "Current Status and Development of Intelligent Positioning Clothing" [J]. Shanghai Textile Technology, 2019.

[3] Shen Lei, Fang Donggen, Tang Ying, "Research Status and Development Trends of Intelligent Clothing Materials" [J], Shanghai Textile Technology, 2016.

[4] Nie Feng, Xu Liping, "Analysis of Cardiac Clothing and Development" [A], Textile Report, 2020.

[5] Fang Donggen, Shen Lei, "Overview of Research on Intelligent Clothing Materials" [J], Knitting Industry, 2016.

[6] Xue Zhebin, Shen Lei, Ren Xiangfang, "Research and Development Model of Intelligent Clothing System Based on Children's Safety" [J], Journal of Fashion Science and Technology, 2016.

[7] Huang Xu, Li Shuang, Xing Qianhe, "Heating Characteristics of Graphene Films and Application in Clothing Materials" [J]. Journal of Fashion Science and Technology, 2017.