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Capturing 3D Photo With A Mobile Phone

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Abstract

In this paper, we provide an overview of underlying concept of 3D photographs and methods available to capture such photos with a mobile phone's camera. After an introduction to 3D photos, we describe challenges in capturing a good 3D photo. We then evaluate major capture methods, providing the pros and cons of each method. Finally, we talk about how Ittiam's single camera solution enables mobile phone users to take a great 3D photograph.

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Introduction

3D photos consist of two separate left and right views. The two views give different projections of the world onto the retina giving a perception of depth to the human brain.These two views are captured separately such that horizontal distance between them is same as interocular distance, the distance between the two eyes. In case of humans, interocular distance is 5-7 cm. Below image shows the left and right views of a flower.

Figure 1Left and Right Views of a flower (Photo by Lone Primate)

Once captured, 3D effect can be reproduced when the image is displayed such that each eye sees the corresponding view. 3D images can be displayed on devices using predominantly two types of display technology.

- **Stereoscopic –** These technologies rely on special glasses worn by user, such that a different image is seen by the viewer's left and right eyes. There are two major methods. In the first case, the eye-wear combines images from two offset sources to create a 3D view. LCD shutter glasses are a good example. In the second case, the eye-wear filters the offset images from a single source. Anaglyph are one such technology. Below image shows a pair of LCD shutter glasses and red-cyan anaglyph glasses.

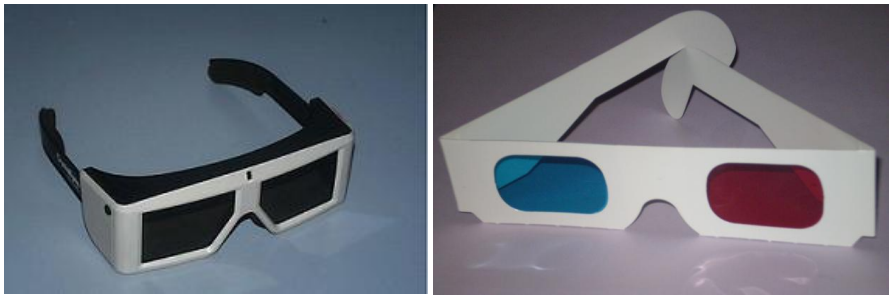

Figure 2 LCD shutter glasses and Paper anaglyph filters

- **Auto stereoscopic** – These display technologies use optical components in the display to enable each eye to see a different image. They do not need user to wear special glasses.

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Challenges in 3D photo capture

A typical 3D photo capture method faces the following challenges

Capturing left and right views almost at the same time

For a good 3D photo, both the left and right views should be captured almost at the same time. If the two views are captured one after another, with a slight delay, the capture method has to compensate for potential issues like movement of objects in the picture, change in light conditions between two shots.

Ensuring both views are aligned

The left and right view of a good 3D photo should be perfectly aligned. This is difficult to achieve, when the two views are not captured simultaneously. It is highly likely that camera would have moved leading to misaligned views. A good capture method has to detect the extent of such misalignment and compensate for it.

A good 3D capture method has to choose an optimal tradeoff between additional hardware, processing power, increased shot-to-shot delay and quality of 3D photo.

Choosing an optimal distance between the two viewsfor the best 3D effect

The extent of 3D effect in a photo depends on the distance between the two views. Typically this distance should be equal to the interocular distance. However in some cases, the distance can be varied to enhance the 3D effect. A good capture method should choose an optimal distance between two views to provide the best 3D effect.

Ensuring that cost of additional hardware required is minimal

Most mobile phone manufacturers would like provide the best possible 3D capture solution to their customers, while keeping the costs of additional hardware to a minimum. A good capture method should strike a balance between cost of additional hardware required and quality of 3D photo.

Choose an optimal trade-off between quality and additional processing required

Most existing phones have limited spare processing power. For such phones to support 3D capture, the solution should provide an acceptable quality with reasonable additional processing.

Keep the shot-to-shot delay to an acceptable level

A good method should strive to keep delay between consecutive photo captures to an acceptable level. Ideally, this shot to shot delay should be as close as possible to the non-3D capture delay.

Options available to capture 3D photo on mobile

In this section, we present typical 3D capture methods that can be used on mobile. We also discuss the pros and cons of each method.

Dual camera capture method

In this method, two cameras are mounted on mobile. Distance between the two cameras is kept close to the interocular distance. The two cameras capture the left and right views simultaneously. The captured views are then converted in to a 3D photo.

Pros

- The two views are aligned and captured at same time.
- There is no need for additional processing after the capture.

Cons

- The solution requires additional camera, increasing the cost of the solution.
- Since the two cameras have to be separated by a reasonable distance to get a good 3D effect, the solution cannot be used on small form factor phones.

Applicability

- Dual camera method is most suited forpremium smart phones, aimed at providing best 3D photo capture solution.

Figure 3 Phone with two cameras

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Single camera manual method

In this method, user captures both the views. After capturing the first view, the user will move the camera in lateral direction to capture second view. The application may assist the user by showing the superimposed preview of the first view, while capturing the second view.

Pros

- There is no need for additional processing or hardware.
- The method can be used on any existing camera phone.

Cons

- The two views may not be aligned.
- Since user has to choose the second view manually, there is the good chance that distance between two views is not optimal for 3D effect.

Applicability

- Single camera – manual solution is most suited for capturing 3D photos on existing phones with camera, where additional processing power is not available for superior solution.

Single camera automatic method

In this method, camera phone contains software to captures multiple photos, while the user moves the camera in lateral direction. Thereafter the software chooses the two photos for best 3D effect and performs post processing to compensate for any misalignment.

Pros

- The method does not need additional hardware.
- It will work on all single camera phones, with reasonable spare processing power.
- Post processing techniques like convergence of views can be added to create a better 3-D effect.

Cons

- The solution does require additional processing power.
- The shot-to-shot delay is more than earlier two methods.

Applicability

- Single camera – automatic solution is most suited for capturing 3D photos on reasonably powerful phones, where spare processing power can be used to get superior quality photos.

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Ittiam's 3D capture solution for phones with single camera

Ittiam has been working on image and video processing technology since 2001. Using the vast experience in the field, Ittiam has created a 3D capture solution for phones with single camera.Some of the salient features of Ittiam solution are listed below

Features

- **Multiple input pictures** - Ittiam's solution takes up to 6 photographs, while user moves the phone in lateral direction. Having larger set of pictures allows the solution to choose the best two pictures for 3D effect.

- **Choosing best views using binocular disparity**–The solution uses binocular disparity to choose the two views with best 3D effect. Binocular disparity refers to the difference in image location of an object seen by the left and the right eye. The disparity is more for nearby objects and reduces as the distance of the object increases. The binocular disparity is calculated using frequency domain techniques. Phase shift property of Fourier transform is used where a translation in the spatial domain translates to phase shift in the frequency domain. Correlation of the phase information of the two images results in peaks at disparity values.

Figure 4 Red-cyan anaglyph image generated by the Ittiam Solution

- **Aligning two views using sensor data** - Ittiam's solution aligns both the images before processing them for disparity analysis formore accurate results. This is done using the parameters provided by the MEMS Sensors like accelerometer and magnetometer. Once the two views are identified, misalignment compensation is done for larger input images.

- **Post processing for better 3D effect -**The final image pair selected is taken through a set of post processing steps including (a) Correction of vertical alignment between the two images using vertical disparity information (b) Providing a small convergence angle to both views to mimic the behavior of the eye. This helps the brain fuse the images faster and more easily.

- **Reasonable processing requirement -** The disparity related processing is performed on the down sampled images using frequency domain techniques. In addition, alignment is corrected using sensor data, instead of more expensive image processing techniques.

- **Support for regular display –** Ittiam's solution support'sRed-Cyan anaglyph output. This allows users to view the 3-D image on a regular display using a pair of red-cyan glasses.

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Conclusion

In this paper, we provided a brief overview of 3D photos and key challenges in capturing such a photo. We then discussed three capture methods and their pros and cons. In the final section, we provided an overview of Ittiam's 3D capture solution aimed at single camera phones and described how Ittiam solutions addresses the major challenges to create a great 3D photo.

References

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