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3D 가상 이미지의 텍스타일 소재로의 적용을 통한 삼차원 변형가능한 'Living Textile'과 환경변화에 관한 연구(1)

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An Investigation into Three Dimensional Mutable 'Living' Textile Materials and Environments(1)

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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 have researched towards finding the most effective method for 3D imaging techniques for textile applications. 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 word: holography(홀로그래피), lenticular(렌티큘러), 3D imaging(3D 이미징), 3D textile(3D 텍스타일).

Ⅰ. Introduction

Textiles have also gone through many changes and can be expected to continue to evolve. According to Raymond Loewy, it seems that the important improvements and innovations in clothes for the "World of Tomorrow" will be in the fabrics themselves. It is reasonable to assume that new types of fabrics will be developed which will greatly affect the design of clothes. Such fabrics, might, for instance, be constituted of microscopic cellular construction, made of a contracting and expanding fiber. When affected by atmospheric variations, the cells would automatically open or close and regulate air penetration. In other words, fabrics would be air-conditioned. Stitching will probably be replaced by some cementing or moulding process[1].

To identify initial idea, the use of the term 'living' in the research title is not used to describe actual 3

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1) L. Suzanne, D. P. Warren and T. J. Nick, *Fashioning the Future: Tomorrow's Wardrobe*, (Thames & Hudson, 2003). p. 147.

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.

Currently examples of mutable materials exist either as fictional narratives or through three dimensional image techniques such as holography. Traditionally, holographic materials are made as thin films and are generally for graphical applications only. Our research aim is to explore the potential application of the illusions created by various 3D imaging techniques and develop textiles to create new environments where reality and fiction are fused.

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.

Ⅱ. Theoretical Basis & Technical Experiments

1. Holography

The word hologram is derived from the Greek meaning "the whole image.[2]" A hologram creates a real three dimensional image by reconstructing the light waves that were reflected from the original scene or object[3]. Holograms are mostly made using lasers as the light source, and in general the image is recorded on photographic emulsions (Fig. 1).

Holography, which was developed in the 1960s, is very much a 21st Century visual medium[4]. The three dimensional holographic images show the remarkable possibilities that can be achieved through this manipulation of light. Only with holographic techniques can the artist display accurate, projected three-dimensional light imagery floating in space in front of the hologram with the same perspective, parallax, form and content as the original scene.

〈Fig. 1〉 Margaret Benyon, Split Benedict 1989, reduced reflection hologram collage.

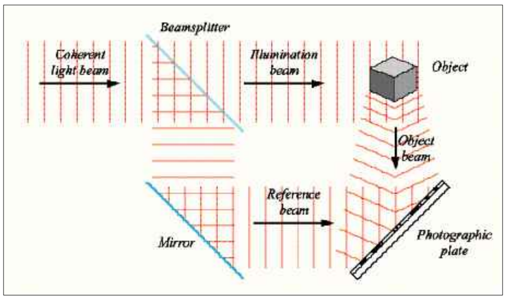
The attraction of holography is that it has many facets, both metaphorically and literally. With a hologram it is possible to turn space inside out, cut it up, record the absence of objects, make the invisible visible, and make the solid transparent in paradoxical ways not possible in other media.

1) Making a Simple Hologram

In normal light, such as that from a light bulb or the sun, the individual ‘particles’ or waves of light (called photons) move randomly through the air. A coherent light is a light in which the photons are moving together in an ordered way.

To make a hologram a source of coherent light is needed, in general. The best source is a laser. Laser is an acronym for Light Amplification by Stimulated

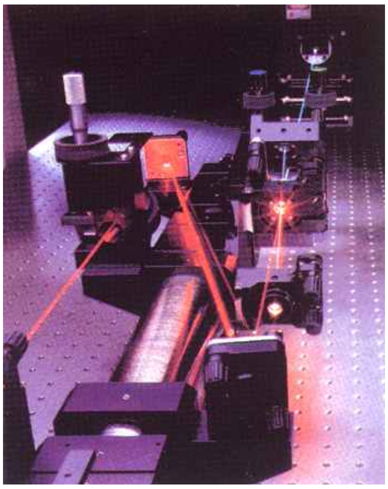
2) Howard M. Smith, *Principles of Holography*, (New York: Wiley, 1975).
3) Winston E. Kock, *Lasers & Holographyan Introduction to Coherent Optics*, (New York: Dover Publications, 1981).
4) J. C. Vienot, P. Smigielske and H. Pref. de D. Gabor Royer. *Holographie Optique: Developments, Applications,* (Paris: Dunod, 1971).



<Fig. 2> Holographic recording process[9]

Emission of Radiation[5]. "A hologram is the recording of two sets of waves[6]." The first wave, called the reference beam, comes directly from the laser. The second wave hits an object, bounces off and interferes with the first wave (Fig. 2)[7,8]. The hologram records this very complicated pattern on a high quality photographic plate.

The first thing to do is split the laser beam into two parts. Both beams must come from the same laser to make sure all the photons are in step with each other. To split the laser beam in two, a device called a beam splitter is used. A beam splitter can be as simple as a piece of ordinary window glass or a precision coated optical device[10]. Like most things in life, the more you pay, the better the result. The purpose of the beam splitter is to allow some light to go straight through and for some light to reflect off its surface. In this way, the single beam becomes two beams (Fig. 3).



<Fig. 3> Laser equipment on special, anti-vibration table.

Now we have a laser, a beam splitter and two beams that are spread out. Using some mirrors, the first beam (reference beam) is shone onto the holographic plate. The second beam is directed at an object. The recording plate is placed where these two beams meet. The whole set-up is called a holographic camera: If the reference beam and the beam bouncing off the object both hit the holographic plate from the same side, a transmission hologram is made. If the reference beam hits the plate from one side, while the beam from the object hits the plate from the other side, the result is a reflection hologram[11].

There are many kinds of holograms, but all holograms fall into two basic categories, Transmission Holograms and Reflection Holograms.

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5) Winston E. Kock, op. cit.
6) Bryngdahl Leseberg, "Methods of Digital Holography," *APPLIED OPTICS* Vol. 23 No. 14, 15 (1984).
7) U. Schnars and W. Juptner, *Digital Holography: Digital Hologram Recording, Numerical Reconstruction, and Related Techniques* (Hardcover), (Springer-Verlag Berlin and Heidelberg: Gmb H & Co. K, 2004).
8) P. Hariharan, *Optical Holographyprinciples, Techniques, and Applications*, (New York: Cambridge University Press, 1984).
9) Frère, Leseberg, Bryngdahl, "Computer-Generated Holograms of Three-Dimensional Objects Composed of Line Segments, Department of Physics," *University of Essen Journal of the Optical Society of America A* Vol. 3 No. 5 (1986).
10) U. Schnars and W. Juptner op. cit.
11) M. Wenyon, *Understanding Holography*, (New York: Arco Publishing Company, Inc. 1978).

2) Different Types of Holograms

(1) Transmission Holograms

Most holograms you will see in everyday life are Transmission Holograms. "The hologram is transparent to allow light to pass through from behind and reconstruct the holographic image[12]. The holograms found on credit and bankcards are of this type.

"Transmission holograms are also known as Rainbow Holograms as the light being used to illuminate them is split into a spectrum, the hologram representing the 'correct' color(s) from one angle, while at other angles seen in different colors of the spectrum (from deep blue to red)"[13]. Transmission holograms can be large or small, be one off's, or mass-reproduced using a technique known as embossing[14].

(2) Reflection Holograms

The other basic type of hologram is the Reflection Hologram. This is usually a single color - often yellow/gold looks the best and brightest - but can be two or even three colors[15].

Black and white holograms, although difficult to make, are possible.

"Using the photographic analogy again, reflection holograms are like photographs in the sense that they are lit from the front and reflect the light back to the viewer"[16]. The Reflection Hologram looks visually different to a Transmission Hologram. Its monochrome nature and high resolving power makes it look more like a three dimensional photograph.

(3) Holographic Stereograms or "Moving Holograms"

A hologram may be produced from a series of two-dimensional pictures. These may come from video, computer graphics, artwork, and photography, or can even be hand drawn animations. The result is a hologram that presents a succession of two dimensional images. If the initial images are made in the correct way, the resulting holographic image can be three-dimensional[17].

A combination of 3D and movement is also possible. This effectively creates a "holographic movie.[18]" "There is a technical limitation to the number of frames from which the hologram is made. The maximum is about 60 frames.[19]" This creates a small piece of animation.

(4) Colour Holography

After 40 years since the appearance of the first laser-recorded monochromatic holograms the possibilities of recording full-colour high-quality holograms have now become a reality. In theory, "the first methods for recording colour holograms were established in the early 1960s. Already in 1964 Leithand Upatnieks proposed multicolour wave front reconstruction in one of their first papers on holography.[20]" The

12) P. Hariharan, op. cit.
13) Bryngdahl Leseberg, op. cit.
14) Y. Roichman, I. Cholis and D. G. Grier, "Volumetric Imaging of Holographic Optical Traps," *Opt. Express* Vol. 14 (2006), pp. 10907-10912.
15) G. C. Righini, "Reflection Holographic Filters for Compacting Optical Processors," *App Optics* Vol. 13 No. May (1974), pp. 1019-1022.
16) D. J. Cooke and A. A. Ward, "Reflection-Hologram Processing for High Efficiency in Silver-Halide Emulsions," *Appl Opt* Vol. 23 (1984), pp. 934-941.
17) Toda, Takahashi, Iwata, 3D video system using Grating Image Tsukuba Research Laboratory, Technical Research Institute Toppan Printing Co., Ltd. SPIE Vol. 2406, Practical Holography IX (1995).
18) Lucente, Hilaire, Benton, Watlington New Approaches to Holographic Video, SPIE Proceding #1732, "Holographics International '92", (July 1992).
19) John David Sutter, Viewer-Plane Experiments with Computed Holography with the MIT Holographic Video system MIT, (September 1994).

early methods concerned mainly transmission holograms recorded with three different wavelengths froma laser or lasers, combined with different reference directions to avoid cross-talk. The colour hologram was then reconstructed by using the original laser wavelengths from the corresponding reference directions. However, the complicated and expensive reconstruction set-up prevented this technique from becoming popular.

Choosing the correct recording and exact laser wavelengths is the key issue where accurate colour reproduction is concerned. Most colour holograms have been recorded using three primary laser wavelengths, resulting in good colour rendition.

3) Holography as Art

Since 1947 many artists have used holography for the imaging of three-dimensional space, and they do so still today[21]. The technical route of three-dimensional imaging systems in the history of art has been comprehensively traced by art historians, from the development of geometrical perspective in painting. Artists who use holography as an artistic tool show a huge difference in their character and expressions, compared with other artists as the development and use of holography is quite new.

Actively working holography artists include Margaret Benyon (U.K.), Dieter Jung (Germany), Paula Dawson (Australia), Douglas Tyler (U.S.), Shunsike Mitamura (Japan) etc. These artists did not use holography from the beginning of their career but started as painters, sculptures, designers or many more diverse backgrounds, but then incorporated holography technique in their work as another transformed tool for expression. This may be a result of holography having such a short history and being relatively new that many artists are naturally becoming attracted to experimenting with a curiosity. Furthermore the increasing use of holography may also be a consequence to the present contemporary art movement which attracts more inventive techniques, original expression and expansion of artistic territory in the field of unlimited imagination shown in reality. Technology has been the source of the greatest cultural thrust in the twentieth century and in the twenty first century artists using technology are continuing to share in its potential as the source of change. By using holography as a medium from the beginning of its development, artists have already influenced the direction of its use.

The uses of holography by artists are varied and individual. Holography artists have come from the diverse backgrounds of the visual and literary arts, communications and, as well as time-based and "live" art. The majority have little or no scientific background, but a strong sense of personal challenge and a willingness to invent, and solve problems. Holography has also made artists out of people without any background in either art or science. The impact of their first experience of holograms is such that they feel driven, compelled, to make them for themselves. From the many choices possible at the different stages of making a hologram it is possible for each holographer's work to be unique to themselves, to their world view and to the medium.

4) Practical Experiments using a Pulsed Laser

Although pulsed lasers capable of freezing live or moving subjects were developed during the early years of holography, they were relatively scarce and expensive; out of reach of most holographers.

In Pulse laser technology it only takes 25～35 nano seconds (10^{-9}sec) of laser triggering time (exposure time) therefore we can have a clear hologram output

20) E. N. Leith and J. Upatnieks, "Wavefront Reconstruction with Diffused Illumination and Three-Dimensional Objects," (1964), pp. 1295-1301.

21) A. Pepper, "Drawing In Space A Holographic System to Simultaneously Display Drawn Images on a Fat Surface and in Three Dimensional Space" (A PhD Thesis, University of Reading, 1988).

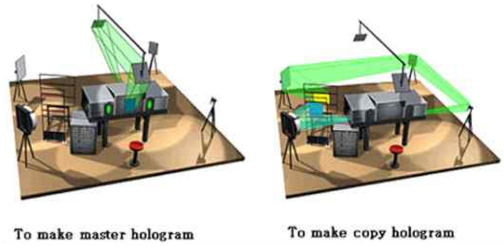
<Fig. 4> Pulsed holography camera GP-2J in pulsed hologram studio in Korea[22].

even under vibrating conditions which is slower than the exposure timescale[23]. Furthermore this is a revolutionary technology which even allows recording an image of flowing water and people in holograms.

One beam (the reference beam) comes directly from the laser, while the other (the object beam) comes from the same laser but impinges on the object, and is distorted by it, before striking the photographic film. What is recorded on the film is the interference pattern produced by the two beams. Likewise hologram uses laser beams on an object to record the image on a photographic film.

The general idea of a hologram is to record an object in its true appearance, size and form existing in three dimensional space into a two dimensional plane like a mirror image. The hologram or the mirror itself is a two dimensional planar object but within the hologram or mirror image a three dimensional space can be perceived. Therefore a hologram is made by a technique which creates a reflection of an object in three dimensional space into a two dimensional plane. In reality the object does not exist even though it may appear very real as a hologram; the image creates a convincing illusion that such objects exist inside the two dimensional plane.

By double exposure in two different angles We have recorded two images of ourselves, one as We



<Fig. 5> Diagram showing holographic portraits production.

normally are and another while wearing a mask. The image changes depending on the angle you view the hologram.

In order to make the master hologram the subject is positioned within the hologram camera and a single flash of laser light illuminates them for fractions of a second. The master hologram can only be distinguished through the laser beam. Therefore, checking whether the master hologram has been exposed correctly with a laser beam needs to be done before initiating the process for the copy of the hologram production.

The picture above is an example of experimental work with Pulse laser. This image produced by double exposure changes depending on the location and the angle of the viewer.

A similar work is shown above by Edwina Orr's Self-Portrait - one of the prime developers of holography in the UK - holding a lens in which her reduced image can be observed. Pulsed lasers, although generally green in colour, have great clarity and detail.

<Fig. 6> Experimental hologram work by Pulsed laser.

22) HOLO SPIRIT Co. Ltd - pulsed hologram studio in Korea, http://www.holospirit.com/
23) Srinivasan V. "Pulse Width Modulated Computer Generated Holograms," *V Sci Instr* Vol. 14 (1981), pp. 1141-1142.

〈Fig. 7〉 Edwina Orr's Self-Portrait, 1980[24).

〈Fig. 8〉 The hologram portrait of the Queen.

5) Holography: Analysis & Summary of Experiments

Holography has a number of properties in common with other media. In traditional terms it can be seen as an expanded form of both painting and sculpture, since it records three dimensions on a two dimensional surface. Almost fifty years on, holograms have indeed become part of everyday. As anti-forgery devices, they appear on credit cards, bank notes, concert tickets and bottles of wine.

There are many visual potentialities that can be realised with the hologram that are not available through any other media. Therefore it is not surprising that before the application of holography became ubiquitous visa credit cards and packaging, holograms were seen as technologically advanced. However, despite having many sophisticated advantages, holography has tended to remain within the sphere of novelty products (such as the portrait of the Queen) and anti-forgery products, rather than exploited as an alternative communication or decorative media in its own right.

Today, Benyon, "the mother of British holography", has all but given up on the medium to which she devoted her entire career. Tired of being ignored by the artistic establishment she also lacks the cash to finance what is a costly, and highly volatile, pursuit. Even Britain's leading collector of holographic art, Jonathan Ross has said "In the public mind, holograms have become kitsch and naff.[25)]"

Currently the biggest problem facing holography is the difficulty in recording natural colour of an object and also recording background images. For example, recording a landscape in the distance is almost impossible because the recording studio would have to be big enough to contain the real size of the whole landscape and the film would have to be the same size as the landscape in order to record all the reflected laser beams. In the case of recording a natural environment an extensively huge Pulse laser with a strong output is required to act on a highly sensitive holographic recording material. Also in order to overcome the limitation of viewing angles, increasing the size of holographic recording material might be another difficulty. Other limitations include difficulty in recording objects in their true colour.

Other limitations include the necessity for having extensive knowledge in technology and materials in

24) Bjelkhagen Hans I. Holographic Portraits Made by Pulse Lasers Leonardo, Vol. 25, No. 5, Archives of Holography: A Partial View of a Three-Dimensional World: Special Issue. (1992), pp. 443-448.

25) D. Jonathan, *Holograms: High Art or Just a Gimmick?*, (BBC News, 23 Jun. 2004).

holography (such as holographic film, facility, emulsion, etc) to properly create images. Although holography in art is still in its early developmental stage, we need to start to recognise its potential with technological advancements bridging the gaps between imagination and reality. Holography was first introduced as a new form of visual art among artists and has given us new experiences in three dimensional images.

Furthermore, holography has given us a new method and a fresh direction in expressing and experiencing visual images. The biggest challenge facing artists in this field is not only dependent on further development in laser technology and holographic emulsion but also depends on how artists themselves can express their ideas through holographic art world. At present, as contemporary art attracts more inventive techniques and as artistic practice expands into unlimited imaginative areas, holography has become an important tool for artistic expression.

6) Critical Analysis of the Result in Holography Experiment & Summary with Particular Reference to Textile Applications

As previously mentioned, our main objective of the practical experiment was to gain experience and understanding of 3D imaging technologies and to investigate potential applications for expressing three dimensional moving images in textiles.

Holograms created by initial continuous wave (CW) laser are advantageous over pulsed laser hologram because they have a better resolution. However the use of CW lasers for holography are very sensitive to vibration during recording and its use is limited in a sense that this method can only be used to record solid objects. Therefore people, animals, plants etc are impossible to record by this method.

In contrast, the pulse laser technology only takes 25～35 nano seconds (10^{-9}sec) of laser triggering time (exposure time) to record, resulting in a clear hologram output even under vibrating conditions which is slower than the exposure timescale. Therefore under this particular method people, animals, plants and even smoke or movement of water can be recorded for hologram. However enlargement or reduction of the image is very difficult and there is also a disadvantage of inability to express natural colour.

As you might already expect holography can only take place in a complete dark room where only the laser beam can be exposed to the holographic film. Also the holographic film needs to be developed to produce a hologram. Although the methods for developing holographic film depends on the holographic emulsion, in this particular pulsed laser hologram experiment there were four stages; developing, fixing, bleaching and drying. After developing the film, brightness, 3D depths and contrast of the hologram depend on the chemical being used, the reaction time of the chemical and the temperature of water.

Therefore depending on the holography artists there are several techniques for developing different types of films. Thus, there are many factors involved during recording and developing holographic images in the darkroom that we may need to take into consideration which influences the final piece.

The main disadvantage may be when the final piece does not reach our expectations in terms of its brightness, depth or contrast it is very difficult to find the cause. Anything could have gone wrong during and between recording and/or developing stages and because so many factors are involved in the final piece we cannot even predict the outcome during any mid stages of holography production.

The advantage of the hologram is the ability to observe 3D images in a wide range of angles. However, due to many limiting factors it is expected to be difficult to apply this technique in textiles as there would be many problems to be solved.

To summarize the difficulty in applying hologram to textile is that the image's brightness and contrast or clarity are poor under day light, the difficulty in expression of natural colour, landscape recording is impossible, lack of labs to experiment and the use of facility are very expensive, also in order to overcome the limitation of viewing angles, increasing the size of holographic recording material might be another difficulty.

In conclusion through the experiments, theoretical understanding and analysis, We think holography has great potential but it is not suitable to achieve the aim of our research without making any further development in technology and chemicals to make the production process more simple and secondly the holographic image needs to be easy to view under day light while expressing natural colour.

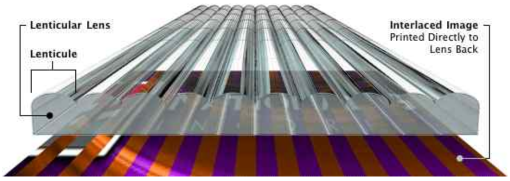
2. Lenticular Technique

Lenticular printing is one of the most exciting print technologies to emerge in recent years. The technology converts static, two-dimensional images into dynamic educational and promotional products that leave eye catching lasting impressions. Adding the perception of motion and depth, Lenticular printing creates excitement by stimulating the mind beyond the eye.

The basic process used to produce these lenticular images was quite simple: the printer first printed the image on paper, and then laminated that paper to thick vinyl lens material.

1) Understanding of the Technique

Lenticular print can easily be described as specially prepared graphics that are designed to work together with a lenticular lens to allow the viewer to see different images depending on the angle at which they view it. The use of both imagery and lens material are inseparable when it comes to making the desired effect come to life in a lenticular print. The image itself is a composite of two or more graphics that are interlaced together. The lens is a unique plastic that is made up of individual lenticules that must be perfectly aligned with the interlaced image underneath

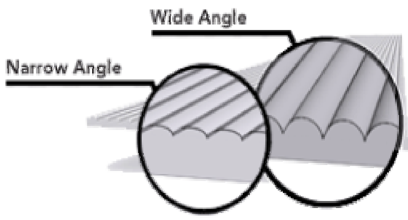


<Fig. 9> A schematic representation of Interlaced Image.

it in order for the effect to work. Based on the angle of the viewer, each lenticule acts as a magnifying glass to enlarge and display the portion of the image below. Many lenticules working in harmony form the entire lenticular image. In this way, lenticular print can appear to show motion or even three-dimensions because each eye is viewing the lenticular print from its own angle.

One side of an extruded plastic sheet is embossed with columns of tiny corrugations called lenticules[26], hence the name "lenticular" in lenticular extruded lens. The lenticules are all the same size and are spaced equally across the sheet. The other side of the sheet remains smooth in order to be printed upon. The frequency of lenticules is called lines-per-inch or LPI[27], and can vary from 10 to 200. Just as no one eyeglass prescription works for everyone, no single LPI works best for all project effects.

The curvature or angle of the lenticule is important to keep in mind when selecting the proper lens. For an optimal 3D effect, a narrow-angle lenticular lens[28] with a viewing angle between 15 to 44 degrees



<Fig. 10> Angle of Lenticules.

26) A single (or multiple) lens in a lenticular sheet
27) Lines-per-Inch. In the lenticular process, this would also mean "Lenticules-per-Inch."
28) A lenticular lens sheet with a viewing angle between 15-35 degrees. Narrow-angle lenses work best for 3D effects.

works best. When working to achieve a good animation effect, a wide-angle lenticular lens[29] with a viewing angle between 44 to 65 degrees works best.

2) Lenticular Lens Options

There are so many variables involved in putting together a great lenticular piece. Selecting the correct lens is ultimately one of the most important decisions to make. A simplified chart system to aid in finding the best lens options for your planned effect is summarised.

A chart system to aide in finding the best lens options for your planned effect. The first step in lenticular design is to choose the effect that best suits your graphic or the message you are trying to communicate. There are five different forms of lenticular effects to select from, 3D, flip, animation, morph, and zoom. Each focusing on a slightly different way to create a bold and captivating image that is sure to demand attention.

3) Lenticular Effects

(1) 3D Effect

Objects within an image are layered to give the illusion of depth and perspective. Unlike 2-dimensional design, using this lenticular effect allows graphics to appear more realistic. Lenticular 3D can be incorporated into most images or design styles.

(2) Flip Effect

A dramatic swapping of two images-each vanishing and then reappearing from one to another. Utilizing this lenticular flip effect is most beneficial for demonstrating "cause-and-effect" or even "before-and-after" comparisons.

(3) Animation Effect

With a series of images coming together to create an animation much like a short movie clip, this is the most complex lenticular effect. The illusion of motion

〈Table 1〉 Lenticular materials[30]

Planned effect					
Print process	3D	Flip	Morph	Animation	Zoom
Large format inkjet	A, B, C, E, F	A, B, C, E, F	A, B, C, E, F	A, B, C, E, F	A, B, C, E, F
Offset	I, L	H, I, J, K	H, I, J, K	H, I, J, K	H, I, J, K
Flexography	K	K	K	K	K
Traditional photographic	ALL	ALL	ALL	ALL	ALL
Screen	A, B, C, E, F	A, B, C, E, F	A, B, C, E, F	A, B, C, E, F	A, B, C, E, F
Digital photographic	ALL	ALL	ALL	ALL	ALL

Lens types												
	A	B	C	D	E	F	G	H	I	J	K	L
LPI	10	15	20	20	30	40	60	60	62	75	100	100
Viewing angle	48°	47°	47°	29°	49°	49°	26°	54°	44°	49°	42°	30°
Gauge (mil)	150	98	85	150	52	33	48	20	27	18	14	23

29) A lenticular lens sheet with a viewing angle between 40-65 degrees. Wide-angle lenses work best for "flip" and "animated" effects.

30) http://www.lenstar.org/how/plastic.htm

actually comes from either a selection of video frames or sequential still images. This lenticular animation effect is great for emphasizing body movement or mechanical action.

(4) Morph Effect

The conversion of one image into another is used to create the illusion of transformation. This lenticular morph effect can be used for showcasing a product or feature that may change or create change.

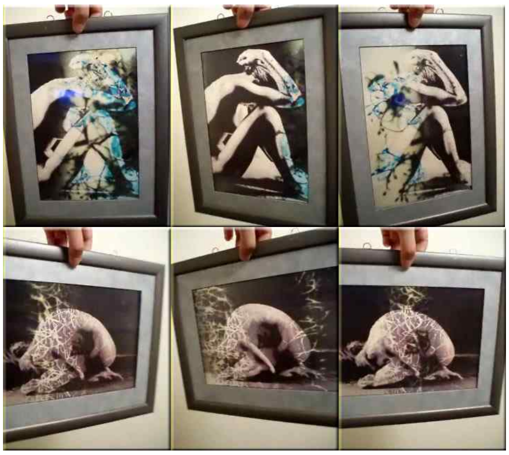
(5) Zoom Effect

The illusion of movement from background to foreground to create the effect of "leaping out" or "jumping back." A lenticular zoom animation can consist of one or more objects, or even a full image. This effect works best for highlighting elements such as products, logos, or important messages.

4) Practical Experiments with Specific Lens using Magic Interlacer Pro

Firstly computer software that We are using for the

〈Fig. 11〉 Images from Experimental Lenticular work *Software : Magic.Interlacer.Pro.100.with.FlashBand. Generator.v2.3.0.Lens : 30 LPI lens.*



〈Fig. 12〉 Images from Experimental Lenticular work *Software : Magic.Interlacer.Pro.100.with.FlashBand. Generator.v2.3.0.Lens : 30 LPI lens*

experiment is described briefly as the following. Magic Interlacer Pro is a user friendly graphical intererlacing program designed and developed by two of the world's leading lenticular artists[31]. Interlace up to 100 images for 3D, Animation, Motion, Morphs, Flips and more. A Flash Band is basically a small black and white interlaced flip image. One image is white, and the other image is black. FlashBand assists in determining the exact pitch of lenticular lens material to match printer calibration[32].

5) Lenticular Experimental Analysis & Summary

After working with 30LPI Lenticular lens film, We have realised there are a few problems in lenticular techniques. One of the biggest problems is the time consuming process of calibrating the output device. A black and white interlaced image is used to help to determine the exact pitch for the lens. Unfortunately, running the same file on various devices will often give different results. Therefore calibrating the output device is an essential procedure for lenticular technique. Another problem of lenticular technique is the

31) http://www.promagic.net/pro100.html
32) http://www.shortcourses.com/how/lenticular/lenticular.htm

difficulty of correct alignment of final interlaced image with a lenticular sheet. The more LPI (Lines-per-inch) in a lenticular film the more detailed animation there can be as the image flips. Therefore with an increasing LPI lenticular film the alignment requires a much more accurate approach. You may require another device to assist in accurate alignment.

Ⅲ. Conclusion

Human lives today are controlled by electronic communications as there is an overemphasis on seeing and hearing, numbing the other senses by light and sound from cinemas, videos and computer screens. The future in textile will lie on developing sensory faculties for touch, taste and smell, experience new emotions and experiment with new forms of expression[33].

Innovative developments and highly advanced technology are now being combined in the laboratory to create such exciting new textiles whose aesthetic quality is as important as their performance. Advanced technology will be the basis for the future of materials, and in years to come we may be able to work with mutable, flexible, almost 'living' materials. Technology will take us from our old familiar world to a future which offers a very different environment.

The rapid development extending from the period since digital technologies became more accessible allows designers to transform traditional textile materials into fluid forms that merge with media normally associated with film and animation.

In order to look into the future of textiles in the context of the research, it has been important to consider how technologies might continue to evolve.

The development of technical textiles is already bringing greater sophistication to this field and this is likely to result in future textiles being more suited to resolving some of the technical issues.

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.

Therefore current techniques in Holography and Lenticular have been thoroughly investigated through literature searches and practical experiments as these techniques have an advantage of displaying 3D images with naked eyes.

Out of techniques, Lenticular technique can produce illusionary effects while expressing both the image and the colour at the same time. In contrast, Holography technology has many aspects that still need to be developed further. Currently the biggest problem facing holography is the difficulty in recording natural colour of an object and also recording landscape images.

Lenticular technique is already widely being used in a range of products and advertisements and many people would have come across its effects. Experimental analysis has revealed that the most important part in this technique to experience the 3D effect and changing images depending on the viewing angles is the lenticular lens and the accurate alignment of the sliced background image.

In lenticular, there are no real limitations to the range of possible colours, and they do not require any special lighting. Images are cleaner and brighter than holograms.

As technology develops, thinner and more flexible and transparent materials will be available and they can be combined with textile application. Such combination can open lenticular technology for a wider use in the future.

Through the investigation and experiments concerned with 3D expression and technologies, Lenticular Technology holds a potential to direct a new textile development to have an impact on how we view the environment.

33) R. Pompas, Textile Design Training at the Nouva Accadmia Di Belle Arti in Milan. *Textile Forum* 1/2000.

국문초록

본 연구는 다양한 3D imaging 기술이 생산해낼 수 있는 환영효과를 직물에 적용할 수 있는지에 대한 가능성을 통해서, 현실과 허구의 경계가 없어지는 새로운 환경을 조성하기 위한 직물을 개발하여 변형 가능한 삼차원의 살아있는 직물 같은, 관점에 따라 패턴과 색깔의 이미지가 바뀌는 흥미로운 직물패턴의 실현 가능성을 알아본다.

본 논문은 Ⅰ, Ⅱ로 나뉘어 있으며, 각 논문에서 각기 다른 실험을 실시하여 결과로의 적용가능성과 제한점을 살펴봄으로써 Holography, Lenticular, 등 가상의 3D 테크놀로지를 통해 2D 평면의 구조에 3D 가상 이미지의 텍스타일 적용 가능성을 기계적 실험을 통해 확인하며, 3D imaging 기술에 대한 경험과 이해를 얻고, 3D imaging 기술을 적용할 수 있는 잠재력을 연구하기 위한 것으로, 실험은 현장에 있는 전문 텍스타일연구가, 과학자, 예술가 그리고 디자이너들의 협업으로 이루어졌다.

References

Cooke, D. J. and A. A. Ward (1984). "Reflection-Hologram Processing for High Efficiency in Silver-Halide Emulsions." *Appl Opt* Vol. 23.

Frère, Leseberg, Bryngdahl (1986). "Computer-Generated Holograms of Three-Dimensional Objects Composed of Line Segments, Department of Physics." *University of Essen Journal of the Optical Society of America A* Vol. 3, No. 5.

Hariharan, P. (1984). *Optical Holographyprinciples, Techniques, and Applications*. Cambridge. New York: Cambridge University Press.

Kock, Winston E. (1981). *Lasers & Holographyan Introduction to Coherent Optics*. New York: Dover Publications.

Leith, E. N. and J. Upatnieks (1964). "Wavefront Reconstruction with Diffused Illumination and Three-Dimensional Objects"

Leseberg, Bryngdahl (1984). "Methods of Digital Holography." *APPLIED OPTICS*/ Vol. 23, No. 14, 15.

Lucente, Hilaire, Benton (1992). Watlington New Approaches to Holographic Video, SPIE Proceding #1732, "Holographics International '92"

Pepper, A. (1998). "Drawing In Space A Holographic System to Simultaneously Display Drawn Images on a Fat Surface and in Three Dimensional Space." A PhD Thesis, University of Reading.

Pompas, R. (2000). Textile Design Training at the Nouva Accadmia Di Belle Arti in Milan. *Textile Forum*.

Righini, G. C. (1974). "Reflection Holographic Filters for Compacting Optical Processors." *App Optics* Vol. 13.

Roichman, Y., I. Cholis and D. G. Grier (2006). "Volumetric Imaging of Holographic Optical Traps." *Opt. Express* Vol. 14.

Schnars, U. and W. Juptner (2004). *Digital Holography: Digital Hologram Recording, Numerical Reconstruction, and Related Techniques*. (Hardcover). Springer-Verlag Berlin and Heidelberg Gmb H & Co.

Smith, Howard Michael (1975). *Principles of Holography*. New York: Wiley

Sutter, John David (1994). Viewer-Plane Experiments with Computed Holography with the MIT Holographic Video system MIT, September

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

Toda, Takahashi, Iwata (1995). 3D Video System Using Grating Image Tsukuba Research Laboratory, Technical Research Institute Toppan Printing Co., Ltd. SPIE Vol. 2406, Practical Holography IX.

Vienot, J. C., P. Smigielske and Royer, H. Pref. de D. Gabor (1971). *Holographie Optique: Developments, Applications*. Paris: Dunod.

http://www.lenstar.org/how/plastic.htm

http://www.promagic.net/pro100.html

http://www.shortcourses.com/how/lenticular/lenticular.htm