



T.C.
ÇANKIRI KARATEKİN UNIVERSITY
INSTITUTE OF FINE ARTS
DEPARTMENT OF ART AND DESIGN

**EMPLOYING SMART TECHNOLOGY IN
THEATRICAL COSTUME DESIGN**

Rawaa Hikmat Abed AL-SULTANI

MASTER'S THESIS

Supervisor
Prof. Dr. M. Emin SOYDAŞ

Çankırı – 2023

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CONTENTS

SCHOLARLY ETHICS STATEMENT	iii
TEZ KABUL VE ONAY	iv
FOREWORD	v
ABSTRACT.....	vi
ÖZET	vii
LIST OF FIGURES	viii
1. INTRODUCTION.....	1
1.1. Research Problem	2
1.2. Research Significance	3
1.3. Research Objectives	3
1.4. Research Methodology	4
1.5. Literature Review.....	5
2. THEATRICAL COSTUME DESIGN AS A CONCEPT.....	8
2.1. The Importance of Costume in Theatrical Performance	8
2.2. Aesthetic Values in Costume Design.....	9
2.3. Fashion Designer.....	10
2.4. Proportionality	11
2.5. Balance.....	13
2.6. Union.....	14
2.7. Rhythm.....	15
2.8. Emphasis	15
2.9. Harmony.....	16
2.10. Sources for Fashion Design	16
2.11. Color Concept	19
2.12. Color in Art	20
2.13. Principles of Theatrical Costume Design.....	20
2.14. A Historical Overview of European Theatrical Costume Design.....	24
3. SMART TECHNOLOGIES AND TEXTILES.....	30
3.1. Smart Fashion	32
3.2. Smart Textiles	32
3.2.1. Textiles for Wearable Electronics	36
3.2.2. Smart Color-Controlled Technologies Used in Fashion Design.....	36
3.3. Smart Textile Types	39
3.3.1. Smart Textile Generations	40
3.3.2. Smart Textiles and Industrial Revolution	40
3.3.3. Textiles Mixed with Other Materials	42
3.3.4. Smart Heating Textiles.....	44
3.4. Smart Curtains for Theater.....	44
3.4.1. Luminous Smart Fabric Design for Curtains and Floors	47
3.5. Smart Microcontroller.....	49
3.5.1. Programming.....	50
3.6. The Future of Smart Textiles	51

4. SUGGESTED SMART MODELS FOR THEATRICAL COSTUME DESIGN	53
4.1. Application and Analysis	53
4.1.1. Inspiration and Theme Identification	54
4.1.2. Material Selection	55
4.1.3. Pattern Application.....	56
4.1.4. Production	60
4.1.5. Presentation	60
4.2. Results.....	69
 5. CONCLUSION AND SUGGESTIONS	 71
5.1. Conclusion	71
5.2. Suggestions	72
 REFERENCES.....	 73
 APPENDICES	 DVD
APPENDIX-1: Videos of Theatrical Performances Applying Designed Smart Costumes	

SCHOLARLY ETHICS STATEMENT

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13/01/2023

Rawaa Hikmat Abed AL-SULTANI

TEZ KABUL VE ONAY

ÇANKIRI KARATEKİN ÜNİVERSİTESİ GÜZEL SANATLAR ENSTİTÜSÜ

Enstitümüz Sanat ve Tasarım Anabilim Dalı öğrencisi Rawaa Hikmat Abed AL-SULTANI tarafından hazırlanan *Employing Smart Technology in Theatrical Costume Design* başlıklı bu çalışma, 15/12/2022 tarihinde yapılan Tez Savunma Sınavı sonucunda oybirliğiyle başarılı bulunarak jürimiz tarafından Yüksek Lisans Tezi olarak kabul edilmiştir.

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Prof. Dr. Ersoy YILMAZ
Enstitü Müdürü

FOREWORD

I would like to express my sincere appreciation and thanks to Prof. Dr. M. Emin Soydaş for the help and support he provided me in completing this thesis in its final form. I thank Prof. Dr. Ali Hamood Twaij as well for standing by my side throughout this period of study. I also extend my thanks to everyone who helped me and stood by my side during my studies. I hope that these efforts contribute to the body of science and knowledge.

Rawaa Hikmat Abed AL-SULTANI

ABSTRACT

Thesis Title: Employing Smart Technology in Theatrical Costume Design

Author: Rawaa Hikmat Abed AL-SULTANI

Supervisor: Prof. Dr. M. Emin SOYDAŞ

Thesis Type: Master's Thesis

This thesis is about smart technologies and innovative fabrics represented in theatrical costume design in the modern era. After giving information on costume design and smart textiles as a theoretical framework, the applied part of the study is presented as the author's own models for costume design using smart technology. Thus, in the thesis, certain questions were tried to be answered by considering these issues. Throughout the study, the author realized the difficulty of obtaining smart textiles, both because of the very high prices and trying to find the places where they are sold. So, the author designed and produced the textiles and costumes on her own by way of the necessary electronic equipment, namely the microcontroller, a set of LEDs and inflatable clothes, which are used in two different performances. It is understood, as a result, that smart theatrical costumes could help to form an entertaining show with a captivating and almost magical atmosphere, where, for example, the colors are used to express the psychological state of the theatrical performer, and the inflatable costumes enable the actors to reach impossible shapes and sizes. Costume design using modern technologies opens the doors for new theatrical performances that could not be held in the past.

Keywords: theatrical costume design, smart technology, theater, fashion design

ÖZET

Tezin Başlığı: Tiyatro Kostümü Tasarımında Akıllı Teknolojinin Kullanılması

Tezin Yazarı: Rawaa Hikmat Abed AL-SULTANI

Danışman: Prof. Dr. M. Emin SOYDAŞ

Tezin Türü: Yüksek Lisans

Bu tez, modern çağda tiyatro kostümü tasarımında temsil edilen akıllı teknolojiler ve yenilikçi tekstiller hakkındadır. Teorik bir çerçeve olmak üzere kostüm tasarımı ve akıllı tekstiller hakkında bilgi verildikten sonra, çalışmanın uygulama kısmı olarak akıllı teknoloji kullanılan tiyatro kostümü tasarımı için yazarın kendi örnek modelleri sunulmuştur. Böylece, söz konusu hususlar tezde ele alınarak belirli sorular cevaplanmaya çalışılmıştır. Çalışma boyunca yazar, hem satıldığı yerleri bulmaya çalışmak hem de çok yüksek fiyatlar nedeniyle akıllı tekstil ürünlerini elde etmenin zorluğunu fark etmiştir. Bu nedenle bir mikrodenetleyici, bir dizi LED ve şişirilebilir giysi gibi gerekli donanım yoluyla, iki farklı performansta kullanılan kumaşları ve kostümleri yazar kendisi tasarlamış ve üretmiştir. Sonuç olarak, mesela renklerin tiyatro sanatçısının psikolojik durumunu ifade etmek için kullanılması veya şişirilebilir kostümlerin oyuncuların imkânsız şekil ve boyutlara ulaşmasını sağlaması gibi uygulamaları içeren akıllı tiyatro kostümü tasarımlarının çekici ve neredeyse büyülü bir atmosfere sahip eğlenceli bir gösteri oluşturmaya yardımcı olabileceği anlaşılmıştır. Modern teknolojilerin kullanıldığı kostüm tasarımı, geçmişte yapılamayan yeni tiyatro gösterilerinin kapılarını aralamaktadır.

Anahtar Kelimeler: tiyatro kostümü tasarımı, akıllı teknoloji, tiyatro, moda tasarımı

LIST OF FIGURES

Figure 2.1. Illustrations of the ancient Greeks in a variety of costumes.....	25
Figure 2.2. Ancient Roman costumes	26
Figure 2.3. The play of ‘Secrets and Miracles’	27
Figure 2.4. Shakespeare costumes	28
Figure 2.5. An exhibition on the interaction between city clothes and stage costumes..	29
Figure 3.1. Fabric that regulates body temperature.....	31
Figure 3.2. A high-tech product combining optical and electronic textiles	31
Figure 3.3. Luminous fiber optic fabric for several uses	31
Figure 3.4. Fiber-rich fabric	33
Figure 3.5. Integration of nanotechnology into fabrics to create smart textiles.....	33
Figure 3.6. Dynamically connected multiple wearable devices.....	34
Figure 3.7. Small electrical and electronic additions to fabrics	38
Figure 3.8. Smart fabrics with high performance	38
Figure 3.9. A clip of a smart tissue	42
Figure 3.10. Luminous fabrics for curtains and wall coverings	43
Figure 3.11. Luminous fabrics and small lighting units with polyester threads	43
Figure 3.12. Stage curtain with LED lighting technology.	45
Figure 3.13. Black LED string curtain for stage backdrop	46
Figure 3.14. Chairs made of fabric and optical fibers.....	47
Figure 3.15. Holographic fabric	49
Figure 3.16. Pinout diagram.....	50
Figure 3.17. <i>Arduino Uno</i>	50
Figure 4.1. Organza fabric	56
Figure 4.2. LED neon light strip	56
Figure 4.3. The front and back of the trousers	57
Figure 4.4. The front and back of the shirt.....	57
Figure 4.5. The sleeves.....	58
Figure 4.6. The trousers	58
Figure 4.7. The shirt.....	59
Figure 4.8. The sleeves.....	59
Figure 4.9. Working on production	60
Figure 4.10. Innovative costumes containing LED.....	62
Figure 4.11. The green LED in one of the costumes	63
Figure 4.12. The pink LED in one of the costumes	64
Figure 4.13. LEDs placed in the most moving areas of the body	65
Figure 4.14. Actor with costume.....	66
Figure 4.15. Actor with costume.....	67
Figure 4.16. Costume lighting during the play	67
Figure 4.17. Acting during the play.	69

1. INTRODUCTION

Technological progress that the world is witnessing has led to the development of materials, applications, methods of employment, and an increase in diversity. Among these applications, smart electronic textiles began to be used by a group of internationally known fashion designers, and they began to be preferred in theatrical performances. This study specializes in smartly designed costumes using modern wearable technologies that rely on LED lighting and blowing.

The trend of smart fashion is seen in clothing, accessories, fabrics and the play of color to showcase the dynamics of movement and color. This trend uses unconventional materials and various techniques to combine technology with fashion (Sherine, 2018). Therefore, this field has achieved many global and technical applications that had been difficult to achieve and found many solutions and alternatives to enrich the aesthetic and functional values.

Smart technologies possess the feature of artificial intelligence and that work either directly or through software commands from the computer, which does not leave an aspect of life and does not enter it. Regarding fashion design, 3D printers, laser cutting machines, LED are examples. Smart textiles are fabrics formed by the integration of textiles with electronic components to provide improved functionality for this product, allowing the creation of new types of functions that were not present in traditional fabrics and fashion, which generated a transformation in its functional and structural structure, and which are fabrics that can sense and respond to stimuli.

Costume design is the art of creating clothing that enhances a character's or a performer's overall appearance. A costume can refer to the attire of a nation, class, or period. In many circumstances, it may contribute to the richness of the artistic and visual universe that is unique to a particular theater or film production. Basic designs are created to identify a character's status, give protection or modesty, or add visual appeal. Costumes are not limited to theater, film, or musical performances. Although both construct stage clothes, costume design should not be mistaken for costume coordination, which merely entails changing existing clothes.

1.1. RESEARCH PROBLEM

A new design trend has recently evolved that combines fashion design and interactive design. As a result, fashion design has grown more relevant to modern interactive technology. Fashion design, technology, and interactive design are all paradoxical notions that will be examined in this study, especially since 'interactive', the research's starting point, has a solid link to electrical design. Electronic design technology is the foundation for the development of interactive processes and the functioning of the overall interactive fashion design system. The phrase "wearable electronics" describes the electronics utilized in garments.

Electronic technology and user interface designs are used in interactive design. With modern life becoming increasingly interactive, now is the time to anticipate interactive fashion design and better grasp how it interacts with the wearer. By examining the interaction between the garment and the wearer and the setting in which it is worn, this study deals with the concept of interactive design.

The smart interactive design in the theater is the highest level of technology employed in the field of fashion design and lighting, because the interactive design can meet a higher level in understanding events or dialogue between representatives of the recipient and thus the ability to take reactions. Smart systems and modern technologies contribute to the formulation and establishment of a new thought in the art of theater and the creation of design and technical diversity not limited to traditional stereotyped systems.

The problem of the current research includes the following questions:

- 1- What are the smart designs that are used in theatrical costumes?
- 2- What are the possible innovative ways of using smart fashion techniques in theatrical costume design?
- 3- What kind of applications can be used in smart theatrical costumes?
- 4- How is it possible to raise the level of innovation and design in theatrical costumes?

These questions generated a real problem for the research because there is a vast difference between innovative electronic technologies and the ways to use them, according to the author, a fine arts specialist. However, art is a highlight—the beautiful aspect of the beautiful image of designs. Beautiful designs make people accept these fashions and smart technologies and their demands.

Limitations for this research are as follows:

Chronological: Literature and framework encompasses the second half of the twentieth century until now.

Spatial: It includes a design application in Iraq within the University of Babylon and the University of Kufa.

Objectively: The study is limited to smart technology in the theater and its impact on theatrical costume design.

1.2. RESEARCH SIGNIFICANCE

This study focuses on designing a smart costume using modern wearable technologies that depend on LED lighting and blowing. The importance of the research relies on producing new examples of smart technologies and raw materials used in theatrical costumes. It attempts to highlight the importance of smart technologies internationally in general and theatrical costumes and to understand the need to apply innovation through smart fabrics. It provides the opportunity for researchers to conduct more applied studies on these technologies, which helps spread the use of smart technologies.

1.3. RESEARCH OBJECTIVES

The current research aims to:

- 1- Employ smart technology in designing theatrical costumes.
- 2- Study the impact of innovative technologies on raw materials.
- 3- Study the relationship of the actor's movement with the surrounding space and the extent of the costume's ability to move by changing the movement of the actor's body.

1.4. RESEARCH METHODOLOGY

The research follows the applied analytical method because it suits the purpose of the research in a successive time, leading to what we live today in terms of the dominance of digital technology over most aspects of life. The author employed smart digital technology in theatrical costumes to keep them in the spirit of the age, especially since the youth group is prevalent in Iraqi society, and this group is greatly affected by technology, which transferred costumes from imitation and monotony to interaction and suspense.

The shows were traditional and suited to specific age groups, but today the topic is different. It is challenging to attract the interest of young people due to their various viewings via the Internet. The designer cannot attract the recipient except by using and employing exoticism, as the eye is not accustomed to witnessing such controversial experiences. Depending on the indicators of the theoretical framework, models were selected, represented by the clothes worn by the actors in the play, which consist of two types:

The first type used smart clothes built from a group of LEDs and connected to the microcontroller, a smart device that controls anything.

The second type used inflatable costumes, which are filled with air to change into a shape that an actor cannot normally reach.

Devices were used for printing on clothes of all kinds: thermal printing, direct printing, magic colors, laser cutting and smart embroidery devices, a three-dimensional printer, and smart cutting devices. Tests were conducted to assess color stability and quality using the above techniques and their effect on the raw materials (washing, friction, sweat) for the samples under study.

The author observed that it was challenging to get smart textiles due to the limited number of stores that carried them and the prohibitively expensive cost of these fabrics. Therefore, the author developed these fabrics and styles using the microcontroller and a set of LEDs as her tools. The LEDs were incorporated into the fabric of the costume by using a microcontroller, a little device that works at 3.7 volts. In terms of the LED in conjunction with the fabric, it is a silicone-coated

substance that is very flexible and can be folded and bent without difficulty with high flexibility. The author also came up with an inflated version of the outfit, the second sort of costume developed. Air was pumped to give it the form initially envisioned for it.

1.5. LITERATURE REVIEW

1- A study by Wassan Khalil Al-Wasiti, entitled "*Modern Technology and Career Transformation in Fabrics and Fashion Designs*" from the University of Baghdad, College of Fine Arts, 2013. The study dealt with functional transformation in the design of fabrics and fashion due to the introduction of advanced technological elements in the textile composition of fabrics and fashion.

The researcher addressed the study's problem with a question: Do recent technological developments have a role in achieving a state of career transformation in the design of fabrics and fashion? The study set two objectives; the first is to reveal the technological elements introduced to the design of fabrics and fashion that led to transformations in their functional structure. The other is to identify the types of functional transformations that have occurred in the designs of fabrics and fashion due to the introduction of technological elements.

She identified the fundamental aspects of design concepts that stem from the character of change and transformation related to benefit. In this topic, the researcher also linked the aesthetic value of fabrics and fashion to its performance dimension, which is entirely different from the formal dimension. She also identified the products of Yonsei University and NASA because they were the first institutions concerned with developing fabrics and fashion at advanced technological levels.

The researcher reached several results, the most important of which are:

- The use of materials with advanced structures of technological levels played a role in creating functional transformations in the design of research community models. It is through the adoption of innovative methods in manufacturing materials and new methods of employing them to create jobs whose images vary according to employment and design.

- It resists perspiration and odors through the technological dimension in the design of fabrics and fashion that can evaporate perspiration and change odors to others that are commensurate with the wearer. It represented a shift in the functional nature of fashion fabrics.

The researcher concluded that the ability of modern technology to find new and raw materials could be employed in the textile composition of fabrics and fashion. This stemmed from the development of scientific knowledge at the level of design thought and other neighboring disciplines and the possibilities of transforming the functional formulas of fabric and fashion designs.

2- A study by researcher Prof. Dr. Sherine Sayed Mohamed Hassan, entitled "*Using smart technologies with color control in fashion design*" from Helwan University, Faculty of Applied Arts, 2018. The study dealt with the presentation of the use of color-changing innovative materials technology in the field of fashion design, which changes colors depending on the type of stimuli that affect it. The study included the use of three different techniques: thermo chromic dyes, photo chromic embroidery thread and glow colors in the dark. The researcher addressed the problem of the study with several questions:

- What are the smart materials used in the field of fashion design?
- What is the possibility of using smart technologies in fashion in the field of fashion design?
- What is the relationship of modern technology with modern fashion trends?

The study's objectives were determined into two goals: The first is an analytical study of the techniques in international fashion for smart fashion and the ways of using them in smart clothes. The other is to clarify the importance of using smart materials and their various technologies in international fashion.

3- A study by the researcher Prof. Dr. Laila Abdel Rahim Al-Maghraby entitled "*Contemporary Art Therapy in the Use of Hologram Technology in Designing Theater Costumes*" from the Higher Institute of Applied Arts - New Cairo Institute of Sciences and Arts, 2018. The study dealt with the use of modern technologies in designing theater costumes by asking: What is the need to establish design

foundations that depend on the technical development associated with theater costumes?

The study's objectives were to use modern technologies in fashion design and to present modern design trends in fashion. It was limited chronologically with the last years of the twentieth century until now, and spatially with the models from Europe and America.

4- A study by researcher Esraa Abed Rahi Radi, entitled "*Technical Characteristics and Mechanisms in Smart Fabric Designs*" University of Baghdad, College of Fine Arts, 2015. The researcher dealt with the technical characteristics and mechanisms in the design of smart fabrics with a multi-functional purpose. The researcher addressed the problem of the study with a question: What are the technical characteristics and mechanisms in the designs of smart fabrics with a multi-functional purpose? The study's objectives were to identify the techniques of smart fabrics, and to reveal the technical design characteristics of multi-purpose smart fabrics. The research tool was the analysis form prepared for this purpose.

The difference between the previous studies and the current thesis is evident in that many researchers used modern technology and functional transformation in the designs of fabrics and fashion. The technology of color-changing innovative materials, chromo-thermal dyes, photo chromic dyes, and glow-in-the-dark colors has also been used in fashion design.

The previous studies also dealt with an analytical study of the techniques used internationally for innovative fashion and how they are used in smart clothes. Other studies also dealt with the technical characteristics and mechanisms of designing smart fabrics with a multi-functional purpose.

The current study deals with smart techniques for the concept of innovative fabrics and their applications in the field of theatrical costume design. It also tries to benefit from previous studies, because it discusses the non-traditional tasks of the cloth, and here the studies come together.

2. THEATRICAL COSTUME DESIGN AS A CONCEPT

Theatrical costumes are considered essential technical elements that complement the theatrical performance. All the visual elements of the presentation meet in an artistic and internal connection; it also combines and integrates to create a consistent stenography in the actor when he interacts with the costume that shows the body's movement and actual dimensions because it has connotations that accompany the postures of the body. The costume affects the body's movement, walking, standing, and sitting. It introduces to the audience the performance of the role played by the actor through the outfit he wears, as it tries to create an illusion of age, profession, and gender.

The actor's costume also gives meaning to the play by clarifying the difference in the character's construction and social classes, the age difference between them, and their moods. When the character moves or utters one sentence, the audience knows whether it is a young woman or an older woman, rich or poor. The character's mood is essential in terms of outfit, as the character's fun outfits are different from the sad character's outfit. Theatrical costumes express the general atmosphere and style of the play and the emotional atmosphere prevailing in each scene. The costumes are designed to give the impression of the unknown inner feeling that is the key to the character (Nassar, 2011).

2.1. THE IMPORTANCE OF COSTUME IN THEATRICAL PERFORMANCE

The theater is considered with all its elements, atmosphere, details, elements, and all the team that works within the theatrical work, as everyone has importance in realizing the theatrical show and making it in its most successful creative form. A certain historical or fictional era is the costumes or theatrical clothes, as they are no less important than others in terms of the reasons for the success of the show (Khalil, 2022).

The costume can speak to the audience with silent words, as well as it can provide the fashion designer with many ideas, just as the theatrical costume can prepare the time and place in order to create perception in the theatrical performance or imagine

age, or to express the emotions of young people. The fashion designer can, through the costume, convince the audience that this character is a regular thinker, or that the other character is distracted, as well as that some decoration in the costume can give status to the character and its influence in the course of theatrical events. Accordingly, costume design is very important because it performs its entire functional role on stage in cooperation with theatrical scenery so that it is homogeneous and compatible with the nature of the body, composition, shape and movement of the actor. The relationship between the costume and the personality is deep and strong. It is considered the roots of the drama so far. A fashion designer who possesses high skills, important methods, advanced techniques, and high-level artistic ideas is considered a teacher, because he possesses high methods and skills in the fashion industry. The costume designer, when designing a costume for a character, is fully integrated with the role of each character in an attempt to understand the needs of individuals and the desires that drive them, as well as knowing the type of fashion that tends to suit each character. Also the fashion designer gets nervous on the opening night of the theatrical show, as James Laffer says, "He is silent behind the scenes when the show begins, and he feels victory when he finishes every work that was done perfectly." Costumes are not only designed and sewn, but also characterized by taste and love for performing theatrical performances (Khalil, 2022).

2.2. AESTHETIC VALUES IN COSTUME DESIGN

Theatrical costume technique is one of the essential elements in the composition of the theatrical element in terms of form and content, as it has a role in deepening the expressive aspect and the identity of the theatrical performance. The costume is a means of presentation, which achieves its goal through the fusion of form and color, as each color has a reflection that creates a unique psychological situation for the recipient or viewer. The process of cognition is manifested in assimilating the values of the figure and its implications in the structure of the costume, and the aesthetic composition of the costume gives a visual and intellectual significance that completes the actor's personality. Therefore, the theatrical costume is one of the essential elements in the theatrical performance (Salem & Alaa, 2018).

Since the costume is a means of presentation achieving its purpose by the fusion between form and color, each color is a reflection that will create the special psychological situation of the recipient or viewer.

The fashion designer seeks to translate the elements of composition into a modern design that lives in a beautiful plastic way with the conditions of reality. It is also the artistic language, which is composed of a unified composition of elements line, shape, color, and weaving, which is influenced by scientific foundations to provide control, integration, balance, rhythm, and proportion, so that the individual obtains a medium that makes him feel harmonious and connects them to the society in which they live.

2.3. FASHION DESIGNER

The fashion designer is considered an artist specializing in his field. He has experience in historical fashion developments. He is also distinguished by a delicate artistic sense, good taste, and social culture. He can sense the needs of society in terms of clothing and express and translate them in his fashion design. Moreover, in his style of dealing and psychological state, accordingly, the designer has all the requirements of the modern man of taste, beauty, and compatibility with the spirit of the modern era in which he lives (Ahmed, 2011); this is in addition to social values and modern ways of life. A fashion designer is an innovative artist who performs a profession with artistic origins and technological bases. He creates an idea and puts an innovation to serve a job offer. The qualities of the fashion are that he has the creative ability to develop new ideas that depart from the known framework of knowledge, whether for the information of the individual or the surrounding information. The innovative person is the one who can extract the most significant possible number of diverse ideas from one idea (Ahmed, 2011):

- a high degree of expressive and intellectual fluency
- a high degree of awareness of the problem
- a high degree of originality and novelty

Well-designed clothing is harmonious in terms of the interplay of design components such as line, texture, and color. These pieces can be treated alone or in combination

to produce a variety of forms and differences based on the design concepts of proportion balance. To generate unique ideas, all fashion designers strive for uniformity across all design elements and adapt the available tools and methods. The fashion designer's abilities and skills are revealed through establishing fit and consistency between design aspects and the individual innovative process.

The acceptance and taste of the consumer determine the product design's appraisal and evaluation. Also, whether it is advertising design, interior design, or electrical device design, the rule of determining the value and quality of design in technical terms is the foundation of fashion and fashion design, and the foundations are widely considered. As a result, the fashion designer must understand the fundamentals of fashion and fashion design, and train and deal with these foundations. His purpose is to create a good design and almost certainly have a significant legal position. Line, texture, color, printing patterns, and fabric work together to create an excellent sense of proportion, balance, and harmony. They must all be present in every piece of clothing, with the rhythm employed in the lines used and the focus discovered.

2.4. PROPORTIONALITY

Proportionality is the resulting relationship between the size of any part of the piece of clothing with the rest of the parts, and also between the lines of any piece of clothing with a piece. The lengths and widths of all parts of the design must be compared to the design. Moreover, fashion exaggerates the proportionality of some parts of the clothes, such as the shoulders, collars, sleeves, bracelets, and pockets. Each of these parts must create a balanced relationship between them and the general shape of the piece of clothing (Derringer, 2013).

The clothes of the ancient Greeks had a sound system in proportion. They were creative and interested in beauty in all aspects of life, so their clothes reached a high degree of perfection. Furthermore, by researching that period, he found in the works of photography and sculpture, the simple effect in the loosening of clothes, which was the result of great care and high contemplation in their thinking. The dress extended from the neck to the ankle, and a belt was tightened at the waist. Thus, the clothes were divided into two parts, the length of one of which was less than half the length of the piece of clothing, and the other was more significant than half (Lee et

al., 2020). This indicates that dividing the outfit has a good effect. The upper- and lower-part ratio is one-third to two-thirds and vice versa. Equal division should be avoided as much as possible, as it is monotonous and boring and does not give us any diversification. Moreover, the division gives some optical illusions:

- Since the eye constantly compares the small parts of the clothes with the large parts, dividing the piece of clothing equal makes it appear longer.
- The division above or below some areas makes those areas look less comprehensive.
- Equal horizontal divisions of a part make it shorter and broader.

Division significantly affects the construction design (Chen & Lapolla, 2021). To obtain new proportions in the design of clothes, it takes time to gain skill and experience in this regard, as the longitudinal and transverse knitting lines divide the piece of clothing, and these lines can make the piece of clothing appear longer, lighter, shorter, or more comprehensive as it is.

Proportionality is the relationship between the outfit's different parts and sections and the outfit's size in relation to the body shape of the wearer. There are three critical indicators of the suitability of the outfit and its parts:

1. Equal-sectioned horizontal segments give the impression of transverse shortness.
2. The eye automatically compares the small parts of the outfit with the more significant parts, dividing the outfit into unequal parts, thus indicating the length of the significant parts, such as "long sleeves and trousers".
3. The width is above or below an area, which makes the space appear smaller. The designer generally moves the lines equal to 205 or less, but he constantly tests different types of proportions, for example the length of the tail, the size and location of the cost used. These components are changed until it reaches the desired effect.

Exaggerated Proportionality: The more significant the exaggeration of the difference between the size of the upper and lower part of the neck, the longer and thinner the body becomes. The very short mini-job, a few inches above the knee, can make a person look tall because the area of bare legs has become large and thus

became the most critical factor in proportion to the whole outfit. The high waist confirms the young age. We should also note that the accessories such as long boots, colored shurbets in the same color as the shoes, and the hair raised to give a sense of length.

Unequal proportionality, even if it is opposite to the upper part - is longer than the lower part to emphasize the thigh area and give a sense of length. The second rectangle is the shortest because the proportion between the two parts is almost equal. However, the falling middle is a problem because most women have the buttocks with the largest chest area. If the fallen upper part is stereoscopic, this confirms any defects in the buttocks area.

We note the effect of the width of the shoulders and the width of the tail on the size of the midline and the silhouette. We also find that the wedge silhouette makes the buttocks look thin. The regular silhouette represents the natural body where the body appears in its natural form and does not suffer from the defects of the wide waist or large buttocks. The silhouette makes the waist thinner than the wide sleeves and side pockets. Using a belt in a dark or contrasting color increases the optical illusion by leading the eye to the smallest area in the silhouette (Al-Amiri, 2005).

2.5. BALANCE

It is how the interior spaces of the shape work for a piece of clothing with each other, as the design in any piece of clothing may be determined or divided by design lines, cost, decorative textile design, texture, color, and good balance in the piece of clothing is comfortable for the eye. There are three types of balance: symmetrical, unsymmetrical, and radial (Lee et al., 2020)

Symmetrical Balance: It is the one in which the inner space of the piece of clothing is divided equally; for example, in a regular job with a sewing line on the center line of the front, the job makes the two parts of the front the right and the left congruent official.

Unsymmetrical balance: The interior space of the piece of clothing is divided unequally; for example, the left side of the men's shirt or one of its sides has a decorative unit, and the other side does not include it. The collar is the means to

create balance or by using some accessories. It has its importance and attractiveness in fashion design, which requires long thinking, observation, high scrutiny, and long experience in its use if some other details, colors, or accessories are added on the other side to create balance (Al-Amiri, 2005).

Radial Balance: It is seasonally used in fashion design, and the radial equilibrium has an emphasis center in the middle of the design elements as they revolve around this center, for example, the shape of the sun's rays.

The symmetrical design is the most rational. It is easy to accept the distribution of the design elements in the costume. Therefore, it is most common in fashion design. The average human body appears outwardly symmetrical on both the right and left sides. The arms, eyes, and legs are balanced from the center line. If an image of the middle of the face were taken and repeated in reverse to complement the face's shape, the face's shape would look completely different from the shape of the natural face. With the same sides of the body slightly different, the eye corrects the slight difference in size and shape; thus, the body becomes symmetrical. The eye sees both sides of the body as equal, and carefully designed clothes can difference reduction, and somebody's defects can be hidden by wearing asymmetric clothing. Asymmetric bodies can theoretically be corrected by confirming one side to balance the difference the defect (Al-Amiri, 2005).

2.6. UNION

Union means that all design elements work together to produce a visual effect.

First rule: The design lines must continue in each area of the costume, whether it is one piece or two separate pieces that are worn together.

Second rule: All parts of the costume should reflect the same shapes.

Third rule: We must avoid the difference between the length of the tail and the length of the sleeves in the outfit.

Fourth rule: The clippers and checkers must match and continue if the pattern patterns are cut on a single fabric direction line, especially in the sleeves parallel to the body.

Fifth rule: Sewing lines and detail lines on the sleeves must continue with the lines. The details on the sleeves must continue with similar lines on the rest of the outfit

Sixth rule: The design lines in all parts of the outfit must be consistent in angles and complement each other (Al-Amiri, 2005).

2.7. RHYTHM

It is the flow of lines, shapes, space, and texture through the piece of clothing. Moreover, this flow or path should lead the eye smoothly from one area to another of the piece of clothing. A good rhythm is when all the design lines match. When designing a jacket with a curved tail, the pockets must also be with curved lines (Ahmed, 2011). The rhythm can also be achieved through repetition. The rows of cornices or felons have a rhythm, and the gradation of size or the gradation of colors also has a rhythm, and the incompatibility of the stripes or checkers drops the rhythm (Lee et al, 2020).

2.8. EMPHASIS

Emphasis is the focal point or the center of attention for any piece of clothing. In fashion design, the process of emphasizing is used to show the features of the body and hide the flaws of the body as well (Ahmed, 2011). This can be achieved by using lines, details, texture, cost, ornaments, and accessories, for example, using a belt in an exact color that emphasizes the middle area to emphasize its beauty. The use of a collar contrasting to the color of the blouse draws attention to the neck area, while the brightly colored kraft tie is the point of interest. Shiny buttons and good emphasis or careful stripes lead the eye quickly. They, therefore, do not know where the focus point and the line have the power to lead the eye to emphasis, so the eye is connected to the line, and natural emphasis creates a center of attention when the eye draws a specific area of the garment (Al-Amiri, 2005).

A designer uses emphasis to direct the eye to what needs to be emphasized. An ideal design has a center of attention. Contrasting colors and decorative units added can create emphasis in the design of any garment and dark areas or dark in a piece of clothing or white or light areas on a dark background that works to confirm some of the characters Speak to the body in the place on which it is laid. A well-planned

emphasis leads the eye quickly to the center of attention. A poorly planned emphasis makes the eye unfocused, and things get confused so that it does not know where the critical point of focus is required (Chen & Lapolla, 2021).

2.9. HARMONY

Harmony depends a lot on personal taste. Harmony means a perfect visual unity in all aspects of the design elements, summarizing all other design principles elements. This means that all parts of the design look as if they belong to the theme of the design; there is no redundant difference that can shock or detract from the appreciation of the entire design or look (Ahmed, 2011). Harmony when designing the overall clothing or model ensemble achieves visual unity. We emphasize that harmony is created when design elements 'color, shape, line, and texture' are used effectively within the limits of design principles 'balance, proportion, focus, and rhythm'. Another consideration for a designer when creating or choosing clothes is the body shape. All parts of the model 'ensemble' must work together to achieve the desired appearance. Whether the clothing set is consistent depends on subjectivity and many see it to express an opinion about beauty.

2.10. SOURCES FOR FASHION DESIGN

Fashion designers are always looking for new sources of inspiration, which can be historical, civilized, national, or famous, as they are inspired by nature or by significant events such as wars and the economic indicators that led to them, military or sailor uniforms, worker uniforms, or the clothing of an artist, a clergyman, or a prominent figure (Ahmed, 2011). Some sources that influence designer ideas and inventions are people's unique customs and traditions and the peculiar policies pursued by different countries. Modern architecture, discoveries and inventions, journey to space, and technical advancement in all areas of life, are among the essential sources that allow designers to innovate and create new concepts and ideas for the fashion industry (Al-Turki, 2000). The designer gets his design ideas from various sources that he considers essential, providing him with innovative designs. Sometimes the designer uses a small detail from the source in his design, and other times he uses the external form, depending on what the source suggests at the time,

and the designer passes in these moments. The sources of fashion design are presented in the following.

- Using historical costumes as a design inspiration: Historical sources are among the treasured sources from which the designer takes his designs. The designer can consult historical literature and museums; not all historical periods are equally fertile regarding new design sources (Abu Ayyad, 2008).

- Using folk clothing as a design inspiration: Designers relate to folk costumes, either from their sources in different nations or through paintings or folk-art centers; this type of source is defined by being rich in attractive ornamentation, and designers also turn to conventional libraries for inspiration (Al-Fiqi, 2007).

- Architecture as a design source: The designer draws inspiration from modern architecture, such as skyscrapers, as well as the art of fan-shaped ceilings, mosque minarets, columns, and star-shaped roadways, all of which were and still are sources of design. Designers can also look to the art of architecture for inspiration (Al-Fiqi, 2007).

- Design inspiration from nature: When a fashion designer sets out to create a piece of art, the first reference he turns to is nature. It is their first teacher because they can take the majority of its materials, values, and foundations for their artistic development from it. It is a good fit for their artistic expression (Suleiman & Zaghloul, 2007).

The role of the fashion designer is highlighted by clarifying the contrast with the personality of each role. For example, the costumes of the cheerful character are completely different from the costumes of the sad characters. The theater director is considered to have the most important role in choosing the costumes for the play. The director's relationship with the costume designer is according to the theatrical text. There are some directors who restrict the fashion designer to choose the type of costume, and some of them cancel the presence of the fashion designer and put the designs himself. Recent studies have proven that the relationship between the director and the fashion designer is a relationship of understanding and this relationship is based on his attendance at the rehearsals of the play every day while reading the text. The relationship is one of the ingredients for the success of the

theatrical work. Theatrical costumes move the audience from theatrical reality to the historical one or transfer it to the world of imagination by portraying what is unfamiliar or even intangible in our real life.

It is possible to consider the work of the theatrical costume designer as the work of interpreting the idea of the theatrical work and clarifying it, i.e. an interpretive and illustrative work of the idea on which the play is based, where it is in complete agreement with the work of the director, who in turn is interested in dismantling and dissecting the characters of the play and reaching the physical, social and psychological dimensions. It gives the exact idea to the costume designer, who is creating the general atmosphere of the play, which is the secret of the success of the theatrical work. Likewise, perusal of the theatrical script and the study of its basic idea, its characters and its different dramatic situations, is considered the main source for the theatrical costume designer to obtain templates for designing his costumes and their style.

Pattern: The blueprint is about lines and curves drawn on paper in an artistic and engineering way based on accurate measurements of a specific body; the basis on which any design is built.

Design on the Mannequin or the Body: It expresses how to deal with the fabric to reach the appearance required to design a specific idea in the imagination of the person forming on the mannequin or the human body directly. Through this approach, we reach a complete harmony between the design and the fabric, the body's shape, and the designer's individual characteristics. It also allows the designer to highlight expressions and artistic touches and innovate, eventually forming a new design with complete freedom of expression (Najwa, 1995).

Design Using the Computer: The design by the computer is a sketch representing the outlines of the design, using symbols on the keyboard or by a similar shape that has been used before for another model and changes are made to it to give the desired shape, and during this process, the program displays on the screen in three modes (in front, side, behind), and accordingly the designer has a three-dimensional image of the design during each step of its appearance on the screen. The intensity and depth of the color are so that the required shades can be given, as well as lighting

at different angles and intensity of the design to give the desired effect (Najwa, 1995).

2.11. COLOR CONCEPT

The word 'color' contains many connotations. Color is not a matter of causality as much as it is visual, as it becomes a semantic element that carries intellectual implications through the energy it contains. Color becomes not just formal feelings on the retina. However, it can become an aesthetic element, as it is the means that expresses traditional values and aesthetic aspects through compatibility and harmony according to an aesthetic approach (Yassin, 2007). There is no dispute that color is like light, created at the beginning of time and throughout the ages; color significantly impacted human life in urbanization and civilization. The man's color at the beginning of his first life was considered the most amusing and entertaining, although it was a complex mystery. The colors consisted of earthy yellow or red powders made from vegetable juices for dyeing clothes and decorating walls. Avicenna promised color as an essential factor in natural medicine, as is the case with us today. Color plays a vital role in treating intractable psychological conditions.

Newton analyzed light and his color theories and conducted several experiments that became the basis for much information. After he saw a light beam in a triangular prism from the bottle, he found the white color changed to a colored light beam or a torrent of olfactory colors (Ines, 2019). Analysing spectrum colors 'red, orange, yellow, green, blue, indigo, and violet,' Newton collected the colors again to be the original white color. Then the chemist Perkin produced the first chemical-colored dye, and these chemical components were similar in appearance to the dusty powders used in ancient times (Ali, 1975). Since ancient centuries, colors have become associated with the celestial planets; for example, the silver color belongs to the moon, the golden color belongs to the sun, the red color belongs to Mars, and the violet color belongs to Mercury. Here, we can specify that there is a prior agreement on the part of societies since the beginning of creation because of the color's impact and implications on humans in those ancient societies. The colors that have had meanings in these times have been determined. The white color symbolized the day, and the black symbolized the night and darkness. Man has linked colors (Frederick,

1993). Colors also invaded the customs and traditions of peoples until they became an integral part of their wealth and were used by ancient and modern humans in some religious rituals of the multi-ritual monotheistic religions (Ines, 2019).

2.12. COLOR IN ART

Concerning color in plastic art, it means a set of relations bearing symbols and contents that express the artist's idea. In the theater, color is considered the visual element that the theatrical artist resorts to as the general framework of the theatrical performance. It works to clarify the general atmosphere of the play, whether it is tragic or comic, and it increases the nervous and psychological emotions through its harmony with the lighting (Ines, 2019). Theatrical design also defines color because of the social class system. This is evident in the Greek plays, which tended to a fixed pattern system by choosing colors, white for priests and youth and purple for the bourgeois class and the clergy. Color attracts attention because it creates an emotional or emotional atmosphere linked to psychological meanings and feelings. It leads to an emotional response in creating a live effect, as some experts in the field emphasize. Colors lead to the acceptance of an idea. The prepared colors that individuals deal with are subject in one way or another to social roots whose meaning in memory can be taken by it, such as white being for purity, black for evil or crime, yellow for jealousy, and red for blood.

2.13. PRINCIPLES OF THEATRICAL COSTUME DESIGN

The theatrical costume is the dress worn by the performing actor as a character above the stage, bearing a characteristic of theatrical trends and through which he determines gender, age, class, and social affiliation, thus having a solid indication of conveying knowledge, and thoughts and feelings to the recipient (Al-Sirs, 2009). Alternatively, it is the clothes that the actor wears to work on the stage, as these clothes may be made for an actor according to the era and the social and geographical conditions in which he plays (Tegam, 2009).

Costume design is one of the elements of scenography, and it plays an essential role in the plastic arts, no less important than the theatrical view. Instead, it is an integral part of its content and a powerful means of expression, as it contributes to determining time and place, expressing the social and moral situation, and

determining the nature of the personality and its connection (Mohammed, 2009). It is considered a vital element of the show. It must be treated so that it brings into harmony with the rest of its elements, in addition to its role in showing the dimensions of each character because the performer's costume in the theatrical performance gives a first impression of the character playing the role. It is a complementary element that interacts with the fixed decor in shaping the scenography of the theatrical scene (Dean et al., 1980).

Theatrical costumes and their complements are among the tools of the theatrical actor, as they are not only a kind of additional decoration in plays but also an essential element of the play itself. And if what is required of the director and the costume designer is to strive to show proportion to the social status in the costume, then it remains for them to strive for taste in choosing colors, as well as in the way of detail and implementation, and the general colors of clothes must be in line with the components of the theatrical scene, its designs, and colors (Tegam, 2009).

Theatrical costumes are considered one of the technical elements that complement the theatrical performance and are important for crystallizing the theatrical idea and embodying its events with perfection, where all the visual elements of the show live in an intertwined artistic and internal connection, and come together to create a wonderful and beautiful scenography. The actor interacts with the costume that shows the movement of the body and its true dimensions, and the costume affects the movement of the body walking and standing and sitting. In the play *Macbeth* by William Shakespeare, for example, the actors of the roles of witches cannot succeed without designing the clothes for the witches that allow them to move with a sufficient degree of physical flexibility, as the costumes are supposed to be suitable in all respects related to the dimensions of the character to be represented. The costume also introduces the audience to the performance of the role played by the actor through what the actor wears to create the illusion of age and profession.

Harmony: Harmony means that the factors and elements of costume design are compatible and complementary in terms of shape, texture, color, as well as the idea. All of these elements must all agree to give unity, stability, and order to the theatrical costume design.

Balance: It means the process of arranging all the costume design elements around the center of the theatrical costume design in a way that creates comfort and stability for the recipient so that all the main points in the costume design are balanced in all parts.

Unit: Feldman believes that unity is the first basis for designing a costume, and that the rest of the other foundations of design are different. The unity in the work does not mean the similarity between all parts of the design, but there can be a lot of difference between them, but these parts gather become a cohesive whole (Hassan et al., 2015).

Concentration: Each design must have a dominant axis or idea to which the rest of the design is subordinated and served by the rest of the design elements. The design is also called sovereignty or control, and it is a place to attract attention.

Rhythm or repetition: Rhythm is the sense of regular movement, which is the repetition of elements in an organized manner and suggests order. It may be continuous or intermittent or clear and explicit or in direction, so rhythm means the frequency of movement on a regular basis so that it can combine unity and change. Rhythm also means organizing the breaks that exist between the units of costume design.

Variance: It can be said that contrast is the feeling of a clear difference between things, and it can work to create a focal point in costume design, adding movement to it. So the contrast works to add more movement and beauty to the theatrical costume if we use it in a good style and form.

Gradation: Gradation is a series of units that are similar in all attributes except for one attribute, which differs from the original in gradual steps. It can be said that gradation is the process of changes that occur through series of decreases and rises of one characteristic of one element.

Radiation: Radiation is the feeling of movement, as it can be set regularly and in all directions, i.e. from a central point, whether that point can be assumed or visible (i.e. clearly visible). Circles, such as the thin circular rods found in a journal, umbrella, or petals in a flower.

Proportion: It is the relationship between the parts of the costume design with the parts of the general design. It can be shapes, or it can be elements or a distance that separates the parts of the costume design (Hassan et al., 2015).

Costumes remain the only permanent element in all forms and periods of theater because the evidence suggests that the choice of costume is a conscious artistic decision in every style in the drama, even when the theater was a common platform or space on the ground. Because the performer in the dramatic event is the center of attention, we pay special attention to the visual impact of the body (Beckering, 2008). The costume designs need to be more daring on a larger scale and simulate subtle details with artistic methods and alternative materials. Fabrics have an important role in this, as different fabrics from those used for costumes produce better results under intense theatrical lighting; woven materials such as burlap, or those that have a broken surface such as velvet, velour, and coarse wool, acquire richness and depth when the theatrical costume is made from them. Furthermore, theater designers constantly experiment with unusual and unexpected materials to enhance the human body (Beckering, 2008). Both the costume designer and the landscape designer must consider several relationships that can be monitored through the following points:

1. Considering the proportions between decoration and costume, because all the elements that make up the scenography have relative positions within the perspective according to the specific spatial dimensions and how to achieve and see them in the void
2. Paying attention to color, as the color of the costume has a strong relationship with the theatrical scene surrounding it. If the color of the costumes used is the same as the color of the scenes or the background, the actor will not appear clearly unless the dramatic work requires that with the use of lighting that serves to confirm or hide the actor (Al-Sirs, 2009).
3. Choosing the material for the outfit and appearance. Sometimes the designer needs to make both from the same material or with materials that show some of them.
4. The existence of a relationship between the actor's location and the viewer, near or far from him. Every movement the actor makes leads to the difference in some

relations from each other. Therefore, the plastic vision differs every time the actor moves from the previous one (Al-Sirs, 2009).

5. Considering the theatrical background in terms of its color, texture, and the light falling on it when designing theatrical costumes. The relationship between them varies according to the quality of the show. There are shows in which the costumes take precedence, and the importance of the background fades in the scenes so as not to disturb the costumes. As for the performances that depend on dazzling and visual and plastic richness, so the importance is due to the theatrical background, and the costumes are part of the design that has the same importance (Al-Sirs, 2009).

2.14. A HISTORICAL OVERVIEW OF EUROPEAN THEATRICAL COSTUME DESIGN

The Greeks, people of taste and art, were interested in architecture, decoration, sculpture, painting, and applied arts, including the fashion industry and design. Above the shoulder, the upper, back, and front edges apply together at the top, and the cloth is draped over the body and chest to form long folds (Figure 2.1).

The Greek costumes were distinguished by their bright colors, red, green, purple, and pink, as well as white and black. The costumes were also distinguished by the presence of fringes and ribbons, primarily yellow, blue, or black, in addition to the introduction of decorations and inscriptions that indicate the sophistication of their aesthetic taste (Al-Tikriti, 1986). The most critical fabrics they used were coarse wool, which the enslaved people and the poor wore. They used the staple enslaved people made with the help of homemakers and then embroidered it. As for silk, it was used by the Greeks in the fourth century after they brought it from China. They used the engraving on cloth and embroidery with colored threads. The colors they used were yellow, blue, dark red, yellow, violet, dark crimson, and the colors that they saw in their lives, such as the colors of crops, rust, and henna, then white and black the outer garment were dark in color (Al-Tikriti, 1986).

Aeschylus, who decided what was used in the cults of Dionysus, was the first to enter the costume assigned to each actor on stage. The way of colors of clothes and the shapes and types of masks, and the most important thing that represents the tragic costume is its greatness and luxury, as it uses valuable fabrics with golden colors and

fringes. As for the colors of the clothes of that period and the symbolic connotations they had, red was the color of boys, white the color of slaves, black and gray the color of children, blue and green the color of the elderly, as white was the color of the queen, yellow for boys, and white with embellished fringes for heirs (Al-Tikriti, 1986).



Figure 2.1. Illustrations of the ancient Greeks in a variety of costumes (*Greek Dress*, 2022).

After of the Greek theater, the Roman theater appeared, where the Romans paid great attention to theatrical costumes, and this was due to the civilization progress that the Roman Empire enjoyed (Pandolfi, 1979). So, they invented a new dress called ‘the toga’. The toga is the distinctive costume of the Roman citizen, and the toga was distinguished by it as a Roman tragedy (Figure 2.2). As for the comedian, the Romans often adopted the costume to represent the current prevailing life, considering traditional aspects and local symbolic considerations related to colors, where a specific type of character colors was identified. They used white for the dress of the elderly, red and purple for the kin, bright red for the needy, yellow for the imprudent, and flimsy clothes for the needy. The actors used to distinguish the roles of older women from what wore white clothes and borrowed hair, and they distinguished the roles of young men with scarlet clothes and hair. Black as for their

fabrics, they used high-quality and expensive fabrics, as well as bright colors that carried the Roman spirit and their love for beauty (Pandolfi, 1979).

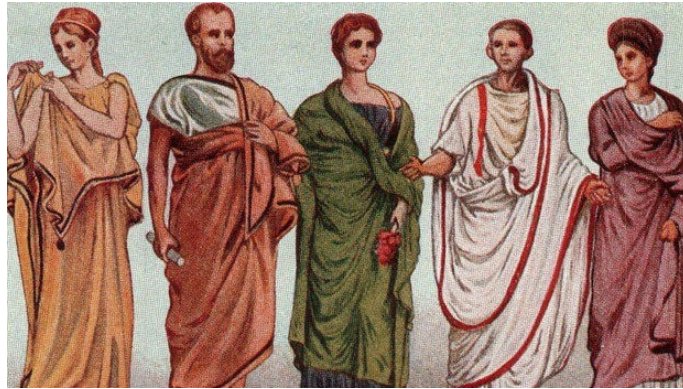


Figure 2.2. Ancient Roman costumes (Said, 2018).

The church intervened in some theatrical activities, primarily limited to the church, considered among the religious rituals presented during the feasts. It grew up in the church, a religious specialty, and it presented some simple plays related to the life of Jesus Christ and the Virgin Mary with a simple acting performance. The actors were priests and children of the religious singing group, the acting was profound and honest, and the dialogues were delivered in voices that indicated prestige and piety. The purpose of the plays was to bring the stories of the Bible into the minds of simple people who could not read the Bible, and plays were held at the time of seasonal festivals called plays 'Secrets and Miracles' that told the story of Adam and Eve. They wore the Dalmatian mantle (Figure 2.3).

The play depicted Paradise set in a high place, surrounded by green scented trees and leaves, and a person wrapped in his suit came and put Adam and Eve in front of him, with white wings, a sign of purity and serenity of the angels. As for the moral plays that appeared after 'Secrets and Miracles,' which express people and accidents, they aimed to teach people and their adherence to virtue and abandon vices, as in the moral plays in which the characters of the four gods appear wearing colorful robes. Their colors indicate mercy and purity. The white color indicates integrity and color red denotes righteousness, while black denotes peace, and these color connotations, predominantly black and white, were used in twentieth-century fashion. As for the French play 'The paranormal', which represent a chapter or a historical event, the costumes tended to the luxurious royal clothes, and they wore masks that resembled

animal heads at the time and angels with wings. Their costumes were compatible with the psychological, religious, and social atmosphere.

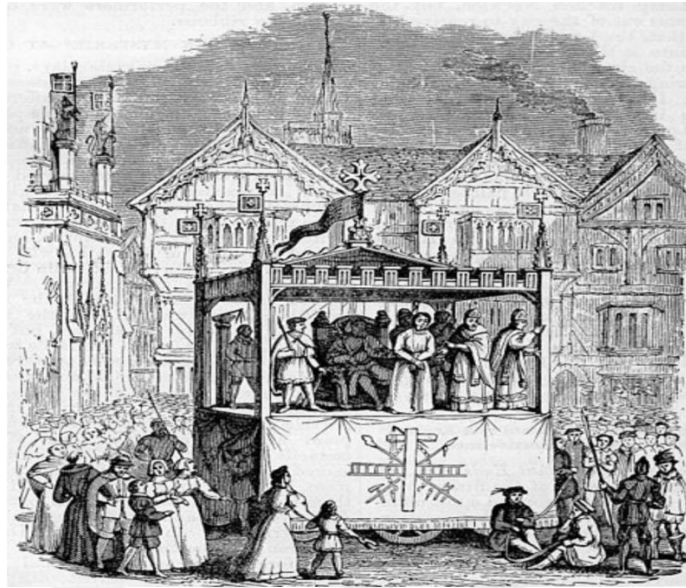


Figure 2.3. The play of ‘Secrets and Miracles’ (*Masrahiat al'asrar*, 2022).

The era of Queen Elizabeth and the period of her reign in England was characterized by several advantages and is considered an essential golden era in history. Queen Elizabeth gave the theater most of her attention by attending many theatrical performances, especially the performances of the playwright ‘William Shakespeare’. In these performances, the costumes were designed according to the characters who play important roles (Figure 2.4). Moreover, it varied, indicating the importance of this civilized era, and the Queen contributed the vast sums spent on the actors' clothes (Aradis, 1986).



Figure 2.4. Shakespeare costumes (*Masrahiaat shakisbir*, 2014).

The impact of the industrial development that took place appeared to have enormous repercussions on the visual elements of the theater, including the costumes, through fabrics with various specifications and flexible characteristics using decorations, sequins, lace, and bright colors, which revealed their color characteristics. Especially the thin colored fabrics added beauty and elegance to the components of the realistic theater scene, which indicated the reality at the time, as well as the use of historical accuracy in the design of the theatrical costume (Abdul Karim, 2012). The list of those interested in this trend was topped by George II, Duke of the province ‘Sachs-Meiningen.’Meiningen was keen in his works to introduce many innovations and discoveries, especially fashion, and attention to detail and historical accuracy significantly impacted the development of theatrical performance. The representatives of Meiningen seem as if they came out of the era's palette. Feininger worked to participate in the design of the theatrical costume and checked all the details. Therefore, due to scientific and technological development in the world, colors, shapes, and new visions embody the spirit of the age created by fashion designers. Meiningen was trying to design costumes himself, scenes, and accessories, and he bought real weapons in his shows, and exercises were taking place on the stage, which was fully equipped in terms of appearance, costumes, and lighting (Abdul Karim, 2012).

Undoubtedly, colors not saturated in the light are more suitable for theatrical costumes with multiple colors. The colors of the costumes should be light under the blue and amber colors in the areas of imagination (Ines, 2019). The red color's general phenomenon is luster; its actual participation is hot, fire, heat, and blood, and its general effect is agitation, excitement, and sharpness. The orange color is bright and glowing, and its actual participation is hot, autumnal, and has a general effect on energy and theater. The green color is clear and foggy, its actual participation is excellent and symbolizes nature, and its general effect is calm, activity, and peace. The blue color indicates its general effect is wet and transparent and has practical participation by being indicative of cold and sky. And the general effect of fear and contempt. The black color indicates darkness; its actual participation is regret and consolation, and its general effect is consolation, sadness, and fear (Ines, 2019).

Theories of theatrical costumes in the twentieth century and beyond, the Swiss stage designer Appiah and the English actor and designer Edward Gordon Craig, called for symbolism and not copying historical lines, and expressed a strong reaction against naturalism. Appiah advocated that “the costume of the stage evokes and suggests but never copies historical lines” (Figure 2.5). The forms and motifs of the costumes were based on traditional Russian folk dress although this garment was altered and made unique to their era by the zigzag influence of Cubism (Tripp et al., 2022).



Figure 2.5. An exhibition on the interaction between city clothes and stage costumes
(Maerid faransiun, 2017).

3. SMART TECHNOLOGIES AND TEXTILES

Computer academics and businesses have long been worried about innovative wearable technology. Wearable smart mobile devices have just recently entered the conception phase, owing to their high cost and technological complexity, and relatively low consumption needs. For example, multinational technological behemoths, such as Google or Apple, have expanded their wearable technology investments in the fashion design sector, resulting in a slew of new ideas for the whole fashion business. Manufacturers at all levels of the garment industry, from mass to high couture in Paris, must prepare for increased market rivalry. Textile materials play an essential role as the most fundamental component of fashion design. These newly-type textile materials appear on a commercial model in tandem with the growth of mobile Internet, sophisticated technology, and the growing worries of the fashion industry about smart textiles. As a result, some well-known designer brands, almost ready to launch their full-fledged campaigns, boldly employ smart textile fibers, gentle on the human body, to improve their chances of increasing sales in a competitive market.

We can know smart textiles as fabrics that have developed through the use of many new smart technologies that can add many advantages to the wearer. Also, smart textiles can be divided into two different groups: aesthetic textiles and performance-enhancing textiles. As aesthetic textiles can include all fabrics that are luminous, as well as fabrics that can change color. Where the system of changing colors and lighting can work by connecting the fabric with the electronics through which they can be operated. As for the purpose of the second type, which is smart textiles that enhance performance, they can be used on sports and military clothes, as this type of fabric is designed for the purpose of regulating body temperature (Figures 3.1, 3.2, 3.3).



Figure 3.1. Fabric that regulates body temperature (*Luminous Fiber Optic*, 2022).

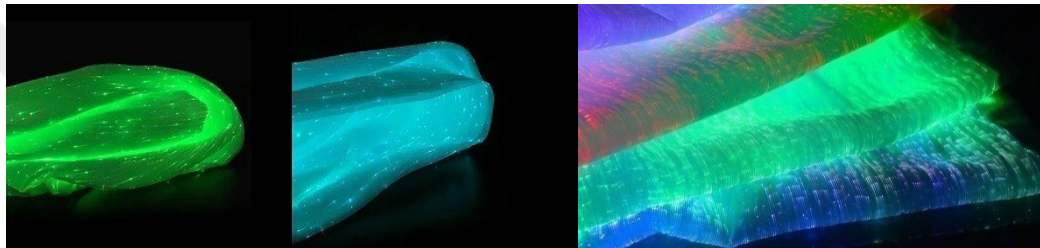


Figure 3.2. A high-tech product combining optical and electronic textiles (*Luminous Fiber Optic*, 2022).



Figure 3.3. Luminous fiber optic fabric for several uses (*Luminous Fiber Optic*, 2022).

Technology is now highly available; it is cheap, and anyone can program, modify, and install it easily. All these factors push us to think and open the doors to new designs of theatrical costumes that are characterized by intelligence in their gestures, whether they are light, sound, or even movement; all these factors combined to deliver the gestures of the theatrical text ultimately and distinctly to the audience.

3.1. SMART FASHION

The future holds expectations for the development of smart clothes, which challenges applying scientific theories to actual scientific reality. There are many ways to classify smart clothes based on the multiplicity of their fields, their use in different areas of life, and the views of specialists, thinkers, and designers interested in them. There are special techniques such as (Kamila, 2013):

- Smart fashion with plastic memory
- Smart fashion with healthcare applications
- Smart fashion for fashion
- Electronic smart fashion
- Smart light-emitting fashion
- Smart fashion of strategic importance, such as space clothing, military clothing, and radiation-protective clothing
- Sports smart fashion
- Color-controlled smart fashion

3.2. SMART TEXTILES

Smart textiles are textile materials and structures that can detect and respond to environmental stimuli through an active control system. They are systems that combine many devices and materials, such as sensors, actuators, and electrical devices (Henock, 2010). They can conveniently display substantial changes in mechanical characteristics such as form, color, and stiffness, as well as thermal,

optical, and electromagnetic properties in response to inputs (Figures 3.4, 3.5 and 3.6).

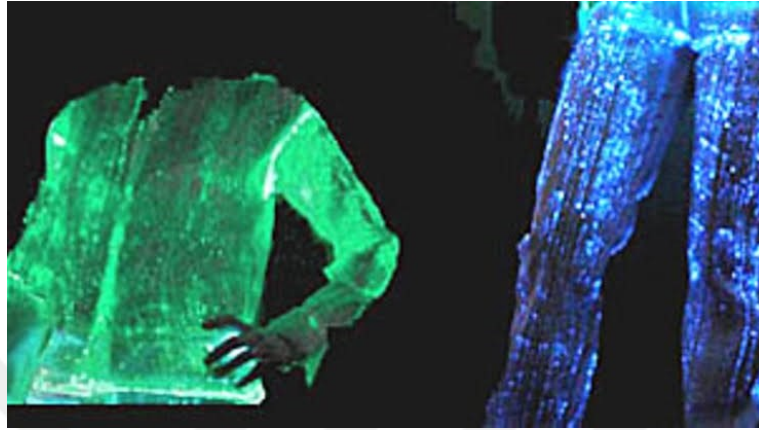


Figure 3.4. Fiber-rich fabric (Griffin, 2021).



Figure 3.5. Integration of nanotechnology into fabrics to create smart textiles (*What is the future of*, 2021).



Figure 3.6. 0Dynamically connected multiple wearable devices (Griffin, 2021).

Textiles and dyes that change color in response to variations in PH, clothes composed of conductive polymers that emit light when exposed to electromagnetic signals, and fabrics that control the surface temperature of clothing to attain physiological comfort are all excellent examples. Current smart textiles may be broadly classified into three types (Ramlow et al., 2020):

1. Plane structures, such as those used in STELLA project are made up of electrical components laminated to textile substrates. STELLA project is an EU-funded innovative textile development project (Yi et al., 2021).The research aims to create a bendable and stretchy material made of electrical circuit components. It is a kind of technology that may be used in stretchy applications. In mechatronics, new materials are being developed for usage in bandages, floor carpets, and rubber band parts (Henock, 2010).
2. Functionalized fibers, such as conductive or optical fibers, are merged with conventional textile fibers during textile production ‘e.g., weaving or knitting’; an excellent example is the following (Ramlow et al., 2020). Chris Chapman and David Sandbach, British innovators, have created an electricity-conducting fabric that may lead to wearable phones, keyboards, and other gadgets, like conventional cloth that can be cleaned, laundered, and ironed. It is constructed of conductive fibers by knitting, weaving, or non-woven fabric construction into regular cloth (Yi et al., 2021).

ElekTex was one of the first businesses to enter the market for wearable electronics. It is a textile-based sensor that was recently created with a commercial product. The product features a traditional fabric construction. It is an electrical gadget that is soft, flexible, and lightweight. Its technique creates a three-dimensional fabric structure in a thin material of less than 1mm (Henock, 2010). Elek Tex has two conductive outer layers separated by a semi-conductive middle layer, which is how it works. Conductive-fabric electrodes are found on the outermost layers. In the vertical position of the surface, the bottom conductive layer contains conductive tracks. Its left and right sides are used for tracking. In the resting state, the semi-conductive middle layer serves as an insulator. Electrical current flows between the top and bottom layers during pressing (Ramlow et al., 2020). During mechanical pressing on the ElekTex fabric's surface, either the semi-conductive core layer enables contact between adjacent conducting fibers to create a conductive channel through the central layer, or the applied pressure puts the two outermost conductive layers into touch (Yi et al., 2021). The core layer's conductive channel forms a local circuit between the upper and lower layers (Henock, 2010).

ElekTex fabric offers a variety of uses due to its conductivity, including remote control, a mobile phone, or a computer keyboard; a sleeve for a jacket for listening to music; and an smart blanket for a hospital that avoids bed sores in immobile patients (Yi et al., 2021).

3. A wearable material made up of a mix of innovative materials such as phase change materials, shape-memory materials, carbon Nan fillers for conductive yarn, conductive polymers, optical sensing fibers, and hybrid structures, in which the textile is either a part of the sensing device or is essential to its functionality (Yi et al., 2021).

The first three categories do not produce a 'genuine' smart cloth. Because it lacks the material comfort and capacity to breathe (Ramlow et al., 2020). Actual smart fabrics are those produced in the manner of the second and third generations. Because they use fundamental textile techniques, are as pleasant as traditional fabrics, and are machine washable (Yi et al., 2021).

3.2.1. Textiles for Wearable Electronics

Textile materials, fabrics, yarns, and threads that contain conductive fibers are known as electronic textiles. They are considered smart textiles in the literature since they are wearable and include local monitoring, computing, and wireless communication capabilities (Ramlow et al., 2020). Electronic textiles are a new multidisciplinary area of study that brings together experts from information technology, microsystems, materials, and textiles. They utilize conductive fabrics, sensors, computational components, data, and power distribution, among other things (Yi et al., 2021). Sensing electronics may be integrated into washable and wearable clothes and yarns to gather data, monitor essential parameters, and send them via a wireless channel for additional processing. Every electronic textile requires a power source, electronic components, and a textile connecting mechanism (Yi et al., 2021). Nu Metrex Athletic clothing that monitors heart rate, fabric keypads for operating Pods, and textile heating goods are such devices. Sensors, thermo chromic displays, data transmission systems, antennas, and heating components may all be made using them (Henock, 2010).

3.2.2. Smart Color-Controlled Technologies Used in Fashion Design

Chromium materials radiate color, fade, or change color when external influences occur on them. These materials are classified according to the stimuli that affect them (Sherine, 2018), so they are known as color-changing materials.

Thermochromic Materials: They are heat-sensitive materials made of different compounds that must be dissolved in inks suitable for the application. The chromo-thermal materials change their color when there are changes in the temperature of the surrounding medium (Ramlow et al., 2020). This effect is reversible. The color change occurs according to the temperature that can change the structural composition of the material (Sherine, 2018). The mechanism of color reflection is carried out at different temperatures so that when exposed to heat, the layer of liquid crystals compresses, which affects the reflected color, and when cooling, its area increases, as shown in, and thus the color changes, as the color of the reflected light depends on how close the liquid crystal layers are together (Ramlow et al., 2020). Chromo-thermal materials can be divided into three types: affected by low or cold

temperatures; type affected by body temperature, including touch, and breathing; affected by high temperatures.

Photochromic Materials: Photochromic materials used in costumes change their colors when a change in light intensity occurs, which is a reversible effect. Usually, this material is colorless in dark places, and when exposed to sunlight or ultraviolet rays, the molecular structure of the material changes, and the color appears. The color disappears when the effective light source disappears (Ramlow et al., 2020). These pigments are available in powdered crystals made of light-sensitive pigments that are dissolved to obtain liquid inks for application use. Once these pigments are exposed to sunlight or ultraviolet rays, they change from the transparent state to the colored state, and when the source is removed, they return to their original state (Sherine, 2018).

Fluorescent Materials: Fluorescent materials produce visible or hidden light due to exposure to light falling on them. The effect stops when the light source light is gone (Sherine, 2018). The bright pigments produced from these materials are weak or white in the sunlight, while when excited by ultraviolet rays, they light up a concentrated radiant color in the dark (Ramlow et al., 2020). In most cases, the emitted light has a longer wavelength and less energy than radiation.

The fabrics we know have become a thing of the past because of the human dialogue about the relationship of cloth with technology. This dialogue has produced future model fabrics that can perform functions faster, cleaner, healthier, brighter, and more luminous. These fabrics, regardless of the vagaries of fashion and differences in practical application and humanity's use of fabric with the basic needs of protection, comfort, and expression, are not traditional fabric; they include power generation or storage by electronics applied directly to fibers, yarns, or textiles and differ from traditional electronics because they can be worn (Simon et al., 2010). Smart fabrics equip us with different sizes of skin, replaceable sensors, with energy and modern technology, and they have a role in protecting us from weather factors and reducing energy consumption (Figure 3.7).

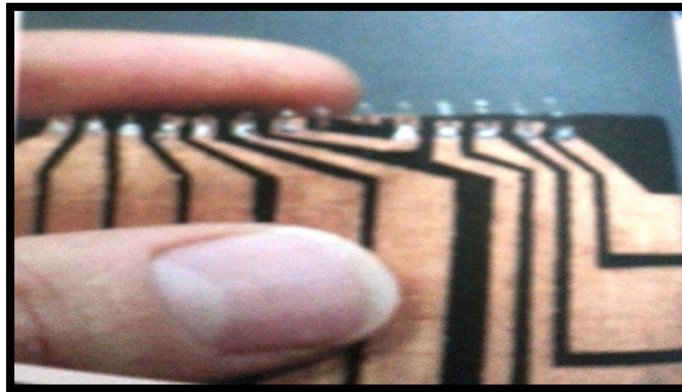


Figure 3.7. Small electrical and electronic additions to fabrics (Bradley, 2012).

Moreover, the additions can change colors, shapes, heat, and conductivity, whether they are connectors, sensors, or colors on fabrics. All these additions will make it easier to perform our jobs (Bradley, 2010). Advances in textile technology and computer and engineering materials science promoted a new breed of smart fabrics by adding wires, electrical circuits, and optical fibers (Addington & Schodek, 2004). The integration between woven fabric and electronics in the world of theatrical design and fashion may become very popular in the world. Walls and furniture could be covered with them, which can produce and sense light by self-operating sensors (Figure 3.8).

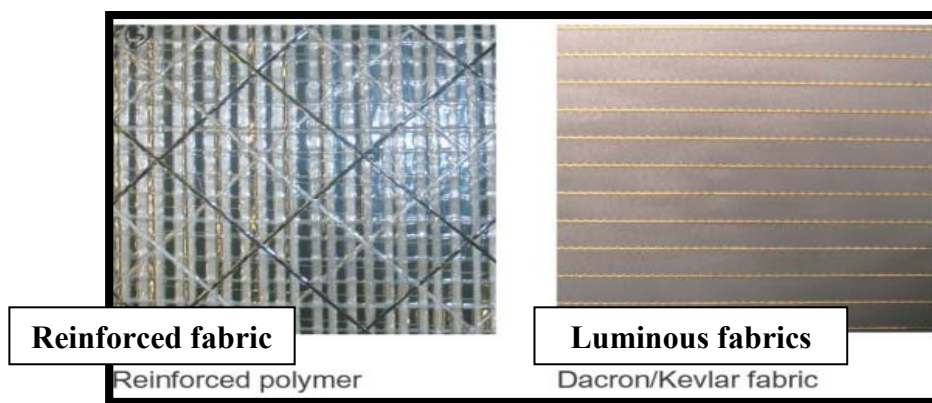


Figure 3.8. Smart fabrics with high performance (Addington & Schodek, 2004).

3.3. SMART TEXTILE TYPES

Textile fibers are the basic unit of all textile's raw materials, as the manufacture of threads is made of fibers, and in the light of which the type of dyes that give textile materials a layer of colors, and the chemicals used to improve both the aesthetic and functional properties of fabrics, are determined. The study of textile performance is a supplement to the study of textile science. For the necessary performance characteristics in some special applications, there are many smart types of fabrics (Mondal, 2007).

- 1- Digital
- 2- Using solar energy
- 3- Sensitive to touch
- 4- Having fast response to electronic stimuli, such as electronic sensory fabric
- 5- Temperature and humidity sensors, such as insulating fabrics
- 6- Optical
- 7- Medical, such as anti-bacterial and therapeutic fabrics
- 8- Motion sensor
- 9- Sensitive to light, such as luminous fabric
- 10- Data logger
- 11- Three-dimensional print
- 12- Affected by electricity, such as fabrics with electrical circuits
- 13- Controller of electronic devices

The author believes that the diversity of the smart fabric, whether it is during weaving or the techniques that follow it during printing in all its sections, enables us to capture, store and process a quantity of information, including light, heat, and sound. The data relating to the health and safety and computing field becomes a

robust information infrastructure through devices, recording different aspects of our activities in our daily lives.

3.3.1. Smart Textile Generations

The design options for smart fabrics include the principle of developing the performance of fabrics in all their uses through enabling technology and achieving quality in design. This development resulted in three generations of smart fabrics (Jimsher et al., 2013):

The first generation is ‘impact non-interactive smart textiles’.

The second generation is ‘active smart fabric’.

The third generation is ‘ultra-smart fabric’.

Each generation is characterized by progressive characteristics down to the advanced super-smart fabric. As for the characteristics of smart fabrics, they can be classified as follows (Addington & Schodek, 2004):

- Fabrics that respond to an instantaneous stimulus in real-time.
- Fabrics that respond to more than one environmental condition simultaneously.
- Fabrics that respond internally to texture or color.
- Fabrics that respond in the place exposed to the stimulus.
- Fabrics that respond separately and predictably.

According to the reaction method, smart textiles can be sorted as (Mukesh, 2004):

- Passive smart tissue, which can sense environmental conditions or stimuli.
- Active and smart tissue which can sense and respond to stimuli.
- A smart fabric that can sense, interact, and adapt accordingly.

3.3.2. Smart Textiles and Industrial Revolution

The art of weaving has enabled humanity to obtain the best resistance to climatic conditions, and the continuation and development of textile work is a vital subject for

human development. The first textiles gradually became a symbol recognizable to any society. With the beginning of the Industrial Revolution, the spinning and weaving industry dealt with spinning machines and mechanical looms, as work was transferred from the home to the factories. The man took cotton, wool, and linen as primary materials in the textile industry. Then new types of chemicals and others were developed, which generated tremendous changes in all aspects and qualities of the fabric (Jone, 2013).

Since the beginning of the nineteenth century, revolutionary changes have been occurring at an unprecedented rate in science and technology with the profound impact of computers, the Internet, the discovery and mapping of the entire human genome, and many more in the world. It helped lay solid scientific understanding foundations to guide and improve the use of technology processing natural fibers and manufacturing synthetic fibers.

Technology has advanced, so that manufactured fibers and their products are superior to natural fibers in many aspects, followed by changes and developments based on the ability to analyze data. By nanotechnology, research and knowledge about smart fabrics are in parallel with many industries, for example, the aerospace industry, the weapons industry, and the pharmaceutical industry. These factors paved the way for new possibilities in art and textiles, with new possibilities in experimentation and cooperation concerning other professional environments. Fashion designers had a role in adopting the innovations accompanying the development of textile and the evolution of techniques used, whether on the outer or the interior shape of the fabric.

The author believes that the roots of smart fabrics go back to the far history, when metals such as iron were incorporated into military clothing to give it strength and durability, and when gold and silver threads were incorporated into the designs of the fabrics of the wealthy. Although the textile industry is one of the vital industries, the textile industries in Iraq suffer from a lack of raw materials and the absence of a vision for research and technological development to enter the field of smart fabrics in this critical industrial sector. The need for these fabrics is a result of several factors, including the atmosphere in the environment, such as high humidity and temperature. These tissues can respond with high efficiency to any changes, no

matter how subtle, whether in temperature, light intensity, or other changes that can occur in the surrounding medium. Also, as its accuracy leads to a direct change in these fibers, and significantly to innovative textile technology, a new world that contains many exciting possibilities, is emerging, coinciding with the goal of fabric, products, technologies, and conditions related to increased production. This can also help to identify new solutions, provide creative elements, and reach the goal for communication, sensing, data processing, and energy conservation (Anne et al., 2010).

By reviewing biological methods for assembling or manufacturing textile polymers, we find that they are often environmentally friendly (Alba et al., 2008). In a sustainable way they can give better management of moisture and better control of heat flow as well as improved thermal insulation and high-performance ability to protect against risks. It is also the case with increased corrosion resistance, health control and assistance in controlling the body. All this is done by enjoying the advantage of easy durability of the fabric and shape retention of the aesthetic design (Figure 3.9).

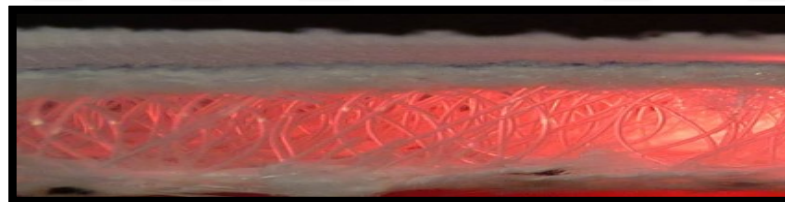


Figure 0.9. A clip of a smart tissue (Addington & Schodek, 2004).

3.3.3. Textiles Mixed with Other Materials

Smart textiles are materials developed by combining different materials designed for a particular need or applications requiring very high performance. It may combine fabrics, glass, ceramics, metals, or carbon to produce fabrics with new and advanced properties, such as silicone coating, 3D chips, color conversion, and texture.

The light-emitting diode ‘LED’ is a light source made of semiconductor materials that emits light when an electric current passes through it. Smart textiles are no longer science fiction. They are combined with fabrics to reach optical textiles, and most smart textiles are designed from materials that can sense and respond to

environmental conditions or stimuli, such as mechanical, thermal, chemical, electrical, magnetic, or any other sources, as well as being inspired by the imitation of nature to create a fabric with higher levels of functionality. There are self-cleaning carpets, textiles with memory and response to the environment, and ‘self’ luminous textiles, an example of multi-colored optical fabric (See Figures 3.10, 3.11).



Figure 3.10. Luminous fabrics for curtains and wall coverings (Bradley, 2012).

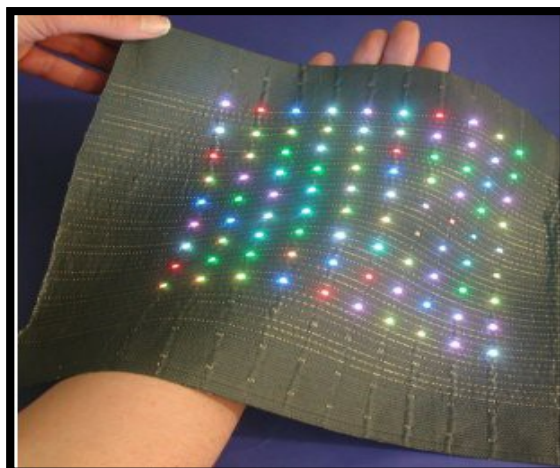


Figure 3.11. Luminous fabrics and small lighting units with polyester threads (Pieterse et al, 2007).

3.3.4. Smart Heating Textiles

It is a type that adopts a new technology that involves a layer of foam in a wet fabric compound that matches the nylon outer and inner layers and absorbs cold water. It expands to close the fabric openings in the hands, feet, and neck, preventing more water from entering as temperatures rise. This constantly regulates the internal temperature batteries, which are often required or dependent on the mechanical properties of the fabric. The author believes that innovation in the world of fabric design is no longer focused on designs and colors as it was prevalent. However, experts in the textile industry have taken care of the quality of the material to suit the needs of individuals according to their lifestyles.

3.4. SMART CURTAINS FOR THEATER

The curtains are one of the internal insulation methods that extend from the top of the nets to the surface of the ground or the lower edge of the lower windowsill. Thermal loss from nets is reduced when used (Goodwin, 2013). The production of a sensitive material that can automatically respond to light that can be used to produce smart curtains reduces energy consumption. Scientists also produced carbon nanotubes and materials that activate when exposed to any light source. When these sensitive materials are placed in a place exposed to light, it can be found that carbon tubes polarize light and convert it into heat, which causes the material to swell and bend. The material returns with the removal of the light source to its initial state. Smart curtains can be opened and closed entirely automatically at sunrise and sunset, depending on the amount of sunlight through the window located in their rooms. These materials can be quickly produced and used in commercial affairs such as light-sensitive motors or robots, so the application of smart fabrics is in a quite wide range, by providing strength and durability specifications, or the ability to change form and color as needed, or connect them to modern technology applications (Schubert et al., 2006).

We are all aware of the effects that Internet applications have had on theater technologies, as they provide exceptional experiences with high-quality display and sound equipment. Technology has advanced so much that one smart application can be used to support various devices in the theater hall, where the designer can control

sound, lighting and curtain devices through the application of smart technology, where TES technology can also use a number of useful solutions such as a projector lift device and a media server device. In smart theater, LED lights can be set based on the type of show presented, where the color of the lighting used in the theatrical show is taken into account in the show to match the scene and the costumes of the actors, as the color of the lighting is reflected on the costumes. So it must be taken into account in each scene as well as the color of the lighting of the curtains in the theatrical decoration by controlling the remote control device that connects to the lighting bar placed behind it. One of the most common examples of technological backgrounds that are used today is the fiber-optic curtain and LED,

Sometimes fiber optic curtains are referred to as star curtains, as these curtains consist of a network in gold colors and fiber optic strands drop from them, which are glowing ends, which appear in front of the heavy black material, and these strands are dimmed by fixed lights that can be controlled using the lighting board. This allows control over the color of the actor's rapid pantomime movements, and the resulting effect is a luminous field of lights. The LED curtains are a variety of designs in distinct colors, with modern, smart, elegant designs that catch the eye and arouse curiosity to know what is behind that elegant curtain (Figure 3.12) (Backdrop Decoration, 2022).



Figure 3.1. Stage curtain with LED lighting technology (*Backdrop Decoration*, 2022).

Smart curtains simulate the light-sensing mechanism of algae, giving us design inspiration for photosensitive fabrics and a vision protection device by filtering harmful rays of light from the electromagnetic spectrum. Advances forward or backward in response to harmful UV rays, equipped with a motor called an eye spot or scar (Selbach et al., 1999). The designs inspired by this natural phenomenon stimulated designers in the direction of optical fibers that can be combined with threads during the weaving process and can be applied to prevent the influence of light and ultraviolet rays (Yu et al., 2004).

The traditional lined and striped blinds have been replaced with electronic blinds, which are lighter in weight and have multiple functions and different materials. The author believes that smart curtains can significantly reduce energy, take advantage of natural sunlight for lighting in the winter, and close during the summer to prevent the effect of high heat. Also, this feature can be employed in the design of fabrics because it can form resistance to sunlight in the summer and equip the interior space with lighting, which shows a group of smart curtains (Figures 3.13, 3.14).



Figure 3.13. Black LED string curtain for stage backdrop (*Backdrop Decoration*, 2022).

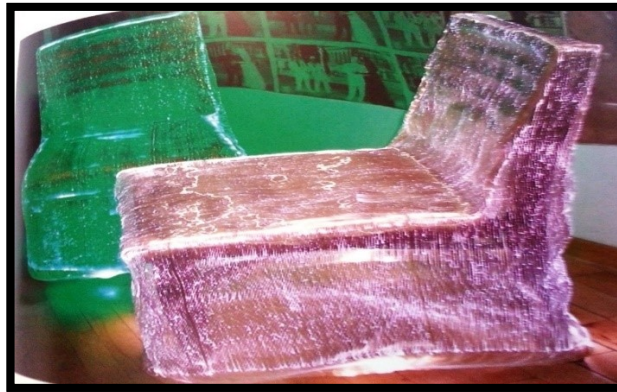


Figure 3.14. Chairs made of fabric and optical fibers (Bradley, 2012).

Clothes are not just fabrics we wear to cover our bodies and protect them from natural influences; they also reflect our taste in fashion. Its advantages are not available in traditional fabrics, such as communication, transformation, energy conduction, and growth (Anne et al., 2010). Instead, its future will carry a new concept ‘smart fabrics’, and what makes this type of fabric distinctive and even revolutionary?

Smart fabrics can be classified into two different categories: the aesthetic category and the performance-improving category. Examples of aesthetic fabrics include all types of fabric, ranging from luminous to changing colors. In contrast, some of these fabrics collect energy from the surrounding environment, such as vibrations, sound, or heat caused by the body. As to performance-enhancing fabrics, they will have a significant impact on violent sports and military industries. They consist of types of fabric that regulate body temperature, reduce wind resistance, and control muscle movement, which will help athletes improve their performance; other textiles have been developed to manufacture clothing that protects against environmental hazards, radiation, and the effects of outer space.

3.4.1. Luminous Smart Fabric Design for Curtains and Floors

The production of light glow in fireflies arises at the expense of a bio-chemical catalytic enzyme reaction, scientifically called ‘bioluminescence’. This process occurs in the lower abdomen of the firefly, the beauty of this bio-chemical reaction lies in its ability to produce cold light rays, ultraviolet or infrared. The glowing phenomenon inspires designers to design luminescent fabrics by coupling light-

emitting diodes LEDs and simulating the bioluminescence of fireflies. This chemical process provides the impetus to design glow-in-the-dark fabrics that will add value to the fabrics and textile industry through innovation to produce a wide range of light-emitting fabrics with Printed Circuit Boards (PCBs) and successfully associate them with wearables. The curtains, carpets, and upholstery field use simple buttons (Bechert et al., 1997).

The author believes that many textile factories cooperate with major international companies producing electric lamps. Colored light-emitting fabrics were presented using lamps that were ultimately integrated into the fabric without compromising the flexibility of the fabric so that the person wearing it appears luminous, and the natural glow inspires it. The exciting aspect is that smart fabric technology can carry messages in the form of writings or drawings in many colors. Then we are not far from the future of using optical fabrics as a source for advertisement and promotion of a commercial product. Advances in textile technology, computer engineering, and materials science are promoting a new breed of functional smart fabrics. It is up to fabric designers to add wires, electrical circuits, and optical fibers and create fabrics that glow in the dark, retain heat, or generate coolness.

The combination of fabrics and electronics is in the interest of the art of design, as there are no smart fabrics to attract attention and meet needs without considering the aesthetic aspects. Designing smart fabrics is not just about meeting needs without regard to aesthetics. Appearance is also a functional need. Information about mobility and privacy is widespread and can be hacked by computers, and the level of security required will vary according to consumer requests. Military clothing, medical fabrics, and fashion, for example, can vary levels of data protection for them, and data encryption standards are required to ensure producing different fabrics that work together efficiently and safely. There is no doubt that electronic sensors are now compact enough to be integrated into any piece of fabric.

There are many examples of advanced visions of smart fabrics inspired by nature, including various designs inspired by the sensitivity of human skin and thermal stimuli for inclusion in fabric and leather designs (Meoli et al., 2002). An example is the smart holographic fabric, which relies on the combination of traditional fabric and modern printing technology utilizing animal skin simulation, achieving a kind of

optical illusion in fabrics through fabric folds and obtaining a third changeable surface, like visual art ‘Op Art’ (Figure 3.15).



Figure 3.15. Holographic fabric (Photo: author).

The author believes that the advantages of designing fabrics with natural features of animals or plants and using modern technologies will revolutionize the spinning and weaving industry.

3.5. SMART MICROCONTROLLER

The Arduino UNO is the best board for electronics and coding. The UNO is the most used and documented board of the whole Arduino family. Arduino Uno is a microcontroller board based on the ATmega328P ‘datasheet.’ It has 14 digital input/output pins of which six can be used as PWM outputs, six analog inputs, a 16 MHz ceramic resonator ‘CSTCE16M0V53-R0,’ a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to start (Figures 3.16, 3.17).

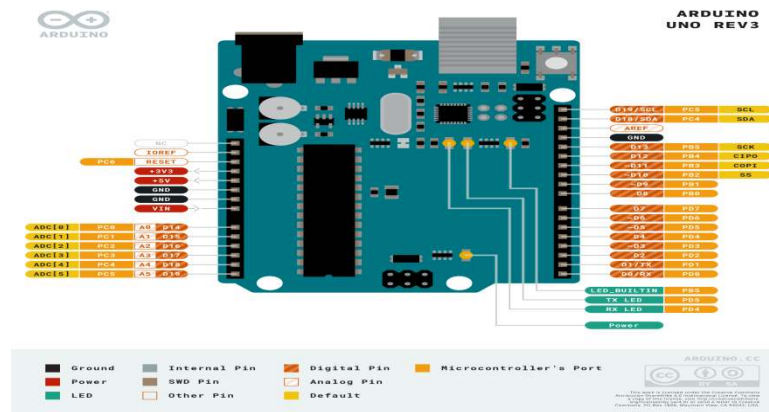


Figure 3.16. Pinout diagram (Hadid, 2021).

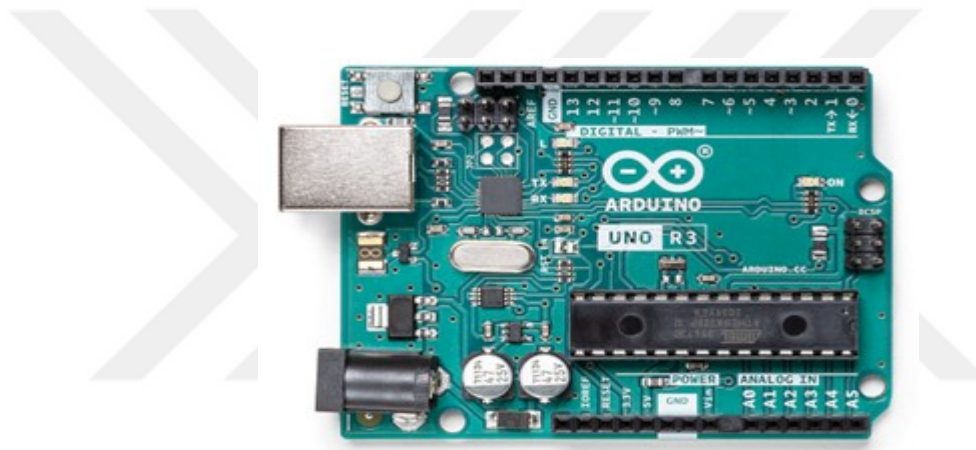


Figure 3.17. *Arduino Uno* (Hadid, 2021).

3.5.1. Programming

The Arduino Uno can be programmed with the Arduino Software ‘IDE’. The ATmega328 on the Arduino Uno comes preprogrammed with a boot loader that allows uploading new code without an external hardware programmer. It communicates using the original STK500 protocol.

The boot loader and microcontroller program can bypass the ICSP ‘in-Circuit Serial Programming’ header using Arduino ISP or similar; see these instructions for details. The ATmega16U2 or 8U2 in the rev1 and rev2 boards firmware source code is available in the Arduino repository. The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by. On Rev1 boards: connecting the solder jumper on the back of the board ‘near the map of Italy’ and then resetting the 8U2.

On Rev2 or later boards, a resistor pulls the 8U2/16U2 HWB line to the ground, making it easier to put into DFU mode. Atmel's FLIP software 'Windows' or the DFU programmer 'Mac OS X and Linux' can be used to load a new firmware. The ISP header also can be used with an external programmer 'overwriting the DFU boot loader'.

3.6. THE FUTURE OF SMART TEXTILES

Modern technology is part of a new wave that aims to communicate various types of information within tissues, including the ability to detect dangerous chemicals. A fabric can be produced in which electronics and special dyes are interwoven to eventually produce a tissue used as a communication network capable of changing its color according to programmed stages and forming new technology. These applications are used in a series that extends from health and sports products to complex military uniforms, known by many names such as smart fabrics, electronic fabrics, and wearable computers. They will become one of the essential drivers of technology and society over the next fifteen years. It will feature people surrounded by super-smart electronic equipment, as giant companies will develop electronic equipment for consumer innovative tissue applications.

Wearable electronic equipment will be sewn into clothing, and a technology known as the electronic square cloth contains electronic wires and microcapsules has been developed. It contains a special thermal color ink that can change its color tones by simply heating or cooling it. They can be used in shoes, jewelry, and handbags with designs capable of changing their colors. They can also be used on the walls of rooms or supermarket sales sites and even camouflage fabrics for the armies. This technology currently controls about 64 threads at a time, each of which can change to dark or light. One of the prominent companies in the semiconductor industry was able to develop an experimental jacket carrying the MB3 program inside.

The sound tape is transferred to the headphones of the mentioned program, and a new version of this jacket is being prepared with the same program, but it is more advanced. This electronic tape is expected to be used in radio communications, for example, to locate a person lying buried under the snow (Axisa et al., 2005). The same company is working on another important project: to develop new technology

capable of using body heat as a source of limited energy to operate a wristwatch and small heat generators. It can use the tiny heat difference between what is outside the human body and the surrounding air by converting heat into electrical energy.

For professions whose members are distinguished by a specific dress, their use has gone beyond imagination, where clothes have become providing psychological and moral support and entertainment for the wearer. The primary purpose of clothing is to cover the body and protect it from external influences such as cold, heat, and sunlight. It is also a means to indicate the economic status or social class to which a person belongs or to know his profession, such as being ‘a policeman, a fireman, a doctor, a cook, and many others’. Body temperature and heart rate are sent via a smartphone to a database on the Internet that analyzes the transmitted information accurately and at high speed. When the remote sensors in the garment identify the person’s psychological condition, they play a piece of music to relieve his condition, choose it from a list that the user has prepared in advance or enable him to listen to voice messages from family or friends; a flat-screen was also sewn on one of the ambushes that enable the user to play back any clip (Simao, 2015).

Air-conditioned or sound-equipped clothes, after they were a figment of science fiction, have become a tangible reality as air-conditioned clothes are produced, which reduce perspiration, provide refreshment and prevent air from entering in cold weather.

4. SUGGESTED SMART MODELS FOR THEATRICAL COSTUME DESIGN

4.1. APPLICATION AND ANALYSIS

For the application part of this thesis work, two theatrical performances are designed through which the smart theatrical costumes are presented. The author drew the costume designs on paper, and then transferred these drawings to the computer, and the necessary measurements were determined according to the bodies of the actors. For the first performance, LED lighting technology was also used through wearable light strips that were installed on the costume. This type of show and its light technology is close to the type of theater known as the "black stage". To present such a smart technique on the clothes of theatrical performers in a technical and enjoyable way to watch needs a dark theater such as the black theater. Since the theatrical show of stupid thieves needs the stage to be completely dark, and since the thieves always live in the dark, the author saw that this type of show fits her fashion design idea in order to highlight the smart technology by using LED lighting in a technically woven manner, but with paradoxes. Moreover, all stage and auditorium curtains must be black. Therefore, nothing appears on the faces or bodies of the actors and nothing of the floor and ceiling of the stage, except what the actor wants to show. No light source is allowed, except for ultraviolet radiation, as this would spoil the viewing pleasure. It is based solely on the LED lighting of the costume, which indicates the movement of the performer through it. The aim of such theatrical performances using smart technologies is to deviate from the usual theatrical performances.

As for the second performance, an inflatable fabric was chosen by means of a small blower installed inside the costume. This fabric is made of two layers of polyester, and it has the ability to increase the sizes of the actors' bodies as needed. The theatrical performance deals with a fantasy idea about the arrival of alien people for immigration, and they certainly differ from us in terms of appearance, which necessitated that the costumes have a strangeness, as the measurement differs from the mechanism of the traditional human body. The presence of lighting is also an indication of the scientific gap imagined by the writer of the play. The use of

technology in theatrical performances is a reason to get out of the ordinary, as we mentioned earlier.

The role of smart technology and its relationship to fashion design and theatrical performances is an important role in stimulating performance, dazzling the audience, as well as raising the quality of the show. Here, this is provided by the introduction of the element of suspense through the lighting used and the method of controlling it with the movement of the actor in a technical and smart way. Accordingly, the smart technology that can be worn must be fully appropriate for the design of the costume. During the two theatrical performances, the stage was completely darkened in order for the smart technology used on theatrical costumes to stand out. In the first show, we used LED lighting strips in several stark colors. The first reason is to highlight the smart technology on theatrical costumes, and the second reason is to make the viewer think that they are stupid thieves. The colors here are symbolic, as thieves live in the dark, and it was necessary to choose the colors pink, green, blue, and yellow, in order to be clear.

4.1.1. Inspiration and Theme Identification

The reason for choosing the theme of the theatrical show is the desire to reflect on the transition to the era of technology and its importance that lies in its use not only on the scale of the theater, but also in other areas such as competitions and talk show meetings. The author was inspired by this modern idea in light of the progress of the technology of this age, as well as to deviate from the tradition of clothing and theatrical performances and keep pace with the era. The idea here is to integrate the most complex smart technologies in the designs of the costume, while doing it in an easy, elegant and hidden style inside the clothes, and also comfortable for the eye.

The idea of the first show talks about two stupid thieves trying to rob a house at night. 'Stupid Thieves' is a silent gestural show based on the actor's body, various expressive gestural movements, and dramatic graphic suggestions, in addition to the costumes, which are a highly effective contributing element. The second show incorporates an inflatable fabric that was used to design the costumes of three actors for their performance 'Space Migration'.

4.1.2. Material Selection

The author developed these fabrics and styles using the microcontroller Arduino and a set of LEDs as her tools. The author could control the LEDs that were incorporated into the fabric of the costume by using an Arduino, a little device that works at 3.7 volts. In terms of the LED in conjunction with the fabric, it is a silicone-coated substance that is very flexible and can be folded and bent without difficulty with high flexibility. The author also came up with an inflated version of the outfit, so the costume used in the second performance was developed. Air is pumped within to give the clothing its initially envisioned form.

Two types of fabrics were chosen for the theatrical performances; the first type was chosen of organza fabric, which is transparent and shiny, which allows light to pass through, and is considered a very important factor in the idea of display and design (Figure 4.1).

Wearable materials were chosen that are easy to carry, light in weight, and do not cause any problem for the actor when wearing them.

In the first design, a group of LED lights were selected and connected to an Arduino microcontroller, which is a smart device that controls anything (Figure 4.2). The use of an external communication battery, small in size, light in weight, that can be sewn to clothes and worn without causing any obstruction to the smooth movement of the actor, is from a rechargeable pack.

For the second performance, a fabric with two layers of 100% polyester was chosen. These inflatable fabrics are waterproof, without pores, so that the actor can fill them with air to make them look like a balloon and no air could seep through. A very lightweight air pump was added, which is also small in size, so as not to burden the actor during movement. He can handle deflating and then blowing it out several times, as required by the theatrical script.

When designing the costume, the internal spaces of the shape (piece of clothing) must be taken into account with each other, as the design can be identified in any piece of clothing or divided according to the design lines in terms of cost, textile

design, decoration, texture, color, good balance in the piece of clothing so that be comfortable on the eye.



Figure 4.1. Organza fabric (Photo: author).



Figure 4.2. LED neon light strip (Photo: author).

4.1.3. Pattern Application

The pattern design tool was used, and the selected designs were prepared on it, after that the designs were taken and executed on the computer. With regard to the first performance, the first design represents the front and back of the trousers (Figure

4.3), the second design represents the front and back of the shirt (Figure 4.4), the third design represents the sleeves (Figure 4.5).

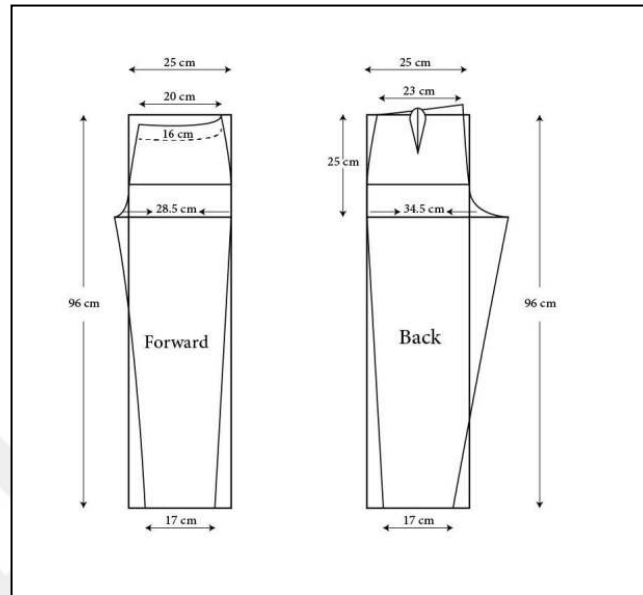


Figure 4.3. The front and back of the trousers.

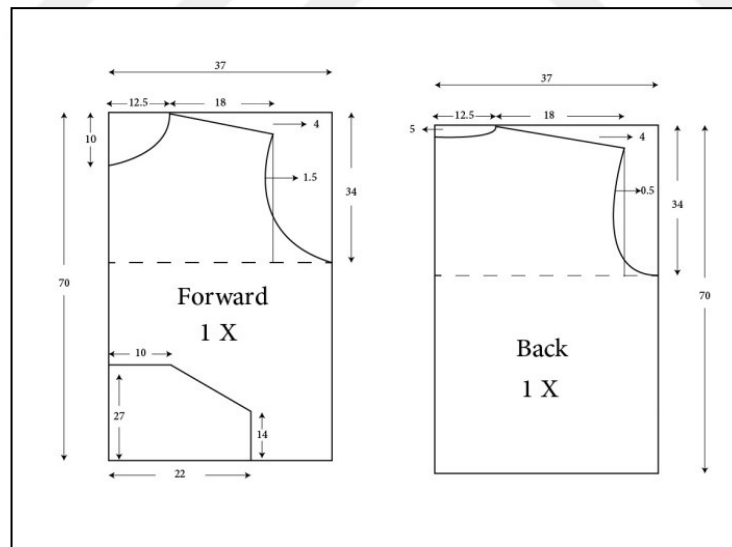


Figure 4.4. The front and back of the shirt.

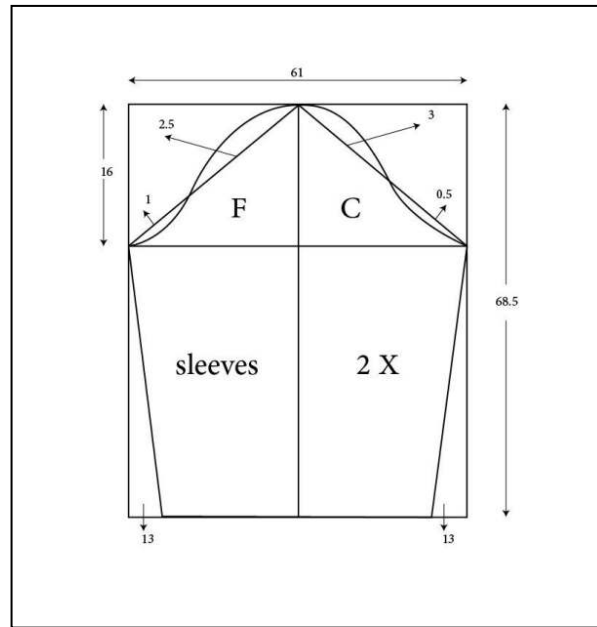


Figure 4.5. The sleeves.

As for the second performance, the first design represents the trousers (Figure 4.6), the second design represents the shirt (Figure 4.7), and the third design represents the sleeves (Figure 4.8). This type of design is in fixed measurements that suit all bodies. Then the selected designs were transferred to the sewing machine for execution.

For the first performance, LED lighting strips were used in conjunction with the fabric, which is a silicone-coated substance that is very flexible and can be folded and bent without difficulty with high flexibility. For the second performance, air is pumped within the costume to give it the form initially envisioned.

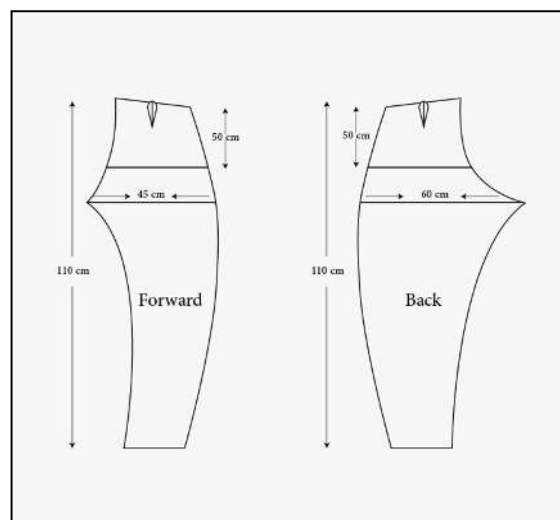


Figure 4.6. The trousers.

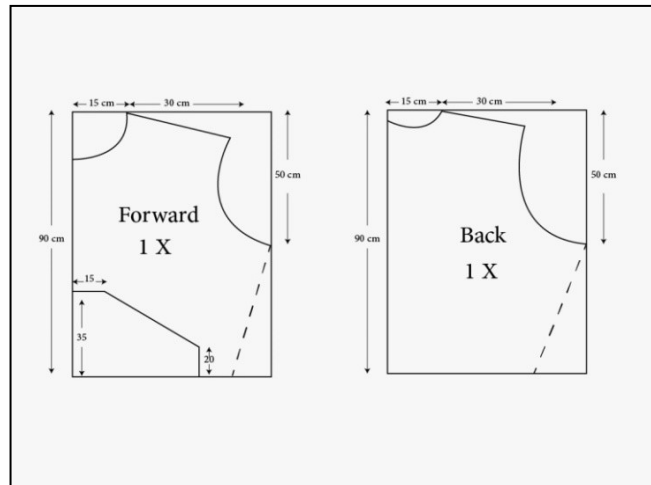


Figure 4.7. The shirt.

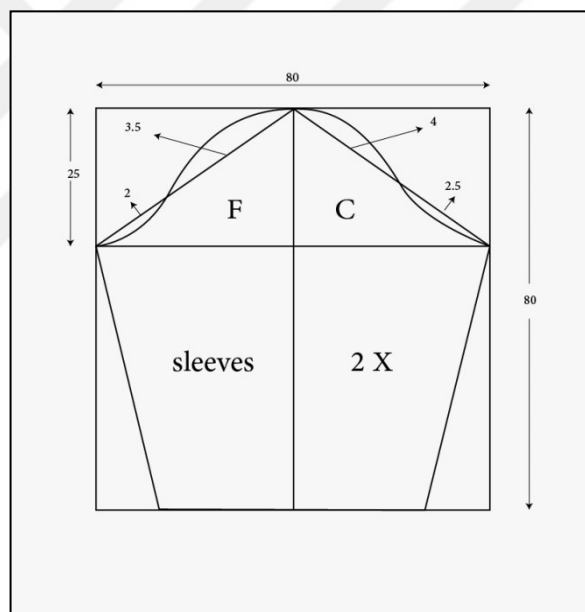


Figure 4.8. The sleeves.

4.1.4. Production

Two types of smart theatrical costumes were produced using a sewing machine. The first is a smart theatrical costume using organza fabric and foldable LED lamps to make it easy to use with the fabric; their lighting is controlled using a device an Arduino, a little device that works at 3.7 volts. In terms of the LED, it is applied in conjunction with the fabric. LED light strips were sewn on the sleeves, neck, and sides of the trousers. It was divided into two parallel circuits connected to the power source, the lamp wires were connected to the battery (Figure 4.9).

The second design uses inflatable fabric by a small blower installed inside the costume. This fabric is of two layers of polyester and has the ability to increase the body sizes of the actors as needed. The blower device was added in a way that can be wearable and fixed, according to the comfort features of the clothes so that they do not hinder the movement of the actor during the theatrical performance.

After working on the sewing technique for the implementation of the designs that have been prepared, the final forms of the designs were completed.

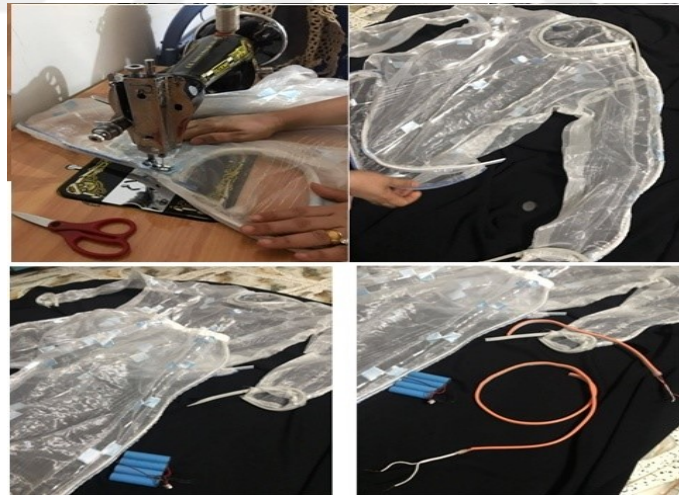


Figure 4.9. Working on production (Photo: author).

4.1.5. Presentation

The costume designs were used in the plays ‘Stupid Thieves’ and ‘Space Migration’. The idea of the first show talks about two stupid thieves trying to rob a house at night; these two thieves enter the house, and with a funny adventure performance,

they end up with sirens sounding so that the police come to them, arrest them and imprison them. 'Stupid thieves' is a silent gestural show based on the actor's body, various expressive gestural movements, and dramatic graphic suggestions, in addition to the costumes, which are a highly effective contributing element that represents the most significant space for drawing the dramatic line through the actor's participation in the drawing of dynamic images through beautiful employment. Light and its link to the actor's clothes and the sound and music effects also played an essential element in drawing the movement of the actor in this theatrical work.

This show is classified within the pantomime shows, and it is known that mime is a style of stage art based on pantomime performance without using speech, as the show is based on the ability of the flexible body to depict the environment of the event and place, in an abstract space accompanied by the influencer music. Silent representation is considered one of the oldest arts known to people and is part of their activities. It continues in cognitive and aesthetic communication, as it depends on the language of direct innate expression of the human being without language barriers.

Pantomime is a type of mime that relies on illusion in movements, such as walking, running, ascending, and descending the illusory ladder, and depicting the imagined environment based on the gesture of the hands and the whole torso. In the pantomime, the gesture depends on every tool, accessory item, piece of decor, or stairs 'the art of emptiness', as everything is imagined, even weights, areas, volumes, and textures across the body. There is no actual physical thing; there are "things in the void," as in the works of Marcel Marceau. In addition, mimicry does not usually use tools, decor, complements, or supplements of traditional presentation, except for body language and its expressive ability to create the illusion of the imagined environment through sensory and emotional memory for action and reaction.

There were two characters in the stupid thieves show; the two of them are the same costumes made of innovative fabric that contains LED; the distribution of LED was in the arms, legs, and around the waist in both characters, and also both characters wear a cover on the face (Figure 4.10). During the two theatrical performances, the stage was completely darkened in order for the smart technology used on theatrical costumes to stand out. In the first show, we used LED lighting strips in several stark colors. The first reason is to highlight the smart technology on theatrical costumes,

and the second reason is to make the viewer think that they are stupid thieves. The colors here are symbolic, as thieves live in the dark, and it was necessary to choose the colors pink, green, blue, and yellow, in order for it to be clear and distinct in the dark.



Figure 4.10. Innovative costumes containing LED (Photo: author).

The color of the LED lighting in the first character was green. However, the green color symbolizes the color of nature, the blue color indicates the sea and the sky, the pink color indicates passion, and the yellow color symbolizes deceit and fraud. Rather, the purpose of choosing these colors was symbolic, in order to highlight the LED lighting technology clearly in the dark (Figure 4.11).



Figure 4.11. The green LED in one of the costumes (Photo: author).

In an attempt to discover its secrets and decoding its semantic codes, the theatrical costume designer sought to put the appropriate artistic touches that lead the recipient to identify the character and dramatic nature of the theatrical performance. About the extent to which these indications are used to influence others and to pay attention to such personalities and not to follow only the external features, but rather to scrutinize the alleged actions in order to be able to develop a specific perception about the character's positivity or negativity. The color of the LED lighting in the second character was pink. One of the connotations of the pink color is the fun that suits the pampered and the lightness (Figure 4.12).

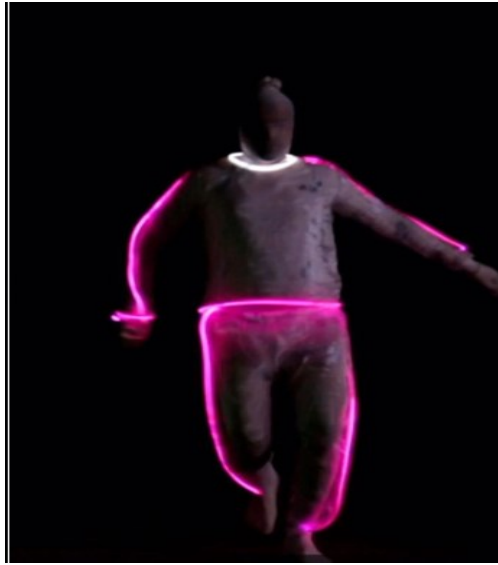


Figure 4.12. The pink LED in one of the costumes (Photo: author).

The thief wearing the pink color looks significantly more foolish than the first thief; the pink color plays a role significant in improving one's mood and making him feel joy and pleasure. As it has a solid and profound emotional impact on inner feelings, it may transform him to a person with a sense of familiarity and acceptance, and make him feel loved by others, so he does not have negative thoughts. So the costume designer used it because it carries the ability to change individual responses that are affected by the factors of darkness and blackness that prevail due to dark theater type.

The theatrical performance relied on expressive physical kinetic performance based on coding, iconography, transcending the limits of realistic logic, approaching the unknown world, and the deep fear within the human soul. The costume designer placed the LED in the most moving areas of the body, namely the arms, legs, and waist, in the implementation of the physical movements of a group of actors in changing and diverse theatrical scenes with a fast pace that is not static and dark, but controlled by fear and anticipation (Figure 4.13).



Figure 4.13. LEDs placed in the most moving areas of the body (Photo: author).

The choice of smart materials came to cover the actors' bodies to reverse the choice of what is known or circulated from fashion. It achieves the aesthetic goal of the shape of the new smart materials, which the recipient did not see in his daily life. The exit of the actors and their heterogeneous and spontaneous movements with their strange costumes and sad musical sounds made the process of aesthetic reception at its highest level and interaction with it and with the events on which the idea of theatrical performance was based.

Furthermore, the deviation in the selection of designs within the foundations of the design and its elements that came close to the actors' bodies helped their expressive dance performance, freedom of movement and mass formations, and moving into dramatic dimensions. Implementing costumes with a material not used as an ordinary material in costumes is an attempt to find a new objective equivalent. It can motivate the recipient to bring the visual image of the dramatic events closer by creating innovative and creative formations subject to the principle of interpretation. It also re-establishes perceptions about the ideas presented within the dramatic action and the character's reactions to the suffering posed by philosophical initiatives within the theatrical event.

For the second performance 'Space Migration', an inflatable fabric was used to design the costumes of three actors for a theatrical performance. The design is made

in one size fits all, especially for adults. It also gives a peculiar movement to the actor's body when walking or jumping. It consists of colors, red, blue, and gray (Figures 4.14, 4.15). Moreover, it contains a set of lights to give a radiant appearance to the theatrical character and movements that are different from what was previously familiar. The theatrical costume designed this way has many advantages. The first and most important is the body size, as the actor's body size can be doubled by filling it with air. The same is valid for height, as this can also increase body length. It also features the possibility of designing strange shapes, such as aliens, animals, or creatures.



Figure 4.14. Actor with costume (Photo: author).



Figure 4.15. Actor with costume (Photo: author).

In several colors, the hidden lighting was used inside the flexible and water-resistant costumes not to be affected by the actors' perspiration. It operates on a lightweight battery for an extended period, up to several theatrical performances, and for 40 hours (Figure 4.16).



Figure 4.16. Costume lighting during the play (Photo: author).

The idea of the play talks about the story of the space dwellers discovering a country called Iraq through an invitation they receive from a group of young people through time and landing on its surface with lively frame and smart clothes for them. The play relies on light effects, innovative equipment representing the spacecraft, a modern display screen, background music that traces the step of the space dwellers, and a luminous outfit for them.

Also, the inhabitants of the space communicate to attend the various classes through gestures coupled with visual tools and bright audio background. The theatrical performance contains a vast amount of information that led to the movement of political debates and popular discontent in a smart manner that relies on simple possibilities. Aerospace clothing is made of fabrics that are made of nylon and have no pores.

The first scene: A group of actors dug a trench, filling it with tar and setting it on fire. The point of this idea is to send a clear message to alien civilizations living elsewhere in the solar system: We are here; you have failed. It takes place in 1958.

Second scene: Radio messages during the uprising period in 1990.

Third scene: An invitation to come to Iraq. A group of young people adhering to the love of the homeland send an invitation to the inhabitants of space to come to Iraq and witness their suffering from unemployment, loss, and illegal immigration (Figure 4.17).

Last scene: Aliens apologize for being silent for such a long time.

The videos of both shows are given as an appendix to the thesis.

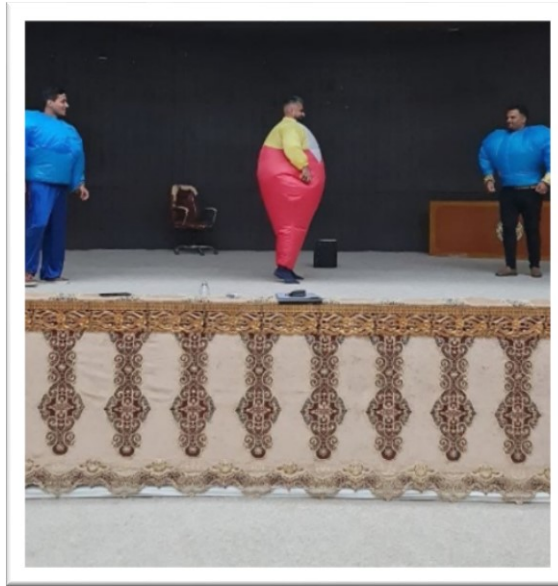


Figure 4.17. Acting during the play (Photo: author).

4.2. RESULTS

The author relied on the works by previous researchers, as they reached important results in the field of smart fabrics. She dealt in her current study with the use of innovative fabrics and their application in the field of fashion design, and employing this smart technology in theatrical costumes. These designs can be considered new because they combined several LED lighting techniques and the employment of pneumatic pumps and also by adding a costume design suitable for theatrical work. So these designs can be regarded as new through the use of design and the method of pumping air in the costume, and this was not previously applied in a small and rare way in theatrical costumes. This wearable technology is also comfortable without causing a problem or hindering the movement of the actor on stage.

- 1- Modern smart technologies have entered all industries, including military, household, and education. Today, it can be used in theatrical costumes.
- 2- Theatrical costumes can be designed using smart technologies, such as photosensitive and inflatable fabrics, and many other types.
- 3- Theatrical costumes can be designed with these smart technologies even at home and without assistance, using only basic information.

- 4- The weight and sizes of these innovative technologies are very light and small and can be used even by dancers with ease and comfort.
- 5- Costume design using modern technologies opened the doors for new theatrical performances that could not be held in the past.
- 6- In terms of material, these technologies are cheap and economical, as they are available and widely spread.
- 7- This kind of costumes and techniques can be reused directly or with a few simple modifications in other theatrical productions.
- 8- These smart costumes clearly impacted the audience in particular and the theatrical shows received a positive feedback in general. Furthermore, they left a positive impression even on the actors themselves.
- 9- The costumes designed by innovative technologies can be used to control the acting and form of the actors. As experienced in this work, through the costumes inflated with air, it is possible to increase the sizes and lengths of the actors.
- 10- Modern interactive technology used in the theatrical costumes for this work helped to increase the physical sensation of the actors during their performances on stage.

5. CONCLUSION AND SUGGESTIONS

5.1. CONCLUSION

The current work presented a review of the current state of smart technologies in order to employ them in designing theatrical costumes. The applications, experimental validation, performance characterization, and main challenges of smart technologies and their use in theatrical costumes were discussed. Innovative technologies are still a new field with opportunities to build innovative products that could revolutionize how people interact with their clothes.

Research and development of smart technologies and theatrical costumes have emerged recently, emphasizing efforts to promote and expand those fashion technologies. Theatrical costumes made with smart technologies are a category of high-tech textiles with massive potential in various fields. Smart, color-changing stage costumes have become a hot spot due to their application in many stage performances.

The research effort in designing theatrical costumes using innovative technologies has grown constantly, and the multidisciplinary approach has become the main factor for this remarkable expansion. Knowing circuit design, smart materials, and microelectronics is fundamentally integrated with a deep understanding of smart stage costume manufacturing.

The costume design with colors and smart technologies and their formations plays the primary role in understanding and realizing the dimensions of the dramatic characters by choosing the colors and their semantic qualities. This is because theatrical costumes of all kinds can embody the external qualities of the dramatic character and work to communicate the idea to the recipient through the visual image embodied in the theatrical performance.

Smart costume design is executed by employing smart techniques based on the text data and in line with the intellectual and dramatic dimensions of the theatrical performance.

5.2. SUGGESTIONS

This study contributes to the education of students in the departments of fashion and textile design and also of theater with modern and advanced techniques that keep pace with the fashion of international theaters. More research on the use of smart technology will reveal new opportunities.

Fashion designers could be motivated to use smart techniques in theatrical costume designs.

Photo-printing of costumes is useful as it constitutes an element of attraction for the recipient of theatrical costumes.

Fashion design specialization could be more engaged with disciplines such as electronics.

Innovative technologies can be applied in the theatrical decor and in the actual decision of theatrical costumes as well.

An industrial line for innovative fashion can be developed to be used in the field of health workers' clothing by adding sensors to measure pressure, heart rate, and temperature.

Smart uniforms could be produced for army workers by adding GPS location sensors.

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