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3D 가상 이미지의 텍스타일 소재로의 적용을 통한 삼차원 변형가능한 'Living Textile'과 환경변화에 관한 연구 (2)

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An Investigation into Three Dimensional Mutable 'Living' Textile Materials and Environments (2)

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Abstract

This research aim concerns questioning how we can generate environments suggestive of nature fused with built environments through textiles. Through literature reviews and experiments with available the 3D imaging techniques of Holography, Lenticular and other new technologies. We also have researched towards finding the most effective method for 3D imaging techniques for textile applications. The advantage of the combining technique is to create the possibility of seeing a number of different floating 3D illusory images, depending on the viewing angle. This objective is to produce intriguing textile patterns and images in which the objects and colours change as viewpoints change. Experimental work was carried out in collaboration with professional textile researchers, scientists, artists and designers conducting research in this field.

Key words: 3D integral imaging(3D 인테그럴 이미징), lenticular(렌티큘러), 3D textiles(3D 텍스타일).

Ⅰ. Introduction

To identify our initial idea, the use of the term 'living' in the research title is not used to describe actual 3 dimensional living forms in a biological sense, rather it refers to 3 dimensional illusory effects applied to 2 dimensional textile substrates. Also, the term is used to indicate verisimilitude or lifelike appearances.

A holographic textile has been developed by Dr. Munzer Makansi but the material has yet to be realised as a realistic material product. According to Textile News,[1)] Dr. Munzer Makansi has developed and patented a way to create such a material. The article states that the process is only a few steps away from being developed commercially but through this research, we have found no evidence that this has been achieved. Dr. Munzer Makansi calls his invention "holographic fabric technology," featuring direct

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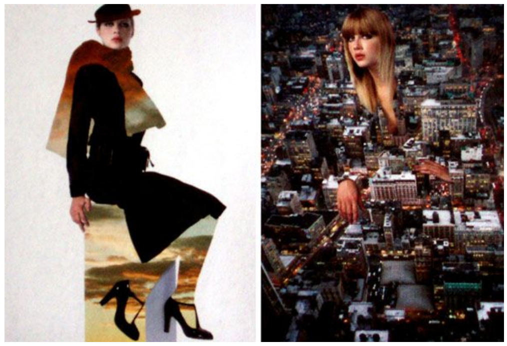
1) Q. Bea, "*Fabric Technology Moving Ahead*," *Textile News*, (August 2001).

embossing of rainbow and hologram images on fabrics with heat and pressure. Using existing holographic film embossing equipment, the fabrics are produced with a thermal embossing process at elevated pressures. The article claims that the fabric is unique in that, upon exposure to light, the fabric projects coloured images that are bright and also shimmer, just as conventional hologram images do.

Makansi said he believes the potential market for his holographic fabric technology is large. Among potential applications are sportswear, fashion apparel and accessories, interior furnishings and fabrics for outdoor uses. These potential applications are fascinating and almost overwhelming. However the fact that such fabrics remain a few steps away from being developed commercially through existing manufacturing technologies has led me to focus on technologies which are readily available and to research their potential in creating alternative and achievable three dimensional mutable 'living' textile materials.

Victor & Rolf's Autumn/winter 2002 ready-to-wear collection created the illusion of a fabric that research laboratories over the world are working on which has variously been described as chameleon camouflage, digital cloth or a textile display. As the models passed the audience, the fabric of the clothes streamed with film footage of traffic in the street and clouds racing across the sky. Brilliant blue detailing in the outfits was replaced by digitally projected images, a process known as blue-screening. Blue-screening is a special effect more commonly used in film and television, where anything painted in a brilliant blue pigment can be digitally isolated and replaced with another image (Fig. 1).

Through this research, we would like to advance textiles further, not by only creating a new form of textile using the technologies we have identified but also emulating the transient, ethereal beauty of nature. The basic idea is to develop a textile that fuses nature and technology within a whole and an inseparable environment. Thus we are investigating textiles, in which the objects and colours change as the viewpoint changes like 3D moving images.



<Fig. 1> Victor & Rolf's Autumn/Winter 2002 Ready-to-wear.

Ⅱ. Theoretical Basis & Technical Experiments

1. 3D Integral Imaging using Fresnel Lens Arrays

This section focuses on the 3D Integral Imaging Technique using Fresnel Lens Arrays as this is the technique that provides the closest method of achieving the main objective of the research project.

1) History of Integral Imaging

On March 3rd, 1908, physicist Professor Gabriel M. Lippmann (1845-1921) proposed the use of a series of lenses placed at the picture surface to form a true three dimensional image. He announced this to the French Academy of Sciences under the title "La Photographie Integral."[2)]

The first in depth study of lithographic printing of integral imagery was described in 1936 by Carl Percy and Ernest Draper of the Perser Corporation. The first integral animation printing effect was proposed in 1958 by Juan Luis Ossoinak of Argentina.[3)]

A number of researchers continued to advance the

2) M. G. Lippmann, "Epreuves reversible donnant la sensation du relief," *Compt. Rend. Acad. Sci.* Vol. 146 (1908), p. 446.

process of Integral Photography over the last 40 years including, most prominently; Roger de Montebello, Lesley Dudley and Robert Collier of the US, Neil Davis and Malcolm McCormick of the U.K. and Yu. A. Dudnikov and B. K. Rozhkov of the former Soviet Union.[4)]

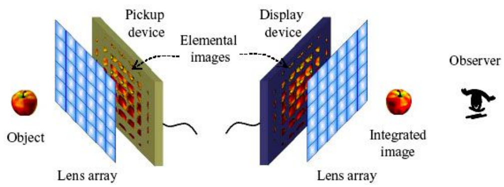
"Creating 3-D integral imagery, by digitally interlacing a set of computer generated two-dimensional views, was first demonstrated in 1978 at the Tokyo Institute of Technology in Japan."[5)] They and others also developed experimental integral television methods. Digitally interlacing integral imagery for high-resolution colour pictures was first proposed in 1989 by Ivars Villums.[6)] "Many thousands of experimental images have been produced throughout the last century by a wide variety of methods, exhibiting 3-D, animation and other impressive effects."[7)]

2) Understanding of the Integral Imaging Technique

Integral imaging is a true auto-stereo method.[8)] An integral image consists of a tremendous number of closely-packed, distinct micro-images that are viewed by an observer through an array of spherical convex lenses, one lens for every micro-image. "The term "Integral" comes from the integration of all the micro images into a complete three dimensional image through the lens array."[9)] This special type of lens array is known as a fly's-eye or integral lens array.[10)]

"Integral, which is also referred to as an integral photography, is one of the currently popular three-dimensional (3D) display techniques."[11)] It can provide bare-eyed observers within a certain viewing angle with full colour and real-time 3D images that have both horizontal and vertical parallaxes.

Figure 2 shows the basic concept of Integral Imaging. In the pickup process, each elemental lens constituting the lens array forms each corresponding elemental image based on its position relative to the object, and these elemental images are then stored. In the display process, the elemental images displayed on the display panel are integrated at the original position of the object forming a 3D image.



<Fig. 2> Basic Concept of Integral Imaging Showing Pick Up and Display Process[12)].

3) A. Ossoinak, Arrangement for the Exhibition of Dynamic Scenes to an Observer in Movement with Respect to a Screen, US Patent 2,833,176 (1958).
4) B. K. Rozhkov, "The Transformation Properties of the Lens-Array System in Integral Photography," *Sov. J. Opt. Tech.* Vol. 54 No. 2 (1987).
5) H. Higuchi and J. Hamasaki, "Real-time Transmission of Three-dimensional Images Formed by Parallax Panoramagrams," *Appl. Opt.* Vol. 17 No. 24 (1978), pp. 3895-3902.
6) I. Villums, Optical Imaging System Using Optical Tone-Plate Elements, US Patent 4,878,735 (1989).
7) D. E. Roberts and Smith Trebor, The History of Integral Print Methods, An excerpt from: "Lens Array Print Techniques" (2003) http://www.integralresource.org/Integral_History.pdf
8) Auto-stereo Method: Stereo Imagery Viewable without the Requirement of Special Glasses.
9) R. L. De Montebello, "Wide-angle Integral Photography-The Integram System," *Tech Digest* (1977), pp. 73-91.
10) P. Gottfried and S. Brosh, Integral Image, Method and Device, US Patent 6483644 (2002). http://www.patentstorm.us/patents/6483644-fulltext.html
11) N. K. Ignat'ev et al., "Two Modes of Operation of a Lens Array for Obtaining Integral Photography," *Sov. J. Opt. Tech.* Vol. 50, No. 1.
12) J. Park, Y. Kim and J. Kim, "3D/2D Convertible Display Based on Integral Imaging and Its Extensions for Viewing-angle and Resolution Enhancement," (Article from School of Engineering and Computer Science, Seoul National University. http://www.samsung.com/AboutSAMSUNG/ELECTRONICSGLOBAL/SocialCommitment/HumantechThesis/WinningPapers/downloads/11th/bronzeprize/ParkJaeHyeung.pdf

2. Fresnel Lens

A Fresnel lens is a type of lens invented by Augustin-Jean Fresnel.[13] "The first Fresnel lens was used in 1822 in a lighthouse on the Gironde River in France, Cardovan Tower its light could be seen from more than 20 miles out."[14]

The Fresnel lens is a thin, flat optical lens which consists of a series of small narrow concentric grooves on the surface of a lightweight plastic sheet in order toreduce the thickness, weight and cost. Each groove is at a slightly different angle than the next and with the same focal length in order to focus the light toward a central focal point. Every groove can be considered as an individual small lens to bend parallel Fresnel light waves and focus the light.

1) Practical Experiments with Fresnel Lens Array

Specialist information and technical support, including Fresnel Lens specifications, was kindly provided by Prof. Byoungho Lee (School of Electrical Engineering, Seoul National University) and Dr. Jeong (Reader, Optoelectronics Research Centre, University of Southampton). Fresnel Lenses were purchased from Fresnel technologies inc. (Texas, US, www.fresnel tech.com) with focal length 15mm, 22 mm (13×13), quantity was 5 each so 10 in total. Software called Imageman2 was provided and demonstrated by Dr. Jeong.

In order to use this Software our computer was firstly calibrated with its pixel size to the Fresnel Lens to be used. Thereby an image which is sliced according to the Fresnel Lens and is aligned by chec-

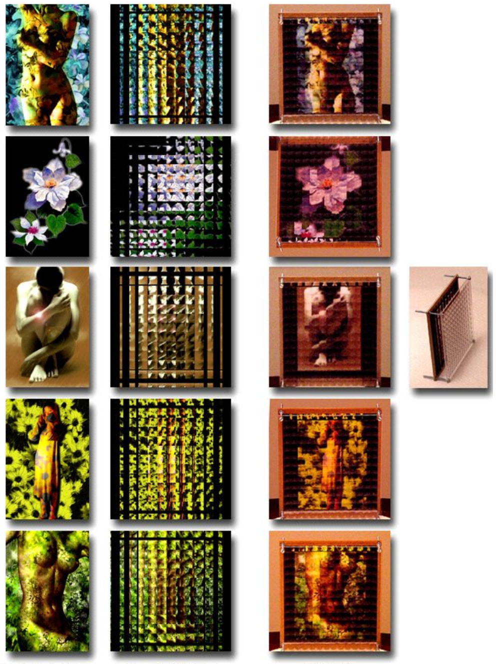
<Fig. 3> Practical Experiment with 15mm Focal Length Fresnel Lens.

<Table 1> Equipment Specifications for Fresnel Lens Array

Setup	Specification	Characteristics
Flat Panel CRT Display	Number of pixels	1,280(H) / 1,024(V)
	Pixel size	0.24mm
Fresnel Lens Array	Number of elemental lenses	13(H) / 13(V)
	Pitch of the elemental lens	10mm
	Focal length	15mm, 22mm
Polarization Shutter Screen	Type of polarization	Circular

13) Augustin-Jean Fresnel: (May 10, 1788-July 14, 1827), was a French Physicist Who Contributed Significantly to the Establishment of the Theory of Wave ptics. Fresnel Studied the Behavior of Light Both Theoretically and Experimentally.

14) Bruce Watson, "Science Makes a Better Lighthouse Lens." Smithsonian. (August 1999) v30 i5 p.30. Reproduced in Biography Resource Center. Farmington Hills, Mich.: Thomson Gale. 2005. http://libproxy.uncg.edu: 2088/servlet/BioRC.



<Fig. 4> Practical Experiment with 22mm Focal Length Fresnel Lens.

king focal length above the image as the resolution is set. In addition, by checking that the image information is being transferred correctly, the image can then be printed. Finally an image product is made by overlaying the printout with the Fresnel Lens. Please refer to Equipment Specifications in the table.

2) Critical Analysis of the Result in 3D Integral Imaging Experiment with Particular Reference to Textile Applications

Important factors to consider in applying 3D Integral Imaging Technique using Fresnel lens array to textiles are firstly the Fresnel lens itself and secondly the flexibility and transparency of the spherical Micro-Convex Lens array. For textile application, A Fresnel lens that has a short focal length is required. The lens itself does not need to be a Fresnel lens. Any lens that contains the similar characteristics of the Fresnel lens could be used. A short focal length simply means the distance between the Fresnel lens and the sliced elemental background image is small. The distance depends on the focal length of a specific Fresnel lens.If such short focal lengths can be achieved there would be only a small gap between the image and the lens and we could then simply use a material that consists of the characteristics of Fresnellens and attach it straight to a textile or laminate it to experience the 3D illusionary effects as a textile material.

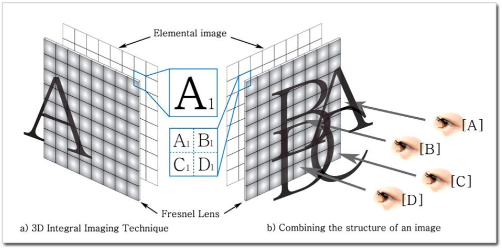
Shorter focal lengths also mean individual Fresnel lens sizes need to be smaller. The smaller sizes of Fresnel lenses means individual elemental background images, working with the Fresnel lens, should also reduce further in size. Spherical Micro-Convex Lens array could be a very good example of a potential material.

In order to apply the spherical Micro-Convex Lens arrays to flexible textiles, the characteristics of the material must be flexible and transparent to experience the 3D illusionary image effect.

3. Combining Lenticular & 3D Integral Imaging Technique using Fresnel Lens array

I have investigated various 3D technologies for textiles, which can be both real and illusive, interacting with light and different viewing angles, shifting and moving in time. Through case studies, comparative analysis and testing process we have found that Lenticular technique has theadvantage of showing different images with different angles even though it has a few drawbacks, and also we have concluded that 3D Integral Imaging Technology holds a potential to direct a new textile development to have an impact on how we view the environment. In particular, 3D Integral Imaging Technology can create 3D images in a 3D space due to the lens array and the 3D display appearing much more natural than any other display techniques.

In this chapter, the following diagram and experimental work shows how we have combined Lenticular and 3D Integral ImagingTechnology.



<Fig. 5> Diagram Showing the Combining Structure of Lenticular & 3D Integral Imaging Technique.

1) Method of Experiments

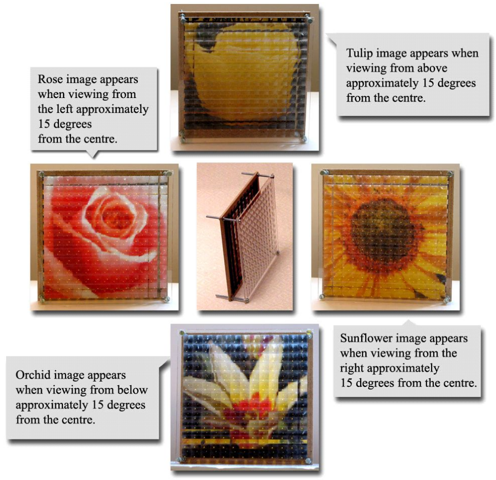
The advantages of the combination shown in the diagram above are that the elemental image can be divided according to the Lenticular technique. This allows different images to be seen through the interaction between the composition of the divided image and the Fresnal lens placed in front of the image. Normally the elemental image is composed of just one image, but in the case of the model developed through the research, the elemental image is composed of different images and this creates the possibility of seeing a number of different floating 3D images, depending on the viewing angle. In this way the new effect is created by combining the structure of an image normally associated with the Lenticular technique with 3D Integral Imaging Technique using Fresnel Lens array.

2) Practical Experiment

Figure 6 shows an example of the effect of combining the advantages of two technologies, Lenticular & 3D Integral Imaging technique using Fresnel Lens array. This combination of techniques allows the viewing of many different 3D images as the viewpoint changes.

3) Critical Analysis of Combining Lenticular & 3D Integral Imaging Technique using Fresnel Lens Array

The advantages of combining Lenticular and 3D Integral Imaging Technique using Fresnel Lens array



<Fig. 6> Experimental Work of Combining Lenticular & 3D Integral Imaging Technique using 22mm Focal Length Fresnel Lens.

are that the Lenticular technique has an advantage of showing different images with different angles and 3D Integral Imaging Technique using Fresnel lens array has the ability to separate and rearrange elemental image through its lens which effectively creates 3D images appearing to float in mid air. In other words, the advantages of combing two techniques are firstly, the ability to overcome the initial limitation of one direction of 3D display in vertical or horizontal expression in Lenticular technique. The experimental works of combined two techniques allow the viewer to experience the floating 3D image in unlimited directions of viewing angles. Therefore there is the advantage of viewing angle covering a wider range than the Lenticular technique on its own. The second advantage of combining the techniques would be the ability to create floating 3D images while simultaneously allowing the viewer to see different images depending on their viewing angle.

We propose a technique that combines the advantages of Lenticular and 3D Integral Imaging technique that could express 3D mutable 'living' textile even closer than 3D Integral Imaging Technique alone. The experimental work of these combined techniques demonstrates a potential to achieve the original aim of our research project. Furthermore, as the focal length is short, the development of a flexible material for the Fresnel Lens that could be attached to fabric can be seen as the best method for achieving the textile research aim.

Ⅲ. Conclusion

Technology essentially broadens our language as a designer. we're interested in languages that allow you to go beyond consideration of the body of 'normal' clothing to create new ways of looking. The importance of technology in our work is that it presents a fresh means of expression.[15)]

Imagine a girl wearing a T-shirt featuring a fairy and the fairy’s wings are actually moving on the T-shirt as she walks. Or imagine a woman wearing a textile with photographic images of that change as the light hits the material at different angles. That day may not be as far off in the future as you might think. Technology will take us from our old familiar world to a future which offers a very different environment.

When inventions and technological development are working together to be in harmony they can come closer to having a wider affect on our lives. The new technologies in textiles are making it possible to create specific materials for a variety of technical, decorative and contemporary art solutions.

In this technical context, we have found it necessary to collaborate with scientists who have been able to show me what is possible and what the limitations of the project currently are.

Specifically the aim of the project was to explore the potential application of the illusions created by various 3D imaging techniques and to develop textiles to create new environments where reality and fiction are fused. As described earlier, our objective was to produce intriguing textile patterns and images in which the objects and colours change as viewpoints change like 3D mutable 'living' textile.

We have investigated various 3D technologies for textiles, which can be both real and illusive, interacting with light and different viewing angles, shifting and moving in time. Through the investigation and experiments concerned with 3D expression and technologies, we have concluded that 3D Integral Imaging Technology holds a potential to direct a new textile development to have an impact on how we view the environment.

3D Integral Imaging is promising as it is not restricted to only one direction of 3D display which is the disadvantage of the Lenticular display technique, but has unlimited directions of viewing angles by the use of lens arrays. In particular, 3D Integral Imaging can create 3D images in a 3D space due to the lens array and the 3D display appearing much more natural than any other display techniques.

Also since the viewing angle covers a wide range, a number of people can experience the 3D display at the same time. Additionally we propose a technique that combines the advantages of Lenticular and 3D Integral Imaging technique that could express 3D mutable 'living' textile even closer than Integral Imaging Technique alone.

The experimental work of these combined techniques (Fig. 6) demonstrates a potential to achieve the original aim of our research project. Furthermore as the focal length is short, the development of a flexible material for the Fresnel lens that could be attached to fabric can be seen as the best method for achieving 3D mutable 'living' textile.

Finally, there are still aspects of the technology and materials that need to be further developed in order to apply the technique industrially and commer-

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15) L. Suzanne, D. P. Warren and T. J. Nick, *Fashioning the Future: Tomorrow’s Wardrobe*, (Thames & Hudson, Sep., 2005), p 95 (Hussein Chalayan).

cially to flexible fabrics. To fulfil the original research aim, firstly, there needs to be further development in miniaturizing printing technology as this would allow for the combining technique to be applied to printed fabric with the level of accuracy of adjustments required for the technique to succeed. This is important because very precise adjustments to the printed image need to be made for the image to interact with the lens in such a way that the effect of a floating 3D photographic image is achieved.

The proposed technique depends on technical factors being combined using high levels of resolution and for the best results the elemental image would need to be microsized. Hence, to advance the work with the microlens, miniaturizing printing qualitieshas to be improved, because the size of each elemental image is almost a pixel size.

Secondly, to achieve 3D illusory photographic effects onto fabric, high refractive thin transparent film materialswhich do not disturb their transparency need to be developed.

References

Bea, Q. (2001). "Fabric Technology Moving Ahead." *Textile News*. August 13.

De Montebello, R. L. (1977). "Wide-angle Integral Photography-The Integram System." *Tech Digest* 73-91.

Didik, F. X. (2001). A Brief History of Stereo Images, Printing and Photography from 1692-2001. Tch. Rep. Didik.com/Vari-Vue.com

Gottfried, P. and S. Brosh (2002). Integral Image. Method and Device US Patent 6483644. http://www.patentstorm.us/patents/6483644-full-text.html

Higuchi, H. and J. Hamasaki (1978). "Real-time Transmission of Three-dimensional Images Formed by Parallax panoramagrams." *Appl. Opt.* Vol. 17, No. 24.

Ossoinak, A. (1958). Arrangement for the Exhibition of Dynamic Scenes to an Observer In Movement with Respect to a Screen, US Patent 2,833,176.

J. Park, Y. Kim and J. Kim, "3D/2D Convertible Display Based on Integral Imaging and Its Extensions for Viewing-angle and Resolution Enhancement," (Article from School of Engineering and Computer Science, Seoul National University) http://www.samsung.com/AboutSAMSUNG/ELECTRONICSGLOBAL/SocialCommitment/HumantechThesis/WinningPapers/downloads/11th/bronzeprize/ParkJaeHyeung.pdf

Roberts, D. E. and Smith Trebor (2003). The History of Integral Print Methods. "An excerpt from: Lens Array Print Techniques" http://www.integralresource.org/Integral_History.pdf

Rozhkov, B. K. (1987). "The Transformation Properties of the Lens-Array System in Integral Photography." *Sov. J. Opt. Tech.* Vol. 54, No. 2.

Suzanne, L., D. P. Warren and T. J. Nick (Sep 2005). *Fashioning the Future: Tomorrow's Wardrobe*. Thames & Hudson.

Villums, I. (1989). Optical Imaging System Using Optical Tone-Plate Elements, US Patent 4,878,735.

Watson, Bruce (1999). *Science Makes a Better Lighthouse Lens. Smithsonian. August v30 i5 Reproduced in Biography Resource Center*. Farmington Hills, Mich.: Thomson Gale. 2005. http://libproxy.uncg.edu:2088/servlet/BioRC