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Implementation of Holographic View in Mobile Video Calls

Vignesh.M*,
Computer science and engineering,
Anna University, Chennai.

SaravanaJothi.M,
Computer science and engineering,
Anna University, Chennai.

Abstract--- Implementation of holographic video calls in mobile devices using of hologram projectors additional to TFT displays. Here we use hologram projectors for video calls by storing video as holographic images through the method of Computer Generated Holography. Problem statement: Hologram video calls are not in usage, they are simply under research condition. Hologram makes video calls in 3D virtual display. In order to bring hologram usage in mobile phones by means of hologram projectors in the way of computer generated holography. Approach: Computer Generated Holography (CGH) is the method of digitally generating holographic interference patterns. A holographic image can be generated e.g. by digitally computing a holographic interference pattern and printing it onto a mask or film for subsequent illumination by suitable coherent light source. Alternatively, the holographic image can be brought to life by a holographic 3D display (a display which operates on the basis of interference of coherent light), bypassing the need of having to fabricate a "hardcopy" of the holographic interference pattern each time. Consequently, in recent times the term "computer generated holography" is increasingly being used to denote the whole process chain of synthetically preparing holographic light wave fronts suitable for observation. Holographic computer displays for a wide range of applications from CAD to gaming, holographic video and TV programs, automotive and communication applications (cell phone displays) and many more. Results: 3D hologram images are set in the video frames by hologram projectors while we make a video calls. Conclusion: By using the hologram projectors in the mobile phones. Holographic images are stored in the frames in video. While making the video call 3D hologram video will be displayed through hologram micro projector. Voices are transmitted through microphones and speakers.

Keywords -- Hologram, Holography, Computer generated holography (CGH), LBO projector, Fourier transform method, 3 Dimension, video frames, point source algorithms.

I. INTRODUCTION

3D video technology is used to create a hologram on a speakerphone. "We see 3D [video] technology moving into the cell phone, which will have the ability to transmit information off the cell phone to create a 3D hologram, projecting the hologram on any surface in life size," With a cell phone hologram, a user would be able to walk next to a hologram of a friend, or a worker could project an enlarged 3D image of a product needing repair to walk inside it and detect problems, Bloom said. "The repair person could go inside the device instead of looking it up in a manual, it has lots of implications." The cameras that are being used to create early versions of holograms still need to be miniaturized, and software needs to be written to for receiving input from those cameras, many of the innovations on cell phones and other mobile devices. For example, IBM predicts that commuters will get personalized commuting information, possibly on a cell phone or desktop computer that combines a person's calendar for a given day with recent traffic reports from multiple sources. The information could come from tracking the speed of cars on a freeway, based on the time it takes for a cell phone to move from one cell tower to the next one.

II. MATERIALS AND METHODS

Computer Generated Holography (CGH) is the method of digitally generating holographic interference patterns. A holographic image can be generated e.g. by digitally computing a holographic interference pattern and printing it onto a mask or film for subsequent illumination by suitable coherent light source. Alternatively, the holographic image can be brought to life by a holographic 3D display (a display which operates on the basis of interference of coherent light), bypassing the need of having to fabricate a "hardcopy" of the holographic interference pattern each time. Consequently, in recent times the term "computer generated holography" is increasingly being used to denote the whole process chain of synthetically preparing holographic light wave fronts suitable for observation. Computer generated holograms have the advantage that the objects which one wants to show do not have to possess any physical reality at all (completely synthetic hologram generation). On the other hand, if holographic data of existing objects is generated optically, but digitally recorded and processed, and brought to display subsequently, this is termed CGH as well. Ultimately, computer generated holography might serve all the roles of current computer generated imagery: holographic computer displays for a wide range of applications from CAD to gaming, holographic video and TV programs, automotive and communication applications (cell phone displays) and many more. Which will be like fig 2.1.

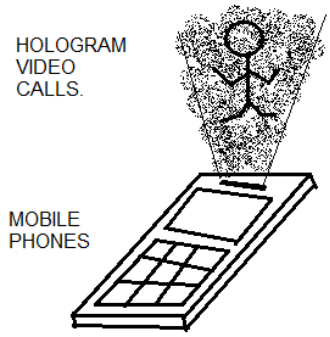

Fig 2.1

Holography is a technique originally invented by Hungarian physicist Dennis Gabor (1900-1979) to improve the resolving power on electron microscopes. An object is illuminated with a coherent (usually monochromatic) light beam; the scattered light is brought to interference with a reference beam of the same source, recording the interference pattern. CGH as defined in the introduction has broadly three tasks:

1. **Computation** of the virtual scattered wave front
2. **Encoding** the wave front data, preparing it for display
3. **Reconstruction**: **Modulating** the interference pattern onto a coherent light beam by technological means, to transport it to the user observing the hologram.

Note that it is not always justified to make a strict distinction between these steps; however it helps the discussion to structure it in this way.

Wave front computation

Computer generated holograms offer important advantages over the optical holograms since there is no need for a real object. Because of this a breakthrough in three-dimensional display was expected when the first algorithms were reported at 1966. Unfortunately, the researchers soon realized that there are noticeable lower and upper bounds in terms of computational speed and image quality and fidelity respectively. Wave front calculations are computationally very intensive; even with modern mathematical techniques and high-end computing equipment, real-time computation is tricky. There are many different methods for calculating the interference pattern for a CGH. In the next 25 years a lot of methods for CGHs have been proposed in the fields of holographic information and computational reduction as well as in computational and quantization techniques. In the field of computational techniques the reported algorithms can be categorized in two main concepts.

Fourier transforms method

In the first one the Fourier transformation is used to simulate the propagation of each plane of depth of the object to the hologram plane. The Fourier transformation concept was first introduced by Brown and Lohmann with the detour phase method leading to cell oriented holograms. A coding technique suggested by Burch replaced the cell oriented holograms by point holograms and made this kind of computer generated holograms more attractive. In a Fourier Transform hologram the reconstruction of the image occurs in the far field. This is usually achieved by using the Fourier transforming properties of a positive lens for reconstruction. So there are two steps in this process: computing the light field in the far observer plane, and then Fourier transforming this field back to the lens plane. These holograms are called Fourier Based Holograms. First CGHs based on the Fourier transform could reconstruct only 2D images. Brown and Lohmann introduced a technique to calculate computer generated holograms of 3D objects. Calculation of the light propagation from three-dimensional objects is performed according to the usual parabolic approximation to the Fresnel-Kirchhoff diffraction integral. The wavefront to be reconstructed by the hologram is, therefore, the superposition of the Fourier transforms of each object plane in depth, modified by a quadratic phase factor.

Point Source Holograms

The second computational strategy is based on the point source concept, where the object is broken down in self-luminous points. An elementary hologram is calculated for every point source and the final hologram is synthesized by superimposing all the elementary holograms. This concept has been first reported by Waters whose major assumption originated with Rogers who recognized that a Fresnel zone plate could be considered a special case of the hologram proposed by Gabor. But, as far as most of the object points were non-zero the computational complexity of the point-source concept was much higher than in the Fourier transformation concept. Some researchers tried to overcome this drawback by predefining and storing all the possible elementary holograms using on top special data storage techniques because of the huge capacity that is needed in this case, others by using special hardware In the point-source concept the major problem that has to be circumvented is the competition among data storage capacity and computational speed. In particular, algorithms that rise the computational speed need usually very high data storage capabilities while on the other side algorithms that lower the need of data storage capacity lead to high computational complexity though some optimizations could be achieved . Another concept which leads to Point Source CGHs is the Ray tracing method.

Ray tracing is perhaps the simplest method of computer generated holography to visualize. Essentially, the path length

difference between the distance a virtual "reference beam" and a virtual "object beam" have to travel is calculated; this will give the relative phase of the scattered object beam.
Over the last three decades both concepts have made a remarkable progress improving computational speed and image quality. However, some technical restraints like computation and storage capacity still burden digital holography making potential real-time applications with current standard computer hardware almost impossible.

Interference pattern encoding
Once it is known what the scattered wave front of the object looks like or how it may be computed, it must be fixed on a spatial light modulator (SLM), abusing this term to include not only LCD displays or similar devices, but also films and masks. Basically, there are different types of SLMs available: Pure phase modulators (retarding the illuminating wave), pure amplitude modulators (blocking the illumination light), and SLMs which have the capability of combined phase/amplitude modulation
In the case of pure phase or amplitude modulation, clearly quality losses are unavoidable. Early forms of pure amplitude holograms were simply printed in black and white, meaning that the amplitude had to be encoded with one bit of depth only . Similarly, the kinoform is a pure-phase encoding invented at IBM in the early days of CGH . Even if a fully complex phase/amplitude modulation would be ideal, a pure phase or pure amplitude solution is normally preferred because it is much easier to implement technologically.

Reconstruction
The third (technical) issue is beam modulation and actual wave front reconstruction. Masks may be printed, resulting often in a grained pattern structure since most printers can make only dots (although very small ones). Films may be developed by laser exposure. Holographic displays are currently yet a challenge (as of 2008), although successful prototypes have been built. An ideal display for computer generated holograms would consist of pixels smaller than a wavelength of light with adjustable phase and brightness. Such displays have been called phased array optics. Further progress in nanotechnology is required to build them.

III. THREE DIMENSIONAL LIMITATIONS

Not only arbitrary mutual intensity functions unrealizable for coherent fields, arbitrary band limited three-dimensional wave function are also not realizable. It is well known that the fourier transform of a coherent three – dimensional scalar field far away from any evast sources yields a three – dimensional function. That is a wavelength of the optical field in question.
In other words, a two dimensional manifold can describe any reliable coherent three-dimensional field. Therefore, there are many of three-dimensional field that cannot be realized. Eg. A “plane wave” whose wavelength is twice a long as the wavelength of a field.

$$U_{(x,y,z)} = e^{f2\prod t / 2t} \qquad (1)$$

The limitation arises from Huygens’s principle. Where a coherent field convolved with a spherical wave must result in the same coherent field. The fourier transform of a spherical wave lies centrally on the surface of sphere of radius 1/ λ .Therefore, through the conditional theorem, any physically valid field must also be on the surface of the sphere. In other words, enforcing that the three – dimensional scalar field is a proper solution to the Helmholtz equation results in the loss of one dimension. However, in many application areas, only the intensity and not the phase of the coherent field is important. Since the intensity is simply the field multiplied by the complex conjugate. This means that the possible extent of the Fourier transform of the intensity is equivalent to the auto correlation of the hollow sphere. This operation does “fill” the three – dimensional space, making it more difficult to determine a simple pattern that would be impossible to generate using a fully coherent field. However, recall that this auto correlation operation is still a function from a 2-D manifold to a three dimensional pattern. Therefore, the set of possible three- dimensional intensity patterns must have size less than or equal to the set of possible three-dimensional field patterns and there the same limitations still apply. Although the freedom to choose the phase may yield potential gains. With the discussion so far, limitations of coherent fields have been the result of obvious dimension a mismatch issues, but in the following section, we will demonstrate that not all band limited two-dimensional intensity patterns can be generated by a coherent field, either this conclusion will make it obvious that not all band limited intensity pattern containing a impossible two – dimensional intensity will also be impossible to generate using a coherent field.

Available CGH devices

Currently, several companies and university departments are researching on the field of CGH devices:
- MIT Media Lab has developed the "Holovideo" CGH display
- See Real Technologies have prototyped a CGH display
- Cortical Cafe CGH Kit is a CGH related hobbyist site with instructions, source code, and a web-application for CGH creation.

IV. HOLOGRAM PROJECTOR

A hologram projector is a video projector that can display a two-dimensional (2D) image. Light is routed to a specific location, making the device efficient, and the projector has the capacity to produce video frame rates for a realistic hologram. It is a small device and can be integrated into laptops or mobile phones. The technology is mainly used in 2D applications, but models that can produce three-dimensional (3D) images are in development.

Calculations made by a microchip process hologram patterns. The light produced by the device undergoes diffraction, which can be controlled to form a high-quality image, all without a bulky lens. A liquid crystal display is built on top of the chip, on which the pattern looks like a cluster of dots, while laser light provides the illumination to project the image onto a wall or screen.

Various applications can benefit from a hologram projector, such as home entertainment and advertising. It also has potential for many businesses, automotive companies, as well as in the aerospace industry. The device can be mass produced inexpensively because the circuitry is built into a common type of field-programmable gate array, so a relatively new technology can be implemented using components that are already available. 3D devices are being designed, and one prototype even creates a tactile sensation when someone puts their finger out to touch the hologram. Ultrasound waves in the air allow a pressure sensation to be felt when the hologram is touched. The visual quality of the hologram is not affected. Video games could incorporate such technology, and there are an enormous number of current applications of holographs in the video game industry.

The idea of a hologram projector is not new, but the concept has been difficult to develop because incorporating holograms into video requires fast processing power. So many mathematical calculations take place that even powerful computers would take a long time to create individual video frames. Images projected this way have been low in quality, and the lasers required for the application have been very high-cost.

Several companies have caught onto technologies that can support the processing speed needed. The dynamics of a hologram projector allow for small parts, so it can be small enough to be incorporated into small electronics such as laptops or personal digital assistants (PDA). Video images can be created that, until recently, looked like something seen only in science fiction.

Holographic Display

Generally Holograms are 2D canvas which can display 3D objects. You can find them in many places in real life such as your credit card and driving license. There you can see 3D object in 2D sticker and depending on the angle you look at it you can get different views, same as in real 3D object. Those holographic stickers are difficult to reproduce and used to indicate originality of products.

Using the same underlying fundamental concept laser devices can create 3D images in thin air. This is a brand new experience to us. Every time we see a reproduced image its 2D and there is a screen. Even if you experience Wi-Max 3D, still there is a screen. But with Laser hologram there is no physical screen. It juts appear 3D objects in air.

Normally in a Smartphone we see images in 2D display and touch responsiveness is also limited to 2D surface. Yes, some applications are capable of displaying 3D images, but still they are virtual 3D and displayed on 2D surface.

The day engineers equipped a Smartphone with a Holographic display, the images stuck in 2D display will pop out of the phone as real 3D objects. Smartphone home screen will spread out in air and menu item will start floating near them. Once this becomes reality it will be the next big thing in Mobile handset evolution.

Display real 3D images in air won't be adequate to deliver a great user experience. There has to be motion sensor which can understand hand gestures and control the UI accordingly. When you combine this kind of motion sensor to a Holographic display, you will be able to actually touch a 3D object which popped out from your phone and turn it around with your fingers. Same concept will work even better with large screens in tablets.

Technical Challenges

Smartphone displays are mainly used for information presentation such as web browsing, multimedia application and Games. In those case color reproduction need to be accurate and frame refresh rate need to be greater. And the holographic display should be able to display 2D images whenever necessary. Current laser hologram technology needs to go a long way to meet the above requirement. Current state is color reproduction quality is very low and refresh rate is average. When it comes to hardware, it's not ready to live in tiny Smartphone body. If you consider the power consumption laser hologram will kill the most powerful Smartphone within seconds. Therefore we need to polish up hologram display technology before it's plugged in to a Smartphone.

When it comes to 3D motion sensors, the situation is way better than holographic display. Technology already produced few 3D motions sensors and some of them are already in the market such as Microsoft Kinect. Still the technology needs lots of polishing up to miniaturize the hardware to place them in Smartphone body. In our life we have experienced speed of technology many times. Back in 1990s we were using 2G mobile phones for sending text messages. After 10 years we have Smartphone with multi-touch displays, high speed data connectivity, GPS and HD displays. Today it might sounds like a day dream to embed holographic displays and 3D motions sensors in Smartphone, but technology will surprise us within couple of years with way advanced technology for sure. Element for synthetically generating a hologram We describe a method of determining an aberration correction for a holographic image display system using a spatial light modulator (SLM) to display a hologram. Embodiments of the invention measure the corrections needed for a particular projection system, using the same system SLM as used to generate the images to provide wavefront-sensing holograms.

The projector's projection optics are used to provide the wave front sensor and there is no need for lens lets. Embodiments of the invention use a plurality of successive holograms directing light from differently-located patches on the hologram into the image.

Holographic Laser Projection Technology

LBO's technology represents a revolutionary approach to the projection and display of information. Unlike other commercially-available projection technologies, LBO's projection engine exploits the physical process of two dimensional diffraction to form video images. A typical imaging projection system works by displaying a desired image *Fxy* on a micro display, which is usually sequentially illuminated by red, green and blue light to form colour. In this case, the micro display simply acts to selectively block (or amplitude modulate) the incident light; after passing through some magnification optics, the projected image *Fxy* appears. Conversely, holographic laser projection forms the image *Fxy* by illuminating a diffraction (or hologram) pattern *huv* by laser light of

wavelength □. If the hologram pattern is represented by a display element with pixel size □ then the image *Fxy* formed in the focal plane of the lens is related to the pixellated hologram pattern *huv* by the discrete Fourier transform *F* [·], and is written as *x*

$$F_{xy}=F[h_{uv}] \qquad (2)$$

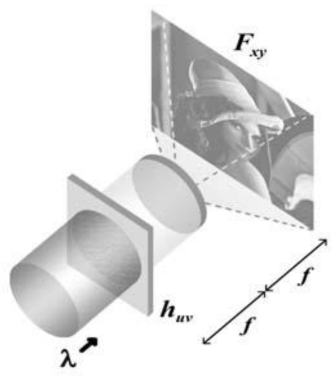

Figure 4.1 – The relationship between hologram *hu*v and image *Fxy* present at the back focal plane of a lens of focal length *f*, when illuminated by coherent monochromatic light of wavelength .

The crucial efficiency advantage of LBO's system occurs because the hologram *huv* is quantised to a set of phase only values □*uv*, where *huv* = exp j/*uv*, so that the incident light is steered into the desired image pixels – without blocking – by the process of coherent interference, and the resultant instantaneous projected image appears as a direct consequence of Fourier optics. To achieve video-rate holographic display, a dynamically-addressable display element is required to display the hologram patterns; LBO's system uses a custom-manufactured ferroelectric liquid crystal on silicon (LCOS) micro display manufactured by Display tech, Inc. To achieve high image quality a fast micro display is used to display *N* holograms per video frame within the 40ms temporal bandwidth of the eye, each of which produces an image *Fxy* exhibiting quantisation noise [5]. If the intensity of the *i*th displayed image is

$$\mathrm{I} = \frac{\frac{1}{N}\sum_{i=1}^{n} Fxy\ (i)}{2} \qquad (3)$$

Uniquely, the key to holographic laser projection technology lies not in the optical design but in the algorithms used to calculate the hologram patterns *huv* from the desired image *Fxy*. LBO has developed and patented

proprietary algorithms for the purposes of calculating *N* sets of holograms both efficiently and in real time, as first demonstrated in 2004 [7]. Crucially, such algorithms can be efficiently implemented in a custom silicon chip. A practical realisation is rather simple and is shown in the schematic of Figure 4. A desired image is converted into sets of holograms by LBO's proprietary algorithms and displayed on a phase-modulating micro display which is time-sequentially illuminated by red, green and blue laser light respectively. The subsequent diffraction pattern passes through a demagnification lens pair *L*1 and *L*2, which can be chosen to provide ultra-wide projection angles in excess of 100°. Due to the nature of Fraunhofer diffraction, the image

Remains in focus at all distances from the lens *L*2.

Functional Diagram Of Hologram Display:

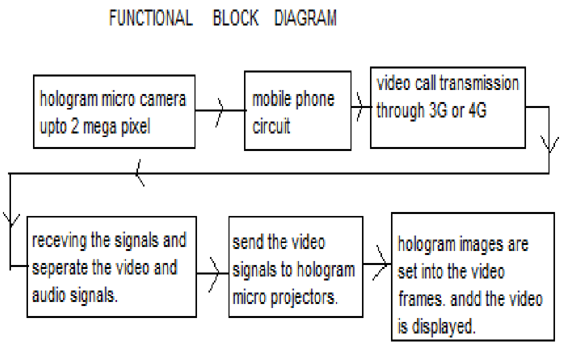

Fig 4.2 Functional block diagram

V. RESULTS

The holography video calls can be implemented through implementing micro hologram projectors in the mobile display through LBO projector models in the way of computer generated holography. The image will be visualized in 3D model. Their originality will be viewed by peaks and depths of each holographic images set into the video frames.

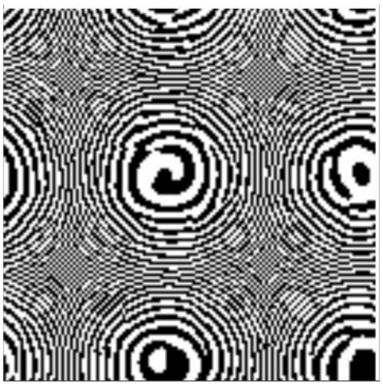

Fig 5.1 Hologram

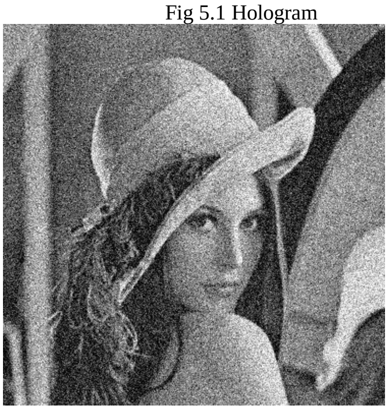

Fig 5.2 video sub frame

Fig 5.3 video frame

The relationship between hologram *huv*, sub frame *Fxy* and frame *Vxy* in LBO’s holographic projection technology. Normally in a mobile phone we see images in 2D display and touch responsiveness is also limited to 2D surface. Yes, some applications are capable of displaying 3D images, but still they are virtual 3D and displayed on 2D surface as shown in fig 5.3. The day engineers equipped a mobile phone with a Holographic display, the images stuck in 2D display will pop out of the phone as real 3D objects. Smartphone home screen will spread out in air and menu item will start floating near them. Once this becomes reality it will be the next big thing in Mobile handset evolution. Display real 3D images in air won’t be adequate to deliver a great user experience. There has to be motion sensor which can understand hand gestures and control the UI accordingly. When you combine this kind of motion sensor to a Holographic display, you will be able to actually touch a 3D object which popped out from your phone and turn it around with your fingers. Same concept will work even better with large screens in tablets.

VI. DISCUSSIONS

A new ground-breaking holographic 2D projection technology could result in a new generation of pocket-sized digital video projectors and miniature projection displays incorporated into other handheld devices. Digital video projectors produce large, high quality images are becoming increasingly popular as they grow cheaper with mass production, but the technology is limited in its miniaturization, preventing projectors from being incorporated mobile device markets. Holographic projection of 2D (rather than 3D) images represents a compelling alternative to conventional image projection. Video projectors based on this holographic technology can be made very small so a projector could be integrated into a laptop, a PDA, or even a mobile phone. Holographic projection of 2D (rather than 3D) images represents a compelling alternative to conventional image projection. Holograms are efficient: they work by routing light to the places where you want it, and away from the places you don't. Video projectors based on this holographic technology require very few components, which means they can be made very small - and the smaller you make holograms, the better the image that results. So a projector could be integrated into a laptop, a PDA, or even a mobile phone. The concept of a holographic projector is not new, but up until now technical issues have prevented development of an actual product based on this technology. Holograms are extremely complex objects mathematically, and calculating them fast enough for video applications is very difficult; even the most powerful computers would take minutes to generate a hologram to project just a single video frame. The projected images produced by holograms tend to be sparkly and of very low quality. The lasers that are required to illuminate the holograms have, until very recently, been very expensive and limited in availability. A hologram pattern, which to the naked eye looks like a collection of random dots, is displayed on a small liquid-crystal-on-silicon (LCOS) micro display - a tiny, very fast liquid crystal display built on top of a chip. The hologram patterns are calculated by Light Blue Optics' proprietary "hologram chip" so that when the micro display is illuminated by laser light, the light interferes with itself in a complex manner through the physical process of diffraction which, when carefully controlled, results in the formation of a large, high quality projected image on, for example, a screen or a wall. Unlike a conventional video projector, heavy, bulky lenses are not required: diffraction does all the work for you, and the projected image is sharp and in focus at any distance. There are a huge number of applications for this technology in fields including business, home entertainment, aerospace and advertising.
At present, the focus is on 2D applications, in particular tiny personal projectors for business and home use. The illustration shows an artist's impression of a potential early product - a personal video projector, which you could download movies to and then play anywhere, using a wall as the screen.

VII. CONCLUSION

3D [video] technology moving into the cell phone, which will have the ability to transmit information off the cell phone to create a 3D hologram, projecting the hologram on any surface in life size With a cell phone hologram, a user would be able to walk next to a hologram of a friend, or a worker could project an enlarged 3D image of a product needing repair to walk inside it and detect problems. IBM is already working on the cell phone hologram concept in its labs, and Bloom predicted that a prototype should be ready in five years. The cameras that are being used to create early versions of holograms still need to be miniaturized, and software needs to be written to for receiving input from those cameras.
Based on how much 3D video has caught on in recent months in gaming and other areas, we expects people will want holograms on their cell phones. "I definitely want a hologram on my cell phone, to be able to say, 'Beam me up, Scotty,' even though it would be a virtual and not a real person”.

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