3-D EVOLUTION IN WIRELESS COMMUNICATION

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ABSTRACT

The wireless market is always in demand for more services to the customer. Under this scenarios imagine the next generation wireless device (mobile, laptop etc.) in which you can view 3D images on the screen, as well as send and receive 3D images. The difference between 2D and 3D image is that in 2D you will find only amplitude variation recorded. But in a 3D image both amplitude and phase are available. It is easy to send 2D information, by reading information in each pixel, but in order to send, receive and view 3D information the phase information is to be send along with amplitude information. This paper creates a model by integrating the well-known technology of Computer Generated Holography to convert 3D information to 2D for sending it using the existing communication framework and a lightweight wireless device made using micro holographic optical element for recreating the image. The paper also shows how these implementations can be made without a major change in existing wireless communication technology. This new technology is made possible because the data volume of digital holograms is much less than the information obtained when it is re-created, which makes it possible to be sent on wireless networks. Getting the complete effect of 3D on the next generation wireless device screen as well as sending/receiving of 3D frames is definitely going to be a major selling factor for any company in the wireless device manufacturing and communication industry.

1. Introduction

This paper is a discussion on how holography can be used for 3D communication and how the received information can be displayed on a handset. Progress towards real-time holography is handicapped by the limited information bandwidth available in present-day electronic, computing, and communication systems. The information content of a typical hologram is several orders of magnitude larger than that of a conventional two-dimensional image, such as the image on a CRT display. For example, a hologram of dimensions 100mm by 100mm and a viewing angle of 30 degrees contains approximately 25 Gigabytes of information, or the equivalent of 25 billion samples of information - all for a single frame. In order to update such an image with 8-bit resolution at a rate of 60 frames/second, a data-rate of 12 Terabits/sec would be required for transmission of the hologram. This enormous bandwidth is well beyond the range of current technology.

Though extensive research is going on about the applications of computer generated holography, no insight is yet made on how this technology can be used in wireless communication.

2. Current Status of 3D in the field of mobile communication

The existing developments in the field of 3D for mobile communication include

(a) Handsets that can show 3D games
(b)Displays that can show 3D image on the mobile screen.

The 3D gaming service is now available in almost all 3G handsets. The 3D

display handsets, developed by South Korea's Samsung are expected to come to market only in the first half of 2005[1]. Both these developments are a result of increase in the resolution of LCD display and the viewer is actually seeing a 2D image that gives the illusion of 3D due to increased information represented on the display. Actual 3D comes only when we are able to represent depth information along with amplitude information. The actual 3D representation is realized in optics using optical filters as in 3D movies or using the concept of holography. This paper describes the details about holography for realization of actual 3D communication using computer generated holography to send/receive information and micro holographic optical elements to make a light weight handset.

3. 3D Wireless Communication

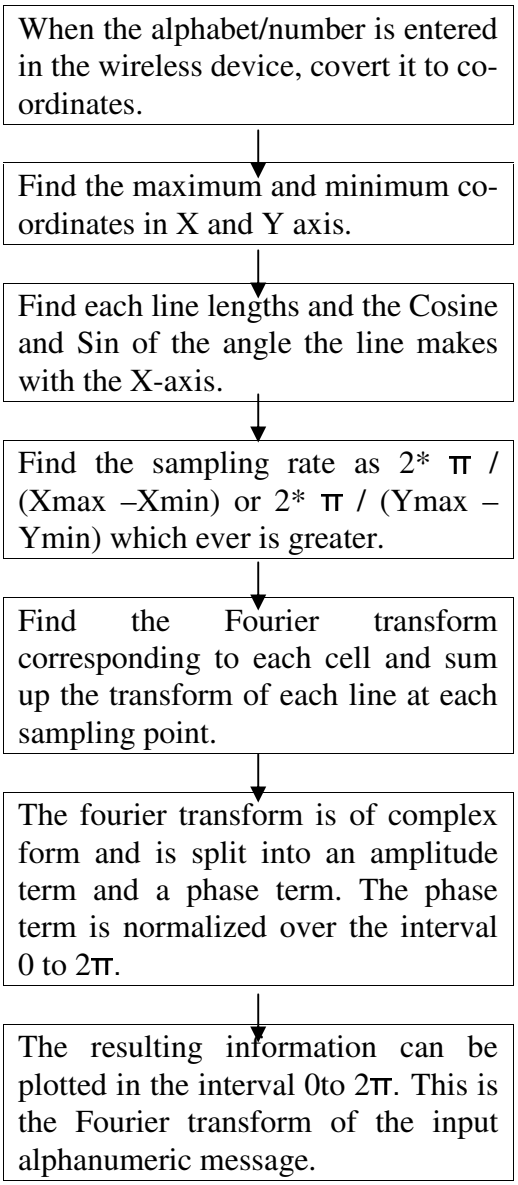
3.1 Overview

We first start with an algorithm to send 3D information between handsets. This is followed by explanation on how the technology can be utilized for sending images. Then the paper discusses about the transfer of animation and real time information. The paper also includes information on why it does not obsolete existing technology and what are the current limitations of this approach.

3.2 Compression of 3D information for Sending messages

In order to send 3D message the handset should have the software that convert alphabets to fringe patterns. So that whatever message it creates and whatever messages it receives are converted to fringe patterns. Reconstructing the 3D from the fringe is handled later in this paper.

It is possible to convert alphabets and numbers to fringe patterns using computer generated holography. The basic algorithm to generate computer generated hologram is given below:



The implementation [3] of this algorithm is based on the theory that any letter or

object constructed from N straight lines has a Fourier transform:
$F(x,y) = (i = 1 \text{ to } N) \sum F_i (x,y)$

In computer generated hologram the function F(x,y) is calculated at a number of points depending on the image clarity required and the availability and capability of the system computing the transform.

Though the straight line objects are only 2D objects still when we look at the reconstruction we will see the depth effect because the background is projected behind the surface of the image giving parallax between foreground and background.

Thus 3D messages can be created in a handset using the above algorithm. When a message is sent to this handset from a handset which does not support 3D, still the above algorithm is enough to compute the transform of the message and present it in a 3D format to the user of the next generation handset.

3.3 Compression of information of 3D objects for sending to wireless device

A 3D object shot using a digital camera can be converted to a complex Fourier transform. All that is required in the wireless device is a digital camera with high shutter speed to take the picture in slightly different angles of a 3D object. Next the system computes 2D transforms of each of the images. These 2D transforms are super imposed to get a complex 3D transform or fringe pattern. The complex fringe pattern on illumination will recreate the 3D object. The number of images shot directly corresponds to the depth and clarity of the 3D reconstruction as a more approximate Fourier transform is obtained. Calculation of Fourier transform of a 3D object (3D hologram) will require systems with good computing capabilities. This system can produce more image clarity and better suited for wireless communication compared to the 3D display developed by Seoul National University (ref : [1] Technologyreview.com on November 10, 2004) which involves generating six 2D holograms to represent the 3D image and producing a different image for the left and right eye using 3 holograms for each eye, because the resultant 3D Fourier transform suggested in this paper is the product of a set of 2D transforms computed from the images shot. Hence with a good digital camera more images can be shot to get the final 3D transform, which can be send to other handsets.

3.4 Transfer of animation and real time information

In order to transfer and display simple animations in wireless device, the Fourier transform information corresponding to each frame needs to be send. This information can be easily displayed on a spatial light modulator [2] with good frame rate. Since most of the spatial light modulators available nowadays have frame rate more than 50 hz, the persistence of vision cause the feeling of motion in the 3D images.

This is in a recent development in mobiles to be able to capture real time events (2D form) and send it. There is a long way to go to integrate a system with computing capability to convert Fourier transforms of real time events on a small handset. The system should be able to create computer generated holograms for

real time by computing the transforms of each frame corresponding to the real time event.

3.5 Does not obsolete existing technology

The next generation handset is expected to have computer generated hologram generation software, so that when a message arrives in non 3D format, then a Fourier conversion is expected to be done and then presented to a spatial light modulator to show 2D image with normal depth effect. As far as sms is concerned, messages can easily be received and transform computed. When pictures/messages are received in the next generation handset from a handset which does not support 3D, the Fourier transform computed will not be good enough to produce full 3D effect, but depth effect will be experienced because the background is projected behind the surface of the image giving parallax between foreground and background.

Thus this new technology does not expect a sudden shift for all users to use 3D compactable handset. The existing technology remains fully supported with additional functionalities being added.

3.6 Limitations of this technology

After discussing the features and how it is can take effect without making existing technology obsolete it is also necessary to discuss the threats existing currently for this technology.

Facilities such as the internet and media which are inherently 2D cannot be represented in this 3D handset. A better alternative would be a handset which provides for both kinds of displays. If there are 2 display panels one in front and one at the back of the mobile then even these issues can be handled. Technology will rise to a level where all media will change to 3D, Philips has started production of holographic TV. The sampling factor needs to be carefully selected and enough provision given to avoid loss in order to recreate a hologram with minimum noise.

3.7 Proposed 3D pattern re-creation on wireless device

The display of holograms requires a coherent laser source; moreover the setup should be rigid. The most important factor was that the lens setup used to consume a lot of space. All these were factors which marred the development of a compact system to reconstruct hologram from interference pattern. Even fiber optic communication relied on micro lens to do functions like coupling and filtering. Even a slight change in the alignment of these lenses produced major changes in the output; hence the packaging took a lot of space. With the development of micro holographic optical elements (MHOE) almost all optical elements as well as setups can be integrated to a thin film. Hence our 3D display handset uses lens made of MHOE to make the handset compact and light in weight. The components inside the suggested handset (shown in figure 1) and the purpose of each component are stated below (Only a rough sketch is prepared. Proper packaging is required. The overall set can be made rigid and stress resistant quite easily because all lens used are MHOE, hence issues of critical alignment are avoided to a large extend):

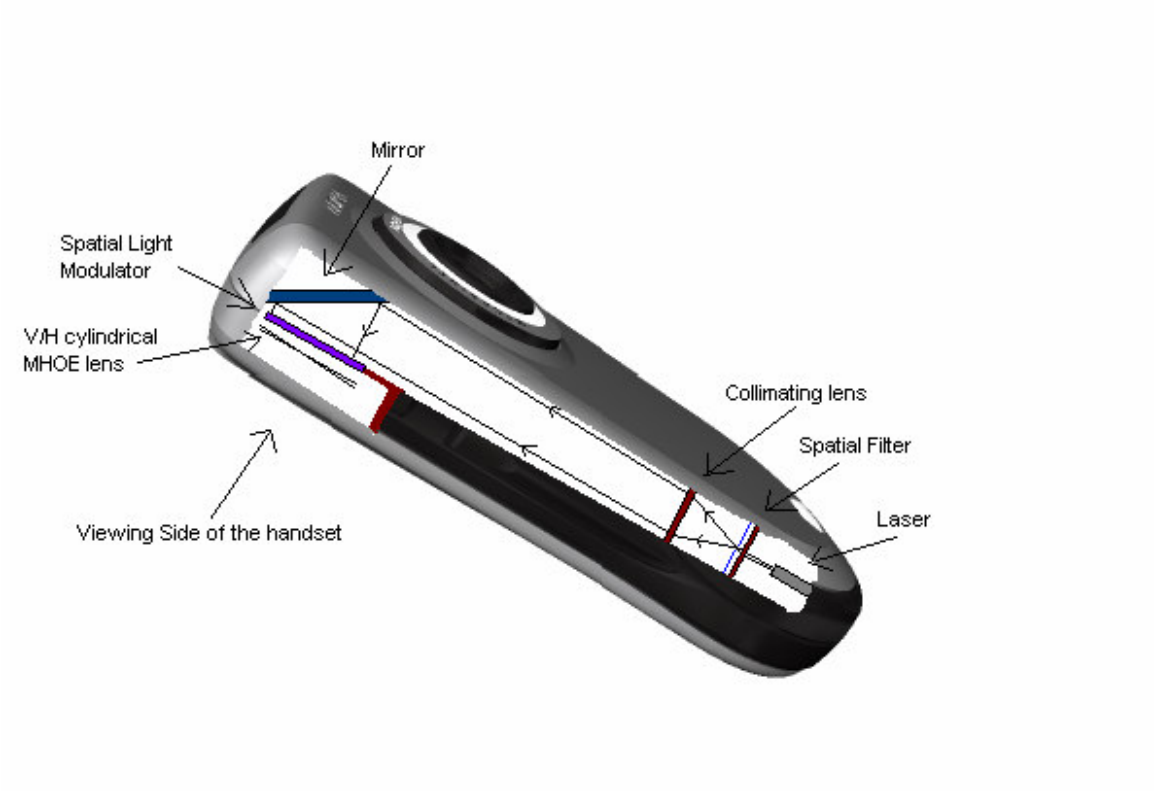


Figure 1: Model of 3D display handset.

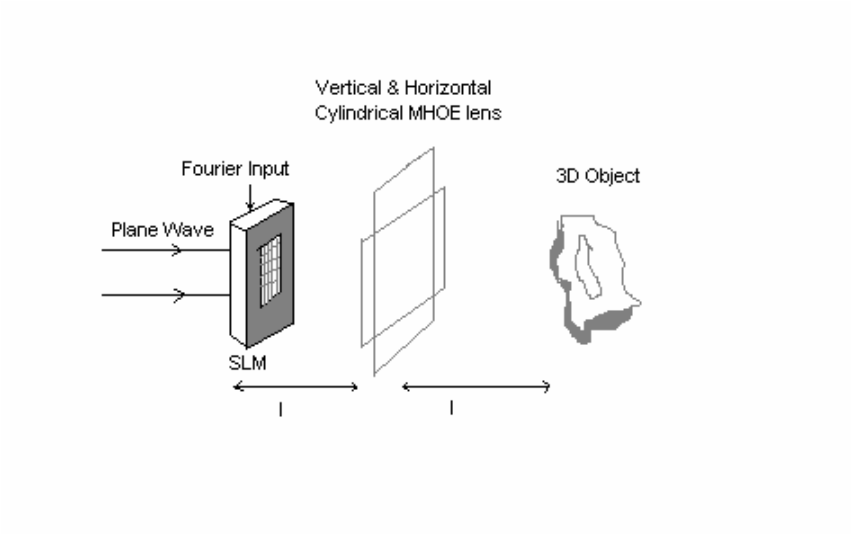


Figure 2: SLM (Spatial Light Modulator)-lens arrangement for reconstruction of 3D image.

Laser: A lot of micro lasers are available in the market, which can produce a nearly gaussian response. For this purpose even a laser diode is enough, because after spatial filtering and collimating we will get a beam to provide proper illumination.

Spatial Filter: The output from the laser will contain noise components that should be filtered. Moreover the beam needs to be expanded for full illumination of spatial light modulator (SLM). The MHOE lens causes expansion and pin hole arrangement produces filtering. The total arrangement is usually packaged.

Collimating lens: The expanding beam coming out from the spatial filter is collimated using this MHOE lens.

Mirror: The mirror placed at 45 degree, turns the beam by 90 degree illuminating the SLM.

SLM: The Fourier transform information received by the handset or created by the handset for some input; is given to the SLM. The SLM thus produces the transform which is illuminated by the beam reflected by the mirror. The result is a 3D image. More insights on use of SLM for holographic reconstruction can be found in ref [2].

Vertical/Horizontal cylindrical MHOE lens: The 3D image created is given good clarity by the two cylindrical lens arrangement.

We could have replaced all the lenses with Computer Generated Optical Elements (CGOE) that get formed on the SLM. But an SLM is heavier and space ying compared to MHOE. Moreover the underlying computational system needs to be highly capable to produce CGOE corresponding to each lens thus making MHOE a better choice.

4. Conclusion

A proper implementation of this paper will be a giant leap into 3D communication technology, taking communication from multimedia in 3G to a more attractive 3D technology. Moreover the proposed new technology does not obsolete existing technology and will help in a slow transformation to this high end technology. Getting the complete effect of 3D on the next generation wireless device screen as well as sending/receiving of 3D frames is definitely going to be a major selling factor for any company in the wireless device manufacturing and communication industry.

5. References:

1. Sites: www.technologyreview.com, www.Samsung.com, and www.3G.co.uk

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4. Joseph W. Goodman, “Introduction to Fourier Optics”, McGraw-Hill book company.