

JUNE 2019

M.Sc. in Textile Engineering

MERVE UNCÜOĞLU

**REPUBLIC OF TURKEY
GAZİANTEP UNIVERSITY
GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES**

**AN INVESTIGATION OF INNOVATIVE WEARABLE
TECHNOLOGICAL TEXTILE PRODUCTS:
SPECIFIC APPLICATION**

**M.Sc. THESIS
IN
TEXTILE ENGINEERING**

**BY
MERVE UNCÜOĞLU
JUNE 2019**

**AN INVESTIGATION OF INNOVATIVE WEARABLE
TECHNOLOGICAL TEXTILE PRODUCTS:
SPECIFIC APPLICATION**

**M.Sc. Thesis
in
Textile Engineering
Gaziantep University**

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June 2019



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REPUBLIC OF TURKEY
GAZİANTEP UNIVERSITY
GRADUATE SCHOOL OF NATURAL & APPLIED SCIENCES
TEXTILE ENGINEERING

Name of the Thesis :An Investigation of Innovative Wearable Technological Textile
Products: Specific Application

Name of the Student : Merve UNCUOĞLU

Exam Date : 28.06.2019

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ABSTRACT

AN INVESTIGATION OF INNOVATIVE WEARABLE TECHNOLOGICAL TEXTILE PRODUCTS: SPECIFIC APPLICATION

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M.Sc. in Textile Engineering

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June 2019

148 pages

The emerging technologies and the resulting innovative material approaches give rise to new potentials in the field of textile and fashion design and allow the development of creative products through the formation of new perspectives. The use of smart textiles is becoming widespread for this purpose. Intelligent textiles are materials that respond to these stimuli when they are interfered with external influences such as force, temperature, heat, light, chemical reactions, electricity, and magnetic. Wearable technology products have come to the fore with the combination of textiles on the use of information and communication technologies on accessories or clothes. In the development of wearable systems, the integration of information and communication technologies into a garment or fabric is the most important goal. Electrostatic textiles are obtained by impregnating antistatic agents in fabrics, coating fabrics and nonwoven surfaces with conductive materials, and folding conductive strands with non-conductive yarns. In this study, design, engineering, science and technology will come together by interdisciplinary collaborative or interdisciplinary electronic textiles, smart textiles, nanotechnology-coded garments; fashion concept that is interfaced with technology, original application project and studies will be done from current fashion design products. Within the scope of the exemplary application, a caftan with flexible leds and sensor is designed.

Key Words: Smart Textiles, Fashion Design, Technology, Wearable Technology

ÖZET

YENİLİKÇİ GİYİLEBİLİR TEKNOLOJİK TEKSTİL ÜRÜNLERİNİN ARAŞTIRILMASI: ÖRNEK UYGULAMA

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Haziran 2019

148 sayfa

Gelişen teknolojiler ve bunun sonucunda ortaya çıkan yenilikçi malzeme yaklaşımları tekstil ve moda tasarımı alanında yeni potansiyeller doğurmakta ve yeni bakış açılarının oluşumu ile yaratıcı ürünlerin geliştirilmesine olanak sağlamaktadır. Bu amaçla akıllı tekstillerin kullanımı yaygınlaşmaktadır. Akıllı tekstiller, kuvvet, sıcaklık, ısı, ışık, kimyasal reaksiyonlar, elektrik, manyetik gibi dışarıdan gelen etkilerle müdahale edildiğinde, bu uyarıcıları algılayarak tepki veren malzemelerdir. Giyilebilir teknoloji ürünleri, aksesuar veya giysiler üzerinde bilgi ve iletişim teknolojilerinin kullanılmasına yönelik tekstiller ile birleştirilmesiyle gündeme gelmiştir. Giyilebilir sistemlerin geliştirilmesinde, bir giysi veya kumaşa bilgi ve iletişim teknolojilerinin entegre edilmesi en önemli hedeflerdendir. Elektronik tekstiller, kumaşlara antistatik madde emdirilmesi, kumaşların ve dokusuz yüzeylerin iletken malzemelerle kaplanması ve iletken ipliklerin iletken olmayan ipliklerle katlanmalarıyla elde edilirler. Çalışmada tasarım, mühendislik, bilim ve teknolojinin disiplinlerarası ortaklaşa veya etkileşimli geliştirdikleri elektronik tekstillerden akıllı tekstillere, nano teknolojiden kodlanan giysilere değinilmiştir; teknoloji ile etkileşimli moda konsepti güncel moda tasarım ürünlerinden özgün uygulama projesi ve çalışmaları yapılmıştır. Örnek uygulama kapsamında, esnek ledlerle döşenmiş, sensörlü bir kaftan tasarlanmıştır.

Anahtar Kelimeler: Akıllı Tekstil, Moda Tasarım, Teknoloji, Giyilebilir Teknoloji



"Dedicated to My Grandfather"

Mehmet Enver FİYİLİR

ACKNOWLEDGEMENTS

I would like to thank to my supervisor Assoc. Prof. Dr. Züleyha DEĞİRMENCİ who has shared my excitement in all the process of this thesis subject, which has helped me to gain new perspectives and vision of academic work, has given me support and knowledge and excited me with her patience and guidance during this study period (during my undergraduate and graduate education), my dissertation and my co-supervisor Assoc. Prof. Dr. Ebru ÇORUH for the guidance, advice and encouragement.

I would like to thank academicians Assoc. Prof. Dr. Gülseren KARABAY and Assist. Prof. Dr. Gökçe ÖZDEMİR for their contribution and knowledge.

I would like to thank all engineers and designers who have combined multidisciplinary approach to designing textile products that are functional but also modern and pushing the limits of imagination by bringing together textile, technology and design at engineering level.

Finally, many thanks to my dear mother Hatice UNCUOĞLU, my dear father İbrahim Mustafa UNCUOĞLU, my sister İclal Sena UNCUOĞLU and my brothers Muhammet Enver and İsmail Mert UNCUOĞLU for face up to all difficulties with me and who provide with me their support patiently and faithfully at every stage of my life. I would like to endless thanks my precious uncle Mehmet Yusuf Celal UNCUOĞLU for always encouraging and supporting me in my career.

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CHAPTER 1

INTRODUCTION

Since the existence of humanity, textile products have started to be used due to basic requirements such as covering and protection from environmental conditions. Over time, it turned out to be voluntary and fashion came to the fore. In recent years, it has become popular to bring functionality to textile products depending on the developing technology. At the last point of our arrival, the design of functional and modern textile products has become a necessity for many fashion designers. The smart textiles produced for this purpose are groundbreaking for wearable technological textile products.

Fashion is a phenomenon that changes every period, every society and is at the center of change. In the rapid developments in technology, the power of fashion has added power. In other words, combining technology with fashion brought a new breath to the designers and made them more original. In short, the necessity of this age in which technology enters all areas of our life is to integrate technology into textile products.

Fashion reflects all of the social, cultural, and environmental characters, so fashion describes the person's sense of life at a specific time and place. Fashion is nurtured by society and society adopts temporary innovations which are the necessity of fashion process. Technological developments and practices under the influence of every area of our life continues to develop. For this reason, designers and scientists bring together fashion and technology to imagine the future wearable technological designs. Bringing fashion and technology at the level of engineering forces the limits of imagination. Some of the developments in the field of fashion and technology can remain in our lives without us noticing, while others may remain fantastic even though they occur. In fact, since every new study is a sketch of the next one, it is not easy to predict what the next product in fashion and technology will be.

The questions that come to mind when it comes to wearable technology and fashion are as follows: Is the design element used to improve the technology or is the technology used to upgrade designs? While the world is preparing for the results of a important feature of wearable technology, and these products are designed to suit the intended use of people (medical, sports, military, etc.). Interest in wearable technology is increasing day by day because people want to immortalize every moment of their life and want to follow all vital data (such as heart rate, breathing, heart rate, blood pressure, body temperature). To this end, many ordinary textile products such as a new watch, t-shirt and sweatpants come together with technology. This necessitates the continuous interdisciplinary work of engineers to meet the requirements of the era. When it comes to textiles, each product is also preferable and it is about how they follow fashion.

As a result of the developments in the field of engineering, differentiation of textile materials and the leading textile materials have come together with the phenomenon of fashion to find out what it has created. The aim of this thesis is to analyze the elements of technological fashion process from an engineering point of view, to analyze the studies on the subject from both an engineering and a designer point of view, and to examine the collections of designers who design with this perspective and to make a sample application where fashion and technology are brought together. In this thesis, innovative textile products, the processes of designing and producing these products, the designers are investigated in detail and it is aimed to combine this information with fashion.

When it comes to design, the designer is expected to have traces of his age. The need for the era in which we live is to design systems that are capable of storing, analyzing and responding data. When the situation is not different for fashion designers, the number of studies is increasing day by day for combining the production and fashion with technological textiles.

Electronic textiles (e-textiles) are derived from the combination of textile materials with electronic evenings to serve a particular purpose. The elements that make up the system are designed for each product, as invisible as possible and cannot be easily integrated into other systems. They are easy to adapt to issues such as e-textiles, measurement, power control response. It is thought that the clothes of the future can be controlled by computers. In this study, the latest developments in smart textile, materials and their production processes are mentioned. Each technique shows the

advantages and disadvantages and our aim is to emphasize a possible balance between flexibility, ergonomics, low power consumption, integration and ultimately autonomy [1].

The common feature of textile materials is protection from external factors and aesthetic features. Today, smart textiles are used to bring a new dimension to textiles to meet the rapidly changing needs of consumers. With the electronic measurement and storage features of these systems, new wearable electronic systems emerge. In this article, the concept of i-textile is presented together with building blocks for its realization. It also describes the design and development of smart shirt, a smart garment. This t-shirt allows detection, monitoring and data processing devices to be combined. The article discusses the implications of product implementation and health service transformation. Finally, we discuss developments to advance this paradigm and turn passive textiles into new generation interactive or "smart" textiles [2].

There are many applications of wearable electronic clothing that can record from sports to artistic space. In this study wearable devices that can read and record data and systems are described. Sensory function of garments It is obtained with fabric strain sensors based on teeth coated with polypropylene or carbon filled tires. Conductive materials are used. Piezo resistive systems are used in fabric. Also attached to the strain fabric strips to form conductive tracks at strategic points. The sensory system of the smart shirt produced can be divided into two parts: first, the textile part (where a wearable device receives biomechanical signals and a hardware / software location), and the other is the area where the wireless communication system stores the acquired data [3].

Although many ideas have been put forward on electronic yarns and textiles, they are not suitable for practical use. In addition to chemical / mechanical strength and high electrical conductivity, important materials qualities; touchability, wearability, lightness and "smart" functionality. The aim of this study is to convert cotton ropes into smart e-textiles using a polyelectrolyte based coating with carbon nanotubes (CNTs). Nano pipes (20 z / cm) provide efficient charging transfer over the network, making them promising materials for garments with high information content. In addition to the integrated moisture sensing, CNT- cotton yarns show that the main protein of blood, albumin, can be used to detect with high sensitivity and selectivity. Despite future challenges, the results of this study show that these materials can be

applied as simple, sensitive, selective and versatile wearable bio-monitoring and medical sensors [4].

Babies who are taken to intensive care unit after being born are very sensitive and vulnerable to external conditions. Designed in this study, smart jacket, body sensor and cable networks allows the user to continuously monitor. With the help of this coat, the clinically monitored baby, family and hospital will have more comfortable conditions. Here we describe the first version of the neonatal coat that provides ECG measurement with textile electrodes. It also explores a new solution for skin contact difficulties caused by textile electrodes. Jackets have aesthetic features that appeal to parents and medical personnel with new wearable technologies. A design process in close contact with users and experts leads to a balanced integration of technology, user focus and aesthetics. It shows prototype and experimental results obtained in clinical setting [5].

In this study, wearable devices (a smart shirt, a leotard and a glove) that can read and record the vital signs and movements of a person using the smart garment system are discussed. The detection function of garments is based on piezo-resistant fabric sensors based on carbon-charged tires (CLR) and different conductive materials. This study was carried out to demonstrate the feasibility of intelligent garments that can monitor vital signs and human posture. The results show that electroactive functions can be applied to the same weaving system where vital signs and movements are converted into readable signals and transmitted to detailing devices [6].

The emergence of wearable textile systems in recent years exhibited the need for wireless communication tools integratable into garments. In literature, several planar antenna designs based on textile materials have been presented, however, without an adapted feeding structure for wearable applications. An aperture-coupled patch antenna (ACPA) meets this requirement since the rigid coaxial feed is replaced by a microstrip feed line that couples its power into the antenna through an aperture in the ground plane. This letter presents the first ACPA entirely made out of textile material. The result is a highly efficient, fully flexible, and wearable antenna that is integratable into garments. In order to overcome difficulties with feeding structures for wearable antennas, we designed the first ACPA entirely made out of textile material. Excellent agreement was found between the simulated and the experimental results, even when bending the antenna or bringing it in the vicinity of the human body. Furthermore, the antenna provides sufficient antenna gain to be applied in a

wireless link. The outcome of our research is an antenna that is integratable into wearable textile systems for body and personal area networks operating in the 2.45-GHz ISM band [7].

Wearable technology is already in our life. The latest generation of Apple watch includes AFib (Atrial fibrillation) detection. Atrial fibrillation is a heart arrhythmia that affects about 1% of the population worldwide. It's mostly detected in adults over the age of 60, and in those with high blood pressure and diabetes. Atrial fibrillation is the leading cause of stroke, with sufferers being five times more likely to have a stroke than those without it. The KardiaMobile and KardiaBand wearable devices incorporate the Apple watch's heart rate sensor. If the sensor detects an unusual heartbeat, the devices alert the user to place their fingers on a small electrocardiogram (ECG) pad on the watch band. The devices then visually display the user's heartbeat, and announce whether the heartbeat is normal or the user is experiencing atrial fibrillation. In the future, wearables will be used to collect biometric data, such as heart rate (ECG and HRV), brainwave (EEG), and muscle bio-signals (EMG). They will also be used to monitor the elderly. Being able to review data transmitted from a wearable device means that a patient doesn't have to be transported to a medical facility, and this has the potential of saving millions of dollars a year [8].

1.1 Purpose of the Study

The primary purpose of this thesis to make a comprehensive research on fashionable textile products, smart textiles, designers who design technological clothing and fashion. After the research, a sample application was made using fashion and technology together. This application focuses on electronic, textile and fashion trilogy. During the application of a sample garment designed, the most suitable materials for this garment were selected and the applicable electronic system planned for the product. Application of the thesis is one of the side aims.

1.2 Structure of the Thesis

According to the purpose, the thesis is written in 7 chapters.

- In the first chapter, an introduction was made.
- In the second part, smart textiles are explained and the theses on this subject have been investigated.

- In the third chapter, fashion and textile concepts are examined.
- In the fourth chapter, designers are researched and their technological designs are exemplified.
- In the fifth chapter; current wearable technological textile products have been investigated in detail.
- In the sixth chapter; sample application planning, design, production items were taken into consideration.
- In the last conclusion section; As a result of current researches, studies and sample application, inferences were made on the point where technology has come from.



CHAPTER 2

SMART TEXTILES

2.1 Introduction

In the past, textile fibers were obtained only from plant and animal natural sources, industrial revolution and production techniques were developed and regenerated and synthetic fibers were produced [9]. The workability of the fibers and their availability from different materials have rendered functionality beyond the covering of textile materials.

Technological developments and emerging innovative material approaches give rise to new potentials in the field of textiles and fashion design and enable the development of innovative products through the emergence of new products. The use of intelligent wearable textiles is becoming widespread for this purpose. Intelligent textiles are materials that react to these stimuli when interfered with external influences such as force, temperature, heat, light, chemical reactions, electricity and magnetic. With smart textiles with superior performance features, technology has now become part of our body. And the future is beyond our imagination [9, 10].

2.2 Technical Textiles

2.2.1 Production of Technical Textiles

The materials produced for technical performances and functional properties rather than aesthetic and decorative features are called technical textiles. Technical textiles have superior performance and functionality. The usage areas of technical textiles are the areas where technology and functionality stand out [9].

2.2.2 Areas of Use of Technical Textiles

Technical textiles have a wide range of uses due to the discovery of new products, to meet new generation needs and to replace traditional products and materials [11].



Figure 2.1 Application of technical textiles [12]

Civil engineering 	Agriculture and fishing 	Construction and textile architecture 	Medical, hygienic and sanitary applications 
Automobiles and passengers transport 	Packaging and goods transport 	Personal protection 	Sports and leisure 
Industrial uses 	Environmental protection 	Technical textiles used at home and in public buildings 	Technical textiles for clothing 

Figure 2.2 Application of technical textiles [13]

There are mainly twelve applications of technical textiles which are listed in the below:

- Medical and Hygiene Textiles
- Industrial Products and Components
- Agriculture, Horticulture and Fishing
- Home Textiles
- Transport / Mobiltech Textiles
- Clothing Components
- Packaging and Containment
- Construction – Building and Roofing
- Geotextiles in Civil Engineering
- Sport and Leisure
- Protective and Safety Clothing or Textiles
- Ecological Protection Textiles

2.2.3 Fibers Used in Technical Textile Production

Technical textile materials can generally be produced from both natural and regenerated and synthetic fibers. Natural fibers with sufficient length, fineness and durability are used in the production of technical textiles. In addition to the aesthetic and physical properties of cotton fiber, it is seen that it is mostly used on absorption and medical properties. Examples include filler materials with absorbing ability, linings for garment products, substrates in coatings, filters, medical and hygienic applications, sewing thread and cleaning cloths. Wool, high elasticity, natural curved structure and air holding properties, provides a good effect for comfort and temperature, and this feature provides wool fibers as insulation material. Examples of the use of fibers such as linen and bamboo are biocomposite materials and bag teas for the automotive industry. Silk is indispensable for medical textiles with its high gloss, strength and dimensional stability as well as its conformity and gradual disintegration [9].

Regenerated cellulose fibers are used as a desiccant in disposable hygiene products, in medicinal products, in teabags, in cleaning cloths and in the production of cellulosic fibers. Synthetic fibers have an important place in the production of technical textiles. For example, polypropylene fibers are used in automotive industrial products, coating materials, filters, medical and hygienic applications. Polyester fibers are used in non-woven materials (nonwovens), as a primer in apparel products, in automotive products, filters, knitted fabrics, medical and hygienic applications, sewing threads, conveyor belts and cleaning cloths. Aramid fibers due to their super tensile strength and elasticity; It is used in the production of protective clothing, in the production of airplanes, sports equipment, heat-resistant and non-flammable materials and garments. Acrylic fibers, automobile upholstery fabrics, filter cloth, (nonwoven) non-woven surfaces, canvas, awning, sun visor and so on. used in the production of materials. Technical textile materials can generally be produced from both natural and regenerated and synthetic fibers. Natural fibers with sufficient length, fineness and durability are used in the production of technical textiles. In addition to the aesthetic and physical properties of cotton fiber, it is seen that it is mostly used on absorption and medical properties. Examples include filler materials with absorbing ability, linings for garment products, substrates in coatings, filters, medical and hygienic applications, sewing thread and cleaning cloths. Wool,

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2.2.4 Transition From Technical Textiles to Smart Textile

Technical textiles produced for the purpose of developing certain properties are directed towards intelligent textiles under the influence of advanced technology. Intelligent textiles, textiles developed with the principle of improving a technical specification, which has the ability to react by perceiving any effect or change of effect is textiles. We can say that the functional structure of technical textiles is improved. It is able to perceive, evaluate and react to environmental factors such as heat, light, mechanical, chemical, electrical and magnetic effects. Compared to technical textiles, the integration of advanced technology and functionality into textiles in the production of intelligent textile products is the leading role [9].

2.3 Smart Textiles

2.3.1 Production of Smart Textiles

Textile products that are designed considering the technical and performance characteristics they have, rather than their aesthetic or decorative properties, are called smart textiles. They are materials or structures that detect, evaluate and react to environmental stimuli from mechanical, thermal, chemical, electrical, magnetic or other sources. Smart textiles have gone a step beyond the technical textiles and brought a different dimension to textiles. Intelligent textiles are textile products that have the ability to detect and react to any effect or change in effect, in the sense of improving the technical properties of technical textiles [10, 15]

Smart textiles are one of the highest value-added and advanced technology. These products can be considered as a combination of fiber technology and material science, electronics and information technologies. When we look at the areas of use, especially in many areas where technology and functionality are available. Textile artists include fashion textiles, wearable art objects and smart textiles in many areas.

2.3.2 Development Process of Smart Textiles

Intelligent textiles are obtained by using advanced technology in the product design process of unconventional smart materials.

A smart textile system can show features such as detecting warnings, reacting, providing / generating / storing, communicating, providing data, and ensuring that these data are associated with each other [9]. In addition to these properties, flexibility, wear comfort, usability, washability, durability are also expected to contain such features.

2.3.3 Components of Smart Textiles

Smart textiles consist of textile materials, sensors, information processing, actuating devices, storage and communication components. These components, which will be integrated into the textile material, should not disturb the comfort of the garment. This is important for wearability. It must also have a specific ergonomics.

- **Sensors:** Provides the necessary parameters from the environment (heat, light, pressure etc.) or from the person's body. Since the clothes are in direct contact with the human body, they are used to measure the body parameters. Examples of biosignals that smart textile sensors can detect include [9]:

- Heat and light,
- Pressure,
- Cardiogram (heart beat graph)
- Myography (electrical signals caused by muscle contraction)
- Ultrasound,
- Movement for parameters such as breathing.

Systems that measure heart, breath rate, heat, motion and humidity in textiles are available with integration of sensors into textile material. In smart textiles, heart, breath, motion sensitive sensors are produced from real textile material.

Sensors significantly affect the usability of smart textiles.

- **Information Processing:** Processors are needed to obtain the desired output by processing the information collected by the sensors. It is one of the problems faced by the data processor that the diversity of the signal differs between the users, the lack of a standard value, the complexity of the signals analysis and the energy required for the processor [16, 17].

- **Actuating Devices / Actuators:** Devices designed to perform the necessary action according to signals from the sensor or processor. By acting on an effect transmitted by the sensor and passing through an information processor first, they perform operations such as moving objects, releasing materials, and making sounds. So the main action or purpose is realized by this component. Shape memory alloy is a mechanism that is activated due to its reaction to heat change. It is among the devices that are activated in certain materials (odor, skin-protective, anti-microbial products, etc.) that under certain conditions can be released [16, 17].

- **Storage:** It is a storage unit that stores information or energy in smart textile products, which injects the drug or odor. In smart textiles, the energy source required for the operation of sensors, processors and actuating systems is provided by energy storage. It is another type of storage in microcapsules that can store liquids and allow leakage of this liquid from the surface when they are broken [16, 17].
- **Communication:** It is one of the smart textile components. It is shaped according to the type of communication and need factor [16,17].

2.3.4 Classification of Smart Textiles

Passive Smart Textiles: Depending on the effect they have, they have a sensor function against environmental stimuli. In other words, textile products that can detect the effects from the environment. They are semi-intelligent and fully functional systems that perform more tasks.

Active Smart Textiles: Detecting warnings, they have the function of reacting. They are activated by sensing environmental conditions through sensors (sensors), reacting to the activator (activator), directly or through a central control unit. It is available in active smart textiles with the ability to adapt along with detection and response capability.

2.3.4.1 Classification of Smart Textiles by Materials

Intelligent textiles are divided into five groups: Hohenstein Research Institute, transfer systems, adaptable systems, smart clothing, transfer systems, micro technology and nano technology [15].

- **Transfer Systems:** When exposed to moisture, pressure and heat, the textile surfaces combined with nano capsules, molecular tanks or microcapsules emit certain active substances [15, 18].
- **Transporter Systems:** Electronic stores that can be changed or uploaded using laser codes or radio frequency fields. With this system information can be integrated into a fabric. And this information is maintained throughout the textile chain and made available to the garment manufacturer. Electronic textiles are also used in smart textiles. The more compact and lighter the electronic

components to be integrated, the easier it can be installed in the garment. It also increases the functionality of the textile [15, 18].

- **Adaptive Systems:** According to the usage purpose of textile, it can be adapted according to changing conditions in environment and body. Space is designed to protect the astronauts from the effects of heat changes between the extreme heat and the cold [15, 18].
- **Smart Clothes:** Includes textile-based information and communication technologies that integrate electronic parts into clothing. Electronic parts, computer keyboard, mobile phone, mp3 player, camera can be integrated into textiles [15, 18].
- **Micro Technology and Nano Technology:** With the use of micro and nano materials, very small electronic components and sensors are integrated into the text in an unobtrusive way [15, 18].

2.3.4.2 Classification of Intelligent Textiles According to Production Methods

Norstebo gathered intelligent textiles in five groups according to production methods; phase shifting (PCM) intelligent textiles, SMM smart textiles, smart textiles derived from chromic materials, smart textiles from electronic / conductive textiles, other smart fabrics and textiles [10, 19].

Phase shifting (PCM) smart textiles: They have the ability to store or spread a high amount of energy during melting or solidification due to their high fusion temperature. Hidden heat storage materials. They use chemical bonds for heat storage. Phase replacement is provided by integration of microcapsules with phase change feature to textile. In the use of phase-changing materials, heat storage and transfer properties are important [10, 19].

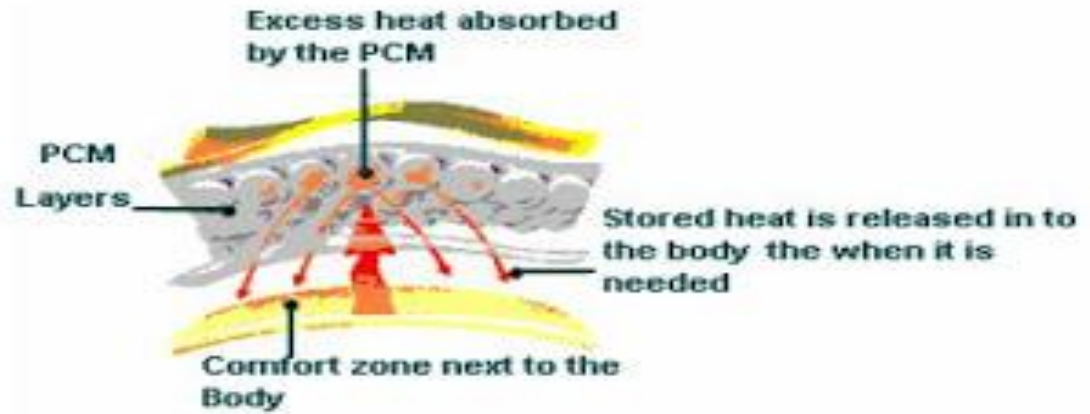


Figure 2.3 Phase change material [20]

Smart textiles with shape memory (SMM): Materials that can be converted into programmed formats when they are affected by a specific stimulus. The shape memory feature is an acquired feature [10, 19].

- Smart textiles from chromic materials: In the light of the environmental impact, chemical bonds in the molecular structure are broken or changed. The result of this situation is the intelligent textiles in which the changes in the electron equalization occur, such as reflecting, absorbing, spreading and transmitting optical modifications. Chromic materials; thermochromic (heat changing color), hydrochromic (changing color with liquid), electrochromic (changing color with electricity), piezochromic (changing color with mechanical effect), chemochromic (changing color with chemical effect), biochromic (changing color with biological effects) are classified as [10, 19].

- Smart textiles obtained from electronic / conductive textiles: By adding electrical properties to textile fibers, circuit or LED systems can be produced by integrating textile materials and by developing textile-related functionality properties and smart textiles with electronic features can be produced. The desired properties can be provided by conductive yarns or by making the textile surface conductive. In electronic smart textiles, conductivity must be able to withstand chemical processes applied to fabric and physical effects [10, 19].

2.3.5 Usage Areas of Smart Textiles

The usage areas of smart textiles are different according to their properties. Different classifications are made in different sources of usage areas. The subheadings to be examined in this study are shown in Figure 2.4.



Figure 2.4 Application of smart textiles

2.3.5.1 Smart Textiles Used For Military Purposes

The expected properties of these materials are [21]:

- Functionality
- Performance
- Lightness
- Protection (Ballistic, cuts and wear, biochemical threats, weather conditions)
- Contact
- Tracking via satellite
- Smart textile surfaces that form an invisibility shield
- Location notification and traceability

The problems that arise with globalization require countries to invest in defense industry. In order to use textiles for this purpose, they must reach the functionalities determined. Thanks to the multifunctional fibers developed today, military apparel, protective hospital suits and high performance sportswear are designed. Thus, the lightness of the garments decreases and their mobility increases. There are different designs on camouflage of military clothing.

Future Force Warrior, the military uniform, reduced the weight of the soldier from 120 pounds (approximately 54.43 kg) to 40 pounds (approximately 18.14 kg). Thus, it has developed the ability of mobility and survival [10].



Figure 2.5 Land warrior and air warrior [22]

2.3.5.2 Intelligent Textiles Used for Space Studies

It was always a matter of curiosity whether we were alone in the universe. There are extensive research on the moon and the solar system. Especially in recent days, it is a matter of wonder whether there is life on another planet from Earth. Plans planned for the planet Mars are also busy. Therefore, it is necessary to increase the functionality of the materials to be used for astronauts and spacecraft for space studies. The expected properties of these materials can be summarized as follows [10]:

- Protection
- Performance
- Functionality
- Comfort
- Using composite structures for pressure and impact resistance

There are also studies on designing wearable textiles that will connect astronauts to life. Astronauts working in the International Space Station are intended to be able to return to the station even if they lose their astronaut consciousness by means of special tracking equipment and sensors in their clothes in case of falling into space.



Figure 2.6 Space outfit [23]

Biosuit, developed by Professor Dava Newman, is a lighter and body-wrapping space suit. Thanks to the nickel-titanium shape memory alloys in the structure, the space around the astronaut can be expanded to increase mobility and comfort. In addition, gas pressure is prevented by a mechanical pressure system [24, 25].



Figure 2.7 “Biosuit” space suit [26]

Tesla Motors CEO Elon Musk's SpaceX (Space Exploration Technologies) has designed space suits [27]. Pressure dresses designed to reduce the pressure of the cabin during the launch, suitable for wearing in spacecraft, not suitable for walking in space. The SpaceX outfit, which passes the double vacuum pressure test, protects the astronauts from space conditions.



Figure 2.8 “SpaceX” space suit [27]



Figure 2.9 NASA- The next generation of suit technologies [28]

“The Z-2 suit is a technological planetary surface suit; the suit is designed for maximum astronaut productivity on a planetary surface – exploring, collecting samples, and maneuvering in and out of habitats and rovers. The Z-2 uses advanced composites to achieve a light-weight, high-durability suit that can withstand long-duration missions in the harsh environments found on Mars.

The PXS suit is a technology demonstrator focused on improving suit fit and performance while minimizing the amount of equipment required for long-duration missions to low-Earth orbit and beyond.” [28]



Figure 2.10 NASA's 'Technology' Z-2 spacesuit [29]

2.3.5.3 Smart Textiles Used in Work Wear

When it comes to working clothes, clothes that are designed to save the lives of firefighters, policemen, bomb disposal experts and workers who have to work in extreme hot and cold places for a long time come to mind. The expectations from these clothes are as follows [10]:

- Security
- Comfort
- Functionality



Figure 2.11 Firefighter suit [30]

Viking fireproof jackets produced by the integrated thermal sensor technology (TCT) with the temperature becomes critical when it reaches the critical level. This allows the user to complete the task without injury. Thermal sensors are integrated into the inner and outer layers of the coating to monitor ambient temperature and body temperature. The waterproof plastic-coated LED on the arm and back areas is connected to the surface [10, 31].



Figure 2.12 Viking firefighter suit [32]



Figure 2.13 Easy Jet airlines cabin team uniforms [33]

CuteCircuit designed British Airline uniforms for Easy Jet. With the programmable LED technology, information about the flight crew and flight numbers is provided in the jacket flaps of the cabin crew. There is also a microphone system that allows the flight crew to communicate with each other. Engineers are designed with hooded jackets. It has hands free feature and features that can be used in flight controls in the dark [33].



Figure 2.14 Easy Jet airlines cabin team uniforms [34]

2.3.5.4 Smart Textiles Used for Health

Many studies are carried out to improve the quality of life together with the developing technology. Smart textiles also have a large share of this cake. In the case of illness, smart clothing provides a general disease table, facilitating remote monitoring. Physiological measurements (breathing measurement, heart activity, muscle activity, oxygen saturation, blood pressure, body movement position, electrodermal activity) can be made by sensors integrated into intelligent textiles [10].

In order to facilitate the detection of high fever in infants, the Babyglow baby garment was designed by Chris Ebejer. These garments are designed with the use of thermochromic pigment dyes.



Figure 2.15 Babyglow – High temperature indicating sleep suits [10]

The University of Brighton has developed a glowing band-aid to minimize the risk of infection. This includes technology particles which may be useful within the band. The band used in combination with the active substance such as gel, if bacteria is formed, the fluorescent attachment compatible with human health turns green. Thus, it can be easily diagnosed if there is an infection in the wound area.



Figure 2.16 Lightning injury band [35]

The Quell Relief smart knee brace works according to a mobile application. Sensors embedded on the product store information about your health status. The product has an electrode inserted into the support. The product is activated when you tighten it with a belt and press the outer button. Afterwards, it helps in two different ways as sleep and therapy. Most of the chronic pain is caused by your inability to get enough sleep so that you can monitor your sleep patterns and help you solve your problems. In the therapy of the product, weekly data is collected on how long you are exercising [35].



Figure 2.17 Smart knee brace [35]

Owlet smart socks, while the baby sleeps in a separate room, showing the heart rate and oxygen level, parents can control the baby's health comfortably.



Figure 2.18 Owlet smart baby sock [36]

2.3.5.5 Smart Textiles Used for Interior Design and Home Textile

The studies to be carried out on this subject can be enriched depending on the imagination of users and designers. With the increase in awareness of intelligent textiles, the use of smart textiles has increased in interior design and home textiles. Energy curtains can store solar energy and use the energy stored as lighting.



Figure 2.19 Energy curtain [37]

Ian Walton and his teammate Eoin McNally have designed a pillow. It allows you to wake up with a gentle light flare instead of an alarm clock. LED fabric is used to reflect this glare. Helps you wake up with light-up lights 40 minutes before your alarm sounds [38].



Figure 2.20 Glo pillow illuminating alarm clock [38]

Textile surfaces can also be used as electronic interfaces, giving light to the clothes / furniture [39].



Figure 2.21 Philips' Lumalive furniture [39]

2.3.5.6 Wearable Textiles for Sports and Leisure

With the increase in the number of jobs done in the head office indoors, the interest in sporting activities has been increasing day by day. For this purpose, the use of smart textiles in sports and leisure activities is increasing.

Thanks to the sensors integrated into the AdiStar Fusion t-shirt, heart rate data can be monitored. Data analysis can be made by transferring to computer system with the help of transmitters. To monitor the heart rate, Polar's WearLink transmitter and Adidas special fibers work together. Sensors ECG collects heart rate values [40].



Figure 2.22 Adidas polar fusion [40]

Sensoria smart fitness socks track data by pressing the foot of the user in real time. It works in conjunction with smartphones to provide performance measurement [41].



Figure 2.23 Sensoria smart fitness sock [41]

Due to its water repellent and breathable structure, Supplex fiber can be used in lycra, swimming clothes, aerobics clothes, leggings and tights.

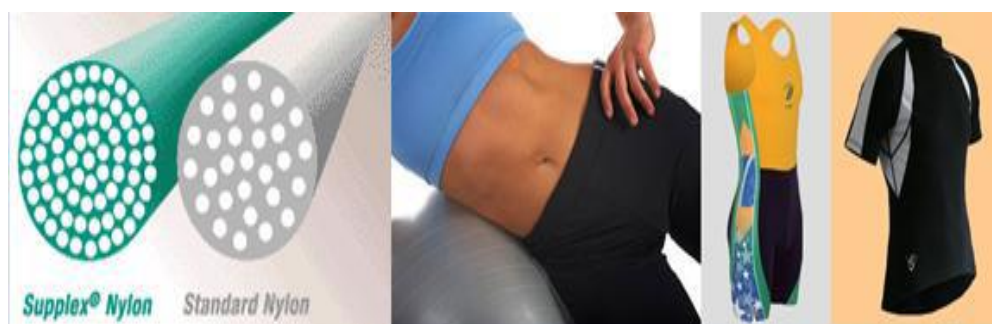


Figure 2.24 Smart textiles with supplex nylon fiber [42]

2.3.5.7 Smart Textiles for Fashion Applications

The interest in fashion is for generations, leading designers to different quests. With the effect of developing technology, fashion is not only the aesthetics of the model, color or aesthetics of the fabric. In addition to visibility, smart textiles are needed to design products with multi-functional superior performance features. And nowadays, many studies are carried out in which the clothes are transformed into a functional feast as well as functional.

- One of the first designers to combine technology and textiles is the German textile designer Irene VanVilet. In Copper / Nylon Stripes and Copper Satin Weave designs, the warp of the fabric is polyamide 6.6 and the weft is copper and polyamide. Flexible copper yarn is used on satin braided lines. Polyamide yarn is used in the textured lines with a cloth base. This creates a contrast and gives the surface a soft-radiant appearance [18].
- Australian fashion designer Helmut Land has designed an aesthetic-looking, simple silhouette of clothing for a protective garment that absorbs the harmful effects of sunlight and absorbs the light [18].
- Textile designer Sophie Roet designed the Wandering Lines-Red fabric. In the warp, she used a shimmering phosphorescent thread, like a brightly colored silk, and a polyolefin phosphorus. When the fabric is exposed to intense light, the phosphorescent-featured yarn absorbs light and shines in light [18].



Figure 2.25 “Wandering Lines-Red” by Sophie Roet [43]

- Amy Konstanze Mercedes's Rainbow Winters designs include printed clothing that changes color against sunlight, water and noise. Printed using thermochromic and hydrochromic inks and color changing [18].



Figure 2.26 “Rainbow Winters” by Amy Konstanze Mercedes [44]

- When the Airmail Dress dress of Hüseyin Çağlayan is folded, it can turn into a standard letter envelope. The dress is made of Tyvek20, nonwoven, paper-like textile product. Communication, transfer and migration are processed in this envelope [10].

“Airmail dress by Hüseyin Çağlayan (1999), Çağlayan designed his Airmail dress to be folded into an envelope and sent through the mail. The dress—made from Tyvek, a nonwoven, paper-like textile- incorporates the blue and red markings of postage envelopes. His Airmail collection appropriates the actual materials of global communication to create a streamlined wardrobe for the future.” [45]



Figure 2.27 Airmail dress by Hüseyin Çağlayan (1999) [45]

- Hüseyin Çağlayan's Remote Control cloth is made of glass fiber, metal, cotton and synthetic materials and can be deformed by remote control [46]. Wireless technologies put the function of directing on the body with clothes placed in the electrical circuit. Thus, the wearer can put the garment model into different forms at any time.



Figure 2.28 “Remote Control” by Hüseyin Çağlayan (2000) [46]

- Electric Girls ballet performance is the pioneer of today's led floodlight. Illumination of ballerinas on the skirt of ballerinas is hidden [47].



Figure 2.29 Ballerina dress with led light [48]

- Dress by its designers 24000 pieces of full-color leds, four layers of chiffon are embroidered on silk. It is the world's largest wearable screen [49].



Figure 2.30 World's largest wearable display- Cute Circuit's Galaxy Dress [50]

- In Kinetic Dress design, interactive communication is provided between the clothes and the wearer's moods and mood. Depending on the movements of the wearer, there are patterns with flashing led lights [51].



Figure 2.31 Cute Circuit's Kinetic Dress [51]

- In the interactive presentation that starts with heart, breath and trace, we see the garments consisting of technological designs produced by 3D printer technology. Wrapping clothes, colors and patterns create a whole new form of life [52].

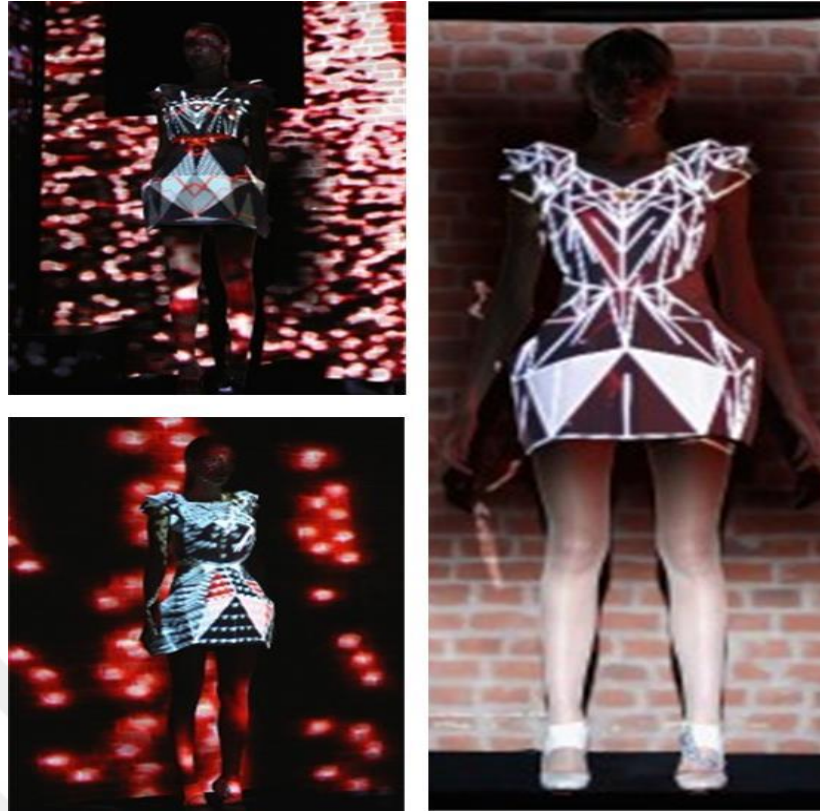


Figure 2.32 Life Print by Arzu Kaprol [52]

The need for dressing has changed and the desire for being different and the different impulse has come to the fore. This is why designers and engineers have designed smart textile materials in a different way and have directed products to new application areas that can bring visibility as well as functionality. Intelligent textiles, science, technology, design, social sciences, such as bringing together many areas, has led to interdisciplinary studies. It is seen that smart textiles will shape the future. And therefore, in the fashion and textile field, smart textiles have an important potential. Thanks to its intelligent textiles with superior performance features, high value-added products can be produced. This will be important in terms of sustainability and will provide awareness in terms of the country's economy. According to the fashion sense of the current consumption culture, fashion followers expect continuous innovation and change in ready-to-wear fashion products based on mass production. Wearable technology product designs of fashion followers offer alternatives with their functionality and originality.

CHAPTER 3

FASHION AND TEXTILE DESIGN

While fashion shows itself as a reference point in our clothing preferences, the temporary innovations bring out the passion of being original in us and where the imagination becomes concrete. Since it is shaped according to the conditions and possibilities of the current period and society, it is the mirror of the society and the period. Because fashion is influenced by changes in people's thinking and environmental, social, cultural and economic conditions. In addition, changes in science and mechanization affect fashion. The traditions, customs and demographics that societies have are also influential in every aspect of the fashion cycle. Fashion is influenced by many socio-cultural, economic and political factors.

Fashion, an abstract concept, is an area that embodies imagination. By making predictions for the future of the fashion, directing the designs requires being open to innovations.

Change is the irresistible rule of life. While everything in the world changes continuously, changing the fashion itself rather than being a prisoner of changing fashion makes it easy for us to keep up with this change.

Fashion is perhaps a self-renewing habit, depending on time. Breaking the previous habit and putting new habits in place brings a new breath to fashion.

To be able to reveal new and original designs, considering each culturalist's own cultural values; it is possible to be sensitive to art, to the environment, to people, to the world in which they live. In other words, reaching the universal line by blending with the colors of the local area brings together the innovative and creative works in fashion.

Developments in the field of technology, rapid urbanization and globalization add to the power of fashion, fashion shows, cinema, television, internet and more through social media all over the world at the same time and are rapidly spreading.

Considering its historical process, fashion is a phenomenon that can maintain its existence in parallel with the process of change and development of life, sometimes repeat itself but mostly renews itself.

3.1 What is Fashion?

Temporary innovations in human life with the need of change are expressed by fashion concept. Innovation is the source of fashion. Today, it is an integral part of our lives, but it is a concept that has been transformed into a large industrial sector. We will cover the fashion concept used for each product or service produced in this work and limit it as “clothing fashion”.

The concept of fashion derives from the Latin word “modus”. It means no boundary. It was used as “La Mode” in Medieval France. In English it means “fashion” [53].

Fashion has emerged with the passion of calling people change and revealing new forms. These are temporary innovations that arise as a result of the need for the society to decorate and change. It is the design of the present and the future by reflecting the personal worlds of people.

3.2 History of Fashion

XIV. and XV. Century Fashion: XIV. In the 14th century, with the Renaissance, new views emerged in the fields of science, art and literature in European countries. Clothing is no longer a necessity, now began to change depending on fashion. It was also accepted by law that the clothes were a status symbol. XV. In the 15th century, a fashionable aristocratic perspective prevails, in the following centuries this situation will change, and fashion will begin to descend into the lower sections [53].

XVI. and XVII. Fashion in the 16th Century: The development of cotton production in the world has played a leading role in the development of fashion. The United Kingdom (including India) is one of the countries where cotton production and industry are developing rapidly. The first cotton clothing was seen in the 16th century. By the 17th century, Manchester became a cotton country. East India used

cotton fabrics in the domestic market. The most requested fabrics in this period; French silk, English wool and silk. Cotton fabrics were preferred because they had a casting of French silk and were easier to clean [53].

XVIII. Fashion in the 18th Century: French fashion dominated the periods. Fashion expressed national dignity. With the French Revolution of 1789, the fashion has transformed from bourgeois style to folk type clothing and appearance. In the 16th Louisian period, fashion trade and fashion magazines emerged. From the French Revolution onwards, it is new to fashion, changing all habits and modernizing people. With the industrial revolution, mechanization allowed the increase in production and this increased cost. In this way, fashion is spread over different layers of people. With the decree issued in 1793 in France, everyone was given freedom of clothing. It is seen that fashion is affected by socio-cultural events in this century. Along with the French period, tailors have begun to produce personalized and optional new garments and haute couture has emerged [53, 54].

XIX. Fashion in the 18th Century: In this century, the human body and the style of clothing were discipline. 2. With the industrial revolution, ready-made clothing has become common. In 1846, the invention of the sewing machine (Elias Howe), the development of the sewing machine (Isaac Singer) in 1851 led to the development of the clothing industry. In 1857, newspapers had fashion pages. Between 1857 and 1858, the British entrepreneur, Worth, opened its first fashion house in Paris. The use of corsets has also emerged in this century. He was also the first person to present Charles Frederic Worth (1825-1895) models on live models [53].

XX. Fashion in the 18th Century: With the invention of the sewing machine, the garment products made in the homes increased. In this way, fashion is spread all over the people. The division of labor started in the garment sector and the garments became standardized. Newspapers and magazines often contributed to the spread of fashion by giving fashion inserts. This period is an active period in which fashion is reconstructed with a new concept every year. In the 1920s, with the First World War, the effect of unlimited freedom was reflected on the clothes. It is the most important feature of this century that social events affect fashion. World War I made the fashion more simple in this century compared to the last century. Fashion designers tend to meet the needs of the masses rather than small groups of customers. Women

started working in factories, railways and hospitals in World War I, which started in 1914. For this reason, women wear clothes that are more masculine and more prominent. In the 1930s, cinema began to affect fashion. In 1937, Marie Claire magazine was published. In the 1930s, the Parisian surrealist led the way for fashion. At the end of World War II, the social difference in women and men's clothing in Western Europe disappeared. In the 1950s and 1960s, the Pop Art movement emerged, neons were made, plastic and futuristic designs began to be seen. Courreges and Ungaro in France in the 1960s; In England, Quant created modern fashion. In 1964, Courreges created the space-age collection. Along with technological developments, sensitivity to nature and interest in nature have increased. At the end of this century, due to the economic crisis, the money spent on clothing decreased and second hand clothing market developed [53, 55].

Haute Couture: Haute Couture refers to luxury clothing that is custom made and produced by measure. The meaning of the word Couture means sewing clothes, sewing, or needle processing. Haute is supreme, magnificent, elegant and elegant. The "Haute Couture" statement, created by the combination of two words, represents an excellent artistic and uniqueness in the clothing industry. Haute Couture emerged in Europe with the desire of the bourgeois dressed up of tailors to wear out their work garments, which are uniform, but at least to be different in their nightwear. This movement was initiated in 1858 by Charles Frederic Worth of British origin in Paris. He is the first designer to put his brand name on labels. In 1945, the French Laws "Haute Couture" has been protected. In the 19th century, Charles Frederic Worth came to Paris from London to work for Napoleon III. Five years after his arrival in Paris, he created modern Haute Couture from traditional garment production. He invited his customers to his workshop and displayed his collections on live models. Before this system, customers would call the designers home and tell them what they wanted. The fashion house of Worth was closed in 1956. Jacques Doucet, who came after Worth, and Degas, Monet and Van Gogh were influenced by this movement and followed Worth's steps. In 1898, Doucet opened a new era in this field and introduced the logic of cultured designers [53, 56].

In order to qualify as an official Haute Couture design house, it must meet the requirements of the French Ministry of Industry and Fédération Française de la Couture. First, a designer should prepare custom designs for personal clients and

offer personal accessories [53, 57]. At least 20 full-time technical staff are required to conduct workshops. He should present his collections twice a year, including in January and July, only for an elite section [53].

Today, the fashion houses such as Elie Saab, Iris Van Herpen, Viktor & Rolf, Karl Lagerfeld / Chanel, Dior, Giorgio Armani, Alexandre Vauthier, Fendi, Jean Paul Gaultier are the most successful brands in Haute Couture. In our country, we have designers who make many successful Haute Couture such as Raşit Bağzıbağlı, Arzu Kaprol, Bahar Korçan, Cengiz Abazoğlu, Cemil İpekçi, Dilek Hanif, Faruk Saraç, Özgür Masur, Yıldırım Mayruk, Tuvanam and Özlem Süer.

Pret-A-Porter: In 1949, Weill introduced the pret-a-porter. In contrast to the Haute Couture tradition, Pret-a-porter is a high-quality, factory-made fashion produced in mass production. Garment products are adopted by every cut [53].

3.3 States of the Fashion Process

In Fred Davis' book titled Fashion Culture and Identity, the stages of the fashion process, which Sproles explained on the basis of its 5-phase scheme, were defined as inventing, promoting, pioneering in fashion, increasing public visibility and exhaustion of fashion [53].

3.3.1 Invention

The basis of the invention of a new product in fashion is the desire to change. The aim of innovation in fashion is not intended to be useful. The ultimate goal is to create unique designs. The invention in fashion is not always the result of a designer's original designs or creative ideas, but can also occur as a result of coincidences. To give an example of a product or a design to become fashionable [53];

- To show the value that Prince De Gall gives to a woman who gives her flowers, she puts a hole into the left bank of her jacket and puts on flowers to show her the value of the present.
- Ruff collars that a Spanish princess wore to hide her goitre neck became fashionable.
- The mini skirt is fashionable when Mary Quant burns the skirt of the girl working in her atelier.

3.3.2 Promoting

At the basis of the introduction, the new designs of fashion designers need to be spread to the whole world at the same time with the fashion shows and other communication channels. The fashion, which lives in a multi-season period, especially in autumn and spring shows, is experiencing a period when new products are produced before the promotion process is completed [53].

3.3.3 Leading in Fashion

The pioneer in fashion can be defined as acceptance, acceptance or rejection of a new fashion. From the time of the Haute Couture period, the palace leaders and the aristocratic sector were seen to lead the fashion. XIX. From the century up to today, more upper classes have been pioneered. Nowadays, everyday fashion consciousness has developed. In addition, fashion shows made thanks to information and communication technologies, designs of the next year are easily transferred to individuals from all walks of life [53].

3.3.4 Increasing Visibility Within The Community

The visibility of fashion in society starts with fashion shows. The next step is to transfer these fashion shows to target audiences by means of mass media.

3.3.5 Fashion Exhaustion

It is the beginning of a new fashion cycle. It only means the end of the existing fashion. Therefore, the fashion cycle is ongoing.

3.4 Which Factors Affect Fashion?

Fashion varies according to every period and every society. It is a phenomenon that is at the center of change. Fashion is influenced by many socio-cultural, economic and political factors.



Figure 3.1 Changing fashion [58]

Changes in people's thinking structure, changes in taste and requirements are also influenced and changed by fashion. With the desire to be different, the individual can express himself by making original choices. This is possible in contemporary societies.

In the rapid developments in technology, the power of fashion has added power. So combining technology with fashion makes it possible to design both functional and modern textile products.

The colors and lines of the year are determined by the International Fashion Council. The decisions of this council are guided by current sociological, psychological, economic and political factors in the world.

3.4.1 Economy

Today, fashion is manifested in every field. Economic factors significantly affect fashion. The general economic situation, poverty and wars in countries change people's fashion preferences. According to economic developments, the quality and display of the fabrics used in clothing come to the fore. Fashion is also directly influenced by the prices of materials or materials used in products [58].

3.4.2 Politics

Political changes are a reflection of contemporary fashion. Political events, laws, political revolutions affect fashion and constitute trends. For example, the Hippie movement that emerged during the Vietnam war in America became a fashion that

protested the war among young people [58]. Fashion is a phenomenon shaped by politics and economy. When we look at the history of fashion, some clothes and accessories have become widespread in the use of politics.

3.4.3 Technology

Technological advances have a great influence on fashion preferences and the development of the fashion industry. TV shows, fashion shows, films, events, music videos and advertisements are also effective in the spread of fashion trends.

3.4.4 Media

Media plays an important role in fashion. Criticisms, guidelines and comments in television, newspapers, magazines, fashion websites, blogs and social networks guide us to determine fashion choices in recent years.

3.5 Fashion's Place in Our Life

People's basic philosophy of life; it is about living well, feeling good and looking good. Looking good makes us feel good; Feeling good is also the basis of good living. And fashion reveals a passion for being original and loving.

Fashion is a process that begins with the establishment of human beings and especially with the formation of aesthetic perception. It is constantly changing and renewing itself.

The place of fashion in our lives is undeniable because it is already in life. Fashion is current, popular and original. Fashion is a creation process inspired by many things. Fashion, nature, culture, history, literature and fine arts, ideas and ideas, cosmopolitan social structures are fed from many sources, such as. Fashion is the magical mirror of societies, traditions, events. Today, it is a concept that has been transformed into a large industrial sector.

3.6 Fashion Change and Fashion Consumption – Future of the Fashion

Clothing and appearance from the past to the present has been important for people. Although the meaning of clothing and fashion has changed, people have never lost their lives. The production change and consumption of fashion are affected by all economic, political and cultural issues and it affects all segments of society. Given

that fashion is a process of creation, it is unlikely to compress fashioned fashion with intellectual and intellectual accumulation into just one calendar period. That is why; something that is fashionable in the old days is considered to be fashion today, and the ones that do not go out of fashion are fashion.

Fashion is constantly undergoing a constant and continuous renewal under the guidance of a complex and established system, which is not under the control of the requirements, but the necessity of being privileged in society, the innovations in the art of tailoring and the change of economic thoughts. The fashion industry has now not only been able to meet the needs of shopping and fashion lovers, but also has the ability to shape their wishes. With the increasing history of daily life, we are turning to products that make our lives easier, making technology an indispensable part of our lives. And now fashion is shaped not only by fashion trends but also by technology trends.

CHAPTER 4

DESIGNERS COMBATING TEXTILE AND TECHNOLOGY

4.1 Textile, Technology and Designers

Design is a creative process that takes a specific purpose. In this process; By developing prepared sketches and plans, the idea of the existing design is transformed into a concrete product.



Figure 4.1 Special designs

- a) Elie Saab Couture spring summer 2015 Paris [59]
- b) Adler "Brocéliande" collection [60]
- c) Sophia Webster shoes [61]

There are 5 basic principles of a design. Equilibrium, proportion and visual hierarchy, visual continuity, integrity and emphasis [62]. Equilibrium is to ensure the unity of the design elements forming a composition in harmony and relations. Ratio is the relationship between dimensions. Visual hierarchy is the measurement of visual elements according to the message to be emphasized. Visual continuity is the ability of design elements to provide smooth transitions. Integrity means that design elements have a holistic meaning in relation to each other [63].

The emphasis is focus of the design. Raw materials of a design are as follows; line, tone, color, texture, format, measure and direction. In the light of these, design process, definition of problem, information gathering, creativity and invention process, finding and applying. In this context, it is about the vision of the designer that the innovative textile materials produced in the textile sector are combined with the fashion to the garment sector [64].

The designer is described in different ways in different sources. So what is the designer called? The Designer is a person who turns forward-looking, innovative, original and original ideas into a concrete product with a specific purpose. The designer offers products that are suitable for the environmental conditions. However, when it comes to fashion, it is seen that textile products that are believed to be in need of individuals are not designed to respond directly to the needs of individuals. Because human needs; it changes and varies in parallel with the scientific and technological developments. And this situation affects the design process to a large extent. In a design process; The design affects the product and the designer as much as it affects the cultural, economic and social factors. In order to increase the quality of human life, creativity and intelligence; technology, design, art, engineering, economics and social sciences are combined with interdisciplinary studies, resulting in technological designs.

Wearable technology products have emerged as a result of the use of information and communication technologies on garments and the integration of technology with textiles. These innovative products, which come from our imagination and become part of our lives, make life easier and increase the quality of life. In the Coded Couture exhibition where wearable technology designs are presented, the exhibition curators have defined the coded tailor: Beyond being just the size of the clothes that fit the size of your body, it gives you access to your soul, communication with others around the world and even your own creativity [47].

In this part of our thesis, we will talk about the designers who do not know the boundaries of creativity, bring together textile and technology.

4.2 Sample Designers

4.2.1 Genius Fashion Designer Hüseyin Çağlayan

Hüseyin Çağlayan was born in 1970 in Nicosia, Cyprus. In 1993, he graduated from Martins Fine Arts University, Department of Fashion Design. He started his career in Soho, selling his designs. He won the first place in a fashion competition in London. He started to prepare his collections with the prize money he won. Hüseyin Çağlayan's first dressed singer was Björk. In England in 1999 and 2000 he was twice fashion designer of the year. He won the Design Star of the Year Award by The Fashion Group International in New York. In 2006, he was awarded the Order of English Knight. He brought together technology and design by making changes in the form and functionality of the garment [47]. There are technological fabrics, control mechanisms, microchips, laser lights are included in his designs [65].

- Airmail Dress

When folded, this dress can turn into a standard letter envelope. The dress is made of paper-like textile, which is Tyvek (a material with a high tear resistance but easy to cut with scissors or a knife, which is waterproof but waterproof synthetic, similar to paper). Communication, transfer and migration are processed in this envelope [65].



Figure 4.2 Airmail dress (1999) [65]

- Aeroplane Dress / Remote Control

This dress consists of glass fiber, metal, cotton and synthetic materials. It is made of a composite material which is formed by a mixture of fiberglass and resin poured into a special mold. The skirt sides and backs of the garment can be moved and closed by a remote control. Wireless technologies put the function of directing on the body with clothes placed in the electrical circuit. Thus, the wearer can change the garment's pattern at any time [66].

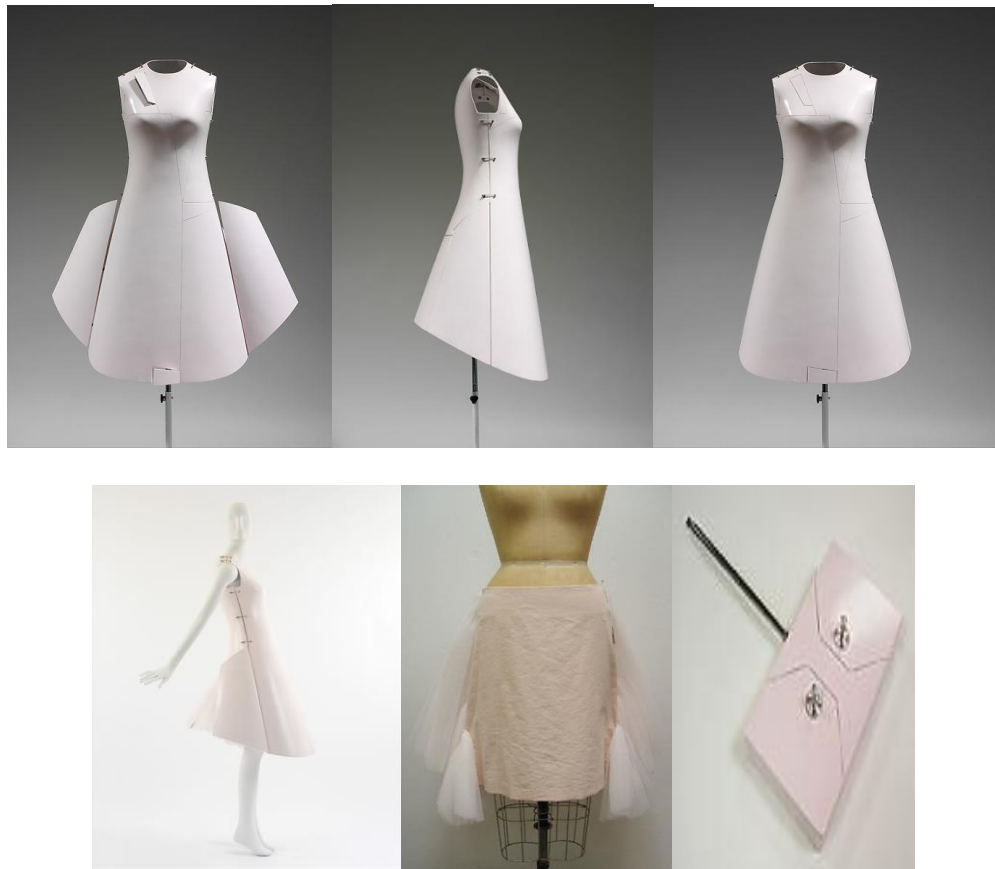


Figure 4.3 Aeroplane dress / remote control (2000) [66]

- “One Hundred and Eleven” Collection

This collection is made up of moving clothes. The theme of the collection is the transformation of an era to another [67]. Self-expanding skirts, a growable and shrinkable hat, open and close catches and pulling into a hat is designed by using mobile clothing [68].

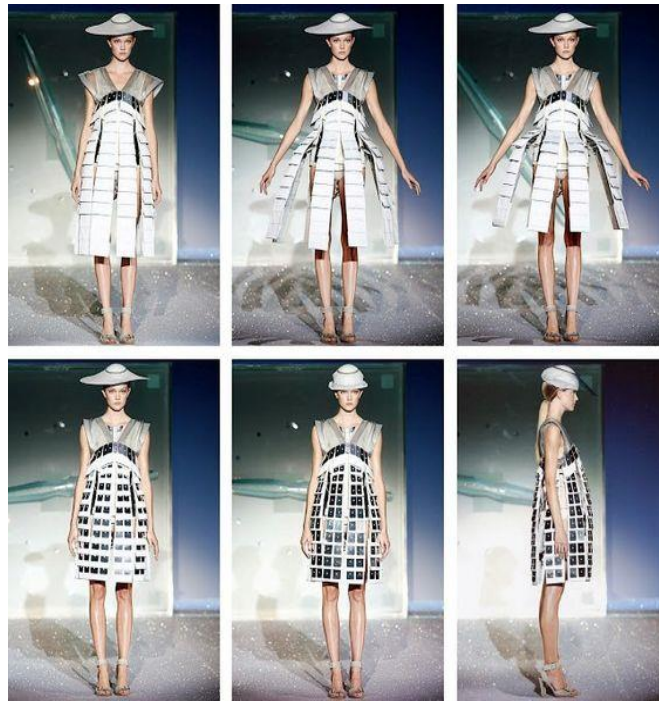


Figure 4.4 “One Hundred and Eleven” collection [69]



Figure 4.5 “One Hundred and Eleven”- mechanical transforming dresses [70]

- “After Words” Collection

The theme of migration and asylum was studied. From the idea that an individual will carry the basic furniture of a living room in his body, clothes and objects that have different meanings and functions when they are transformed are designed [71]. The seat covers that can be turned into clothes and the coffee table that turns into a skirt are part of this collection.



Figure 4.6 “After Words” collection (2000) [67]

- Readings

These dresses were awarded the British Insurance Designs of the Year by the London Design Museum in 2008. The dresses are decorated with Swarovski crystals. And is illuminated by laser from the inside. These crystals reflect, taking laser beams. Designs are in constant communication with the audience [72].



Figure 4.7 Laser dress and laser hat [72]

- Airborne – The Video Dresses

Video Dresses is created with 15000 LEDs placed under the fabric [73]. One of the clothes shows the shark floating in the ocean while the other dress shows the rose flower.



Figure 4.8 Airborne – The video dresses [73]

- Intel's Curie Module Powered Smart Belts and Glasses



Figure 4.9 Smart belts and glasses [74]

During Paris Fashion Week, in the Room Tone show, the processor manufacturer designed accessories with Intel. The arches and goggles developed by Çağlayan reflect the stress level of the wearer. Models used Intel's Curie module to wear smart belts and goggles. Accessories measured the stress level of the models. He projected the measurement results onto the podium wall [74].

The spectacles detect the biometric data via the sensors. By using Curie's Bluetooth connection, it sends it to the belt produced with the 3D printer. And the belt uses this data to transfer the image to the wall through the projector. The EEG electrodes in the glasses read the asymmetric brain wave activity from the contacts. The optical heartbeat sensor and microphone in the nasal belt measure heart and breath rhythms.

Intel Compute Stick is used in the belt. This allows the belt to process and visualize the data from the glasses. The Curie module is a small chip that supports wearable technology products with low power consumption. It has many features. It can make many different objects smart [74].

4.2.2 Interactive Fashion Designers Ryan Genz and Francesca Rosella

CuteCircuit is a leading brand in wearable fashion technology. Advanced technology and smart fabrics are brought together and different designs are made. It was founded in 2004 by Francesca Rosella and Ryan Genz [75].

In the future it is thought that our body will interfere with the data. For this reason, they design smart clothes that enable users to communicate with each other in a more intuitive and intimate way.

The haute-couture outfits produced by the cutting-edge technology are preferred by the Cutecircuit brand.

- **The Hugshirt**

HugShirt was designed to meet the need for human bonding and closeness in 2002. It is the world's first wearable haptic telecommunication garment. This design creates a feeling of embracing and embracing each other away from each other. The temperature and pulse rate felt by a tight embrace through sensors placed inside; via cell phone or bluetooth. Rechargeable and washable. In 2004, he won the first prize in the design innovation category. In 2006, Time Magazine named it one of the best inventions of the year [76].



Figure 4.10 The HugShirt [75]

- TransforMe Collection

It is the first collection prepared. The collection consists of chameleon skirts and evening dresses that react to movement. Kinetic Dress provides interactive communication between clothes and the person who wears the dress. Flashing LED lights are used to create patterns that match the movements of the wearer.



Figure 4.11 K-dress by CuteCircuit [77]

"We are living in a digital future, so we do not need to sell 10,000 skirts," says Rosella. We could sell 500 skirts, but then could sell thousands of patterns that you download to your skirt." [77]

- CuteCircuit X-Saab

In 2006, he designed the world's first solar gear [75].



Figure 4.12 X-Saab [75]

- The M Dress

The wearer can make a phone call without having to carry a mobile phone. The SIM card is placed on the label of the suit. The Worldments First Wearable Mobile Phone Garment [78].

- Galaxy Dress

This dress is constructed by laying 24,000 full-color micro leds on four layers of chiffon. Tiny micro leds make it possible to change patterns or colors instantly. It is depicted as the world's largest wearable screen. LEDs are 2x2 mm thick. With the Swarovski crystals on the dress, the dress offers a radiant and aesthetic appearance while the leds are not lit [79].



Figure 4.13 Galaxy dress [79]

- T-ShirtOS and Infini-Tshirt

These T-shirts are customizable. It is the world's first IOS operating system applications. The application animates images, animations, photos, tweets on t-shirts through their applications [78].



Figure 4.14 T-ShirtOS and Infini-Tshirt [78]

- U2 Jackets

U2 music group, on the 360 ° world tour, wore jackets that accompanied the rhythm of music by reflecting the flashing colors from the small holes on the jacket, thanks to over 5000 LEDs. Real-time wireless control [80].



Figure 4.15 U2 jackets [80]

- Subsonica Jackets

The Italian Rock band wore Google-powered jackets designed by Cutecircuit. These jackets allowed fans to interact interactively with the stage show. The animations and images created by the fans were reflected on the jackets of the singers during the stage performances through mobile phones [78].

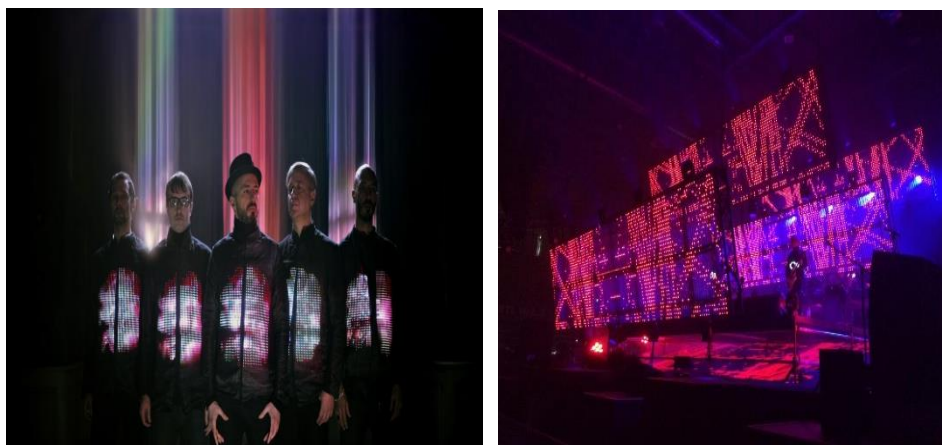


Figure 4.16 Subsonica jackets [81]

- Twitter Dress

Nicole Scherzinger wore the world's first Haute Couture Twitter dress. The black chiffon evening dress with Swarovski stones incorporates fashion and technology. The tweets sent by the fans are reflected on the dresses through the microleds [82].



Figure 4.17 Twitter dress [82]

4.2.3 Fashion Designer Who Used Interface as a Fashion / Engineer of Fashion **Anouk Wipprecht**

Anouk Wipprecht is a Dutch designer who combines fashion and technology at engineering level. With his designs, he pushes the limits of imagination. At the age of 14 he started studying fashion design with analog clothes. When he was 16-17 years old, he combined fashion with robot technology. Fashion design, engineering, robotics, science and interaction / user experience has brought together. Anouk Wipprecht FashionTech designer [83].

FashionTech is a combination of fashion, technology and interaction design. Design is intended to create any technology-based dialogue with the user's body or the environment. It uses the interface as a new fashion. Intel collaborates with companies such as AutoDesk, Google, Microsoft, Cirque Du Soleil, Audi and 3D printing company Materialize [83].

She is interested in emotional, cognitive, and sensual experiences stemming from the closeness of fashion to one's body and identity. Wipprecht therefore devoted himself to producing technological clothing that would trigger various experiences, behaviors and interactions [83].

- Robotic Spider Dress

The designer aims to protect the user's personal space with this dress. Designed with 3D printing method. The Intel-Edison chip is integrated to prevent people from entering your personal space. The Intel-Edison-based Spider Dress consists of sensors and movable arms. In a situation that threatens the user's personal space, moving arms resembling the spider legs around his neck are automatically moving. It extends in response to external stimuli or retracts intuitively [67, 84].

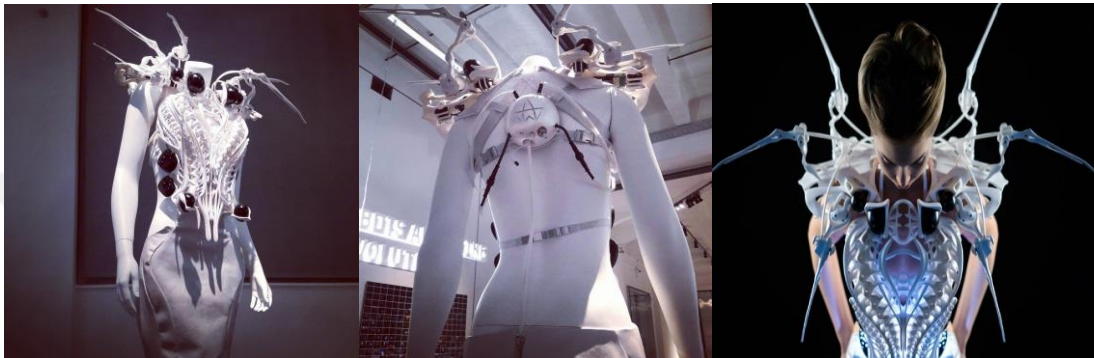


Figure 4.18 Spider dress [84]

- Smoke Dress

As with Robotic Spider Dress, the purpose of this dress is to protect the user's personal space. Manufactured from polyamide and rubber-like materials with 3D printing technique. When an outsider comes too close to wearing these clothes, the dress starts to smoke. The resulting smoke screen allows the user to camouflage himself. Designed using a special microcontroller and sensor system [67, 85].



Figure 4.19 Smoke dress [85]

- Intimacy Black

Intimacy Black is a futuristic dress. It allows the user to experience a completely super-natural experience with his skin. The project consists of high-tech garments made with wireless, interactive technologies and smart foils that can become transparent when electrified [86].

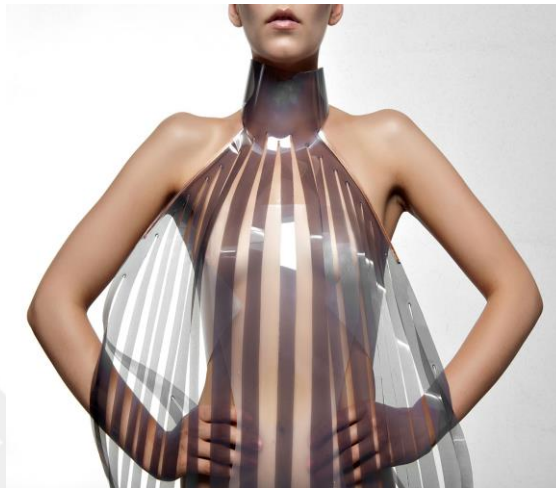


Figure 4.20 Intimacy Black [87]

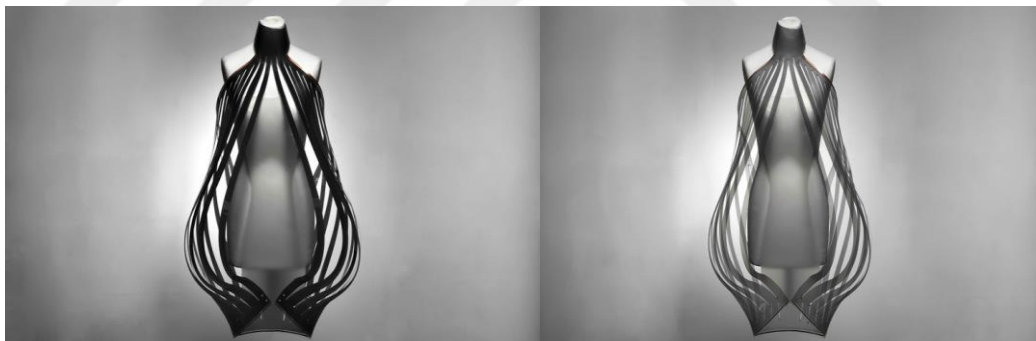


Figure 4.21 Black to transparent [88]

- DareDroid

It is a biomechanical dress designed to present a freshly made cocktail. One-on-one interaction with the dresser is required. This dress is rewarded with a cocktail in return for playing the game of truth or dare on the touchscreen. Sensors placed on the neck undertake to act as sensors and distribute the cocktail through the technological system [89].



Figure 4.22 DareDroid [90]

- Synapse Dress

The dress reports the true feelings and thoughts that people feel in the face of their ability to read bio-signals such as heart beat and brain activity. Thermoplastic Polyurethane, which is a very flexible material, is produced in 3D printing technique. In addition to the ECG, the proximity sensor, camera and LED lights are placed on the dress. The leds used in the dress help to understand the person's feelings more clearly by shining a bright or more relaxing light [91].

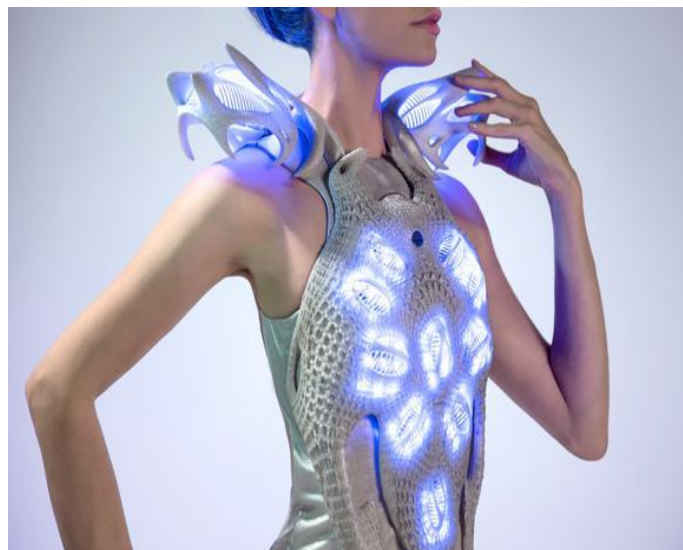


Figure 4.23 Synapse dress [91]

4.2.4 Outfit Architect Arzu Kaprol

Arzu Kaprol, who sees his fashion design as Outfit Architecture and loves to design the whole, was born in 1973 in Bursa. She spent his childhood in her grandmother's fashion house. This facilitated the choice of profession. In 1992, she graduated from Mimar Sinan University Fashion Garment Department. She then completed the Perfectionnement program at the Paris American Academy for couture training. In 1995 he received the Beymen Academia Avant-Garde Designer Award. In 1998, it established its own brand. In 2007, it opened its first store. Between 2008-2012, she had a license agreement with Beymen Group. Won the fashion designer of the year award. In 2011, Paris Fashion Week, Fashion Federation has started to make fashion shows in the official calendar. And opened an office in Paris [92].

Successful designers, who bring fashion and technology together, are internationally known for their garment and Atelier collections. The collection has been the choice of world famous names like Meg Ryan, Milla Jovovich, Kelly Rowland, Gisele Bündchen, Angela Lindwall and Chanel Iman [93].

The designer who loves the modern silhouette and dreams of designing the future; everyone wants to wear the clothes he designed. For this reason, it is very modern and very global. But when they open the inside of their back and skin touch their own signature makes the place. It also makes little touches for the wearer to feel well [93].

Turkey's first fashion show designed the hologram, is offering the first digital designer couture show. Arzu Kaprol is a modern and unique designer. She designs timeless clothes with original craftsmanship that grows in details identified with her [93].

- Smart Jacket

Arzu Kaprol has designed the Smart Jacket which changes the function to protect the user according to climate changes. The Vodafone Locate is integrated on the jacket. The Vodafone Locate can work with GPS to precisely determine location [94]. With the Vodafone Locate you can track where the jacket is. When the panic button is pressed, the user receives the Vodafone sim card information and the message that the user has selected [95]. In the winter room of the jacket, automatic extension of

the jacket length, closing of the hood, rising of the collar and backrest heating are activated. In the summer room feature, features such as automatic shortening of the jacket, hood opening, collar lowering and back and wrist cooling are activated.



Figure 4.24 Smart jacket [96]

- “Life Print” Collection (2016)

8. Mercedes-Benz Fashion Week Istanbul's opening fashion show models, Arzu Kaprol's Life Print collection introduced. This collection was designed using a 3D printer. In the interactive presentation that starts with heart, breath and trace, we see the garments consisting of technological designs produced by 3D printer technology. Colors and patterns change into a whole new form [52].



Figure 4.25 “Life Print” collection [52]

- “The Source of Life” Fashion Show (2016)

At the Vodafone Digital Transformation Summit, Arzu Kaprol realized the Life Source of Life theme. The designer has combined digital and technological developments with fashion. Arzu Kaprol designs, clothes, jackets, bolero and fiber optic cables are used on the belt. The design and distribution of Fiber Optic cables on the dress has been the most beautiful fashion reflection in the world of technology. The designs illuminate itself and the scene in the dark thanks to fiber optic cables [97].



Figure 4.26 “The Source of Life” fashion show [97]

- “Inter-Being” Collection (2017)

During the Istanbul Fashion Week, fashion fans watched the show with virtual reality glasses. Thanks to these glasses, guests watched each piece of the collection in a simulated form within the universe created in the virtual world. All the guests seemed to be enchanted at the end of the fashion show. The Inter-Being collection is based on the philosophy that all beings, people, animals cloud, flowers, sky and sea are connected with each other invisible red ropes and a whole [98].



Figure 4.27 Inter-Being [98]

- “Enchanted – Magical” Collection (2018)

In Paris Fashion Week, Arzu Kaprol introduced ARZYU's collection named AR Magical Paris. It is a collection of technology and couture techniques. 3D print, laser cutting, special fiber optics and hand work were used together. The collection includes self-illuminated bridal gowns with fiber optic cables [99, 100]



Figure 4.28 Enchanted collection- Fiber optic wedding dress [99]

4.2.5 The Designer Who Pushes The Limits Of The Body With Three Dimensional Printing Iris van Herpen

Iris van Herpen is a designer who brings together technology and traditional couture mastery. It uses the most traditional and innovative materials and ready-to-wear methods. Her designs have surreal fascination [101].

The designer expressed her vision as follows: Fashion is much more than an industry; the dialogue between us and our outside.

Sometimes a garment is fully adapted to the body and dances. Sometimes it is the opposite, the garment decides how the body moves, and I look for this distortion and intuition. In her designs, she aim to create an unknown space for the future in a more diverse and conscious fashion [101].

Iris van Herpen uses technology as a tool to improve their design. It uses 3D printing technology in avant-garde fashion designs. Through 3D printing, it is possible to create forms that are not possible by traditional methods. With this printing technique, the boundaries of the body are forced both volumetric and conceptual.

High-tech materials in Iris van Herpen's designs; It can be transformed into a cloud of smoke, a ring of leaves, or folding bones [101].

Due to her interest in science and technology, the designer is in constant contact with CERN (European Nuclear Research Organization) and MIT (Massachusetts Institute of Technology) [101].

- Shift Souls

The designer describes this collection as the evolution of the human form. The collection, which is inspired by the sky maps and the galaxies in space, consists of eighteen different parts consisting of voluminous layers [102].

Shift Souls, 3D printing, laser cutting, algorithm-defined multi-layered sculptural forms. Made of dyed silk with color transitions. In order to obtain the layers, frames were made of PETG filaments with a thin 3D laser cut. In this way, the parts look like a hybrid bird shape when worn [102].



Figure 4.29 “Shift Souls” collection [102]

- Transforming Fashion

It is composed of fascinating designs where art, fashion and technology are intertwined.



Figure 4.30 Transforming fashion [103]

The most notable of these designs is The Dome Dress, designed with innovative materials inspired by the weather. This light suit is made of 3-dimensional domes with a volume, laser cutting and metal lace. Super fine metal laser cutting is done [104]

Van Herpen explains: “We tried 3-D printing for this dress and made printed molds to cast this pattern, but I wasn’t satisfied with the way it moved. So we stopped the 3-D printing and instead, we laser cut the superfine metal, which we then manipulated into half-sphere domes by hand. I could create lots of volume and movement without the weight. After that, the domes were attached through heat-shrinking tubes and some bits were adjusted and fine-tuned with needle and thread. There is also silk tulle lining the inside, and to make it look seamless, the lining was hand-stitched from eight layers of tulle in a gradation.” [105].



Figure 4.31 The Dome dress [106]

4.2.6 Designers Who Sees Technology as an Aesthetic Tool Pauline Van Dongen

She is a Dutch designer who specializes in wearable technology. It combines new technologies with traditional techniques and fashion.

- Solar Parka

The waterproof, slim and flexible solar panel is integrated into one of the front pockets of this jacket. Thanks to solar panels, it can capture the sun and turn it into electricity. The photo-voltaic cells in the front pocket can produce enough energy to charge a smartphone for 2 hours [107].



Figure 4.32 Solar parka [107]

- Mesopic Jacket

It is a design that aims to increase human visibility and security measures in dark environments. Developed with Philips Research. It is a light silver and semi transparent jacket. Philips textile LED ribbons are integrated into the fabric to create a light-emitting jacket [108].

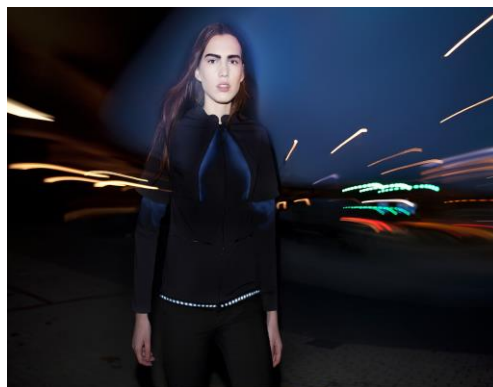


Figure 4.33 Mesopic jacket [108]

- Wearable Solar Dress

It is a suit that can be used for the purpose of charging the solar panels and charging the phone. It is a different design both in terms of functionality and sustainable. Solar energy panels are not erect. Therefore, she has designed small pockets for these panels using leather [109].

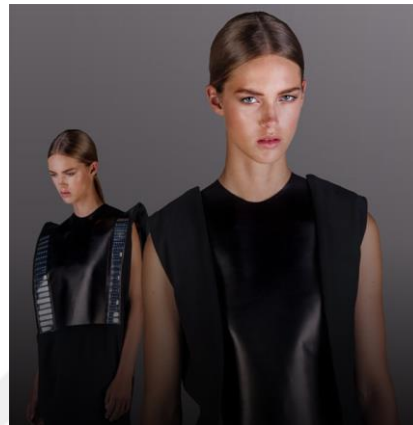


Figure 4.34 Solar dress [109]

- Vigour

This cardigan is designed to support the life of the elderly. It allows for regular exercise and monitoring of elderly people who need muscle stretching. Thanks to 4 sensors made of conductive yarn, the movements of the upper body are monitored and data is transmitted. There is an iPad application that provides direct feedback to both the user and the physiotherapist. Clothes can be worn all day. The sensors in the sweatshirt designed with three-dimensional printing technology should be removed when washing [110].



Figure 4.35 Vigor cardigan [110]

- Skynfeel Apparel

Small laser flaps on the edges of the overalls are designed with inspiration from dragonfly wings [111]. Thanks to aerodynamic design, these flaps provide an extra boost to the athlete / athlete. Therefore, it gives time and distance in the air.



Figure 4.36 Suit for long jump athletes- Skynfeel apparel [111]

- Fysiopal

Fysiopal acts as a second skin that measures tactile signals around the neck, shoulders and back. It has sensory features and communication software. Tactile feedback helps the wearer to correct posture disorders (hump). Designed for use under normal clothing. Dongen has worked with the touch screen company Elitac to create FysioPal, which includes sensors that match the smartphone app. Sensors integrated in the T-shirt; It measures the position of the neck, back and shoulders of the person. The collected information and measurements are transferred to the smartphone application and evaluated instantly. When a posture disorder is detected, it gives a slight vibration and warns the user to change the way he / she is sitting and stopped [112].



Figure 4.37 Fysiopal [112]

4.2.7 Origami ve Archigram Designer Ying Gao

Ying Gao is a professor at the University of Quebec, Montreal. She is also a fashion designer. It combines fashion design, product design and media design. He thinks that clothing is more poetic and interactive with sensory Technologies [113].

- (No)Where (Now)Here

This project consists of 2 interactive clothes. Designed using super organza fabric, photoluminescence yarn, PVDF and electronic equipment. Robotic actuators connected to the face recognition sensor are integrated in the fabric. As the user's facial expression changes, the colors of the garment appear to fade [114].



Figure 4.38 (No)Where (Now)Here [114]

- Walking City

Cotton, nylon and electronic equipment and pneumatic technology consists of 3 interactive clothes. These interesting dresses are fun designs because they are inflatable afterwards. Pleated fabrics take many forms that resemble Japanese origami [115].



Figure 4.39 “Walking City” Interactive clothes [115]

4.2.8 Designer Sisters Ezra ve Tuba Çetin

Ezra and Tuba Çetin brothers design technological clothing by blending technology with their creativity. They attach importance to the consumer's feeling comfortable.

Ezratuba brand is a worldwide successful brand in nano technologies and wearable technologies. In collaboration with Intel, different designs are made [116].

- Butterfly Dress

Butterfly Dress is a design that changes the way people approach fashion. It is made of a luxurious jacquard nested using metallic Lurex fibers. The dress is decorated with butterflies. There is a proximity sensor on the dressing that allows the butterflies to react to external stimuli. At first the butterflies fly slowly. Then it is moving. Butterflies can be flown and released collectively at a dramatic launch triggered by a person or a mobile device communicating through the wireless network [117].



Figure 4.40 Butterfly dress [117]

- Smart Clutch

3D printing and LCD technologies are used. The body of the bag is composed of images that reflect various designs and colors with 3D printed, high brightness LCD screen. The design is compatible with Android and can be controlled with applications. Smart Clutch has several outputs for batteries and chargers [118].



Figure 4.41 Smart clutch [118]

- Heart Attack News T-Shirt

Ezra and Tuba Cetin brothers, the heart attack of their mothers after a heart attack in advance to recognize the t-shirt designed. The very, very small chip version of Holter, which regularly follows the rhythm and certain values of the heart, was placed in a way that would not disturb the person in the shirt. The T-shirt constantly checks the heart and detects any problems that may occur. By telling the doctor if there is a problem, it minimizes the risk [119].

CHAPTER 5

DESIGN METHODS OF INNOVATIVE TEXTILE TECHNOLOGICAL TEXTILE PRODUCTS and CURRENT APPLICATIONS

5.1 Introduction

Wearable technology products are often described as wearable computers, smart textiles, or technological devices that can be integrated or worn on the wearer's clothes / any material they carry [47].



Figure 5.1 Wearable Technology [120]

Innovative wearable technological textile products, health, defense, security, communication and so on. not only in areas but also in the fashion world. In this way, designers push the boundaries of creativity and innovation to produce products out of the ordinary. When the design processes are examined, it is seen that the concept of multi-discipline plays an important role.

These products make life easier and improve the quality of life.

There are many classification methods for the production methods of these products and are categorized according to the methods obtained in this study:

- Chromic Textiles - Smart and Color Changing Textiles
- Electro-Textile Garments (Electronic / Conductive textiles, obtained from fibers)
- Fiber Optics

5.2 Production Methods

5.2.1 Chromic Textiles - Smart and Color Changing Textiles

Color-changing chromic materials provide both intelligent and color-changing textiles with both technological and aesthetic features. Application of chromic substances to yarns / fabrics has brought a new field of application to textile and fashion design. The color changing feature, depending on the light and heat, makes it possible to design fabric and garment designs in individual colors by responding to heat changes in the body according to the user's mood. The change of color depending on the light forced the limits of imagination [18].

With the stimulating effect of chromic materials, external factors, chemical bonds in the molecular structures are broken or equalized. As a result of this, optical modifications such as reflectance, absorption, propagation and transmission occur in the electron equalization. These materials have the ability to change colors, discolour and emit colors. These chromic substances can be transferred to textile surfaces by different methods (paint, printing, finishing, coating etc.). Chromic materials applied in textile field; photochromic (light-changing materials) and thermochromic (heat-changing materials) applications. The textiles obtained by these applications change color by reacting to heat and light. The textiles which can change color against the effect of light rays and body temperature are included in this group. These textiles are preferred in terms of adding aesthetic and visual richness.

Thermochromic dyestuffs change color with heat effect. It changes the heat storage property of textile surface due to its reversible color change feature. Heat storage in dark colors and light reflection in light colors increase. Due to these properties,

thermochromic dyes are used in the firefighters' uniforms. Thermochromic materials have two types; liquid crystal and leuco paints. The difference between these two types; leuco paints have a single-color transition [121].

Photochromic dyestuffs change color with the effect of light rays. These materials work with the principle of light absorption. The use of light-sensitive microcapsules also gives the ability to change color. The washing life of microencapsulated dyes is limited. T-shirts, which provide visual awareness about activity level with the increase of heart rate and body temperature and color change feature; it is located.

5.2.2 Electro-Textile Garments / Conductive Textiles

Intelligent textiles with electronic features can be produced in three ways [10]:

- Adding electrical or optical properties to textile fibers
- Integrating circuit or LED systems with textile surfaces
- Developing hybrid approaches combining commercial and textile-related functionality concerns

Electronic textiles, garments, anti-static material, impregnation of the fabrics [47].

Textile-based information and communication technologies where electronic parts (mobile phones, mp3 players, cameras, computer keyboards, microphones, led lights etc.) are integrated into the clothes are also included in this group. To monitor the vital activities of the wearer such as heart beat, breathing, heart rate measurement, and follow up with wireless communication network. Wearable electronic textiles make life more reliable, healthy and comfortable. The first research on this subject is the research done for the use in clothing. For example, the structure contained in the conductive fiber, optical fiber, monitor with a vest to detect the bullet that pierced the vest is designed. If the optical fiber is damaged, the signal to the monitor is interrupted. Thus, the information that the soldier was attacked reaches the buyers.

5.2.3 Optical Fiber / Fiber Optic

Optical fiber is a flexible and transparent fiber made of high-quality sprayed glass or plastic. These fibers are preferred for wearable technology due to their light-emitting properties. Optical fibers are a communication technology that delivers sound, data and images through light signal, while creating beautiful effects in the fabric. Optical

fibers are used in the transmission of light fibers, which allows the transmission to be at longer distances and with a wider bandwidth [10].

5.3 Wearable Technology Applications

Wearable technology applications are smart applications that make our lives easier and bring us together with technology. Wearable technology products have emerged with the use of information and communication technologies on clothing and the integration of technology with textiles. With the increasing need for products with higher quality and functionality, the textile sector tries to meet this demand with wearable technology applications. In this sense; life-saving discoveries, the future of wearable technology, smart clothing and high-tech timeless clothing.

Wearable technology products continue to come up with new products that respond to various needs every year. These innovative products from our imagination, which are included in our lives, increase the quality of life.

While technology is developing rapidly, human mind implements wearable technology with extraordinary ideas that make technology fun. Wearable technology products come to the forefront with textiles on the use of information and communication technologies on accessories or clothing. The orientation to wearable technological products is due to biological, cultural, psychological and physiological reasons. Integration of information and communication technologies into a garment or fabric is the most important goal in the development of wearable systems. Wearable technological textiles, as in the traditional textile and apparel sectors in the market, are constantly growing in a strong way and are seen as a promising sector.

5.3.1 İpekiş Smart Fabrics

İpekiş has designed its smart fabric collection called as “Eight Wonders of Fabric” which integrates elegance and comfort with fashion. Travel Flexy/Travel Zerogravity, Bionic Finish, Pure Wool Stretch, Cool Dark, BioPerfume, Slimming, Silverplus, Zeropollen, Zerostress are the examples of this collection [123].



Figure 5.2 Zero Gravity smart fabric which ensures freedom of travel [123, 124]

The fabric seen in Figure 5.2 is designed for 100% Australian Luxury Merino wool and has been specially designed for people who travel frequently. Thanks to its natural elasticity, fine texture, light weight and high finishing technologies, it has a structure that is not wrinkled and easily contaminated. When the garment made with this fabric is hung on a hanger in a well-ventilated and slightly damp environment, it gains its original appearance the next day [123].



Figure 5.3 Water, dirt, oil repellent bionic finish smart fabric [123]

In the example in Figure 5.3, 100% wool fabric was obtained by applying Bionic Finish complete water repellent finishing technology and the smart fabric was obtained. Bionic Finish technology; was developed based on the self-cleaning capability of the lotus flower. It protects its brightness, texture and performance without disturbing the nature of the fabric. This fabric; water, oil and dirt repellent, ensuring long-lasting colors and fabric, allowing the fabric to dry faster [123].



Figure 5.4 Woolstretch smart fabric with maximum mobility and durability [123]

Natural Stretch Finish technology provides natural flexibility and durability by using the spring properties of wool. Provides maximum durability and mobility. Provides natural flexibility Resistant to dry cleaning and ironing, as opposed to products made of elastane [123].



Figure 5.5 Woolstretch Cooldark smart fabric [123]

In Figure 5.5, Sun Block Finish Technology was applied to 100% wool fabric and the negative effects of sun on dark colors were reduced. These smart fabrics keep cool against the effects of burning sun, reduce the effect of UV rays, provide maximum balance at body temperature. Fabric provides maximum comfort during the summer months and prevents fading in dark colors [123].

BIOPERFUME®



Figure 5.6 Perfumed smart fabric [123]

In Figure 5.6, 100% wool fabric was applied with perfumed microcapsule technology. With the explosion of capsules on the move, Bioperfume is activated, causing the garment to emit a pleasant odor all day long. It removes unwanted odors such as cigarettes. Contains Aloe Vera, seaweed and vitamin E; it makes the skin look healthy and moisturizes the skin. Feels spacious and energetic [123].

SLIMMING®



Figure 5.7 Slimming smart fabric [123]

In Figure 5.7, 100% wool fabric is placed in an unlimited number of microcapsules that are effective in weakening and supporting skin care. With the explosion of capsules on the move, slimming is activated and easily absorbed by the skin. In the mixture of natural substance extracts contained in microcapsules [123];

- Green pepper accelerates metabolism, increasing body temperature. Thus, fat burning and helps to weaken.
- Brown seaweed, thyroid hormone imbalances and prevents the formation of cellulite.
- The leaves of the mature tree accelerate blood circulation, prevent blood clotting.
- Vitamin E has antioxidant and anti-aging properties.
- Cosmocool prevents oiling and moisturizes the skin.



Figure 5.8 Antibacterial Silverplus smart fabric [123]

Antibacterial silver ion technology was applied to 100% wool fabric. The SilverPlus fabric is the result of applying SilverPlus Antibacterial Silver Ion technology, which was developed and patented by German Rudolf GmbH, on İpekış's 100% wool fabric. In cases such as perspiration, silver ions in the fabric become active and provide freshness and hygiene. SilverPlus smart fabric with antibacterial and antimicrobial effect prevents bacterial growth and prevents unwanted odor formation. At the same time, the fabric, which maintains the natural balance on the leather surface, conforms to the OEKO-TEX 100 standard, which represents quality and confidence in textiles [123].

ZEROPOLLEN®



Figure 5.9 ZeroPollen smart fabric [123]

We can use pollen dust repellent textile products in order to facilitate our lives against pollen allergy and to increase our comfort. An antipollene finish developed with Rudolf Duraner and İpekiş partnership was applied to 100% wool fabric. This smart fabric; Thanks to its special structure, it prevents pollen dust from adhering to fabric surface. It helps to prevent the effects of pollen allergy [123].

ZEROstress®



Figure 5.10 Zerostress smart fabric with negative ion load, stress relief [123]

The tension and stress that we feel are the positive ions we've been burdened with. The negative effect of positive ions is reduced by their confrontation and neutralization in environments with high ions. ZeroStress smart fabrics were produced by applying negative-positive ion neutralization to the fabric. Rudolf Duraner manufactures 100% wool fabric using negative ion technology. İpekiş firm has placed an unlimited number of negative ions in this fabric. These smart fabrics; reduces stress and fatigue. It provides mental and physical comfort. Reduces blood pressure. Reduces palpitations. It extends the capillaries and alkalizes the blood [123].

5.3.2 Kiğılı Smart Applications

Travel series suits are designed with Zero Gravity smart fabric. In addition to its lightness, it forms a second feel of the skin, does not wrinkle and is not easily contaminated. Zero Gravity fabrics are specially finished by tapping 100% Australian Merino wool. Travel series provides a very light and thin texture. The special fabric, whose meter weighs only 200 grams, sits on the body like a second skin. Lightweight, breathable, sweat-reducing, wrinkle-free, hard-to-wear suits, even if used for many years, does not lose the color brightness [125].



Figure 5.11 Travel series suits [125]

5.3.3 Orka Group -Damat Tween Smart Applications

The Orka Group brand Damat Tween has developed a jacket which prevents the radiation emitted by mobile phones. In addition, non-wrinkle suit, anti-stress T-shirt and water repellent suits are among the smart applications of this brand. Non-staining shirts, perfume-scented suits, skin care and energizing garments are among the innovative products. The sets produced with fabrics that serve as air conditioners offer the possibility to wear whatever we want, regardless of the weather conditions [126, 127].



Figure 5.12 Jacket with natural climate effect [126]

5.3.4 Süvari Smart Applications

When the mobile phones are lightly touched, the contact information is added to the contact list to the smart ties designed by the Süvari brand. Wireless technology NFC uses magnetic signals to connect devices such as smartphones and tablets. NFC tags can be used with NFC-enabled phones and tablets to make life easier. The Süvari brand also applies NFC tags to the ties and designs all the information in a tie-style design. This eliminates the need to carry business cards [128].

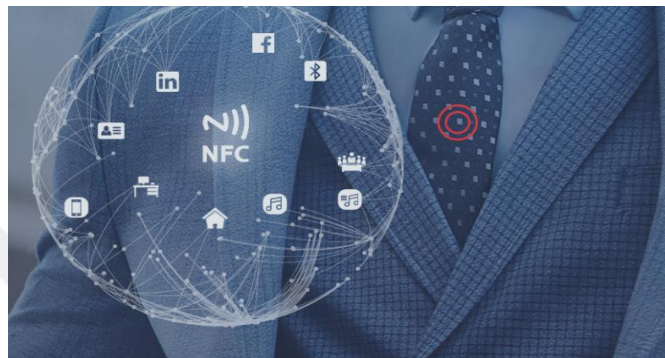


Figure 5.13 Smart tie [128]

Another intelligent application of the Süvari is the non-mating belts on the X-Ray device. Airports, shopping malls, workplaces etc. X-Ray devices facing everyone in public spaces are becoming a problem for people. For reasons of safety, it is uncomfortable for people to be removed. These belts are comfortable for frequent travelers by plane. X-Ray device is not the reason to not; The buckle portion can be easily removed in a single movement and can be fitted again easily. While the skin of the belt remains in the pants without losing its function, only the buckle is removed [129, 130].



Figure 5.14 Smart belt on x-ray device [129]

5.3.5 Derimod Smart Applications

Due to global warming, winter is no longer as hard as it used to be. For this reason, Derimod R & D unit and Italian designers came together and designed leather jackets. They designed the lightweight leather jacket Derimod 690 with Nano-leather technology. They reduced the specific weight of the skin by 50%. Derimod Chairman of the Board Ümit Zaim this application, with organic tanning methods became 50 percent light leather. This is a revolution in the leather industry. It is a revolution in the world. Technology and fashion come together; in the form of. The average weight of leather jackets is about 1-1,5 kg. The Derimod 690 product produced by Nano-leather technology has a weight of 690 grams [131].



Figure 5.15 Derimod 690 leather jacket [131]

In order to increase the demand for leather jackets in spring and summer, Derimod designed the Peluria 490 product, which is 30% lighter and 3 millimeters thinner, using organic tanning (vegetal). This product, which can be defined as the new leather, is the lightest leather jacket in the world which weighs 490 grams which can be worn in spring or even in summer months [132].



Figure 5.16 Derimod Peluria 490 [132]

5.3.6 Nike Smart Applications

5.3.6.1 Nike Adapt BB

Nike has designed Nike Adapt BB, which can be controlled remotely by smart phone. It allows users to adjust their shoes to any frequency they want, and to remotely adjust their application to their phones. Nike Adapt BB shoes can be adapted to the foot structure of the user. It has a special motor that senses the tension required by the foot and adjusts accordingly for a comfortable fit. Smart shoes can be controlled with the Nike Adapt application or the physical keys on it. Thus, basketball players during the game eliminates the problem of adaptation of shoes. It allows players to select different levels of slack during warm-up, during breaks and in matches [133, 134, 135].



Figure 5.17 Nike Adapt BB [134]



Figure 5.18 Nike Adapt BB [133]

Sports shoes developed by Nike's technology called FitAdapt can expand and expand thanks to the motors in it. By detecting the tension needed by the users, it provides a comfortable use. These shoes can also be controlled with the Nike Adapt mobile app that can be installed on iPhones. The buttons can also be adjusted using the buttons on the shoe. It was designed to eliminate the problems of basketball players during the game [134].

5.3.6.2 Nike Air Mag 89

In 2016, Nike designed Air Mag 89, inspired by Marty McFly's shoes in Back To The Future. Laces are self-tying shoes. In the same year, the company produced another model that could bind itself with the name HyperAdapt 1.0 [136].



Figure 5.19 Nike Air Mag 89 [136]

5.3.7 Philips Smart Applications

5.3.7.1 Skin Probe Dresses

The Philips Design Probes design lab has developed the Skin Probe Dresses project. This project examines the future of sensibility in the area of emotional perception. The dress reflects the interaction interaction through patterns and color. It is a series of dresses that communicate with the body from different angles. One of these clothes is transformed into a color that expresses the emotion of the wearer by means of electrons in the fabric. The other design takes various designs as a result of contact with the body [137, 138].



Figure 5.20 Skin Probe dress [139]

5.3.7.2 Mesopic

Mesopic is a jacket design that aims to increase human visibility and security measures in dark environments. This jacket was designed by Pauline van Dongen as part of the Philips Design Probes program. Mesopic is a light silver and semi-transparent jacket inspired by the night city environment. Philips' textile LED strips were integrated into the fabric to create a light-emitting jacket at night. The light is integrated to avoid direct illumination. It is in the form of a thin and effective glare reflected from the illuminated body. The jacket can be used as an aesthetically pleasing functionality throughout the night and is a design product that can be worn during the day [140].

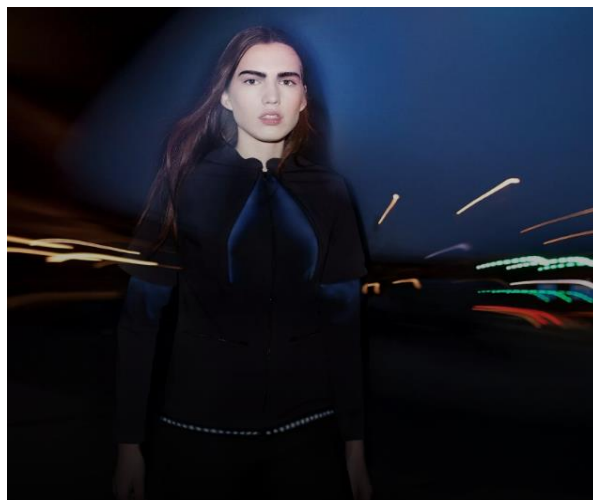


Figure 5.21 Mesopic [140]

5.3.8 Adidas Smart Applications

5.3.8.1 Adidas EQT Support 93/Berlin

Adidas produced a shoe-integrated shoe to draw attention to public transport. The nostalgic trains on the U-Bahn line of Berlin became the starting point for Adidas's EQT Support 93/17 Berlin. It consists of the patterns in the seats of the trains. There is a subscriber card of Berlin's public transport company (Berliner Verkehrsbetriebe: BVG). Thanks to the ticket chip in the shoe, users can benefit from free transportation in Berlin for one year [141].



Figure 5.22 Adidas EQT Support 93/Berlin [141]

5.3.8.2 Adidas- Polar Fusion Apparel For Runner

It is designed for clothes runners. It is intended to measure the heart rate during sports. It is personalized and providing wearable electronic clothing for runners who want to listen and train them more effectively. These products were designed by Polar Electro and Adidas [142].



Figure 5.23 Adidas polar fusion [142]

5.3.8.3 AdiStar Fusion Cardio Bra

Thanks to the sensors integrated into AdiStar Fusion t-shirts and bras, heart rate data can be monitored. Data analysis can be done by transferring to computer system with the help of transmitters. To monitor the heart rate, Polar's WearLink transmitter and Adidas special fibers work together. The Polar WearLink connector must be attached to the name of the Fusion Fusion suit. ECG from textile sensors placed in shirts or bras collect heart rate values. Polar RS800sd displays and records all information in real time. These products are fully washable after removal of the polar transmitter [143].



Figure 5.24 AdiStar fusion cardio bra [143]

5.3.9 Tommy Hilfiger Smart Application

Tommy Hilfiger designed solar panel charging jackets. With the support of Pvilion, the solar panel manufacturer produced two models of jackets with solar panels on the solar collectors. These jackets, which are produced separately for men and women, are equipped with flexible solar panels that can be easily removed and installed. Solar panels with water resistant, lightweight and flexible silicone technology produced by Pvilion are applied to jackets. The panels on the jacket collect the solar energy and store it in the battery in the front pocket of the jacket. There are two USB ports on the battery, allowing multiple devices to be charged at the same time [144].



Figure 5.25 Tommy Hilfiger solar panel charging jackets [144]

In addition, Tommy Hilfiger is rewarding the users who wear their products thanks to smart chip technology. Tommy Jeans Xplore series is embedded with a smart chip. For every Tommy Jeans Xplore-specific IOS app, Awear Solutions smart tags are available, providing low-energy Bluetooth connectivity. When the IOS app is downloaded and activated, the application provides communication between consumers with the Tommy Jeans Xplore product. Product and application use, depending on how often the product is worn, gives the consumer awards and experiences. The clothing brand has turned to these smart applications in order to create micro-community of brand ambassadors. Examples are swetshirt, denim jacket and crossbag [145].



Figure 5.26 A Tommy Jeans Xplore sweatshirt with smart chip technology [145]

5.3.10 Penti Smart Application

Turkey's underwear fashion brand Pent, wearable tech Spirea is moved until bra with MyBride Touch. Spire monitors real-time perceptions of respiration. The Spire health tag captures bio-signals in real time with clinical sensors in it, giving you the power to control daily activity, sleep quality, stress, breathing, concentration, and heart rate. It allows monitoring of sleep and stress control. Penti's Mybra Touch bra provides the control of the stress level in everyday life with the Spire Health Tag. The wearable Spire Health Tag on the bra works with the application downloaded to the smartphone. Spire body is a design that works according to our movement, is washable and does not need to charge [146]. This application is the first wearable tech moved to Turkey's underwear [147].



Figure 5.27 Spire health tag [146]

5.3.11 HTC Smart Applications

HTC has introduced its name to the wearable device industry with the smart wristband it introduced at MWC. Then wearable Re Sok designed the smart sock he called. These smart socks with GPS feature find the socks with the signals that each other has spread. In this way, you do not need to search your wife's socks for hours. The disadvantage is that smart socks cannot be washed in washing machines [148, 149].



Figure 5.28 Re Sok smart sock [148]

5.3.12 Sensoria Smart Applications

Sensoria smart socks are a product in which technology is placed in textiles. The socks are followed by real-time tracking of the foot of the user and records the data. It works in conjunction with smartphones to provide performance measurement. By connecting to the smartphone via Bluetooth, it transmits the received data to the smartphone screen instantly. Electronic performance meter counts the steps at the same time, measures the step speed, determines the weight distribution according to the press of the foot and measures the rhythm [150, 151].



Figure 5.29 Sensoria smart fitness sock [150]

5.3.13 Owlet Baby Sock

This socks allow the parents to comfortably control the baby's health, while the baby sleeps in a separate room, showing the heart rate and oxygen level. The Owlet smart socks kit consists of 3 fabric socks, a smart sock sensor, a base station, charging cables, and instructions to be used by the parents to download the baby's vital signs, which can be safely worn on the foot of a 0-18 month old baby. It is made of washable, soft, thin and light, anti-allergic fabric. The electronics must be removed when washing [152, 153]



Figure 5.30 Owlet baby sock [154]

5.3.14 Weatherproof Smart Coats

The Mercury jacket designed by Ministry of Supply has carbon fiber heating elements. It can cool down according to the ambient temperature and adapt to all weather conditions. There are sensors that measure the air temperature both inside and outside of this jacket. This coat can be controlled via Bluetooth via the app. By learning the user's preferences, it can automatically adjust itself to the ambient air temperature over time [155].

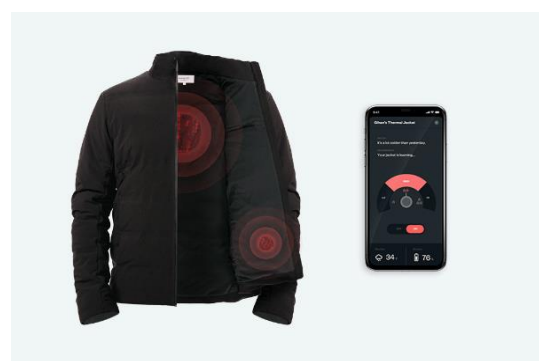


Figure 5.31 Smart coats that adapts air conditions [155]

5.3.15 Ultra Thin Wearable Electronic Screen

The Japanese research group Takao Someya of the University of Tokyo Engineering Department, produced a super flexible and ultra-thin electronic leather. The electronic display that the patient can wear is able to export vital activities such as heartbeats wirelessly to a remote electrocardiogram. On the 1 mm-thick screen, micro LED lights are located in a rubber plate. Due to the flexibility and lightness of the material used, the electronic display does not cause any discomfort in the skin. The patient can carry the screen for 1 week without ever removing it [156].

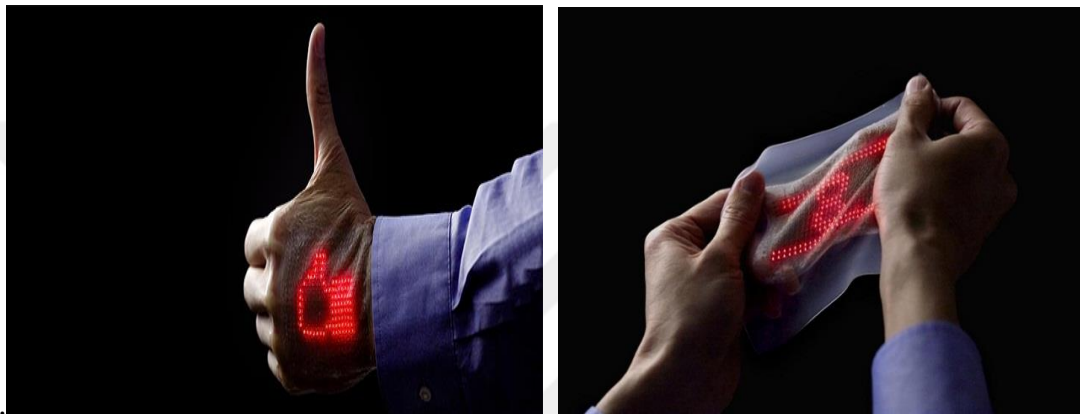


Figure 5.32 Wearable electronic screen [156]

5.3.16 SGNL Phone Cuff Bracelet With Finger Tip

South Korea-based Innomdle Lab developed the smart wristband Sgnl. With bone conduction technology, it is possible to make telephone calls using only fingers. It weighs only 116 grams. After synchronizing with the smartphone via Bluetooth, the user can answer incoming calls with a little touch to his / her ear. Sgnl receives the voice signal via Bluetooth from the phone. When an audio signal is received, the Sgnl will generate vibration through the Body Transmission Unit (BCU), which transfers the vibration to the tip of your finger [157]. Since the transmission is made of vibrations, there is no risk of damaging the human body. When you place your fingertip on your ear, the vibration echoes to create amplified sound within the enclosed space of your ear. When you place your finger on your ear, your finger will not only transmit the sound, but it will also prevent back ground noise.



Figure 5.33 Transmission of vibration through BCU [157]

5.3.17 Sunglasses That Can Share Live Videos on Social Platforms

Acton has developed the ACE Eyewear smart sunglasses. These smart sunglasses enable users to share videos and photos from Facebook, Instagram and YouTube via the smartphone app. This smart goggles are powered by the Dual Core MIPS 1.2GHz processor. It has an 8MP built-in camera that can record 120-degree wide-angle HD video and still images. When the shutter-release button on the top left of the eyeglass frame is pressed, a picture or video is captured. The ACE Eyewear's battery lasts 80 hours in standby mode, while it provides 1.5 hours continuous video and photo capture. Only 50 grams of glasses are available with 4GB of internal memory [158].



Figure 5.34 ACE eyewear [158]

5.3.18 Smart Shiftwear Sneaker

The ShiftWear Sneakers feature a full HD display in color and flexibility. This screen can reflect the moving designs. Various motion pictures selected from the smartphone application can be played on this screen via Bluetooth and Wi-Fi connection. You can reflect your own designs or ready-made designs in the application of your sneakers. It even allows you to sell your designs to other people on the platform for a fee. It is a technology wonder with its personable features [159, 160].

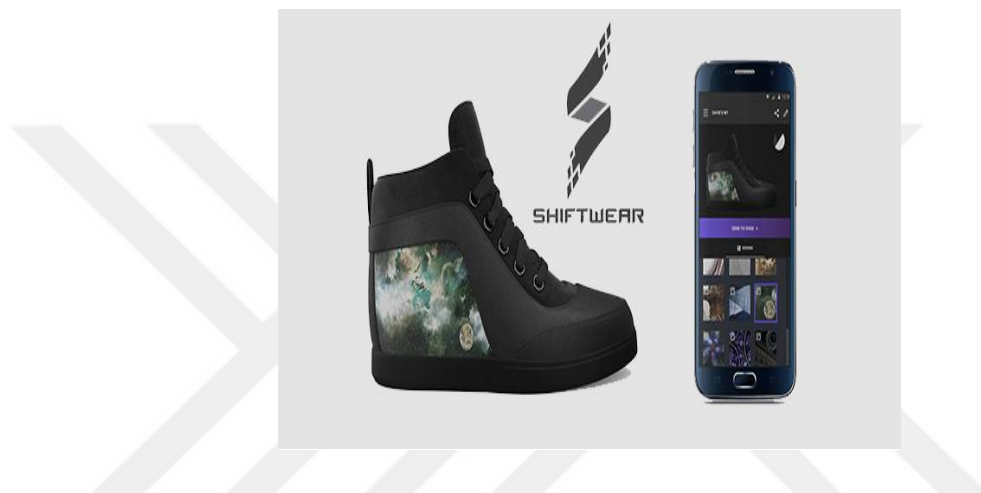


Figure 5.35 Shiftwear sneaker [159]

5.3.19 FORD SafeCap Smart Hat

SafeCap is a smart hat for Ford's long-distance drivers. Produced to minimize traffic accidents caused by carelessness or insomnia. The tiny sensors placed inside the hat allow the driver to monitor the head movements. The hat warns that if the driver senses that he moves his head vertically or horizontally at a certain angle for a certain period of time, he must rest immediately [161].



Figure 5.36 Safecap [161]

5.3.20 Smart Bracelet to Prevent Menopause Symptoms

A Grace smart bracelet was developed by Peter Astbury, a graduate of Industrial Design and Technology at Loughborough University in the UK. By means of sensors placed in the battery part, it can detect the so-called bil firing çev symptom by 1 minute in advance and can reverse the situation. It activates the thermal receptors in the body, transmitting cold air signals to the brain. The feeling of coolness is spreaded all over the body. Thus, the problem of hot flashes caused by menopause is eliminated [162].

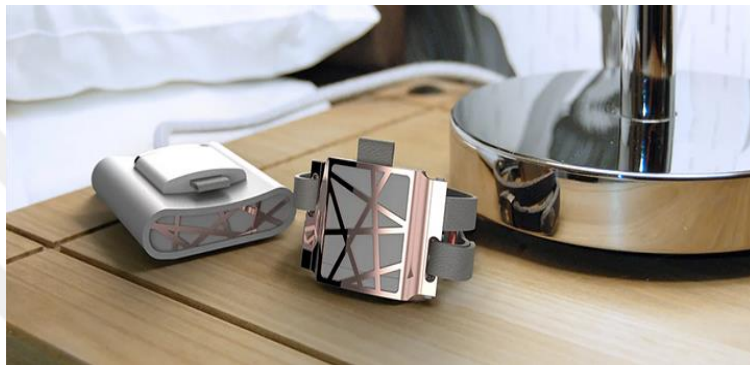


Figure 5.37 Smart bracelet to prevent menopause symptoms [162]

5.3.21 Wearable Keyboard Tap

Tap Systems developed a wearable keyboard Tap for those who want to turn each surface into a virtual keyboard. It is worn in one hand. Thanks to the ring-shaped parts that pass on the 5 fingers on this device, finger movements turn into writing. Thus, each surface can be converted to keyboard and mouse. Each time you touch your fingers or swipe your hand, a character, command, or cursor position is sent to your Bluetooth-connected device [163].



Figure 5.38 Wearable keyboard tap [163]

5.3.22 Ideal Sleep Band: Silentmode

The mask / band, which makes the user comfortable with cushions supporting 360 degrees, is made of memory foam. It has a built-in audio system with passive sound reduction. In this way, users can listen to music lists on the mobile application with the built-in Bluetooth connection. Or he can adjust his own sleep music by plugging in his earbuds. Offers 24-hour battery life [164].



Figure 5.39 Ideal sleep band: Silentmode [164]

5.3.23 Growing Clothes with Kids

Ryan Mario Yasin, who graduated in 2017 from the Royal College of Art, designed Petit Pli. He was inspired by a study of carbon fiber panels with resilient properties that could extend to small satellites. And applied the technique used in research on children's clothes. Combining extension technology with fashion, Petit Pili has designed a raincoat. This raincoat consists of two parts and protects the body against wind and rain. Lightweight fabric structure allows children to move more easily. Thanks to its design, it also prepares the skin to breathe. Designed with synthetic materials, the overcoat is made waterproof with hydrophobic coating. Since it is designed as an upper garment, the synthetic materials used in its design do not touch the child's skin. Therefore, it does not cause any allergies or damage. The specially designed folded fabric structure allows the rainbow to expand and expand with the development of the child. It allows your child to wear it comfortably until 36 months of age. The product which attracts attention with its fabric structure starting to stretch as baby grows, can be adapted to 7 sizes. It not only reduces the family's clothing costs but also provides a sustainable solution by supporting less consumption [165, 166].



Figure 5.40 Petit Pili glowing clothes [166]

5.3.24 Tooth Sensor Following Nutritional Habits

Real-time monitoring of what happens in our bodies is invaluable for health care. Researchers at Tufts University Faculty of Engineering follow consumption habits with a small sensor placed on the teeth. More information is available on oral and dental health. It also records data on dietary habits [167, 168].



Figure 5.41 Tooth sensor [167, 168]

Once these sensors are mounted directly on the tooth, they can be monitored wirelessly with a mobile device. It records all the nutrients a person consumes during the day and transmits all the recorded data to a system. Thanks to its ability to identify and transmit data instantly, it is especially convenient for research on dentists and dental health. Earlier wearable devices designed for diet monitoring were not ergonomic and handy. This sensor is only $2\text{mm} \times 2\text{mm}$ and consists of three main layers. The bottom layer analyzes and transmits data, while the other two layers are designed to be used to identify the consumables [168].

5.3.25 Polar Seal: Heated Sweater

These products; has ultra thin heating technology. Flexible, light, breathable and washable. 3 separate heating levels are available. Heating levels (40 ° C to 50 ° C / 104 ° F to 122 ° F) can be selected at the touch of a button. The Polar Seal heated garments provide up to 14 hours of heat on a single charge.



Figure 5.42 Polarseal heated sweater [169]

The user can heat the area by pressing the buttons with two separate heaters located on the back and back. The button that activates 3-stage heating is located on the left arm of the sweater. Polar Seal sweaters are compatible with standard portable USB chargers. It takes only 10 seconds for the Polar Seal sweater to warm up.

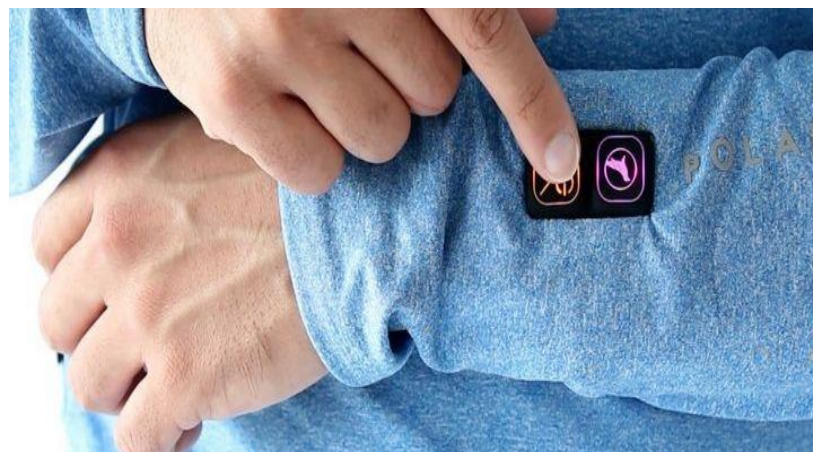


Figure 5.43 Button for activating 3-stage heating [170]

5.3.26 Virtual Reality Glasses (VR))

Virtual Reality (VR) is the name given to the environment created by three-dimensional computer technologies, where both users can discover and interact.

Thanks to virtual reality goggles, technically people are feeling the feeling of being in 3D computer environments. After entering the virtual environment, the user feels completely like that. It disconnects the user from the outside world. With VR Glasses you can simulate any existing structures in real life outside of the virtual world. Virtual and real world can be nested. VR titles are usually used for gaming purposes. Google, Microsoft, Nvidia, Intel, and finally Oculus's partnership with Samsung and Facebook's investment in Oculus, many large companies have started to invest in virtual reality. (Samsung Gear Vr, Oculus Rift, Google Cardboard, Htc Vive, PlayStation Vr ...) [171]



Figure 5.44 Virtual reality glasses [171]

And these virtual reality glasses began to manifest themselves in every aspect of our lives. Arzu Kaprol introduced the Inter-Being collection to its fashion show with virtual reality glasses. Thanks to these goggles, they watched each piece of the collection in the simulated form within the created universe in the virtual world. At the end of the fashion Show [172].



Figure 5.45 Arzu Kaprol fashion show with virtual reality glasses [172]

5.3.27 Incredible By Victoria's Secret Heart – Rate Monitor Compatible Sport Bra

The famous underwear brand Victoria's Secret has designed a smart bra. By measuring the heart rhythm through the sensors placed inside this bra, it provides the data to the users via the connected smart device. It provides the data by following the heart rhythm especially during the sport.



Figure 5.46 Victoria's Secret Bra [173]

“Concealed inside this smart garment are chest placed monitors with tiny electrodes that will be able to connect to your skin and transfer information to a heart rate monitor. The smart sports bra can hold more sensors to the skin comparable to a sports watch, so it can collect more information and produce smarter data. The Incredible also comes with all the Victoria’s Secret sports bra features; maximum support, body-wick technology to keep you cool and dry, breathable padding with wicking lining, concealed wire for cushioned support, soft elastic band for maximum comfort and movement as well as many other features.” [174].

5.3.28 Electricfoxy Ping

Ping is a social network outfit designed by Electricfoxy. It communicates wirelessly with your Facebook account. She won the Best Practice Award at the 2011 International Symposium on Wearable Computers (ISWC) [175].



Figure 5.47 Electricfoxy Ping [175]

“Ping is a garment that connects to your Facebook account wirelessly and from anywhere. It allows you to stay connected to your friends and groups of friends simply by performing natural gestures that are built into the mechanics of the garments we wear. 2011 International Symposium on Wearable Computers (ISWC) Award: Best Execution.” [175]

You can update your Facebook status by closing and opening the hood of this dress. Through the tiny vibration motor on the shoulder of the outfit, it makes you feel like you are touching your shoulder when you receive a message from Facebook. Thus, you can notify your messages [175, 176].



Figure 5.48 a) Draping and modifying the pattern [175]

b) Side panels with patterns the technology circuitry [175]

c-d) Integrating technology components [175]

5.3.29 Ringly Smart Ring

Ringly is a technology wonder that saves you from being dependent on the phone. Ringly allows you to be notified of notifications on your phone. These notifications include; Incoming calls, messages, e-mails, Facebook and Twitter alerts are included. Smart phones are connected via Bluetooth. Selected notifications can be transmitted by vibration and light. There are 4 different vibration patterns and 5 different light color options for notifications [177].



Figure 5.49 Ringly smart ring [177]

5.3.30 Lex Wearable Bionic Chair

The LEX is a bionic wearable chair that enhances posture, comfort, and life. Lex is a special exoskeleton chair worn on the waist. A chair that can be worn and transported. It helps you to sit somewhere at any moment. It is designed for those who have to work standing for a long time or for people who are disturbed in working position. This bionic chair is slightly heavier than 1 kilogram. It is an ergonomic chair that can carry up to 120 kilograms [178, 179].



Figure 5.50 Lex wearable bionic chair [178]

5.3.31 Isansys Wearable Patient Monitoring Technology

The Isansys patient status engine is a wireless patient monitoring system. It collects and analyzes vital sign data. It is a wearable medical device that monitors patients automatically, continuously and in real time. And convert it into applicable clinical views [180].



Figure 5.51 Isansys wearable patient monitoring technology [180]

It uses wireless wearable sensors, including Lifetouch, Lifetemp, pulse oximetry and blood pressure monitor, to collect vital sign data such as heart rate, respiratory rate, heart rate variability, temperature, oxygen saturation and blood pressure on the device. The ECG and PPG are available with an optional display button. This data is then transmitted via Bluetooth to the patient gateway and this data is analyzed. The information is sent to the Lifeguard Server, which collects all patient vital signs and other system data over a Wi-Fi network. The data can then be monitored remotely in a central monitoring unit, nurse station, or any other authorized device [180].

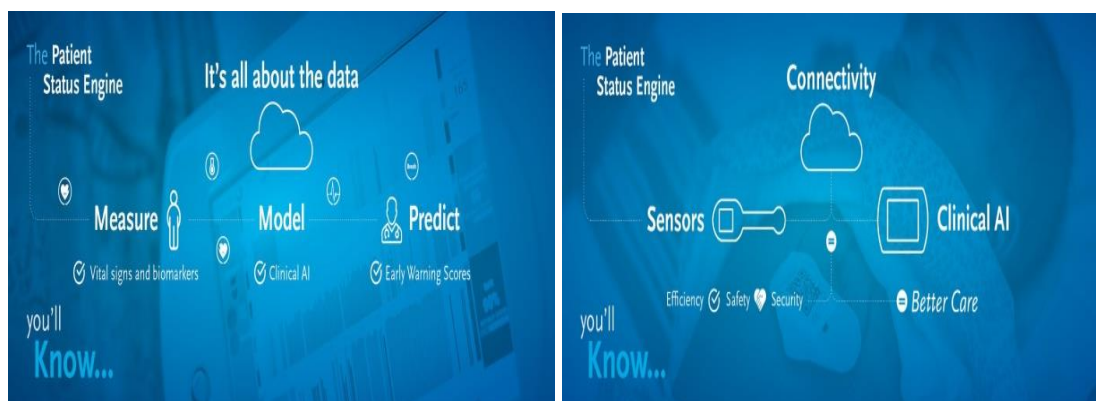


Figure 5.52 Isansys data collecting system [180]

5.3.32 Antelope Muscle Running Smart Sports Outfit

Antelope is the world's first muscle-running smart sports suit. Thanks to the electrodes that activate the muscles, you can operate the basic muscle groups, allowing you to work out where you stand. Proactively enhances power, coordination, speed and durability [181, 182].



Figure 5.53 Antelope muscle running smart sports outfit [182]

The garment stimulates the muscles in the mid-frequency range. The electrodes provide the contraction of each muscle during exercise. Statex's silver textile products offer the basic material for these electrodes. The Silitex material is a fully laminated silver-coated fabric surrounded by a highly conductive layer of silicon on both sides. It is designed as a silver coated stretch fabric combining strong hydrophobic and technical properties [182]. Antelope smart sportswear all over the body wrap-up version of the body, as well as the different parts of the body to target the region's muscles are designed in different models.

5.3.33 Qus Washable Smart Textiles

One of the biggest challenges for many innovative products developed is that products cannot be washed. A company named QUS has developed a wearable technology product that can monitor heart and respiration data via sensors touching a washable fabric. Data is collected and transmitted via Bluetooth [183].



Figure 5.54 Qus smart undershirt [183]

5.3.34 D-Shirt

Another example of an innovative product line is a smart t-shirt. The T-shirt produced under the brand D-Shirt is made of a special fabric that touches your heart rate, your GPS position, your route, your speed and your height with the sensors that record your height [184].

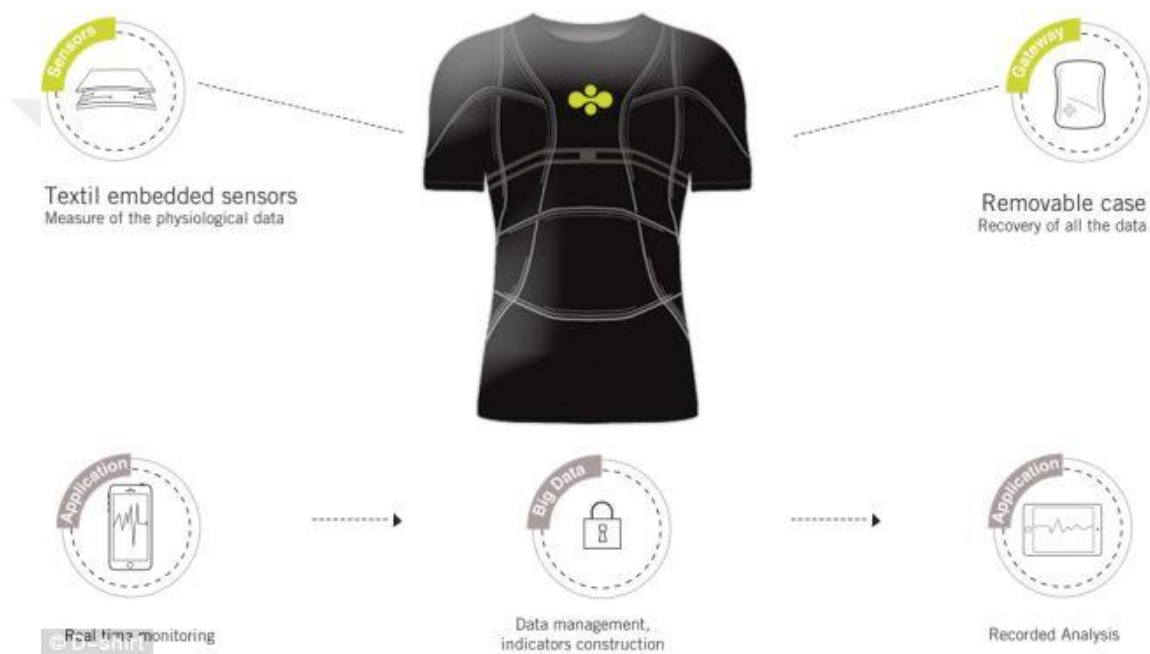


Figure 5.55 D-Shirt [184]

The information is sent to the small removable transmitter located behind this digital t-shirt. It is then transmitted to the smartphone via bluetooth. The garment is lightweight and washable smart textile [184].

5.3.35 Nadi X Smart Yoga Pants

The smart yoga pants Nadi X were designed by Wearable X company. These pants provide personal yoga training. During yoga, it reminds you where to focus with light vibrations. It improves your yoga positions with tactile technology [185].



Figure 5.56 Nadi X yoga pants [185]

The product is equipped with haptic sensors that are sewn into nylon layers on the hip, knee and ankle. The power pack called Pulse, which you will paste into the range behind your left knee, detects sensors and vibrations in the trousers. Pulse, easily rechargeable and can be connected to your phone via bluetooth. Connected to the application in your phone via Bluetooth, the product provides visual and voice instructions. The Nadi X iOS app enables a better quality and efficient yoga experience. These yoga pants have a washable technology [185].



Figure 5.57 Nadi X Yoga pants and pulse [186]



Turn on & connect the pulse

The Pulse contains a battery that powers the sensors and motors woven into the pants — it has 90 minutes of battery life.

Clip in the pulse

It snaps into an insert behind your left knee — you can barely feel the pulse in that location, and it doesn't restrict any poses.



Connect the Nadi X App

Nadi X connects via bluetooth to its companion app which helps remember your poses and suggest future flows for your session.

Vibrations help your flows

The woven-in sensors help give you gentle reminders of where to pay attention during your yoga practice. It's like having a personal yoga



Figure 5.58 High performance for yoga with Nadi X [187]

5.3.36 FingerReader

Scientists from the Massachusetts Institute of Technology designed an auditory device for visually impaired people who could read articles. FingerReader is one of the first examples of 3D printers. At first glance, the FingerReader looks like a big ring attached to it by a wire attached to the wrist. There is a camera in the ring part of the device and a chip providing connection in the box part. When the user extends his finger to any text, text or number, the device can pass the text at the end of the finger with voice to the user [188, 189].



Figure 5.59 FingerReader [189]

The device can be connected wirelessly to a computer or smartphone application. It allows the user to read menus, signs or warning signs where he goes. When the user extends his / her finger and scans it, the device warns with vibration if it moves away from the text line.



Figure 5.60 FingerReader [190]

5.3.37 Smart Gloves for the Visually Impaired

Erhan Akan, a student of the Department of Electrical and Electronics Engineering at the Faculty of Engineering at Anadolu University (AU), developed a smart glove capable of writing hand and finger movements of the visually impaired, with the help of sensors and computers [191].

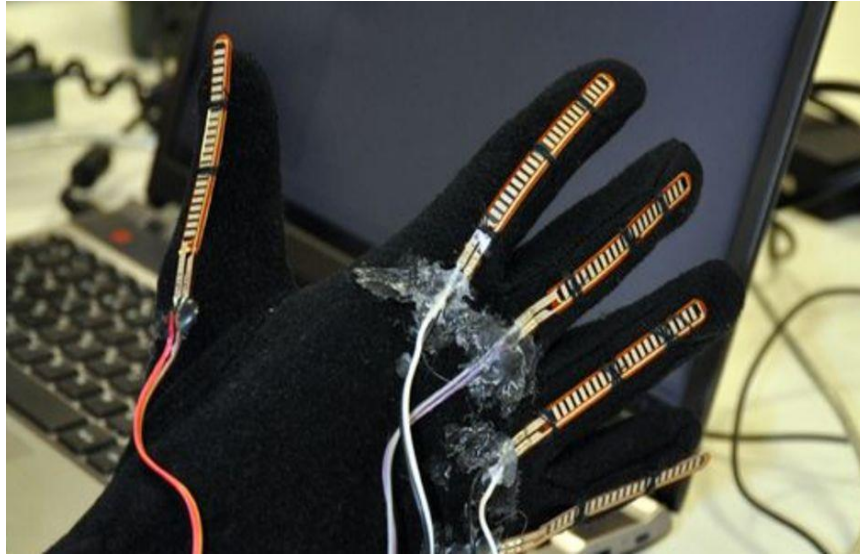


Figure 5.61 Smart gloves for the visually impaired [191]

Thanks to the sensors mounted on the fingers of the glove, hand and finger movements are transferred to the main computer. Thanks to special software that reads hand and finger movements, letters encoded according to sign language can be written easily.

5.3.38 Thread In Motion Smart Glove WIO

Thread In Motion, working on wearable technology, produced a smart glove called WIO. With this smart glove, it is aimed to prevent blue-collar personnel from making mistakes. There are 32 different sensors in the smart glove WIO. Thanks to the conductive yarn technology, it has many features such as haptic feedback mechanism and hands free without requiring wiring. WIO aims to prevent the smart glove user from making mistakes. For example, it may prevent the products to be placed in the wrong shelves or to receive them [192].



Figure 5.62 WIO smart glove [192]

This glove gives the user speed and traceability. It was first used in the automotive industry. It was tested by brands such as Mercedes Benz, Renault, Bridgestone and Lassa. In the future, it is aimed to be used in sectors such as logistics, aviation and retail chain [192].

5.3.39 Beagle Scarf Hoodie

The Beagle Scarf Hoodie is a wearable communications tool designed by Leo Chao for individuals with autism. Designed to meet the needs of children with autism. The smallest noise, smell or anything for these individuals can be very uncomfortable. When he wants to be blocked from the outside world in terms of sound or smell, he is designed to cut off communication and return to his own worlds, to allow them to calm down and to be alone. With headphones on both sides of the headset, it is designed to listen to a customizable sound or music recording when you want to disconnect from the outside world. Thanks to the customizable odor pads, it is designed to offer the scent that it loves or accustoms to, which will calm it down [193, 194].



Figure 5.63 Beagle scarf for autism [194]

Leo Chao's Beagle clothing was made with autistic children and their families. The aim is to awaken emotions in different environments. These children may experience anger problems in different environments. Beagle helps children calm down. There are circuits that can be controlled in the control, such as a change in the available volume, adaptation of the sound [194].

5.3.40 Focals Smart Glasses

North has designed Focals smart glasses. Hidden holographic lenses are available on the windows. It looks like a normal spectacle when viewed from the outside, because it has glasses with a clear glass. It allows you to have a range of Augmented Reality (AR) features. On Focals glasses, Amazon's Alexa digital assistant takes your voice commands. Alexa helps you send messages, use the navigation app, call a Uber taxi, or learn the weather [195, 196].

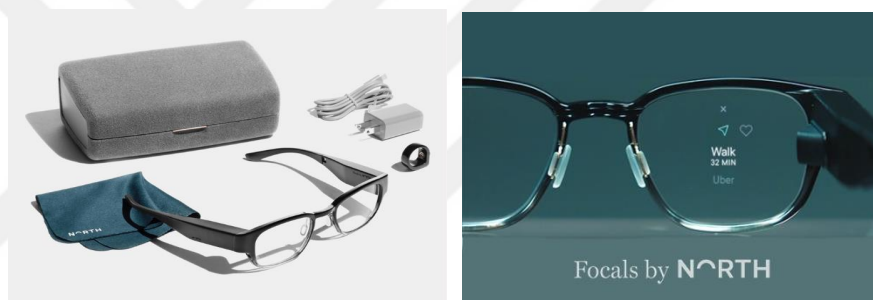


Figure 5.64 Focals smart glasses [195]

The first model is made of glass without numbers. In the following models the special photopolymer film on the right window in which the holographic projector reflects the image is applied to the numbered glass. The company has added some features to its devices as a result of feedback from users. Focals added some interesting features to enhance the user experience. These are applications that display controls on music platforms (such as Spotify), transition between songs, and volume controls. Focals is now planning to provide navigation support for people using public transport. The Rewind feature allows users to take notes with their own voice thanks to the built-in microphone on the device. This note allows him to remember both written and audible on the date he / she determines. For the rewind process, users' voice memos are forwarded to North's servers. And after it is processed, it is made ready for forwarding at a later date [195, 196].



Figure 5.65 Loop [196]

Effortlessly interact with Focals using Loop, a 4-directional joystick that can also be pressed to click, allowing you to interact without lifting your hand [196].

- Focals keep you connected with friends and family throughout the day.
- Focals provide intuitive navigation in your line of sight.
- Focals come with Alexa built-in. Ask Alexa to play music, hear the news, see the weather, control your smart home and more.¹
- Focals provide the information you need when you need it. Check the time and date, your calendar reminders, view weather, or pause it all with do not disturb.
- Focals integrate technology within the silhouette of a traditional eyewear frame.
- Effortlessly interact with Focals using Loop, a 4-directional joystick that can also be pressed to click, allowing you to interact without lifting your hand.
- Focals allow discreet and glanceable access to the right information at the right time- giving you control without pulling you away.

CHAPTER 6

SPECIFIC APPLICATION

6.1 Project Concept and Output Source

The concept of the implementation project is determined as a nature event, the frost. Humidity that the air cannot carry turns into these crystals on plants, soil or leaves due to cold weather below zero degrees, which is called a frost. When a mother embraces her child, the drop falling on her cheeks from her pupil is called a frost too.



Figure 6.1 Frost and tears [197]

In the scope of the thesis, it was decided to design the Ottoman Kaftan which was developed with the application of led wearable technology as the original application project. The legacy of Turkish culture, the symbol of power and status, the Ottoman sultan kaftans made the name of the whole world and inspired many artists and designers. Kaftans, which are at the forefront of the Ottoman garments, have a unique beauty as a work of art with their excellent fabrics and patterns as well as hidden design elements such as mold features, hand stitches and decorative elements. The design process was based on Ottoman kaftans for the shape of the kaftans, and today's kaftans for material selection and decoration.

The aim of the project is to combine the Ottoman kaftans, which are adapted to modern life with their lines, with engineering applications. Therefore, in the focal point of the inspiration of the frost, beaded laces and flexible strip leds were used.

The color of the kaftan is selected is green. Green is the color of nature. It symbolizes growth, balance, harmony, freshness, life and productivity. To simulate the ice crystals on the edges of the green leaf of the rime, the led is placed on the ends of the arm, body and skirt of the kaftan. Just like crystals, LED lights show light from different angles. For this reason, sensors were placed and breaking effect of light was tried to be reflected.

6.1.1 Ottoman Kaftans

The choice of clothing in the Ottoman Empire is not based solely on functional or aesthetic criteria. Clothing is considered as a symbol of professional and social status [198].

During the Ottoman period, the kaftans, which are a symbol of the power of the sultans, were used as outerwear by both men, women and children. Sultan kaftans are not only political power; it was an indication of the rich taste of the Ottoman art and creativity [201].

6.1.2 Form Structure of Ottoman Kaftans

They have a T-shaped form and therefore have a very simple structure. Similar form, since the very old times that have the property. However, kaftan, in Ottoman clothes, was a designer who was very important and seeking reputation and became one of the first terms that came to mind when the Ottoman Empire was mentioned. The kaftans, which have a very large body size, were further extended with triangular pieces down the waist. The kaftans are open from the front and usually have slits on either side of the skirt ends or in the rear center [201].

In our special application project, the traditional forms and patterns of Ottoman kaftans were set out. The kaftans are designed from the front with an open, collarless and small upright collar. Front with ribbon or brit button.

6.1.3 Led Dresses

Led garments give wearable technology a different field of application. These designs are visually captivating beyond functionality.

Strip Led: Thin conductor circuit bands consisting of small led bulbs. Small led bulbs are arranged on a flexible and thin strip. It has been preferred in our original application project due to its wide usage area. It has self-adhesive structures.

Strip leds according to their light power; single chip led strip and three chip led strip. Led Strip is made up of SMD led chips arranged on a flexible pcb. These SMD packages are white boxes on the strip leds. If there is 1 chip in these boxes, these strip leds are called single chip, and if there are 3 chips, they are called 3 chip strip leds.

Single color led strip is available in many colors such as red, green, blue, amber, white and daylight.

According to usage area; Silicone and silicone-free models are available.

Silicone coated strip leds used for outdoor are preferred at the front and arm edges of the kaftan. SMD packages on these leds have silicone coating. This coating was preferred because it protects the strip led. As it prevents oxidation, it also extends the life of the strip led.



Figure 6.2 Silicone single color led strip

At the skirt end of the kaftan, analog strip leds were preferred to prevent visual disturbances during movement. It is preferred because there is no silicone coating on these leds and because the skirt is a moving area.

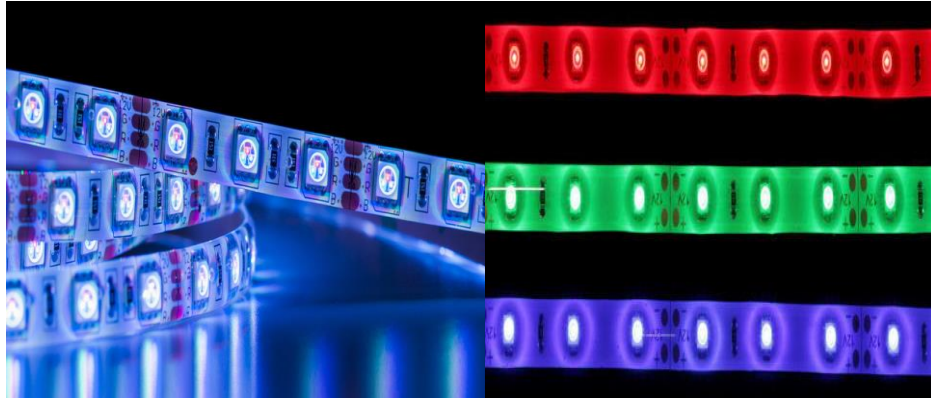


Figure 6.3 Analog single color led strip

The following factors have been considered for installation:

- Required ribbon length
- Power and voltage requirements
- Direction of leds on the strip
- Flexibility of led strip lights
- Whether components such as connectors are required
- Whether the ribbon needs to be programmed

6.2 Design Process and Stages

6.2.1 Research

Research covers product type, product accessibility, theme and story of the materials to be used in the product, user profile, budget and cost analysis.

- Type of kaftan
- Trend forecast
- Material availability
- Theme and story line
- Clients profile
- Budgeting and costing

Theme and Story Line

Theme is determined as a nature event, the frost. Humidity that the air cannot carry turns into these crystals on plants, soil or leaves due to cold weather below zero degrees, which is called a frost. When a mother embraces her child, the drop falling on her cheeks from her pupil is called a frost.

Client Profile

The geography we live in is the design of a very popular garment and the transformation of traditional into an innovative garment by replacing the accessories used in the current versions of this garment with technological objects. This dress aims to be unique by the day it is worn. It is aimed to stand out from existing designs technology.

Age Group

It is planned to wear a young mother in the presence of a baby.

Demography and Geography

The process of marriage in Gaziantep is quite colorful and comprehensive with conceptual ceremonies such as asking for a girl, engagement, dowry, bridal bath, henna night, wedding, looking at the bride, bridal invitations. After the marriage is crowned with a child, a mevlid (a ceremony with praying) is arranged in order to the baby to be a good son for his family and nation. The mother wears a kaftan. This kaftan is one of the most ostentatious legacies of the Ottoman Empire. Kaftans, which are at the forefront of Ottoman clothes, are the indicators of power and status for those around them despite their simple form. As in all societies, the baby is the greatest symbol of fertility, continuity and life. Mothers and babies are praised during prayers and are expected to make good wishes for the continuity of the family.

Motto in Life

Gaziantep is an example of a city that succeeds in conveying the traditions to the next generations. Since all the rituals were performed in a conceptualized way, the baby mevlid inspired this work.

Accessory Board

In our study, the accessories used are;

- Woven satin fabric
- Lining fabric
- Wadding
- Ribbon leds
- Battery and switch
- Lace and beads for trimming

Mood Board



Figure 6.4 Mood board

After all the works, the aim of the project is to add bright lights to the Ottoman kaftans which are adapted to modern conditions with modern lines and to make them remarkable. Therefore, design knowledge, fabric knowledge and engineering applications were brought together.

In the light of the kaftan models examined, an original kaftan design was made in accordance with the brand, modern, theme and geography to be used. After all the works, the aim of the project is to add bright lights to the Ottoman kaftans which are adapted to the modern lines and to make them remarkable. Therefore, design knowledge, fabric knowledge and engineering applications were brought together. The design started with the search for suitable fabric types. Since the product was intended to be used on a special night, woven satin fabric was decided.

This fabric is chosen because it has a natural, smooth and shiny surface. In addition, the fabric is rather pale and thin enough to allow light to pass through. A green hue is chosen to match the theme.

The design stages of the kaftan, sewing and placement of electronic components were carried out as follows:

- In order to make the kaftan to be designed commercially, the market analysis was done and the models and preferred fabric types that are frequently used in modern cafts were investigated.
- Green satin was chosen for kaftan and gold satin was chosen for lining.
- After deciding on the choice of fabric, the necessary fabrics were taken for the design of kaftan according to the measurements.
- Sample drawings of the planned kaftan model were made. The location of the planned leds was decided.
- Wearable technology for textile sample application; firstly, the fabric and leds required for kaftan design were started by selecting. By bringing cultural materials and technology together, this exemplary application has emerged as a result of transforming the imagination into a fashion design process in a special design and application process. The exemplary application is carried out in all stages from the basic starting point to the sewing of garments and the integration of technology.
- Traditional materials and techniques were combined with advanced technology and new methods in the application project, which utilized the Ottoman kaftans as output sources.

- With the help of the molds prepared according to the sample drawing, the lining of the kaftan was cut and sewed.

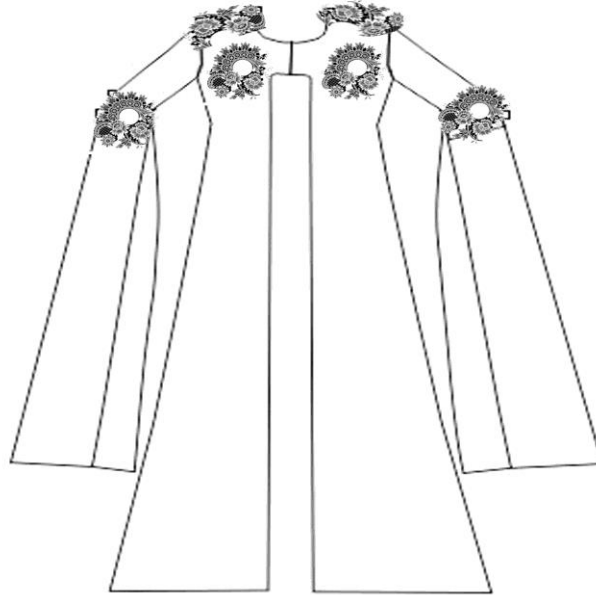


Figure 6.5 Sample drawing- face side of the kaftan



Figure 6.6 Sample drawing- back side of the kaftan



Figure 6.7 Sample drawing- front of and back side of the kaftan

- For the kaftan sewing, the lining is cut and sewed first.



Figure 6.8 Preparation of the inner dress and kaftan

- Then cut the inner dress and kaftan and sew.
- Arms mounted last.
- Led cables were cut according to the dimensions of the application areas (arm, body edges and skirt end).
- Sample fabrics for which led light is applicable were selected. Led lights were tested on satin, velvet, tulle and organza sample fabrics of different colors.

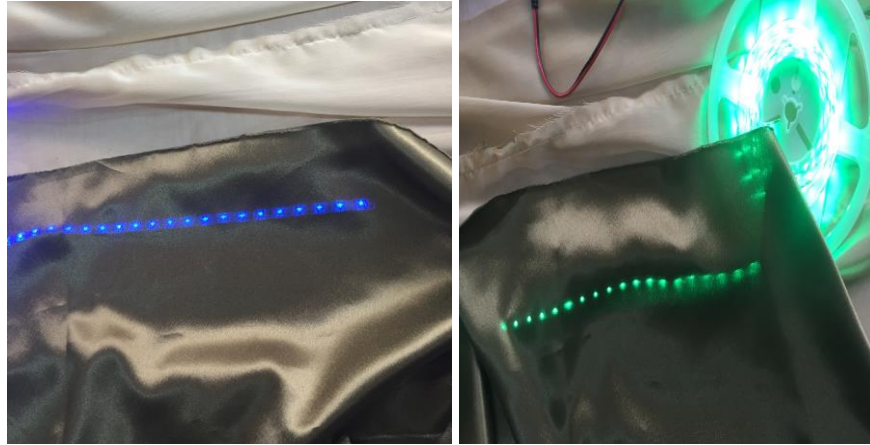


Figure 6.9 Testing of different color leds

- Self-adhesive flexible strip leds were placed on the lining. In addition to the bonding technique, the leds were sewn onto the fabric and secured.



Figure 6.10 Sewing flexible leds

- The leds integrated into the fabric are connected to the power supply by means of soldering process and are made operable. The lining was then stitched together with the lining itself, thus preventing the integrated leds from being damaged and distorting the aesthetic appearance. In order to reach the power sources to which the leds are connected and to make them operational, hidden eyes were created at certain points of the kaftan. Thus, it was possible to replace the batteries and operate the leds with the control system. The batteries of the leds in the front of the kaftan were hidden by creating a special area under the laps. In order to provide access to the batteries of the leds in the arms and the skirt of the kaftan, hidden eyes were created in a way that would not disturb the visuality.



Figure 6.11 Integration of leds into the fabric

- After the led system is integrated into the kaftan, we can control the leds in front of the body by means of the added sensor. Sensor system; It consists of arduinoo controler, light sensor, resistance, voltage amplifier, battery and led strips.



Figure 6.12 Placing sensor systems on the kaftan

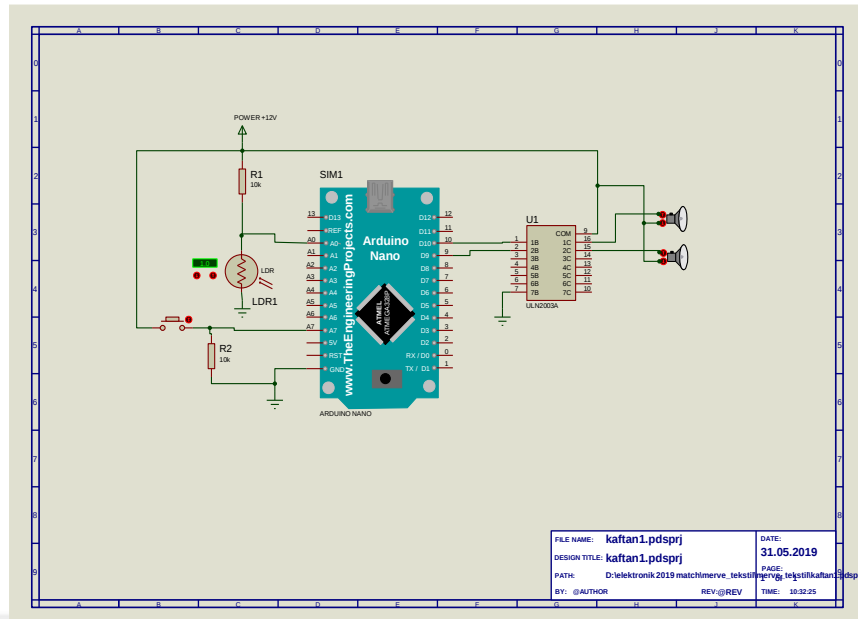


Figure 6.13 Electronic schematic of sensor system

```

const int ledPin = 2;
//const int button = 0;
const int ledPin5 = 5;
const int ldrPin = A1;
const int button = A0;
void setup() {
  Serial.begin(9600);
  pinMode(ledPin, OUTPUT);
  pinMode(ledPin5, OUTPUT);
  pinMode(ldrPin, INPUT);
  pinMode(button, INPUT);
}
void loop() {
  int ldrStatus = analogRead(ldrPin);
  int button = analogRead(button);
  if (button <= 20) {
    digitalWrite(ledPin, HIGH);
    digitalWrite(ledPin5, HIGH);
    Serial.println("button");
  }
  else if (ldrStatus >= 600) {
    digitalWrite(ledPin, HIGH);
    digitalWrite(ledPin5, LOW);
    delay(100); // wait for a second
    digitalWrite(ledPin, LOW);
    digitalWrite(ledPin5, HIGH);
    delay(100); // wait for a second
    digitalWrite(ledPin, HIGH);
    digitalWrite(ledPin5, LOW);
    Serial.print("Its DARK, Turn on the LED : ");
    Serial.println(ldrStatus);
    Serial.println(ldrStatus);
  }
  else {
    digitalWrite(ledPin, LOW);
    digitalWrite(ledPin5, LOW);
    //Serial.print("Its BRIGHT, Turn off the LED : ");
    Serial.println(button);
  }
}

```

Figure 6.14 Code for sensor system

- Finally, using different materials (lace and beads for trimming), the kaftan was transformed into a different design. Thus, while the led lights do not light, it is intended to be a kaftan with fascinating beauty. The motifs were carefully cut on the selected fabric. Then carefully placed on the front and back of the kaftan.



Figure 6.15 Adding of accessories over the kaftan

6.3. Design of the End Product

6.3.1 Examples for Ottoman Kaftans



Figure 6.16 Examples of Ottoman Kaftans [199, 200]

6.3.2 Face Side of the Product



Figure 6.17 Face side of the product

6.3.3 Back Side of the Product



Figure 6.18 Back side of the product

6.3.4 Photographic Views of Kaftan (Kaftan With Led Design)

The professional photographs of the finished kaftan with its design, accessories and led lights are shown in Figures 6.19 and 6.20.



Figure 6.19 Photographic views of kaftan

a)front view, b)back view, c)open view

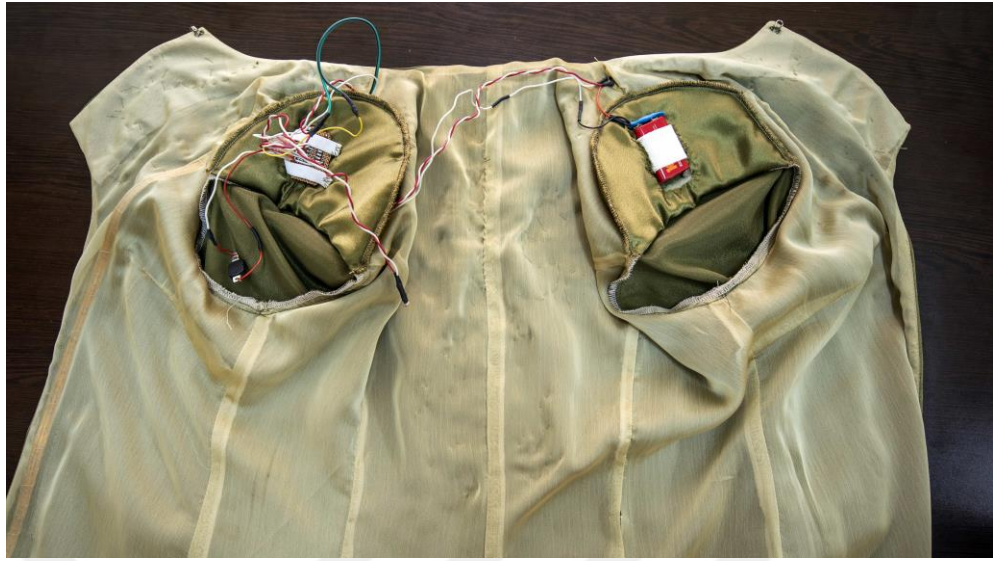


Figure 6.20 Photographic view of kaftan's inside (kaftan with led design)

CHAPTER 7

CONCLUSION

With the developing technology, the expectations of the users are increasing day by day. Textile products also vary depending on the development of technology. The speed of our age also affects the textile sector. In particular, the fact that the manufactured products are susceptible to fashion causes the expectations to change and accelerate. This has led the concept of sustainability to come to the fore in fashion as in all other areas.

It is important for designers to make fashion forecasts and follow-up. However, with the effect of globalization, it has become more important for fashion designers to make different designs. To protect the sector, focus is on slow fashion. However, slow mode alone cannot provide sustainability. For this reason, textile manufacturers are trying to bring textile together with a different technology day by day.

A popular concept for today's conditions, Industry 4.0 is as important for textile engineering as it is for all other engineering. Textile products are trying to get their share from this area with electronic textile products.

In this study, theses, articles, technology news, fair reports and columns are analyzed and the electronic textile products produced according to the last point of technology have been analyzed. In addition, the products were evaluated separately in terms of engineering and designer. Combining technological textile products with fashion, fashion designers and their work leading the sector were included. In the past, textile fibers were obtained only from plant and animal natural sources, industrial revolution and production techniques were developed and regenerated and synthetic fibers were produced. The workability of the fibers and their availability from different materials have rendered functionality beyond the covering of textile materials.

Technological developments and emerging innovative material approaches give rise to new potentials in the field of textiles and fashion design and enable the development of innovative products through the emergence of new products. The use of intelligent wearable textiles is becoming widespread for this purpose. With smart textiles with superior performance features, technology has now become part of our body. And the future is beyond our imagination.

The need for dressing has changed and the desire for being different and the different impulse has come to the fore. This is why designers and engineers have designed smart textile materials in a different way and have directed products to new application areas that can bring visuality as well as functionality. Intelligent textiles, science, technology, design, social sciences, such as bringing together many areas, has led to interdisciplinary studies. It is seen that smart textiles will shape the future. And therefore, in the fashion and textile field, smart textiles have an important potential. Thanks to its intelligent textiles with superior performance features, high value-added products can be produced. This will be important in terms of sustainability and will provide awareness in terms of the country's economy. According to the fashion sense of the current consumption culture, fashion followers expect continuous innovation and change in ready-to-wear fashion products based on mass production. Wearable technology product designs of fashion followers offer alternatives with their functionality and originality.

While fashion shows itself as a reference point in our clothing preferences, the temporary innovations bring out the passion of being original in us and where the imagination becomes concrete. Since it is shaped according to the conditions and possibilities of the current period and society, it is the mirror of the society and the period. Because fashion is influenced by changes in people's thinking and environmental, social, cultural and economic conditions. In addition, changes in science and mechanization affect fashion. The traditions, customs and demographics that societies have are also influential in every aspect of the fashion cycle. Fashion is influenced by many socio-cultural, economic and political factors.

Fashion is constantly undergoing a constant and continuous renewal under the guidance of a complex and established system, which is not under the control of the requirements, but the necessity of being privileged in society, the innovations in the

art of tailoring and the change of economic thoughts. The fashion industry has now not only been able to meet the needs of shopping and fashion lovers, but also has the ability to shape their wishes. With the increasing history of daily life, we are turning to products that make our lives easier, making technology an indispensable part of our lives. And now fashion is shaped not only by fashion trends but also by technology trends.

Design is a creative process that takes a specific purpose. In this process; by developing prepared sketches and plans, the idea of the existing design is transformed into a concrete product. Wearable technology products are often described as wearable computers, smart textiles, or technological devices that can be integrated or worn on the wearer's clothes / any material they carry. Designing a wearable technology differs from all other designs. Because this designed product should meet a need and be controlled by a wearable computer or other technological device. Furthermore, since this will be a textile product, it is very important that it is usable, fashionable, reproducible and easily applicable. Innovative wearable technological textile products, health, defense, security, communication and so on not only in areas but also in the fashion world. In this way, designers push the boundaries of creativity and innovation to produce products out of the ordinary. When the design processes are examined, it is seen that the concept of multi-discipline plays an important role. These products make life easier and improve the quality of life.

In line with the objectives determined during this master theses, researches related to wearable electronic textiles were explained. Smart textiles were then investigated. Then, the studies on fashion and textile design were analyzed. Afterwards, some of the designers who combine smart textile and design in fashion focus and the leading products of these designers are tried to be explained. Then, in addition to the designer's point of view, a detailed investigation of the innovative wearable textile products that are commercially available on the market is presented. The main purpose of this thesis is to compile the innovative technological textile products produced at the last point of current technology. However, on the other hand, as a result of the researches, an application combining fashion design and engineering has been made.

The use of information and communication technologies on garments and the integration of technology with textiles resulted in wearable technology products. These innovative products, which are no longer a product of imagination, are included in our lives, making life easier and improving the quality of life. Kaftan, the subject of the study, has always symbolized strength and status for centuries. The unique design of the kaftan, the grandeur of the selected fabrics and the motifs used for ornaments are highly effective. From this point of view, the T-shape in the Ottoman kaftans in terms of model kaftan, which the author designed from this point, is similar in terms of being tight in front and long-flashy arms. On the other hand, the modern line that the kaftan has to carry in order to conform to the ceremonies in which it is worn in today's conditions is seen in the original design. The main reason why the author made this application is to put together a multidisciplinary study by combining textile, technology with design and engineering applications. [202].

The purpose of this application;

- To be able to design a kaftan with modern lines starting from the design process, including theme and drawing elements. (Ottoman kaftans and contemporary kaftans have been studied in detail and a unique kaftan has been designed in accordance with the purpose of both).
- To be able to choose fabric and accessories according to the product and theme. (Suitable for the selected theme as a theme, green color satin woven fabric and white color flexible led lights are combined in light of engineering information).
- To be able to add the bendable led lights to the designed kaftan without disturbing the wearable form of the kaftan. (The placement of the leds without disturbing the wearable form of the kaftan is provided by lining, wadding and elastane bands).
- To control the LED lights with the help of a light sensor can be realised. (Led light is installed in 3 different areas including body, arm and skirt tip of the kaftan. Each can be controlled separately. With the help of the light sensor used, the shape and level of the LED lights can be changed).

All the objectives planned at the beginning of the study were realized.

7.1 Further Study

A collection can be prepared in the light of what has been learned about the design and designing skills acquired within the scope of the master theses and the integration of electronic tools into clothing. Especially, evening dresses are planned to be combined with technology with less cost concerns. Work can be done on night garment designs that add color changing lights according to one's excitement.



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