

Introducing DLP® 3-D TV

David C. Hutchison
Senior Member of the Technical Staff

Texas Instruments
DLP® TV



Introduction

Now that HDTV has established itself in the consumer marketplace, both consumer electronic manufacturers and consumers are beginning to ask what the next big technology for TVs will be. One new technology is 3-D Television. 2006 saw the introduction of several new cinema titles, such as *Return of Superman*, *Monster House*, and *Nightmare on Christmas*. In early 2007, *Meet the Robinsons* was released by Disney Studios. In each case, the films that were presented in 3-D retained higher receipts than those that were shown in 2-D. With studios like DreamWorks announcing that all future animated titles will be in 3-D, it stands to reason that there will be 3-D content available for home viewing in the near future. In early 2007, Texas Instruments enabled 3-D video processing in its DLP® TV product offerings to its customers. TV producers such as Samsung and Mitsubishi have since then introduced the first DLP® 3-D Ready TVs. This paper outlines the DLP® 3-D HDTV Video Format and shows how stereographic content can be created using this format.

DLP® 3-D Technology

Recently, Texas Instruments has introduced the first 3-D-capable television solutions to its OEMs for 2007 consumer electronics televisions. These solutions utilize the inherent speed advantage of the Digital Micro-mirror Device (DMD) to generate the left and right views required for stereoscopic imaging. Combining this with recent technical innovations in shutter glasses, the user will be able to experience a high quality high definition 3-D image on their DLP® television set.

The foundation for DLP® 3-D HDTV is found in the SmoothPicture™ algorithm. Details of the operation of SmoothPicture™ can be found in reference 2. DLP® 3-D Technology utilizes the SmoothPicture™ subframes to generate independent views for the left and right eyes. A signal is generated for each subframe and transmitted optically to the LCD shutter glasses that are worn by the viewer. The LCD shutter glasses will process the signal and will control the shutter for each eye to ensure that the

correct left and right views are displayed to the correct eye.

There are many advantages inherent in using this approach to generating stereoscopic images.

- 1) One technical hurdle in achieving cost effective stereoscopic displays is that stereoscopic displays require two times the imaging bandwidth of the standard 2-D displays. For a 1080p television set, this means that two 1080p input streams are required. Current solutions to this hurdle are to either cut the horizontal resolution by $\frac{1}{2}$ or cut the vertical resolution by $\frac{1}{2}$. Using these solutions allows for the transmission of two images using the currently available bandwidth but sacrifices either the horizontal or vertical resolution of the image. The solution created by Texas Instruments maintains both the vertical and the horizontal resolution. This solution thus produces the highest quality and highest resolution displays available for stereoscopic viewing.
- 2) Most TV display systems contain an On Screen Display (OSD) menu system. The OSD menu provides the user a feedback mechanism in situations where the user adjusts various parameters such as screen brightness and audio volume. It is desirable for this menu system to work when the system is in 3-D mode. The easiest way to achieve this is to display the menu at 0 depth (so it appears 2-D). With some of the other formats, this requires placing the menu into two separate video streams adding complexity to the TV electronics design. With the offset sampling scheme used by Texas Instruments, OSD menus can be added to the stereo image using the same method as is used for a standard 2-D image. As such, significant system redesign cost can be avoided.
- 3) By utilizing the SmoothPicture™ architecture, Texas Instruments is able to supply a 3-D-capable display with little additional electronic cost. The main cost to this solution is a modest cost in the eyewear. As such, consumers can purchase a 3-D Ready television for the same price as the traditional 2-D

television. They can then choose to purchase the eyewear with the television or upgrade at a later time.

DLP® 3-D Image Format

The DLP® 3-D Image format makes use of how the DLP® SmoothPicture™ algorithm displays an image onto the screen. The left and right images are sampled using the native offset diagonal sampling format of the DMD. The two views are then overlaid and appear as a left and right checkerboard pattern in a conventional orthogonal sampled image.

This format preserves the horizontal and vertical resolution of the left and right views providing the viewer with the highest quality image possible with the available bandwidth.

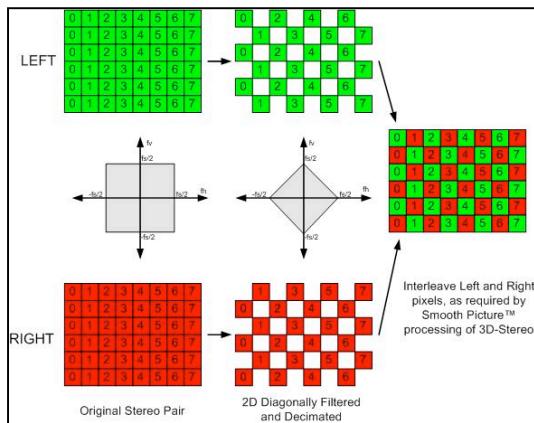


Figure 1 -- The DLP® 3-D HDTV Video Format

3-D Content

One of the advantages of the DLP® Technology is that the data signal uses the same bandwidth as a traditional HD Video Signal. As such, this format can be transferred over current DVI and HDMI interfaces. Thus, game developers, photographers, and videographers are able to display stunning 3-D content using technology that is already available in stores today. In addition, the proper format can be created using common applications, such as Adobe Photoshop and AVISYNTH. (AVISYNTH is a powerful tool used for video post-production. It is available as freeware at: <http://avisynth.org>).

Creating the Left and Right Views

Creating left and right images is a fairly easy thing to accomplish using a basic digital camera. The average distance from one eye to another for humans is approximately 64mm. Thus, when composing a simple scene, one needs to take two images. The second image needs to be shifted approximately 64mm horizontally from the first image. This can be done using a slide plate or by simply shifting ones weight from one leg to another.

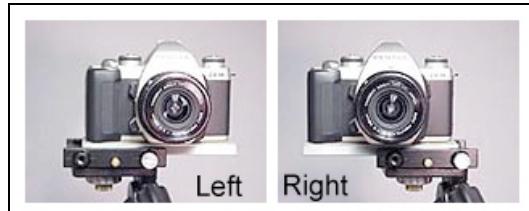


Figure 2 -- A 35mm camera using a slide plate to create the left and right views needed for stereoscopic viewing.

Once the left and right views have been photographed, they need to be combined into a format that can be used for DLP® TV. A photographic editor that supports mask operations, such as Adobe Photoshop, is needed to complete this step. Before combining the images into a single stereographic image, they must be cropped and scaled so that the images will fit correctly on the television set. All DLP® Television systems use either native 720p or native 1080p resolution. Thus, the left and right views must be cropped to a 16:9 aspect ratio and they must be scaled to either 1280x720 lines or to 1920x1080 lines.

Once the scaling and cropping operations have been completed, the left and right views can be combined into a single stereoscopic image. The steps to accomplish this task are:

- 1) Load the left, right, images.
- 2) Load either the 720p or 1080p mask into Photoshop. Copies of the mask are available at: <http://www.dlp.com/3D>
- 3) In Photoshop, make a copy of the left image.
- 4) Apply the mask to that image. This image is called the stereo image.

- 5) Next, copy the right image as a layer onto the stereo image.
- 6) Invert the mask and apply it to the right image layer in the stereo image.
- 7) Set the overlay to 'Normal'
- 8) Flatten the image and save it as either a Bitmap (*.bmp) or a TIF File (*.TIF).

The saved file stereo.bmp is now in the correct format to display onto a DLP® 3-D TV.

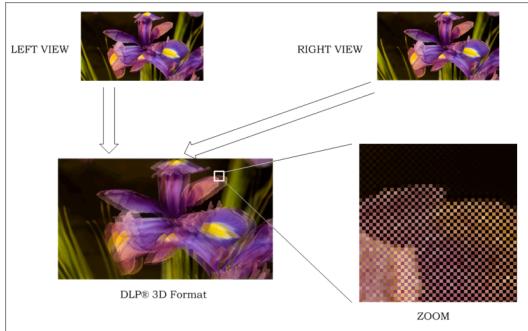


Figure 3 -- An example of combining the Left and Right views into a DLP® 3-D Video Image

Here are some important facts to note about the DLP® 3-D Format. Each pixel of the left image is surrounded by pixels of the right image. The converse of this is also true. As such, here are some simple rules to follow once the image has been packed into the DLP® 3-D Format:

- 1) Do not scale an image that is in DLP® 3-D Format. Most scaling algorithms utilize neighboring pixels to create (or remove) pixels. Since the DLP® 3-D format utilizes neighboring pixels for the left and right views, most scaling algorithms will corrupt the image. Thus, all scaling should be completed prior to converting the images to the DLP® 3-D Format.
- 2) Left/Right and Up/Down swaps of an image in DLP® 3-D Format cause the left and right views to be swapped. Again, all edits to the left and right views should be completed prior to converting the image to the DLP® 3-D Format.

The same formatting can be accomplished very simply for video edits. A script can be written using AVISYNTH. The script will load the left and right images into memory, perform a mask on each of the images, and combine the images into the DLP® 3-D Format. An example of the script is shown below.

```
#Load Left and Right Video
Left =
AVISource("left.avi").ConvertToRGB32

Right =
AVISource("right.avi").ConvertToRGB32

#Load Video Mask
Maskclip = ImageSource("alpha.bmp",
end=FrameCount(left-1),
fps=framerate(left))

# Mask and Combine
Top = mask(left, maskclip)
Vid3d = layer(right, top, "add", 255,
0,0,0,true)

# Add Audio
Audiodubex(vid3d, left)
```

Figure 4 -- AVISYNTH script to create DLP® 3-D Formatted Video

Similar operations can be performed using video edit tools such as Adobe Premier.

For gaming, there are a couple of methods available to generate the desired 3-D format. With most video games, the depth information is already known when the scene is rendered. It is possible for the game software to generate a second view and merge the two together into the DLP® 3-D Format. Furthermore, it is possible to write hardware drivers for the graphics processor which will pull the depth information out of the graphics card and create the stereographic images.

Once the image is converted to the DLP® 3-D format, all that is needed to display the format onto a DLP® TV with 3-D Technology is a HDMI cable. Make sure that the source is transmitting the image data using the native format of the DLP® TV. (either 720p or 1080p). Put on the glasses and then enjoy the show!

Conclusion

Texas Instruments has released new DLP® 3-D Technology to its OEMs in early 2007. OEMs such as Samsung have announced production of DLP® Television sets which utilize this technology to show superior stereographic video.

The DLP® 3-D Technology uses an innovative format that allows for the left and right images to be combined into a single frame. This format preserves the horizontal and vertical resolution of the left and right views and enables superior viewing experiences. Methods for creating stereographic content are fairly simple and can be accomplished with technology

available to the public today. Still images can be converted to the stereographic format using tools such as Adobe Photoshop. Video may also be converted to the format using video editing programs such as Adobe Premier.

References

1. StereoGraphics Corporation. *StereoGraphics Developers' Handbook. Background on Creating Images for CrystalEyes® and SimulEyes®*. 1997
2. Hutchison, D. *The SmoothPicture™ Algorithm: An Overview*, 2005, Texas Instruments.

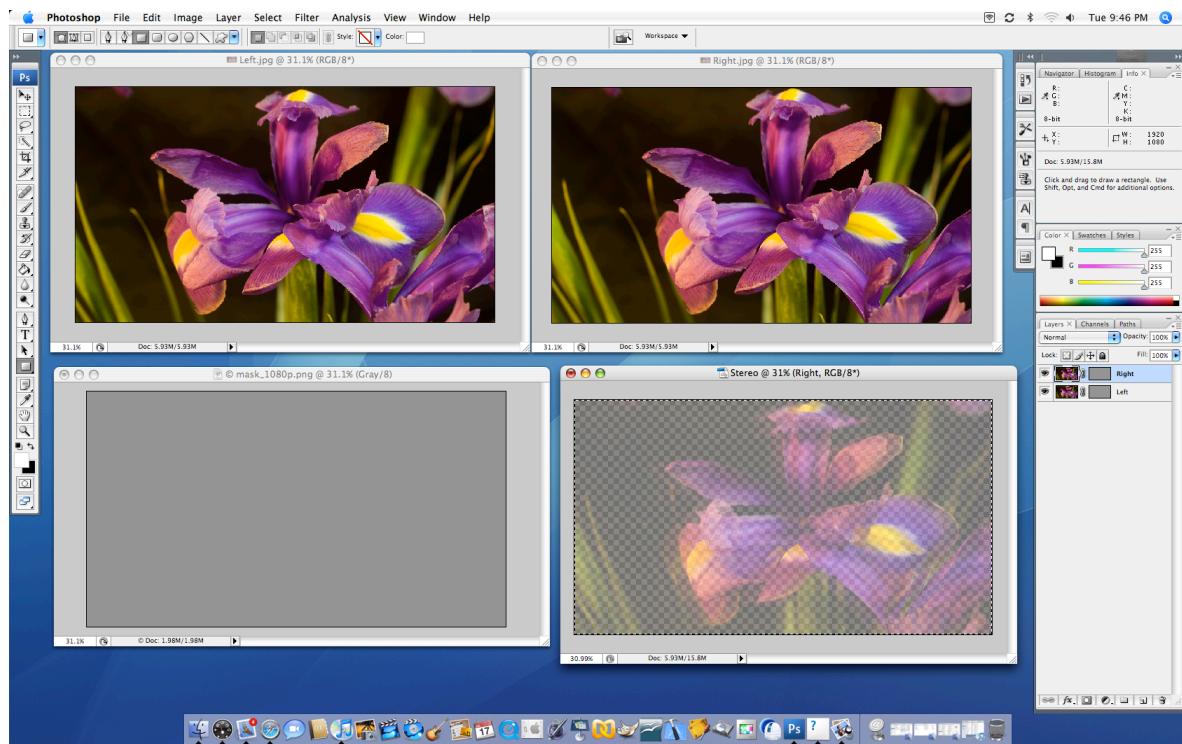


Figure 5 – Adobe® Photoshop® desktop showing left view, right view, mask, and DLP® 3-D Format image.