# Smart Textiles as hybrid interactive materials A responsive behaviour towards transformable surfaces

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**Abstract:**
Finding ingenious solutions in interior spaces is the result of capability and scalability of the designer in reshaping the interior's contents through the use of the materials in the contexts of perception and interpretation. This approach extended to include the concepts of contextual variation into computed responses and ubiquitous integration into architecture. They are also known as Hybrid materials functionally when integrated with high performance intelligent embedded systems as adaptive system property changing or energy exchanging building system energy-saving control through the adaptation of patterns within the digital phase modelling. These materials mimic living organisms in terms of behaviour, in reaction to various environmental impacts and they are known as active, responsive or adaptive materials due to their metamorphic ability to adapt and self-assemble to the environmental surroundings and the requirements of the inhabitants of interior spaces. This research aims to create a framework that provides a strategy for the adaptation of responsive patterns to generate manipulative surfaces of topological richness in spatial variation to enhance environmental performance through passive design. This paper focuses on expressing the interior's identity through computational design and smart materials_ smart textiles in particular_ in a dynamic potential that reflects the diversity of form due to the impact of the emergence of modern trends in design. It changed the shape of interior spaces and gave it incipient interactive responsive properties. Computer design and digital fabrication techniques replaced static forms with living, interactive spaces through smart textile to alter their shape and function. As conclusion, these hybrid formations in design added a new functional dimension. Therefore, the smart materials and responsive proprieties have directly influenced the process of design and architecture, whether it's in the effectiveness of the design or the process of the fabrication and manufacturing of various structures.

**Keywords:**
***Generative Patterns***
***Digital Fabrication***
***Smart Textiles***
***Embedded Systems***
***Smart Materials***
***Responsive***
***Hybrid Behavior.***

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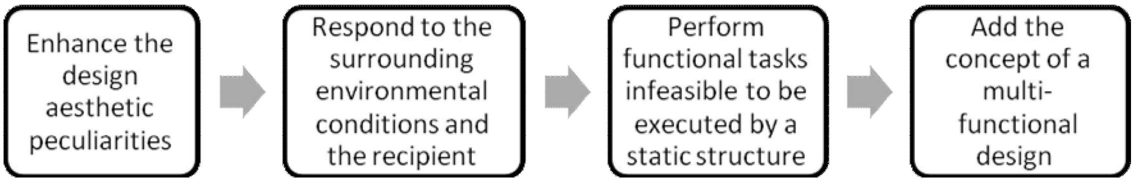
## 1- Introduction

As the architectural thought evolve towards more sustainable concept, a new require for solutions emerge, new patterns and thus the integration of the physical structure of matter in which these design elements are constructed and the quality and impact of sensory perspective, such as colour, texture, and shape. The severity of structural innovation and materials advancement down to secondary technical uses embedded computation. They are designed to become an integral interactive part of life and activities through their proximity and inextricable involvement in everyday actions in terms of symbolic and multi-functional expression. Digital fabrication expanded the extent of innovation to design various flexible forms and created a new dialectic for adaptive structures and interior spaces. Materialism is a relative term in architecture and design used to designate materials and their deployment in diverse structures and elements. Materials are often chosen depending on two factors that work within two inseparable values: form and function. They are characterized by their potential to support different structures, which is determined by the behavior of the material in the transfer of loads to identify the space planning and formation. Smart materials embedded with interactive systems engendered hybrid patterns and dynamic form and structures to inherit responsive proprieties to the interior spaces. As well as their executive function which is determined by a cease-specification units and the amount of the cohesion of the material and its influence to respond in accordance with different requirements and conditions such as color and texture and transparency ratio.

Addington and Schodek identify smart materials as active surfaces and responsive platforms embedded with actuators, sensors or shape-shifting proprieties to function coherently along the internal and external conditions[1]. They are characterized to self-reconfigure to alter the identity of interior spaces through variation of form, immediacy, transiency function and directness[2]. Smart responsive materials are the latest trend in the advancement of materials technology, high in most if not in all fields of life, which in turn is a cornerstone of the evolution of architecture in a practical and theoretical way. They directly influenced the design process, as it is considered as the fundamental pillar in this process which has penetrated into all aspects of architecture, whether it's in the effectiveness of the design, or the process of production and fabrication of building materials. Some materials have the ability to change one or more of their characteristics in response to provide energy (thermal, electrical, mechanical, chemical, and magnetic) from an external source, the change may occur spontaneously dependent on the inherent material properties or may happen by the user. Their behaviour or reaction is basically a chemical or includes only a thin outer layer thickness. A number of these changes occur in their optical properties such as the colour and form of material resulting from the diversity in the chemical reaction and in other cases the material is exposed to transfer one type of energy to another as a result of the reaction of energy exchanging. This behaviour depends on the kinetic force allowing the material to act as a mechanism itself. The pictorial and metamorphic bases are the principles of the kinetic terms approximately to integrate the fourth dimension, time to the design process Therefore; kinetic function became an essential feature of hybrid materials.




## 2- Problem of the study

Opposing the assumption that architecture is about things difficult to change, an emergent evolutionary concept appeared to change this current hypothesis regarding the elements of the infrastructure. It allowed them to interact with the environmental surroundings, therefore, the interior itself. Designers can not only predict, yet control all of these interactions using smart materials. Smart textiles created hybrid forms and generative patterns characterized by a new flexible structure and other properties that enable the ability to implement the idea of responsive interactive design, either independently or in collaboration with other different materials. Therefore, there is not only a loop of design but two interrelated and inseparable loops of tracing and analysis shapes and patterns.

## 3- Aim of the study and methodology

Besides with the continuity of the use of natural materials in the construction conventional methods, it will undoubtedly lead to a deterioration of these resources as an inevitable result of the use of huge amounts of in accordance especially wood. Therefore, it was necessary to develop construction techniques using different materials to achieve the environmental dimension and economic solutions with fewer consumption amounts and achieve the sustainability of resources. The methodology followed by this paper depends on the analytical and descriptive approach to identify the advanced smart textiles and their properties and their applications.

- Descriptive analytical method: introducing the theoretical basis of advanced methodologies for responsive materials and its impact to choosing through architecture and interior design as well as computer aided design and digital techniques.
- Comparative analytical approach: analysing the implementations of advanced smart textiles and their properties through architecture and design and the application of digital fabrication techniques to create these elements.

## 4- Smart Textiles (flexible interactive surfaces)

Following the approach of deploying smart materials as substitutes, responsive qualities and adaptive proprieties became a distinctive value of generative patterns to redraft interior spaces. Intelligent interactive design is related to the use of new materials and flexible irregular form becoming the new trend in architecture to rethink and remodel the design process, the interior design inherited the same concept to coordinate with the architectural development. Smart textiles are reviewed as an interactive model system in the interior design and as intelligent technology of the display models of the interior design elements with interactive smart fabric[3]. Intermingling between the interactive design and flexible surface, the interaction between the design and the user became a reality, and provided an opportunity for new dimensions in their relationship, and responsiveness became the main concept of functionality through the implementation of an interactive system, such as sensors and connectors and mechanical actuators, which affect the way the function of the design, as well as to the final form in some cases[4]. The applications of smart Textile widened in various different fields and have become cover wide applications and are used in many industries such as with nanotechnology and its application in the field of textiles and another part in road engineering techniques textiles, automobiles and even airplanes. They became as a substitute for construction and raw materials, insulation and plastic designs characterized by innovation, creativity and flexibility in the architectural and design even through digital fabrication and nanotechnology techniques[4]. And the most important characteristic of this material _ intelligent weaving _ are the following:

- Flexibility and elasticity in the elements of the design, allowing the implementation of more complex designs and hybrid patterns.
- Reducing the cost of the materials used in the structure and design in both the fields of architecture and interior design.
- Aesthetically enhanced proprieties, also being ecological materials. They made of fabric an ideal choice for building such as fabrics made from carbon fibre, aramid and glass, and they gave designers and architect a new set of materials to work with, characterized with less weight and capability of withstanding the loads and weights in various structures.

4.1 **Historical background**

Earlier, textiles have been used in the field of architecture to build the tents of the Bedouins and nomads in different cultures all over the world. The envelope of this primitive structure skin was woven mats, cloth and woolen fabrics to build shelters. Tibetans and Mongolians used a black tent with high tensile strength and which is used for building construction structures and even in the prehistoric age.

The Coliseum in Rome was created using light-weight fabrics as one of the first appearance of the use of textiles in history. Royal courts provided with open theaters as a kind of entertainment were covered with fabric to protect from the weather conditions[5]. It consists of a layer of protective fabric from the inside and from the outside a layer of ornamented fabric with decorative patterns. The tents were spinning and weaving in the 18th and 19th century was used for military purposes and to build the big circus.

It was in the $20^{th}$ century with the invention of new fibers, new polymers, adhesives and laminated coats brought new possibilities for the textile industry in the architectural design. This led in turn to the construction of giant space with intricate patterns and improved fabrics suitable to meet any functional requirements. Polyvinyl derivatives and poly-tetra fluoro ethylene enhanced the use of textiles, its durability and longevity that structures made from these membranes, can last for 15 to 30 years. In addition to providing durability, it provided hybrid features such as protection of UV, performance of solar radiation and weather protection, transparency, light weight, self-cleaning, filtration, and the characteristics of fire-resistant and adaptation the environmental surroundings[6]. Textiles were used in architecture as shade to provide protection from the sun's rays and to increase energy efficiency. The fabrication and installation of coverage systems and membranes of fabric helped save a lot of energy, rather than using conventional concrete structures. Weaving is also a way to provide natural lighting inside the building and used in a manner that could be harnessed in a building by using a transparent material, thus providing electricity in a sustainable manner. Here are some of the characteristics required by the textiles:

1. High tensile strength is the first basic requirements. It includes the ability to withstand snow, rain and strong winds, and in the case of bridges or weight-bearing walking ways.
2. The presence of high-resistant fabrics mechanical movement and low maintenance EFTE such as fiberglass, which have good twisting properties.
3. Strong outer layer of the textile to reduce the penetrating UV and mechanical kinetic properties as well as maintaining performance in extreme temperatures and climates conditions.
4. Light absorption reflection, transmission and energy-related in the structure. For example reflect PFTE fiberglass coated fabrics in 70% of light while the EFTE transparent up to 95% of the transmission rate and light penetration.
5. Colors, texture and diverse patterns affect the optical and thermal properties of space.
6. Acoustic insulation and thermal balancing are essential attributes in the selection of the fabric. Multi-layered structures with air cavities between them permit air circulation and allow natural ventilation and preserving thermal energy in the structure.
7. Nano proprieties such as self-cleaning and self-maintenance. Thus fabrics with nanotechnology with anti-soiling and self-cleaning properties of the best facilities in such techniques.

Intelligent fabric can be classified into three generations, and they are:

1. The first generation and so-called smart textiles influential non-reactive. Passive Smart Textile that respond to weather conditions and environmental influences.
2. The second generation and is weaving intelligent active Smart textile. They are embedded with sensors and mechanical movement and which operates according to the signals. These signals reach them either directly or indirect way.
3. The third generation and is weaving superior intelligent Ultra Smart Textile and who can feel and reacts and self-adapt to the surrounding influences.

Nowadays, there has been continuous advancement in the materials that interact as catalysts in the external environment and thermal effects and open up possibilities for experiments in the field of interior design and fashion. There are many technological techniques used to enhance responsive proprieties, including fiber paraffin. When the temperature rises, the paraffin turns into a liquid state to allow the passage of excess heat, and when it drops the temperature, it re-solids. This is the first generation of smart fibers, the second-generation conductive polymers are processed within the solid tissue ICP Inherently conductive polymers, which allows for the transfer of energy to the fabric of the space heating or cooling without the need for electronic wiring.

Smart fabric is capable of interacting and adapts to the environmental surroundings either by weaving or merging or integrating. Smart intelligent fabrics are about the structure, which is composed of two main components sensors or actuators[7]. Many smart textiles have been included in the field of architecture and interior design used chromium materials that change color (in reaction to the intensity of light), Thermo-chromic (a reaction to the severity of the temperature), and piezo-chromic (in reaction to the pressure). In addition to these, other fabrics are currently being developed such as phase change material (PCM), and fiber-optic connector, and even the formation of memory material (SMM) to increase the functionality and aesthetics of the fabric used in the structures. Smart fiber Thermo-chromic textiles has the ability to reverse a change in color in response to the influence of heat, the material absorbs the heat, leading to thermal luminescent and consequently affect the color of the material.

4.2 **Thermo-chromic textiles as manipulative surfaces**

Thermo chromatic materials have the ability to change color due to a change in temperature, through the integration of pigments in the tissue. Thermo chromatic effect is caused by changes in the crystal structure. Typical materials include oxides of inorganic minerals thermo chromatic (such as zinc oxide, vanadium oxide), polymer blends or liquid crystals, which at high temperatures change from the crystalline to the liquid state. These spaces have the capacity of self-reconfigure to respond to human stimuli-will toward tending our ever-evolving individual, social, and environmental needs[8].

Computer architecture has replaced static structures with active shape-changing ones that reflected the design process. They helped to engender intelligent, compatible distinctive functions and interactivity. It blurs the distinction between the simulated and the generated structures and opens up the possibilities of developing space associations based on independent and group behaviors. This framework starts initially with a basic unit that has the ability to under distinctive form arrangements through an open finished combinatorial procedure, with novel locomotion and self-structuring qualities[9].

The unit emphasizes its kinetic mechanism, joint system, its self-governance and the unification of the entire system. These structures prompt a wide range of distinctive spatial aggregations that are continuously reconfigurable.

Using technology system in relation to potentially applicable smart materials, lead to optimization of the energy produced by the system, suitable for the intervention and assessing the context in which they must operate.

Digital computer architecture introduced new trends in intermodal and cooperative buildings and interfaces that integrate the various aspects of planning and communication process through a concrete platform to interact.

4.3 **Fabric with optical properties (Optical Fiber Textiles)**

In 2000, a Japanese company launched a new product that simulates the form and order of tiles used to cover foreign bishop at a scale equal to the thickness of the skin; it consists of a protein polymer transparent like a finger nail. The textile is made of multiple layers with thickness of micro polyester and nylon. These multiple layers of the optical properties loathed interfere with the other to produce a change in color from blue to violet and from red to green, and this is the first attempt to produce tissue optical properties.

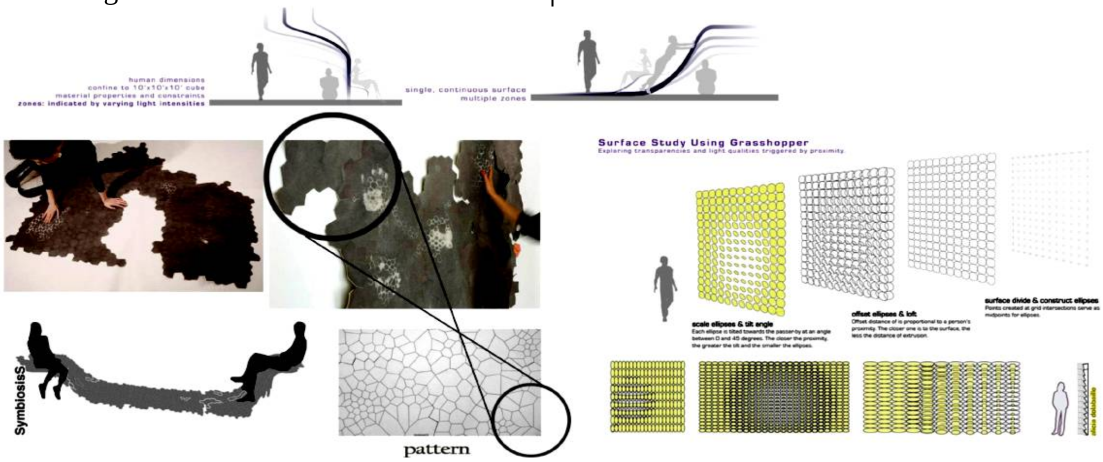



Figure 1.A thermo-chromatic textile multifunctional surface that interact with the inhabitants of the space, and it is generated using digital computer tools (grasshopper).

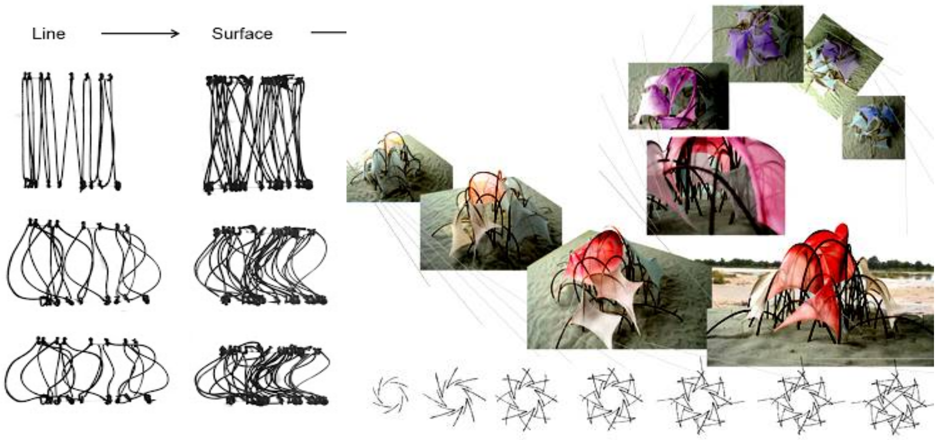



Figure 2. A pavilion or landscape shading created from the knitting patterns and the shape of the thread line coated with thermo chromatics membranes. It is a chromatic powder that change colors due to the changes of temperature and sunlight

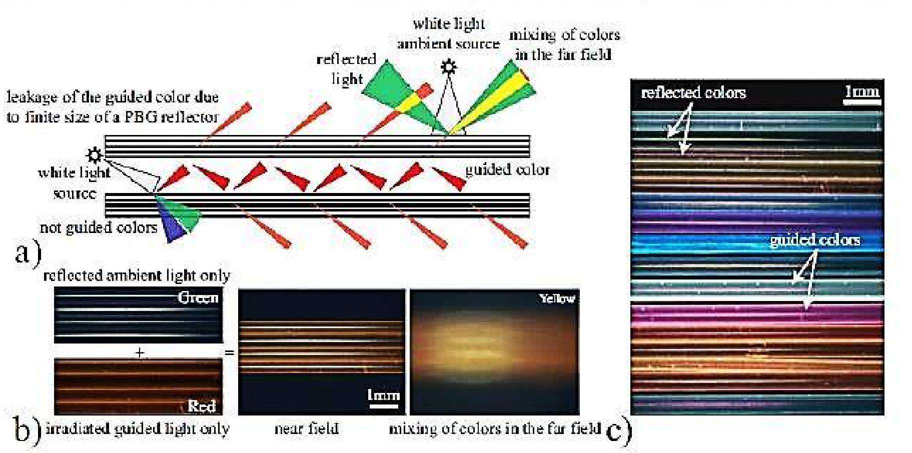



Figure3. Explanatory to perform color scheme and the optical fibers with optical properties when exposed to Light as the color of which is absorbed

And there is the "Luminous fabric _ Fiber Optic Fabric, also called Shining fiber. It is weaving fabric that shines literally through a combination of optical fiber added to the tissue structure of light-emitting fabric[10]. It is made of ultra-light fibers with synthetic fibers. The fiber optic connector on the edge of the fabric to the sensors of the LED, absorb the light, then the light is injected into the tissue. The light is distributed evenly over the entire surface of the fabric, which led to shed light on the fabric itself and make it luminous. The textile output is very unique hybrid fabric, used to emit light in all parts of its surface. Optical fiber fabrics are now available in dozens of colors. The most important characteristics that distinguish them is that they are flexible, fast and lightweight, do not heat or consume energy. It's waterproof and can be washed. This makes the fabric ideal for its luminous and hybrid characteristic and can be used for many applications, such as in the field of fashion and fashion, architecture, interior design, wall claddings, theater (curtains, ...), automobiles and furniture

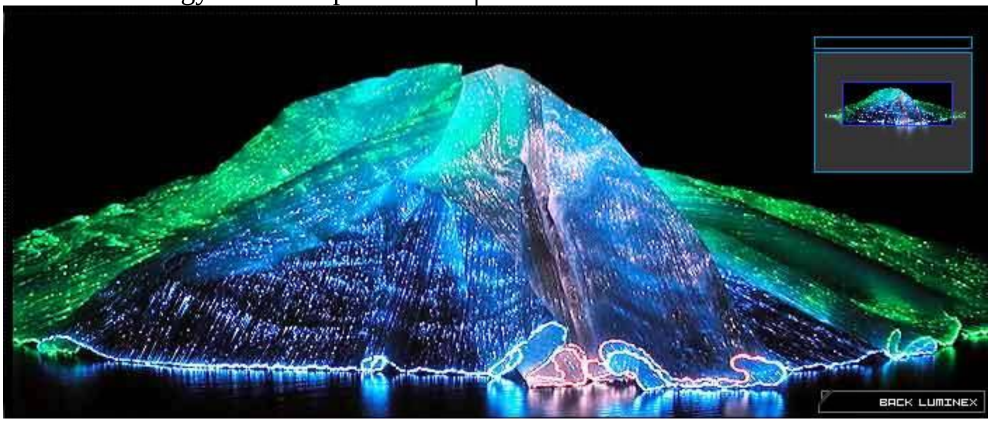



Figure4. LUMINEX illuminated plates. Fabrics illuminated with fiber optics, with LED) connected with the fabric power supply (batteries or AC adapter with a range colors and diversity.

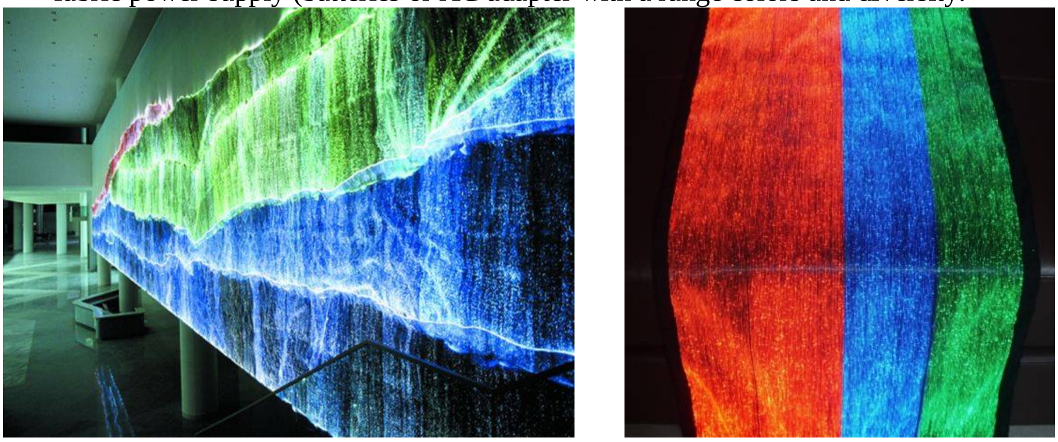


Figure5. Luminous paintings are a piece of optical fiber fabric, ready for use, with the proposed standard or customized dimensions (in a rectangular shape), with the addition of photovoltaic modules and power supplies.

**4.4 Breathing wall**

It is a system bound to the concept that merges the traditional insulation system and the characteristics of the thermal exchange of walls. The goal is heating and ventilation (using the temperature of the building's case to achieve the best air quality in closed and interior spaces. It is a wall designed to allow the transferring of the air into space through a passing insulated layer [11].

With the development of technology and advanced materials, a new concept for breathing wall appeared using the Nanotechnology, the Shape memory textiles (fig.6). This textile is used inside the space to perform an aesthetic and functional role. Strings of metals alloys consolidate the textile. They are dispersed in parallel in several sections on the surface of the textile to give it the ability to sense heat. When the temperature rises or sensing any changes in the temperature, the metal strings bend to an irregular form, reducing the space between the textile strings, which lead to a remodeling in the form of the textile; when the temperature is standard, the strings retrieve its usual primary shape.

This pattern when exposed to atmospheric pressure; they are subject to a phase of change in the range of temperatures ranging from ambient temperature. The basic principle is to exploit the ability of these materials to excessive heat temperatures close to the melting point and then distribute it in the space without any observed difference in temperature to improve the control of thermal flows and increase the possibility of using solar energy.

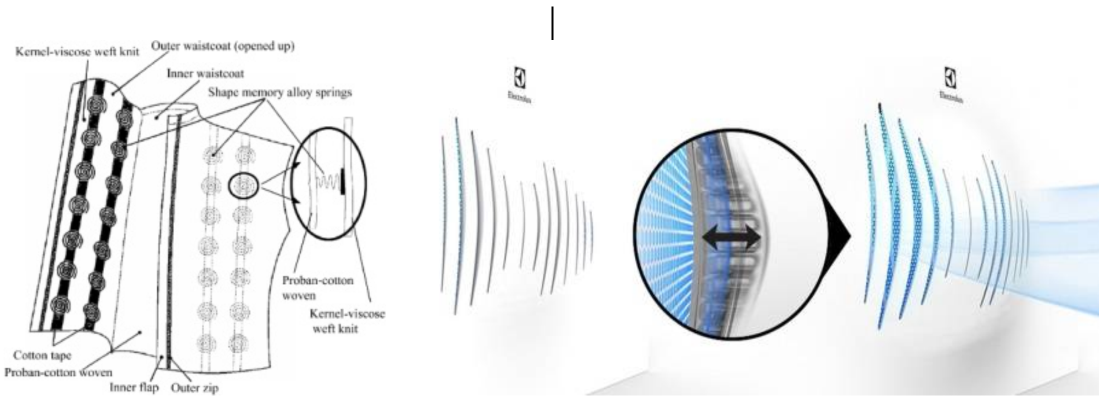


Figure6. Illustration of the affectivity of the textile with heat and metal alloys

## 5- Smart Textile as behavior mechanism

Advance technology has improved smart kinetic systems, which is characterized by lightweight, flexibility and included folding, jaw mounting and conversion parts to change shape -shape Shifting-. Some systems allow the design elements to respond to changing circumstances as well as being self-mobile. Kinetic design and deployable mechanisms unveil the dynamic approach in interior spaces to change the traditional pattern in form and structure into interactive, responsive spaces finished in several materials like wood, metals, polymers, textiles, and smart materials. It introduces the possibility of reconstructing and reshaping interior spaces and its components, while providing alternative economic solutions[12].

5.1 **ETFE (Scientific name copolymer of ethylene and tetra fluoro ethylene and is known as a tough polymer)**

It is a new severity often used in the exterior of the buildings and architecture and it is characterized by several properties, including transparency to allow the passage of light, but it isn't affected by ultraviolet radiation. It is unbreakable and its structure does not weaken with time and does not change, as well as being resistant to pollution and dust and air currents. It is Light weight, fire resistant and can be recycled and reused. It is characterized by its capability and diversity in composition and high-performance.

ETFE is used in the facades and roofs for heat insulation and control unprecedented for traditional materials. Over the years, it does not suffer from the deterioration of the color change, as it does not become rigid and thanks to long durability of up to 25-30 years without the fragility of color stability and high resistance.

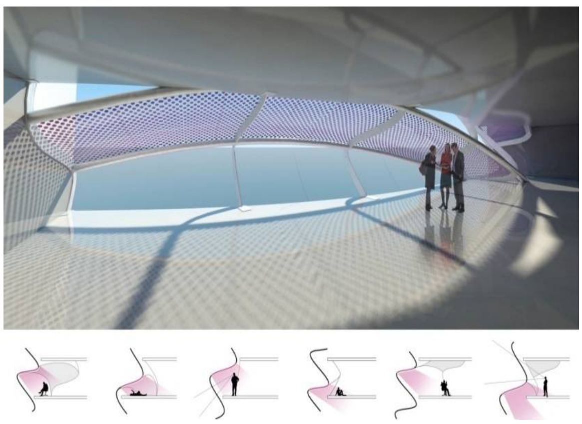


Figure7,8.Passive Shading Skin, Photochromic System (Photochromic ***Powders***) Photochromic membrane respond and change color when it is exposed to daylight.

This membrane is made of layers of ETFE embedded with photo chromatic powder to enable it to react as shade during daylight as it inherits a kinetic movement. Adding different patterns to the layers of ETFE to block the sun's rays in the interior spaces and providing various aesthetic forms in internal partitions and exterior of buildings.

The implementation of ETFE in interior spaces is to develop high-performance qualities, lightweight and flexible structures and kinetic potential. It is used due to its distinctive proprieties as a hybrid fabric as a layer of pure tensile properties of the surface (active form) in conjunction with the (active bending) Ready-added elements to the acquisition of the properties of rubber to regulate the physical structure of the system in balance power.

Figure9.An installation of ETFE layers attached to each other by central joints

**5.2 Generative weaving textile structures**

Table 1. 3-D Weaving High mechanical properties in x, y and z directions

| **1. Braided structures** | ***2.*** **Knitted structures** |
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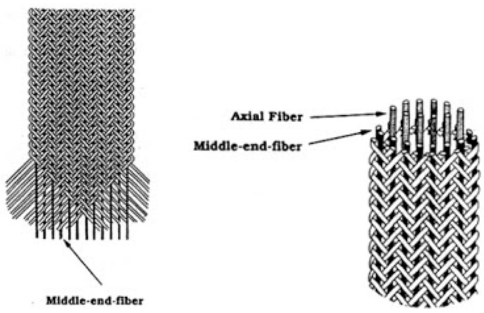
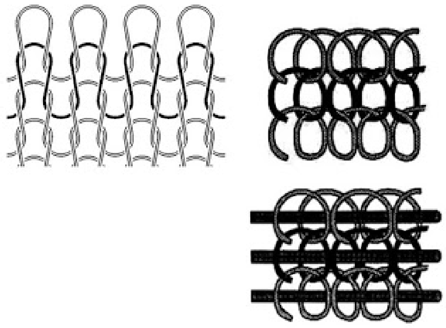
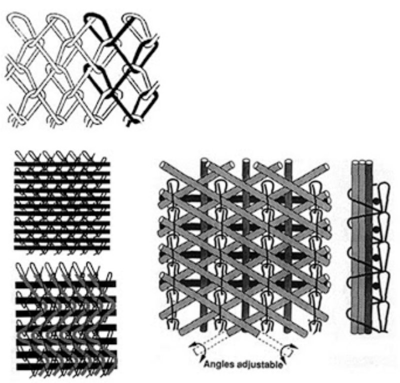
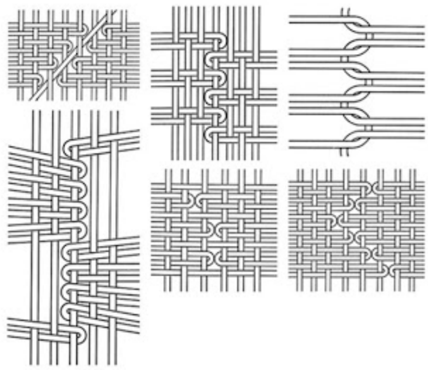
|   |  |
| ***3.*** **Warp structure** | ***4.*** **Woven structures** |
|   |  |

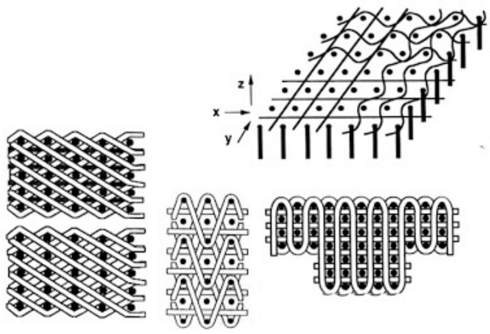



Figure10.Gordana Bogoeva G.;'Textiles structures for technical textiles' in Bulletin of the Chemists and Technologists of Macedonia, Vol.24, No1, 2004

The conceptual design in this particular partition depends on the form of shadows on the ground, passing through the textile loops. They founded a physical system of a series of interrelated episodes of loops and interconnected rings of fibers. This installation and tie depends on the weave three-dimensional system. Using strands of copper, it interconnects series of episodes and links them together to form a three-dimensional structure frequently. The structural form of the design is created on the computer to the terms of dimensions, sizes, ratios and simulation of patterns fabric and its properties in the formation of the rings and the way to behold, and connect to create the shadows formation inside the space as demonstrated in fig.11.

This design system is based duo dimensions, first on the part of the loops. This is the framework of the individual fibers, and then plugged into the double rings at different levels around the bottom. In each level, there is a stitch linking the loops in the perpendicular direction integrated to a three-dimensional fabric structure.

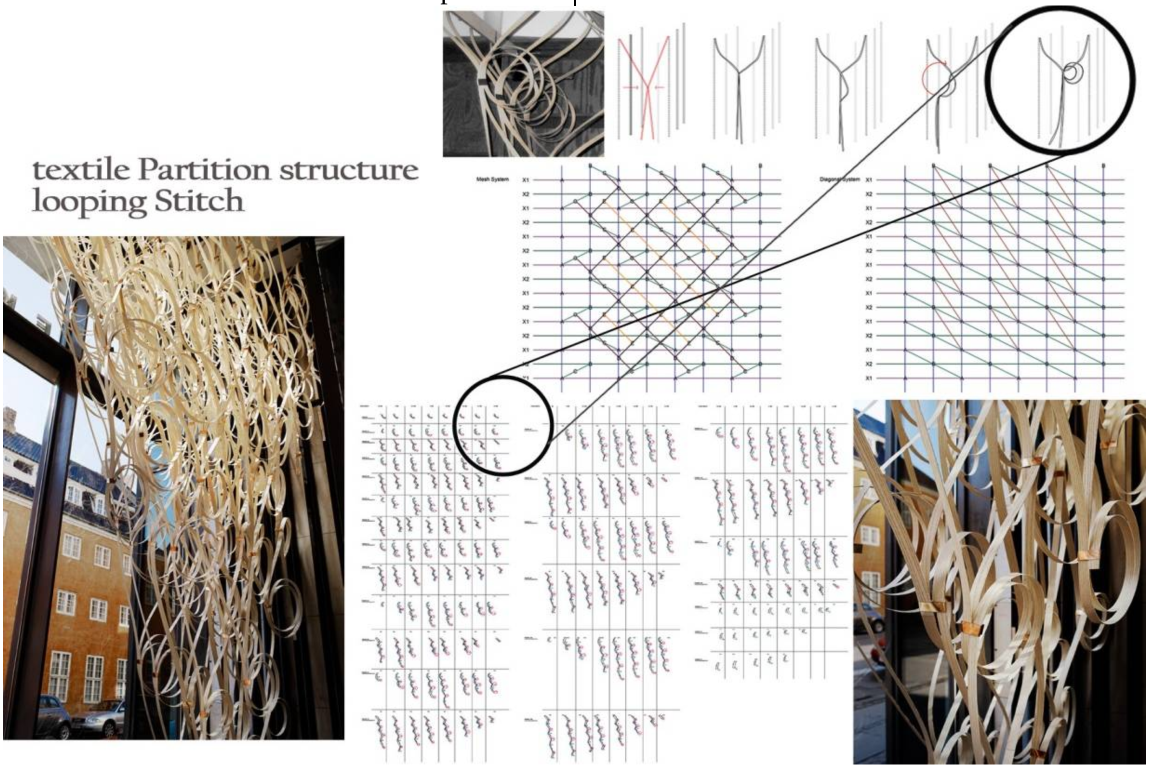


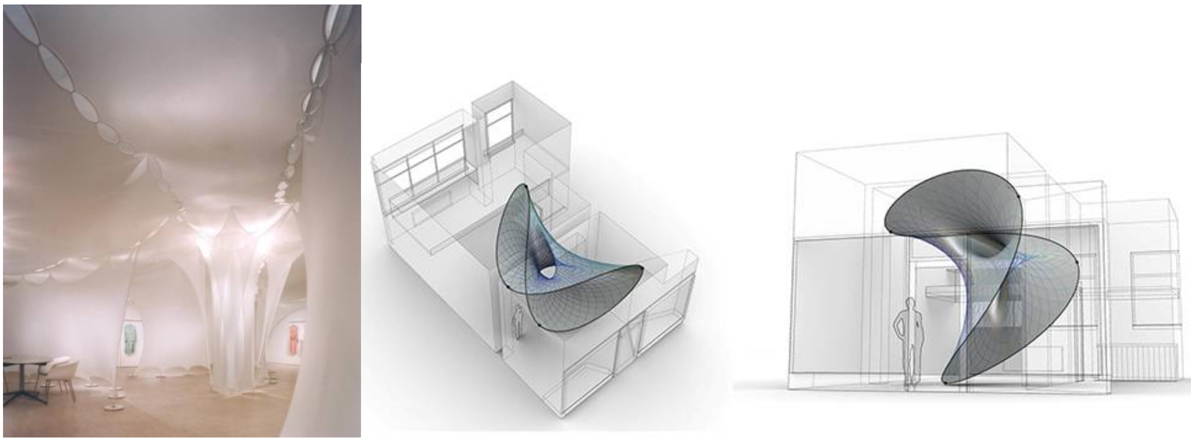

Figure11. Textile partition structure made by interconnecting loops and cooper stiches.

In the structure of each episode, or in other words, every level of this collection of integrated loops is inherently weak, and it is only through the gathering designed system and loops that is given to the whole structure rigidity and strength. There is a sample as an area which has been programmed design space for installation and can test and design.

5.3 **The evolution of the traditional shape of textile in interior spaces**

since the beginning, textiles in the design and composition of architectural and interior space evolution were used in the coverage as shades and the transition to the exterior walls and interior partitions during the treatment process. This raw material urged the designers to generate a new form and add a dimension in the curvature of the structure of the designs. Additionally, they are used as part of the process to achieve stability in a coherent structure for a composite profile.

Modern architecture and digital techniques tent to deploy textiles as an architectural form and its development has taken more - and not just temporary structures, but also for permanent buildings. It managed to create sophisticated and durable fabrics to cover large areas. With the ability to be stretched, which turned out to be used with a high degree of specialization in the sector of the construction industry, smart textile with hybrid proprieties became of the emergent trends through architecture and design to achieve stability and diversity in form and as a multifunctional manipulative surface[2]. At the same time, specific materials were added to the layers to give it responsive characteristics and avoid distortion along with structural factors. The fabrication of stretching the fabrics and cut them to size is implemented on the basis of complex patterns, which, are possible due to the latest computer technology and programs, and also integrate relevant factors are constant.



Figures12,13. Illustrations of the establishment of repeated coherent fiber, allowing for sudden shifts in density and the textile remain coherent in its structure.

This fabric is a blend of 36% Elastin, 64% Polyamide, varied as they are performed using digital fabrication technologies and CNC machines, which led to the restructuring of the internal structure of the fabric[12]. This difference generates a very small areas of firmness and great flexibility in areas where provides pre-structuring of internal tension and stiffness within itself. This is coordinated with the areas in the form of, a double set of 11MM glass fiber reinforced polymer (FRP) rod, impose varying degrees of direct and indirect pressure.

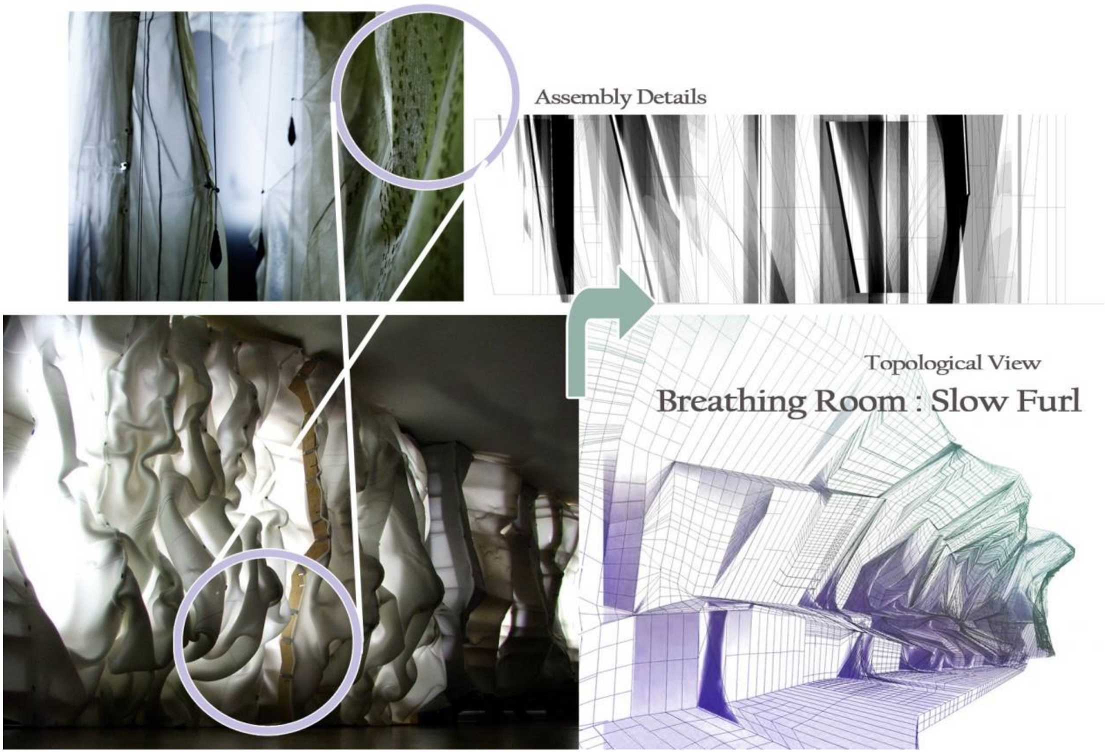
Figure14.Calibration of flexible textiles to enable the structure of a surface of 27sqm. Calibration of these physical and morphological parameters allow the model to rely solely on a fixed two points (on the floor, a large entrance between the front and rear gallery spaces) to create a state of balance.

5.4 **Adaptive responsive design through smart textile**

In interactive design, electronic textiles have spearheaded this material revolution by looking for new aesthetic and electromechanical possibilities for building computers and electronics which are more adequate for the structure, kinetic movements and responsive interactions of the body and environmental surroundings. These textiles are created using computer interactions, but also introduce a wide range of material affordances to the way we design and interact with computers[13].

In order to understand pattern finding through computerized interfaces, materials must respond digitally in a three-dimensional space and computationally controlled to perform into real structures. This generative procedure can happen directly, as in the case of electronically controlled thermoelectric junctions, or in a devious way through an auxiliary process, as in the case of thermo chromatic skins actuated through the resistive temperature and surroundings conditions[4]. The material progression needs to operate in stimulus and responsiveness that can be perceived and acted upon by sustaining serious interactions Reversibility is the ability of the material to shift to another state and return to its initial condition. Meanwhile, repeatability is its capacity to repeat the change methodology in numerous times without affecting the performance.

The structural skin of these installations is integrated as part of the electronic circuit of the robotic context by blending conductive fibers into the textile envelope. Parallel arrays of dynamic substructures, sensors, or microcontrollers are patterned with the layers of the textile. It is considered as a new way of embedding the computational into the built environment[14]




Figures15.The project "Breathing Room and Slow Furl" where textile is introduced as a computerized material through embedded dynamic systems.

## 6- Conclusions

Smart textiles impose a new sustainable ecological solution in architecture and design. It shows not only a direct link, but a cohesive relation between smart materials and computer aided-design. It made these flexible designs possible through computer tools. Modern technology and computer programing tools has led to the emergence of a high-performance fiber textiles and smart materials to develop a new hybrid textiles embedded with sensors and actuators with adaptive and interaction capabilities. Hybrid textiles explore non-traditional areas of inspiration to produce new and pioneering textiles. This paper examines aspects of smart textiles, based on computer embedded systems materials, especially to enhance the aesthetics of the woven interior structure.

- Digital processing provides the bases of the relative values of the physical components, while allowing at the same time the manipulation of their relationships and the degree of their influence on each other.
- It is the simulation of the fabric with (particulate matter) that imposes arranged force in a way that manipulates the surface of the textile and bending resistance.
- Through the comparative study of data sets of digital and mathematical relations between virtual and physical models, generative patterns were translated to dictate specifications rods bending, interlaced surfaces and diversity of knitting fabric density.
- Combination of different materials led to the emergence of complex patterns with hybrid proprieties to respond to the environmental surroundings.
- Hybrid textiles represent different installations of varying intensities in the structural strength and topological surfaces instead of a regular hexagonal pattern.
- The design of this output format is a matrix of relationships between the different shifts and subtle surprise in knitting and spinning intensity before loads and weights.
- Invoked parameters materials that underlie these structures that allows for a large margin of structures to be realized, identified with a various degree of variability in dealing with local varying pressures and external conditions.

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