Standardization for Smart Clothing Technology

Kwangil Lee and Yong Gu Ji

Dept. of Information and Industrial Engineering, Yonsei University, Seoul, Korea
{party38,yongguji}@yonsei.ac.kr

Abstract. Smart clothing is the next generation of apparel. It is a combination of new fabric technology and digital technology, which means that the clothing is made with new signal-transfer fabric technology installed with digital devices. Since this smart clothing is still under development, many problems have occurred due to the absence of the standardization of technology. Therefore, the efficiency of technology development can be strengthened through industrial standardization. This study consists of three phases. The first phase is selecting standardization factors to propose a standardization road map. The second phase is to research and collect related test evaluation methods of smart clothing. For this, we selected two categories, which are clothing and electricity/electron properties. The third phase is establishing a standardization road map for smart clothing. In this study, test evaluations have not yet been conducted and proved. However, this study shows how to approach standardization. We expect that it will be valuable for developing smart clothing technology and standardization in the future.

Keywords: smart clothing, standardization, new fabric technology, clothing property, electricity/electron property.

1 Introduction

Since many people are growing more and more interested in developing digital technology and highly technical clothes, there is a growing number of studies about smart clothing adapted with digital technology. Smart clothing can be defined as 'new clothes that are convenient for use by IT based applications.' [1]. However, since smart clothing is still being developed, there is no standard definition yet. So, it is often referred to as 'digital smart clothing,' 'digital clothes,' and 'intelligent clothes.' Since 1998, Smart clothing has been developed in the United State and Europe. At the beginning stage, many people tried to adapt computers into clothes and use them [2]. For instance, the Industrial Clothing Design + line jackets developed by Levi Strauss in collaboration with PRL(Philips Research Laboratory) allows wearers to use a remote-controlled microphone embedded in the collar for mobile phones and Digital MP3 players [3]. Smart clothing is now being developed for everyday life, with the market expanding into the military, health and medical care, business and leisure industries [4].

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Even though smart clothing technology has just started to develop, the economic outlook is bright. According to NPD (National Purchase Diary) Group's recent research, 50% of male clothing will be equipped with high technological functions by 2010, with women's clothing reaching the same level by 2012 [5].

Smart clothing technology has been actively developed domestically for use in easing daily life [6][7]. However, A Standardization for technology has not started yet. Thus, this study proposes the methodology and standardization road map for smart clothing technology development. Also, this study will be helpful to establish an effective strategy for smart clothing development.

2 Background about Smart Clothes Standardization

2.1 Standardization Trends

An analysis of the standardizations regarding smart clothing shows that until June 2008, there was no application for ISO or IEC certification [8][9]. Technology development and commercialization have been expedited in the United States, Japan and Europe. According to a recent study, however, partial technology development is in progress in Southeast Asia. However, there are no studies or data related to standardization except in Japan, whose fire-fighting uniforms are certified by the IEC [9].

2.2 Necessity of Standardization

It is judged that competition among the United States, Europe and other developed countries has begun in the global apparel market. In order to dominate the growing market, one must urgently focus on technology development. However, many problems have occurred due to the absence of the standardization of technology. For instance, we currently manufacture all kinds of subsidiary materials to aid us in developing the technology. Therefore, the efficiency of technology development can be strengthened through smart clothing standardization.

2.3 Expected Effect of Standardization

– **Revitalization of fashion industry:** Recently, fashion industries have changed from labor-intensive to knowledge-intensive industries. Such a knowledge-intensive, high-valued textile industry is expanding rapidly. As standardization is very important to a high-technology industry such as smart clothing, it will revitalize the clothing industry's parallel with developing technologies.

– **Acquisition of international competitiveness:** The standardization of specifications, telecommunication, protocol and systems for a product's function can encourage competition in the international market, easy entry to the market and leadership in the industry. Therefore, we will be able to take the lead in the global smart clothing market throughout standardization.

– **Increasing market sharing:** It is clear that technology development is required for increasing market share. Therefore, market sharing for smart clothing in the international market can be maximized by standardization along with technology and product development.

– **Positioning in international standardization society:** If we dominate the technology area such as digital textiles and e-textiles, before international specification has been ratified, we will be able to take the lead in the world apparel market. The responsibility for standardization of the technology can reside in a chairman, director or other high-ranking official of ISO/IEC. Therefore, our profile will be high and we will have a step forward when competing with the other developed countries' monopolies and the challenges posed by emerging markets.

3 Methodology

This study consists of three phases. The first phase is selecting the standardization factors to propose the standardization road map. The second phase is to research and collect related test evaluation methods of smart clothing. For this, we selected two categories, which are clothing and electricity/electron property. The third phase is establishing a standardization road map for smart clothing. Figure-1 bellow is the methodology of this study.

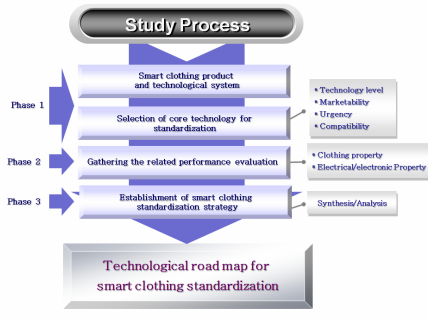

Fig. 1. Methodology for smart clothing standardization

3.1 Standardization Analysis

This phase established the smart clothing standardization analysis according to the smart clothing classification. In this study, the smart clothing classification is a definition of related products and technology among the smart clothing categories. Throughout the smart clothing classification, each standardization factor is selected. Experts analyze these standardization factors to make a list according to three

important, weighted factors. The factors that need to be prioritized are: market competitiveness, product life cycle and possibility of commercial launch. Experts give marks to each product based on the factors and listed in priority order.

3.2 Gathering the Related Performance Evaluation

The next step is to collect data about smart clothing evaluation. The features of smart clothing are divided into two categories, which are clothing and electricity/electron property. The following are the definitions of each property:

– **Clothing property:** Smart clothing is basically considered regular clothing. Therefore, it should have basic clothing functions such as wearability and fashionability. In terms of these functions, abrasion resistance, bending resistance and washability need to be addressed, as well as the design of the clothing. Based on these features, data needs to be collected regarding research, recommendations and safety standards in international organizations such as ISO.

– **Electricity/electron property:** Smart clothing not only has the characteristics of clothing, but also the characteristics of electricity/electron elements. For example, certain levels of the life cycle should satisfy the standards that are developed. Also, despite being adapted clothes, they should work properly. Lastly, over the clothing should be safe for the human body. Therefore, safety standard for electricity also need to be established. International safety standards in organizations such as ISO/IEC and product standards need to be collected.

3.3 Standardization Road Map

Based on research, testing samples and such standardization as mentioned above, a standardization road map has been discovered. The road map was revaluated based on the technology level, technology life cycle, marketability and time expectations. The standardization road map has positive impacts on standardization for smart clothing technology.

4 Case Study

4.1 Standardization Analysis of Smart Clothing

Establishing smart clothing classification - As suggested in Table 1 below, smart clothing can be categorized into four areas: body & environment monitoring clothing, entertainment clothing, photonic clothing and extra functional clothing. We defined the clothing products and related technology among these four categories. This smart clothing classification will be the first step toward a future standard. We will select the standardization factors according to this smart clothing classification.

Table 1. Smart clothing classification

Smart clothes category	Corresponding technology	Related technology	Common Technology
Body & environment monitoring clothing	ECG electrode	ECG measurement	Signal sensor
	GPS built-in	GPS module	
	GSR built-in	GSR module	
	Bio-monitoring	Temperature/humidity sensor module	
		Ultraviolet rays/ozone measurement module	
Entertainment clothing	MP3 player built-in	Fabric signal wire	Conductive fabric
	Cell phone built-in	Fabric key pad	
	Media	Signal transmissibility Materials	
Photonic Clothing	POF (Plastic Optical Fiber)	POF fabric manufacture	Thin film electroluminescent technology
	Photoelectron & LED(Light Emitting Diode)	Photoelectron weaving textile	
		LED manufacture	
Extra functional clothing	Color/Sound responding	Color/Sound sensor	Digital conversions
	Heat emitting function	Heat emitting system	
	Air-conditioning function	Air-conditioning system	
	Masking in army uniform	Anti-radar	
	Thermal resistance in fire fighter	Thermal resistance fabric	

Standardization factor analysis - These factors are divided into two categories, which are standardization of product and performance. Next, four elements are applied: technology, marketability, urgency and compatibility, listed in order from high to low. Evaluation has been done by five professional groups in the area of smart clothing. The results will be used for standards of performance evaluation. Table 2 below is the standardization factor analysis.

Table 2. Standardization factor analysis

Smart clothes	**Clothes Products**	**Test type**	**Technol -ogy level**	**Market -ability**	**Urgency**	**Compati -bility**
A living body signal & environment monitoring clothes	ECG measurement	Performance	●	●	●	●
	Temperature/humidity sensor module	Product	◎	◎	○	○
	GSR module	Product	◎	◎	○	○
	Ultraviolet rays/ Ozone measurement module	Product	◎	○	○	○
	Environment sensor	Performance	◎	○	○	○

Table 2. (*continued*)

Entertainment clothes	Fabric signal wire	Performance	◎	●	●	●
	Fabric key pad	Performance	◎	●	●	●
	Signal transmissibility materials	Performance	◎	●	◎	●
Photonic clothes	Photonic clothes module	Product	●	●	◎	●
	POF fabric manufacture	Performance	◎	◎	●	◎
	Light emitting diode	Performance	◎	◎	◎	◎
	Photoelectron textiles materials	Product	●	◎	◎	◎
	Electron activity textiles materials	Product	●	◎	◎	◎
Extra functional clothes	Smart clothes interface	Performance	◎	◎	◎	◎
	Interface & components for smart clothes	Product	◎	◎	◎	◎
	Smart clothes usage test	Performance	◎	◎	◎	●
	Smart clothes terminology	Performance	◎	◎	●	●

※ Note: Standardization priority: High (●), Medium (◎), Low (◎).

4.2 Test Evaluation Factors for Standardization

– **Clothing property:** Collecting data in terms of clothing function refers to ISO (International Organization for Standardization), BS(British Standards), DIN (Deutsche Industrie Normen), JIS(Japan Industrial Standards), ASTM(American Society for Testing Materials) and KS (Korea Standardization), as well as KCA(Korea Consumer Agency) and KITRI(Korea Appear Testing Research Institute) [12][13][14][15][17][18]. Evaluations in terms of relation, importance and possibility have been done by professionals using 3 weights: High, Medium and Low. Twenty-four evaluation factors were found, as the result chart mentions below in Table 3.

Category	*Test Type*	*No.*	*Relevancy*	*Importance*	*Possibility*
Appearance change	Size changes rate	1-1	•	•	•
	Iron size change rate	1-2	•	•	•
	Form change	1-3	•	•	•
Mechanical properties	Breaking strength and elongation	1-4	•	◎	•
	Tearing resistance	1-5	•	•	•
	Abrasion resistance	1-6	◎	◎	◎
	Seam strength	1-7	◎	•	•
	Flexibility	1-8	•	•	•
	Wide fabric tensile strength	1-9	•	•	•
	Water resistance	1-10	•	•	◎
	Insulation	1-11	•	•	•

Color fastness	Bending resistance	1-12	•	•	•
	Durable press	1-13	•	◎	◎
	Infrared reflectance	1-14	◉	◎	◎
	Fire-resistance	1-15	•	•	•
	Color fastness to washing	1-16	•	•	•
	Color fastness to crocking	1-17	◉	•	◎
	Color fastness to dry cleaning	1-18	•	◎	◎
	Colorfastness to water	1-19	•	•	•
	Colorfastness to ironing	1-20	◎	•	◉
Product Test	Industrial production	1-21	•	◉	•
	A production of rubber	1-22	◉	◉	•
	A button	1-23	•	•	•
	A zipper	1-24	◎	◎	•

- **Electricity/electron property:** The research has been done in terms of credibility, safety and performance. We obtained information from ISO/BS/DIN/JIS/ASTM/KS professional evaluations in terms of relation, importance and possibility [12][13][14][15][17][18]. They had three choices: High, Medium and Low. Twenty-five evaluation factors were found, as the result chart mentions below in Table 4.

Category	Test Type	No.	Relevancy	Importa-nce	Possibility
Reliability	Key Pad and Earphone Jack durability test	2-1	◎	•	◎
	ISO/IEC 9126-2 8.2.1 Fault rate	2-2	•	•	◎
	ISO/IEC 9126-2 8.2.1 Problem rate	2-3	•	•	◎
	ISO/IEC 9126-2 8.2.2 Down rate	2-4	•	•	●
	ISO/IEC 9126-2 8.2.2 Recovery rate	2-5	•	•	●
Safety	Safety of household and similar electrical appliances	2-6	●	•	◎
	General performance – Safety Requirements	2-7	•	•	◎
	Specification for safety of household and similar electrical appliances.	2-8	◎	•	◎
	Particular requirements for electric irons	2-9	•	●	●
	Particular requirements for spin extractors	2-10	•	•	◎
	Specification for safety of household and similar electrical appliances	2-11	◎	◎	◎
	Particular requirements for washing machines	2-12	•	•	●
	Particular requirements for shavers, hair clippers and similar appliances	2-13	◎	◎	◎
	Household and similar electrical appliances. Safety.	2-14	•	•	●

	Particular requirements for floor treatment machines and wet scrubbing machines	2-15	●	•	◎
	Audio, video and similar electricity apparatus – Safety requirements	2-16	●	•	◎
Electricity	Appliance couplers for household and similar general purposes	2-17	•	•	◎
	Ballasts for tubular fluorescent lamps.	2-18	•	●	•
	Auxiliaries for lamps. a.c. supplied electricity ballasts for tubular fluorescent lamps.	2-19	•	●	●
	Single-Capped Fluorescent Lamps - Safety Specifications	2-20	●	•	●
	Information technology equipment	2-21	◎	◎	◎
	Safety requirements for electrical equipment for measurement, control, and laboratory use	2-22	•	•	◎
	Hand-Held Motor-Operated Electric Tools	2-23	•	•	◎
	Fixed capacitors for use in electricity equipment	2-24	◎	◎	◎
	Testing and Measuring Equipment/Allowed Subcontracting	2-25	◎	◎	◎

4.3 Standardization Road Map

Based on previous research, Table-5 shows the application of standard factors from tests. These factors were revaluated in terms of the level of technology, life cycle and marketability. We applied high relation and high marks to the results from previous steps up to 6 categories. We will arrange smart clothing standardization wording in order of each characteristic.

Smart clothing category	Techno-logy	Year				Level	Life time	Market	Property	
		08	09	10	11				Clothing	Electricity /electron
Body signal & environment monitoring clothes	ECG measurement standardization	■	■			◎	◈	•	1-8	2-2
									1-19	2-4
									1-22	2-5
	Temperature/humidity sensor module standardization			■	■	◎	◇	◎	1-5	2-2
									1-6	2-3
									1-8	2-4
	GSR module standardization			■	■	◎	◈	◎	1-8	2-2
									1-19	2-4
									1-22	2-5
	Ultraviolet rays/ozone measurement module standardization			■	■	◎	◇	•	-	2-3
									-	2-5
									-	2-7
	Sensor standardization related with environment			■	■	◎	◇	•	-	2-3
									-	2-5
									-	2-7
Entertainment clothes	Textile-based Transmission line standardization	■	■			•	◆	•	1-4	2-5
									1-5	2-2
									1-6	2-7

	Textile-based key pad standardization		●	◆	●	1-1 1-3 1-23	2-1 2-2 2-5
	Signal transmissibility Materials standardization		◎	◈	●	1-1 1-3 1-8	2-1 2-2 2-5
Photonic clothes	Photonic Clothes module standardization		◎	◈	●	1-5 1-6 1-8	2-9 2-16 2-19
	POF fabric manufacture technology standardization		◎	◈	●	1-5 1-6 1-8	2-9 2-16 2-19
	Light emitting diode(LED) standardization		◎	◇	◎	1-8 1-11 1-12	2-9 2-16 2-19
	Photoelectron textiles materials standardization		◎	◈	◎	1-1 1-3 1-8	2-9 2-16 2-19
	Electron activity textiles materials standardization		◎	◈	◎	1-9 1-10 1-11	2-5 2-7 2-22
Extra functional clothes	Smart clothing interface standardization		◎	◈	●	1-1 1-3 1-4	- - -
	Smart clothing components standardization		◎	◈	●	- - -	2-4 2-5 2-25
	Smart clothing terminology standardization		◎	◈	◎	The definition of related technology and product	

5 Conclusion and Further Study

Smart clothing is a new form of fabric. However, standardization of smart clothing technology has rarely been considered and little research has focused on solving these problems. Evaluation and technology standards have not existed so far, even though the technology has been developing. In order to have an efficient technology development, evaluation and technology standards need to be presented. This study has not conducted a systematic standardization yet. Nonetheless, this study proposed methodology for the standardization of smart clothing, and presents how strategic thinking may help toward achieving a standardization of smart clothing. As a result, we believe that our standardization road map can be used for gaining the competitive advantage in the smart-wear market. In addition, we expect we can occupy a more competitive position for standardization. Further study, testing and evaluation will be conducted on the standardization road map. More research will be continued about standardization trends and international technology. Through it, we expect to have a positive impact on smart clothing development.

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