Research on Intelligent Soft Outfit Design Based on Experience Innovation of Unconventional Fiber Materials

In the Case of Designs in a Poverty Alleviation Action by the Team

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Abstract. Starting from the design and development of intelligent soft outfits, this paper focuses on experiments such as optical fiber performance index determination experiment, optical fiber laser processing experiment, the composition ratio of recycled pulp fiber experiment, yam dyeing on different materials experiment, and analyzes the methods and theory of combining unconventional fiber materials with machinery and automation technology, under the different types of experience innovation.

Keywords: Unconventional Fiber Materials · Experience Innovation · Intelligent Soft Outfit Design · Machinery And Automation · Supply-Side Optimization

1 Introduction

The intelligent soft outfit is an extension and upgrade of traditional soft outfit products. Soft outfit includes almost all movable elements in the home and commercial spaces, involving a very diverse range of product types including furniture, decorative items, curtains, and fabrics. The essence of intelligent soft outfit design is the use of automation control technology combined with mechanical design and manufacturing optimization to achieve better intelligence, experience, and user affinity for soft outfit products. The intelligent soft outfit not only makes the interaction and experience behavior of products and their derivative services more convenient, but also serves as an important mean to enhance the added value of products. High-quality products and services can effectively reduce the spillover of consumers' demand, so as to better satisfy people's yearning for a better life and effectively promote the current domestic circulation in China and the international and domestic dual circulation. This perspective is actually quite consistent with China's current supply-side reform thinking that emphasizes optimizing products and services from the supply side, reducing low-end outdated production capacity, improving industrial development efficiency, and promoting high-quality development. Therefore, it can be said that one of the essences of the intelligent soft outfit is supply optimization.

Usually, the design and development of intelligent soft outfits focus on the integration of appearance and narrative mode as well as the coordination of interactive behavior and

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user experience [1, 3, 6]. However, sometimes there is a tendency of homogenization, such as the uniformity of surface materials, which will aggravate viewers' aesthetic fatigue and affect the user experience to a certain extent. To this end, it is very necessary to combine the sensory experience innovation of the fiber skin with the mechanical structure and automation technology for synergistic optimization [2, 7]. Compared to common materials such as acrylic, plastic, and metal, unconventional fiber materials often create a newer viewer experience. But the simple pursuit of the surface of the gorgeous will also be superficial, so a deeper approach should be explored [4, 5]. From the perspective of viewers and user experience innovation, it is undoubtedly a very inspiring way. This paper will analyze this research and development method and theory in combination with three intelligent soft outfits developed by the team in a design of poverty alleviation and rural revitalization initiative in Heyuan City, Guangdong Province, China.

2 Optical Fiber Under the Experience of Science Visual Illusion

The so-called science and technology visual illusion experience is to form a certain visual cognition through the perception of technological elements or symbols, and then implant this cognition into the design to form a viewer experience with a sense of technological illusion. This experience can reflect the designer's association and perception of technology. It is a design language transformation of the impression of technological elements, and its most obvious experience is to convey the impact and dynamic of technological elements, like Xiangyang Xin's emphasis on "impact" [8], the meaning generated by design is more charming than the design itself. This design (Fig. 1) draws inspiration from the solar panel group and arranges the scaly fan-shaped single elements in a matrix form. Combined with the function of the touch sensor, the fan-shaped scale matrix can make cyclic movements between upright and lying down movements, forming a group undulating dynamic similar to windswept grass. In addition, in order to enhance the sense of technology experience, we drew inspiration from the matrix digital rain of the movie "The Matrix", and chose a mysterious cool green to express the light effect color of the optical fiber skin, showing a technological illusion effect (Fig. 2). In order to realize the above ideas, we will use a laser cutting machine to make a fan-shaped scale matrix of a specific shape. At the specific technical level, we first program the hardware and set the undulating program of the matrix. Then the computer is connected to input the program and upload it to the HOT UNO-R3 development board, and the Arduino Uno R3 development board is connected to the HOT UNO-R3 development board. In order to realize the undulating effect of the scales, the steering gear is installed on each row of the scales to realize the undulating movement of the scales. All the servos are connected to the Arduino Uno R3 development board with Dupont wires so that the program can control the opening and closing of each row of servos. Finally, the sensor is connected to the development board, and it is available to touch the sensor switch with your hand to achieve dynamic undulating motion. (Fig. 2, 3, 4 and 5).

After such a set of combined installation of machinery and components, the original design concept of intelligent soft outfits has been realized. However, it is still necessary to select and optimize the surface fiber material. In this regard, we carried out a series of experiments on the light-guiding performance of optical fiber monomers to screen the

Fig. 1. Design case 1.

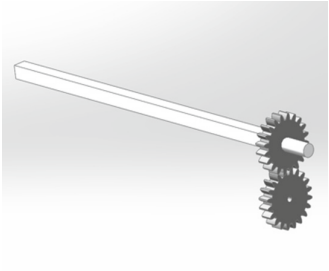

Fig. 2. The mechanical structure connecting the steering gear and the connecting rod structure.

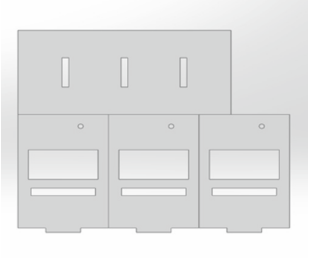

Fig. 3. Steering gear bracket.

optimal way to achieve light efficiency on the optical fiber. An optical fiber is made of glass or plastic that utilizes a light-conducting tool that transmits light in these fiber by the principle of total reflection. Optical fiber is a light-conducting material that conducts light waves and diversified light signals and has the function of three-dimensional integration of communication, medical treatment, and light-conducting.

On this basis, we preliminarily selected three kinds of Polymer Optical Fiber. After experimenting with the performance of the three kinds of fibers, the team obtained the relevant index parameters (Table 1), compared the advantages and disadvantages of the three kinds of fibers, and selected the most suitable materials. Through experimental comparison, it is found that samples A and B are both side-emitting optical fiber, and C

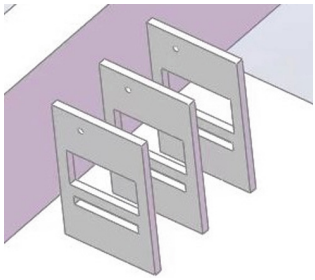

Fig. 4. Overall frame.

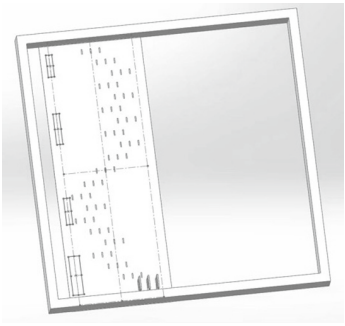

Fig. 5. Fixed arrangement of local servo brackets.

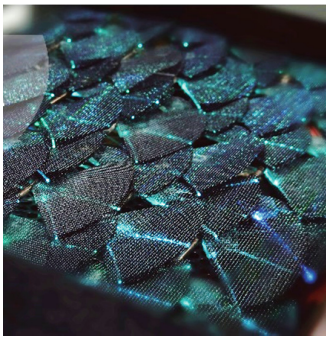

Fig. 6. Details of fiber material

belongs to end-emitting optical fiber. Side-emitting optical fiber, also known as surface light-emitting optical fiber, means that light can not only be transmitted from the incident end face to the output end face, but also a part of it leaks out through the cortex of the fiber, forming the effect of side-emitting light. The end-emitting optical fiber refers to the transmission of light from the incident end face of the fiber to the exit end face in the way of total reflection during the transmission process. Through experimental comparison, it is believed that the selection of side-emitting optical fiber types A and B

Table 1. Optical fiber performance index determination.

Sample code	A	B	C
Diameter (mm)	0.25	0.5	0.25
Product Category	Side-emitting optical fiber	Side-emitting optical fiber	End-emitting optical fiber
Core layer material	PMMA	PS	Polyurethane (PU)
Cortex layer material	PMMA	PMMA	Fluorine resin
Attenuation value / (dB • km^{-1})	≤350	≤90	≤250
Operating temperature/°C	−55~70	≤80	−40~100
Elasticity	10 times the diameter	12 times the diameter	8 times the diameter
Weight g/m	0.03	0.06	0.3

is more suitable for the preset of material technology visual effects in the design concept. When comparing the two materials A and B, the core layer and cortex layer of sample A are both PMMA materials, and the transparency of which is higher. In the experiment, it was found that the PMMA material has higher brightness after light guide due to its higher transparency. In comparison, the skin layer of sample B is PS material, the transparency of which is average, and there will be slight pitting when reflecting light. However, the PS material of sample B is softer and more elastic than A. In addition, the optical attenuation value of B is lower, which is suitable for longer distances. In comparison, the optical attenuation value of A is higher, but the fiber length is generally shorter in the product design preset. Thus, the difference between the effects of A and B is not obvious, but sample A with higher transparency has a better luminous effect. In addition, the ignition point of A is higher than that of B. When burning with fire, there is no smoke and the safety is higher. In contrast, B emits a black and pungent odor amid burning. Hence, based on the analysis of multiple indicators and characteristics, A is more suitable as the final choice.

After selecting the optical fiber material, through experiments such as ring cutting, coiling, crease, threading, laser cutting, laser engraving, etc. on the optical fiber (Table 2), we found that the hybrid effect of the laser engraving and threading process of the optical fiber is the most ideal. After laser engraving, the engraved fiber can be guaranteed to have sufficient luminous flux to achieve a pattern effect with uniform light efficiency. Combined with acupuncture perforation and pulling the optical fiber on the 0.15 mm thick heat-shrinkable sheet, the optical fiber will guide the light evenly in a curved shape on the heat-shrinkable sheet, and the light guide effect of the end and middle points can better achieve the design expectations, so as to create a very technical light effect texture (Fig. 6). In order to find a carrier to better carry the optical fiber to realize the ambient experience, we selected 100% polyester textile fiber as the base material. The effect of

Table 2. Optical fiber laser processing experiment.

Technical Index	**Optical Fiber Laser Processing Data**			
	Fiber Processing method	Laser cutting	*Fiber Processing Method*	Laser engraving
Size	*Fiber Diameter*	0.25 mm	*Fiber Diameter*	0.25 mm
	Fiber Length	2500 mm	*Fiber Length*	2500 mm
Processing Parameters	*Cutting Speed*	200 mm/s	*Engraving Method*	Horizontal one-way
	Corner light Intensity I	5.5%		
	Work light Intensity I	5.5%	*Engraving Accuracy*	0.050 mm
	Corner Light Intensity II	20%	*Work Light Intensity I*	20%
	Work light intensity II	30%	*Work Light Intensity II*	20%
Light Source	*Light Source Type*	LED	*Light Source Type*	RGB
	Light Source Parameters	12V3W Multi-head	*Light Source Parameters*	12V16W-APP remote control

this base material is more transparent, with foil treatment and glitter effect on the surface, which can be well combined with fiber optics to optimize the ambience experience. It is compounded on the heat-shrinkable sheet, and the laser-engraved optical fiber is sewn onto the compound to form a fiber skin. In this way, a high-tech visual illusion experience is formed.

3 Recycled Pulp Fiber Under the Cultural Resonance Experience

Cultural resonance experience is a method of product design creativity through the extraction of cultural elements. In this process, unconventional fiber materials have become an effective means of expressing and highlighting design motifs to sublimate and enhance the user experience of the entire design. Culture becomes the bridge between designers and products. The cultural memory contained in the design has actually become the key to arousing a certain cultural cognition of users and viewers and establishing a good experience relationship. Inspired by fairy tales, the design (Fig. 7) combines the cute image of a rabbit with the decorative function of intelligent outfit products. Rabbits are cute, well-behaved, and somewhat fairy-tale animals, and there are stories about them in many cultures around the world. Such as “Jade Rabbit Pounding Elixir of Immortality” and “Master Rabbit” in Chinese folk mythology, and Blue Rabbit in Rabbit Town in Western Hans Christian Andersen’s fairy tales. This design extracts the shape of the rabbit but does not decorate the eyes and facial features, which makes the product image more imaginative and associative.

Fig. 7. Design case 2.

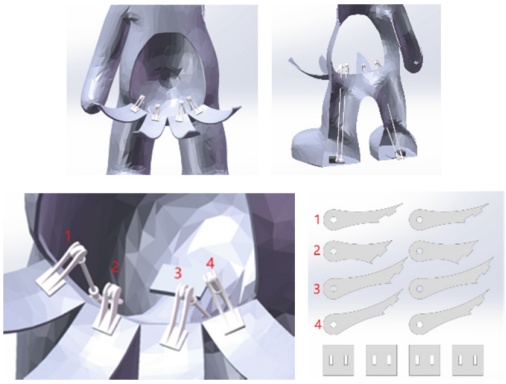

Fig. 8. Structure drawing of design case 2.

In this design, recycled pulp fiber, which is not common in general soft-packed products, are used in skin treatment. The matte and grainy pulp fiber can better optimize the surface texture of soft-packed products, making the user experience different from ordinary acrylic, plastic, and other materials, and more distinctive. Through the application of infrared sensors and the opening and mechanical structure of the rabbit's abdomen, an effect similar to the opening of a gift box that often appears in fairy tales can be created, thereby presenting a small story scene of a jade rabbit in the abdomen pounding elixir immortality, so that the content and design theme can be closely connected to make the design more user-friendly and attractive. In order to achieve the above design intent, we first used 3D printing technology to print a hollow animal-shaped shell and then glued the pulp fiber to the surface of the shell. In order to make the rabbit's belly open and close freely, we designed a four-lobed opening and closing mechanism on the rabbit's abdomen (Fig. 8). At the same time, it cooperates with the infrared sensor placed on the rabbit's abdomen. When the viewer touches the infrared sensor at a distance of 7 cm to 30 cm, the opening and closing mechanism will be triggered, which will cause the rabbit's abdomen to open in a petal-like manner, revealing a small story scene of the rabbit mashing pounding elixir immortality inside its belly. At the specific assembly level, first, it is required to program the hardware and set the opening and program. Then the computer is connected to enter the edited program and upload it to the development

Table 3. The composition ratios of recycled pulp fiber.

Technical Index	The composition ratios data		
	Experiment 1	Experiment 2	Experiment 3
Humidity	10%	5%	5%
Starch	120 g	130 g	120 g
Emulsion	350 g	450 g	450 g
Paper	180 g	180 g	180 g
Sodium Chloride	30 g	30 g	30 g
Mixed Method	Even Mix	Even Stir	Even Mix
Mix Duration	2 min	5 min	5 min

board at the same time. Subsequently, an infrared sensor can be selected. The reflection form of this sensor adopts infrared diffuse reflection type, the sensing distance is between 7 cm–30 cm, and the response time is below 2 MS. The selected sensor is connected to the expansion board, and then a 30 kg steering gear is installed on the opening and closing position of the abdomen, so that the opening and closing of the four-lobed structure of the abdomen can be controlled, revealing the built-in scene of a jade rabbit pounding elixir immortality in the abdomen. At the same time, the development board and power supply are connected to the expansion board respectively, and the power converter is connected to the development board to complete the assembly of the entire device.

Recycled Pulp fiber is mainly used in the skin part, which is a special fiber synthesized from recycled paper, starch, latex, etc. The characteristic of this fibrous material is that the raw material is easy to obtain, and the general recycled paper and the waste paper in the garbage can be used as the raw material after being sterilized. Moreover, the preparation method is relatively convenient and does not require an overly complicated processing technology. In the meantime, it has good recyclability, and can still be recycled and reused after application, which has obvious sustainable characteristics. The preparation method of this kind of paper fiber is mainly to sterilize all kinds of recycled paper, soak it, and then crush and shape it with a mixer. In this design, the three-dimensional plasticity and stability of paper fiber is mainly used to shape the unique fiber skin of the texture experience. From the comparison of experiments (Table 3), it can be seen from the humidity index that the paper in Experiment 1 has too much water, which will bind the starch together first, which is not conducive to the uniform mixing of starch, latex, and papers. Experiment 2 and Experiment 3 are more conducive to uniform stirring and mixing, which can form a finer mixture. Judging from the dosage of latex, when the dosage is 350 g, the viscosity of the pulp is not enough, the surface texture is too rough during shaping, and it is easy to fall off. When the dosage is 450 g, the viscosity of the pulp is high, and the surface texture is smoother and firmer during shaping. From the perspective of starch dosage, when the dosage is 120 g, the pulp is not easy to crack, and the effect is better; when the dosage is 130 g after the pulp is dried, there are many breaks, and more latex needs to be added. From the perspective of mixing time, under the same humidity conditions, the fineness of the surface fiber texture is related to the

mixing time. After stirring for 2 min, the surface fiber particles are larger and the texture is rougher. After stirring for 5 min, the fiber particles on the surface layer are smaller and the texture is relatively finer. The pulp fiber is then shaped and colored to form the fibrous skin of the intelligent soft outfit.

Through the combination and assembly of such a set of machinery and intelligent components, the initial design preset of the intelligent soft outfit is realized. When there is no one around, the rabbit is in a static state, and the servo inside the belly does not work; when the viewer approaches, the infrared sensor will receive the induction, and the internal servo will start to work, and the belly of the rabbit will start to work slowly. The small scene of an inner jade rabbit pounding elixir immortality will slowly appear. When the viewer leaves, the petals on the rabbit's abdomen will slowly close. In the design of this intelligent soft outfit device, the application of fiber materials and the expression of intelligent technology are established based on a cultural resonance of user versatility. The communication and presentation of the concept of cultural IP concept become the purpose and orientation of materials and intelligent technology expression. In such a process, cultural resonance has completed a benign combination of user experience and technology application.

4 Traditional Yam-Dyed Fiber Under the Natural Bionic Experience

The natural bionic experience is the extraction of animal and plant image forms and physiological movements through bionic methods, the restoration of forms with artistic expression techniques, the completion of interactive behaviours with mechanical structures and intelligent technology, and the abstract interpretation with the innovative language of fiber materials. In this way, artistic mimesis is formed, which promotes the process of sublimation of natural objects in the sense of order and form.

The design (Fig. 9) draws inspiration from the forms of marine life and reconstructs the images of sea anemones, roses, and corals. Through the wrinkle texture process of textile fiber (Fig. 10), the observation and performance of marine life are conveyed. Through the sensor's perception of human movements, the opening and closing of marine life are activated with the gesture of "swiping ocean waves". In this way, viewers can experience an artistic presentation of the natural state of matter and its simple physiological actions using mechanical structures. (Table 4)

In order to realize the above ideas, we designed an umbrella-shaped bracket structure to support the opening and closing of the entire device, simulating the physiological

Fig. 9. Design case 3.

Fig. 10. Fiber material details of design case 3

Table 4. Yam dyeing experiment on different materials.

Fabric Name	Times and duration(min) of yam dyeing						
	0	1	3	5	7	9	11
	0	10	30	50	70	90	110
Plain Crepe							
Electro Spinning							
Chiffon							
Crepe De Chine							
Thread							
Silk Satin							
Silk Floss							
Cotton Silk							
Pure Cotton							
Cotton and Linen							

actions of marine organisms. The maximum diameter of the mechanical umbrella rib opening and closing is 80 cm, and the opening and closing power can be provided by a stepper motor. The "swipe ocean wave" gesture is used to activate the interactive behavior through the proximity gesture recognition sensor. The components selected for the whole design mainly include a 57-ball screw stepping motor, DM542 driver, 100W pure copper mute transformer, UNO-R3 development board, Arduino power supply, VL6180X proximity gesture recognition sensor, etc.

5 Conclusions

By and large, combined with a number of experiments and smart soft outfit design research and development cases, from three experience innovation modes, the ways of unconventional fiber materials to improve user experience and enhance perception

optimization are analyzed. This study believes that the creation of an innovative sensory experience is one of the core elements of the development of intelligent soft outfits. According to the design expectations, suitable unconventional fiber materials are selected to create a differentiated and personalized experience combined with a variety of material experiments. Meanwhile, mechanical and automation technology can be integrated to achieve dynamic interaction and enhance this experience, which is a constructive way of thinking about the research and development of intelligent soft outfits.

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