Mobile phone color holography

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ABSTRACT

We have found a way to use movies made by mobile phones video cameras as the source of information needed for digital holographic printing. Actually, in order to print digital hologram, one needs to have a sequence of images of the same scene taken from different angles and nowadays video cameras incorporated into mobile phones can be an acceptable source of such image sequence. In this article we are describing this holographic imaging process in details.

Keywords: Digital Holography, Mobile Phone, i-Lumogram, Hologram

1. INTRODUCTION

Digital holographic printing is a photomaterial exposing technique where object beam is formed by spatially modulating one of the laser radiation beams and another beam is used as reference beam. The modulation is performed in such a way that resulting object beam at the place of its interference with reference beam contains same information that would come to this point from a real object if this object would be used for holographic recording. In digital holography instead of the real object, series of its digital photographs taken from different angles are used. That allows obtaining enough information for single and full parallax digital holograms [1, 2].

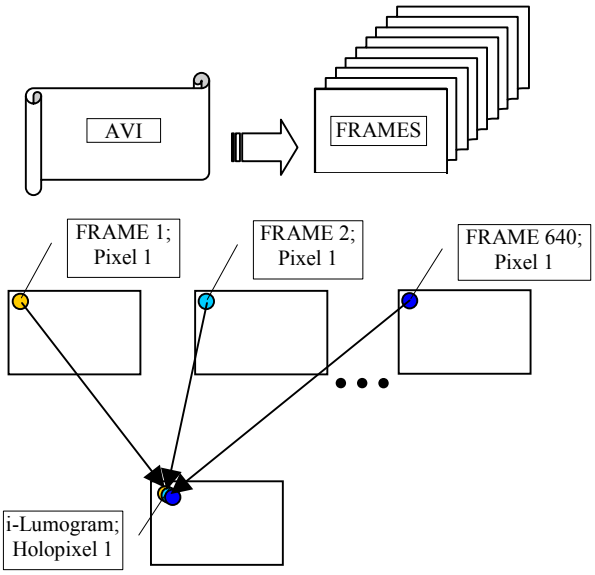

Figure 1. Holopixel formation

Object beam modulation pattern is calculated from ensembles of corresponding digital photographs pixels characteristics. Object beam is modulated by displaying this calculated pattern on transparent (or how it was implemented recently, on reflective) LCD display and illuminating this display by laser beam.

Since information for digital hologram is obtained from digital pictures pixels, the hologram itself always has pixilated structure. Those holographic pixels are called holopixels (Geola) or hogels (Zebra Imaging), currently the size of those

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holopixels is not less than 0.8 x 0.8 mm, and each holopixel contains information from 600-1200 usual pixels with corresponding coordinates that are taken from different views of imprinted scene (Fig. 1).

Spatially modulated object beams together with reference laser radiation beam are exposing one holopixel on unexposed photomaterial. Then holographic media shall be moved for the distance equal to holopixel size and next holopixel is exposed. For colour digital holograms each holopixel shall be exposed three times with Red, Green and Blue lasers.

To make digital holography tools available for common people and to move holographic imaging outside laboratories, in 2005 we have developed life-imaging devices (HoloCam). That moved digital holography outside the laboratories and supplied professional photographers with a tool to prepare a video sequences for holographic printing without any special knowledge about holography insides. So it became possible not only for professional holographers to use digital holography for commercial full colour reflection holograms manufacturing. And the next logical step in digital holography development seamed to enable common people to make an imaging as per digital holography requirements.

2. DIGITAL HOLOGRAPHIC IMAGING BASICS

Every i-Lumogram holopixel have information about corresponding real captured scene discrete area views from different points [2]. For life imaging system video capturing we use a target camera, which moves along the object on the rail (Holo Cam). At the each point of its movement camera is precisely pointed to the center of filmed scene. In such a way we are obtaining series of scene's pictures from different points of view (Fig. 2).

i-Lumogram observer sees holographic scene, on the lightened i-Lumogram, like through window – all objects on it are projected onto image plane surface. Because the hologram is flat, the camera making images for their imprinting onto hologram also shall have straight movement trajectory, or images taken by camera moving in other way shall be recalculated into the images that would be shot during camera's movement on straight line. It is the fundamental point of live imaging system used for images capturing to print i-Lumogram with holographic printer we use.

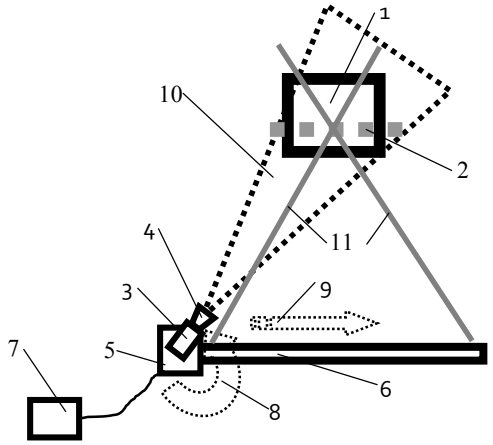

Figure 2 A diagram of the HoloCam system - 1. The object to be recorded; 2. Future hologram image plane; 3. Digital camera at the left-most position at the electromechanical stepper-motor rail; 4. Camera zoom objective; 5. Stepper-motor precision rotation stage; 6. Electromechanical stepper-motor rail; 7. Rotation stage and translation rail controller; 8. Digital camera angular movement; 9. Digital camera linear movement; 10. FOV of the digital camera; 11. two laser pointers beam.

When to-be-imprinted images are shot with virtual camera in 3D design software, the camera just has a wide field of view and is moved in front of the scene. The most of the image obtained in such a way is wasted, however in 3D software case it is really not big matter, in the real scene shot case it is – the most of real camera sensor's area would be just wasted. Therefore HoloCam camera moves along the straight line in front of the scene, but in order to use the full camera sensor's area, HoloCam camera in every point of the rail is looking to the center of the scene. The rail is parallel to the plain, drawn through the scene center, this plain will become a hologram image plain. All objects in front of this plane will be replaying on the i-Lumogram in front of its surface, and all objects behind it, will be seen in the i-

Lumogram window depth. The images shot in such a way are recalculated by Geola's software to fit the specifications of Geola's digital holographic printer. So the volume effect of the life scene captured by HoloCam and imprinted on the i-Lumogram is achieved.

3. MOBILE PHONE COLOR HOLOGRAPHY

Since our i-Lumograms are digital holograms created from sequence of images, it was obvious to investigate possibility to use the most convenient imaging device – mobile phone, as the source of such image sequence. Mobile phone is full multimedia device now. Big part of them can make not only photographs, but to capture a video as well. The resolution of nowadays mobile phone is usually 240x320 pixels, or greater. Mobile phone use for scene capture could make digital color holography available for people in all over the world. In place where people cant use HoloCam for different reasons, people shall be able to use their mobile phone integrated digital cameras to memorize the common moments of life in three-dimensional print.

But when mobile phone is used as life imaging system, it is not possible to move it precisely repeating trajectory of HoloCam' camera. If cameraman will move mobile phone along scene in such a way as HoloCam camera is moving, his movement never will repeat HoloCam camera movement precisely, moreover, the captured video image sequence will have horizontal and vertical nonlinear rotation jitter. Such kind of video will be unfit to use for i-Lumograms printing.

To find a way how to get around this problem, we have analyzed the sequences of images taken by HoloCam's camera and tried to find the way to obtain similar images without needing a precise camera movement. The first approach was to use steady camera and rotating object. On a picture below are shown sequence of images from two virtual cameras that were setup in 3d design software in such a way that they would mimic HoloCam camera and steady camera in front of rotating scene. Three identical objects were placed into virtual scene – the central object was placed in center of the image plane, other two – behind it.

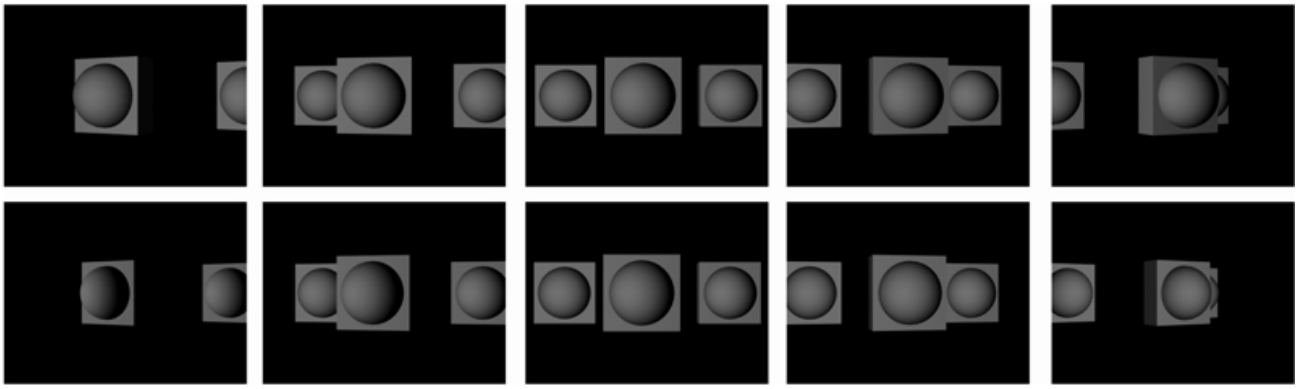

Figure 3. Sequence of images obtained from cameras modelled in 3d design software. Top line – images obtained from steady camera shooting rotating scene. Bottom line – images obtained from camera moving in front of the scene and always pointing to scene's centre (HoloCam).

As it is seen from the images of Fig. 3., the images obtained by steady camera from rotating scene will be quite different from the images shot by HoloCam's camera. Not only the size of the pictured objects is different, objects positions to each other also differ. So it seams that it is not possible to obtain the image sequence similar to HoloCam imaging by simple steady camera. But let's take a look to the center of the captured images – Fig. 4.

The central parts of the images obtained by different cameras look quite similar. The only differences are the central image size and the position on the image the other objects that were behind the central object. That means that if we will use the steady camera to film rotating objects that are not far from the image plain, the whole obtained images would be quite similar to those that would be captured by HoloCam and will differ from them only by filmed image size. But for the image size compensation a simple program reducing the images obtained by steady camera may be used. Some

image scaling discrepancies will of course pertain, but if the resulting print is not big (up to 30x40cm), human eyes do not spot noticeable geometrical image distortions.

Thus it is indeed possible to use mobile phone (or any other steady camera) for holographic imaging. The only necessary requirement is to have the rotating object not far from the image plane and to avoid focusing on the objects far behind the image plain, because such objects will not look naturally on a printed hologram, especially if the size of such hologram exceeds 30x40cm.

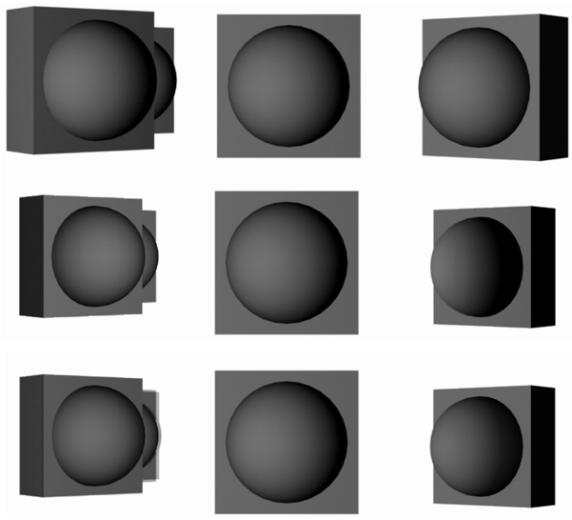

Figure 4. Centres of the images obtained from cameras modelled in 3d design software. Top line – images obtained from steady camera shooting rotating scene. Middle line – images obtained from camera moving in front of the scene and always pointing to scene's centre (HoloCam). Bottom line – mobile phone images' centres reduced and put semitransparent on top of the HoloCam images' centres

All those requirements are fulfilled if we want to make a holographic portrait. Smooth human head rotation in front of the mobile phone camera automatically position the face near image plain and will assure the smooth take of the image sequence. Holocam camera rotation angle is close to 90 degrees, so the human head also shall be rotated for 90 degrees. Head's swinging from one shoulder to another gives the desired rotation angle.

All that allowed Geola Digital uab start holographic portraits taken by mobile phone printing service in early 2009. The resolution of the most of modern mobile phones is not less than 240x320 pixels in movie mode. That is enough to print holographic portrait in size of 30x40cm, however due to reasons mentioned above, we would like to restrict maximum size of the holograms made of mobile phone movies by 20x30cm.

4. MOBILE PHONE HOLOGRAPHIC IMAGING PROCESS

The imaging process is very simple – the subject is asked to swing his head from his left to his right shoulder (Fig.5.) and then filmed movie is sent to Geola as e-mail attachment, or put for us to some ftp server. All that nowadays can be done with the very same phone, which was used for subject filming.

Figure 5. Mobile phone holographic imaging process.

When receiving the said movie, we are extracting from it the image frames sequence. Part of the sequence is useless due to various mobile phone image processing engine artifacts, but the most of the images can be used for holographic printing. This part goes to our software, which resizes the images and makes them as similar as possible to those that would be taken by our HoloCam device. All images from mobile phone video are modified in such a way and then a new sequence is processed by usual HoloCam image processing software.

On the printed i-Lumogram, the head and other body parts that were rotating during the video capture will be three-dimensional. All the other not rotated parts of human body and objects on background, which were captured only from one point of view, will look on i-Lumogram like flat parts with no volume. The information about object shape from one point of view is not enough to print object with different views or effect of volume. Because of that, the best scene for mobile phone color holography is person's head and shoulders.

Like basic tool for mobile phone color holography can be used the mobile phone, video cameras, photo cameras with video capturing features, web cameras with enough video resolution and others video capturing tools with video file converting to digital format possibilities. Every time the scene setup will be the same. Cameraman holds video capturing tools horizontally in subject head level and don’t move when the video is capturing. Subject swings his head slowly from left to right with no swinging velocity acceleration (deceleration) and, for better result, with no delays. Head swinging from left to right is a must. The left to right moving is usual camera moving for HoloCam camera movement on the rail – from left rail end to right (from cameraman side). And HoloCam camera movement is defined by holographic printer software.

Good scene lightening is also recommended. The dynamical range of the image with insufficient lightening of the scene will be not enough to print i-Lumogram in vivid colors. The entire mobile phone holography images processing (calculating, transforming) is made using approximations and can be performed to certain extend even on inaccurate video data. All that makes mobile holography a perfect tool for all who would like to make its own holographic images using as simple tools as possible.

5. CONCLUSIONS

· Digital mobile phone holography is a new step in the holography popularization among the common people all around the World.

· With the basic features, such as: accessibility, mobility and a freedom of the creative process for the every single person we are extending holographic approach to such areas as amateur photography and home video creation.

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