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Random dot stereogram python

Prev: Hard Data Up: ^ Stereo Mainpage ^ Next: In Zerocrossings Compatibility-based Stereo uses simple differences of evaluators that work directly with video intensity. It is clear that an intensity-based algorithm can have difficulties with images made up only of black-and-white pixels, such as classic random dots stereograms. Here's the result of counting with such a pair of videos (see also here rare RDS): the left image on the right picture calculated the difference Another severe stereo algorithm test is a repetitive structure found in many SIRDS. Here's an example of a discrepancy map calculated from the following image: SIRD, coded beach buggy, calculated the map of differences Fabio Policarpo Paralelo Computação Ltda. 41.1 What is stereogram? Stereogram is a 2D image that encodes stereo information so that, when viewed correctly, it reveals a hidden 3D scene. It all started back in the 1960s when Bela Julesz, who worked at AT&T Bell Labs, researched human vision, especially depth perception and pattern recognition, created a random dot stereogram (RDS). Stereograms have evolved from stereo photography, in which two photos are taken from slightly different camera positions (reflecting the shift between our eyes). 41.1.1 Stereo photography stereo photography is very old, dating back to 1838, but some old stereo cameras and stereo photo viewers, such as those shown in Figure 41-1a, can still be found in antique stores. The idea of stereo photography is to take two similar pictures, but from different positions move horizontally (like our eyes). Our eyes are separated from each other by about 65 mm, and due to this difference, slightly different images are presented to the brain. These differences allow you to understand the depth. Figure 41-1 Stereo photography in figure 41-1a two images (stereo pairs) are side by side in front of the lenses. Lenses make it easier to view by presenting each image to each eye. Stereo pairs shall be visualised in such a way that the left eye can be seen with the left eye as shown in Figure 41-1b and the right-hand photo with the right eye as shown in Figure 41-1c. If the images are swapped (with the left image, looking at the right eye and vice versa), the depth perception will be inverted. 41.1.2 Random dot stereograms To create RDS, we begin by creating an image made of random dots, as shown in Figure 41-2a. Then we duplicate the image and modify it by selecting the region and ejecting it horizontally, as in Figure 41-2b (the larger the offset, the deeper it looks). The gaps created by transferring image regions are filled with more randomly generated points, as in Figure 41-2c, and... that's it! Figure 41-2 RDS Generation Now we have two images, original and copied/moved versions. Each display for each eye allows depth of depth and the hidden 3D scene is then visible. You can view RDS as a standard stereo photo. To visualize RDS (or standard stereophotos) using only eyes and without an additional apparatus, just look at two images, such as Figure 41-3, by crossing your eyes against the video plane. This allows you to see four images instead of two, because each image duplicates (as if you are looking at the nose). Figure 41-3 RDS pair, ready for visualization Change the focus point moves the duplicate images to each other, and when the center images merge, you'll see a 3D hidden scene. At the correct focus point, you'll see only three images: one in 3D center and two in 2D edges. For a detailed explanation of how this works, see Figure 41-4. Figure 41-4 Viewing a pair of stereo images 41.1.3 Single-image stereogram Single-image stereogram (SIS), the evolution of standard RDS, requires only one image. The idea is that neighboring vertical segments of the image will match the patterns, thus creating a depth perception. See Figures 41-5. In SIS, we cut the image into vertical strips, reducing the displacement required for viewing. For example, if we piece the image into eight strips, we need one eighth shift to view it. This allows the eye crossing point to be closer to the video plane, which is more comfortable for the viewer. Figure 41-5 Viewing stereograms with four strips the RDS eye crossing point shall be further in front of the video plane (i.e. closer to the viewer) than in the SIS so that the displacement of the visible images is the same image size. In fact, the RDS pair acts as an SIS with two strips. With stereo photography and classic RDS images, viewers must always cross their eyes in front of the video plane. However, in SIS, because the separation of bands is less than the distance between our eyes, there is an alternative, more convenient way to view the image. Viewers can cross their eyes behind the video plane, thus inverting their depth perception, but still creating a 3D image. Figure 41-5 (bottom). The most popular SIS images are generated in a way that can be viewed. 41.2 The creation of a single-image stereogram in SIS is generated from certain depth maps (i.e. grayscale image with depth information) and tile model (usually colour tile image), as in Figure 41-6. Figure 41-6 Input images In Figure 41-7, it is noted that the tile pattern is repeated and deformed based on the depth map. If a random point image is used as a tile pattern, the resulting stereogram is a single-image random dot stereogram (SIRDS). Figure 41-7 Stereogram received 41.2.1 Parameters When creating a new SIS, we must take into account the parameters: the number of bands to be used; depth factor, which may increase or decrease the perception of depth (which in turn controls the deformation applied to the model tiles); and whether to flip the depth values (white can be considered at depth 0 or at full depth 1). Here are some parameters: Number of ribbons (num_strips): integers, usually 8 to 24 Depth factor: The value of a floating point in the range 0.0 to 1.0, with 1.0 means the full depth invert depth: The value of the booleaning value indicating whether the depth values should be inverted (1 - depth) 41.2.2 Rendering To provide SIS, we begin by dividing the depth map and the result image into vertical strips. To simplify this example, we use four strips (num_strips = 4), but really we use SIS more. Then we divide the depth map shown in Figure 41-8 into four strips (num_strips) and divide the result map into five strips (num_strips + 1), because we need a reference bar. Figure 41–8 Image representation This is a pseudocode for sis rendering: select_pattern_texture(); Article draw_strip(0); Article read_strip_to_result_texture(0); enable_fragment_program (); select_depth_texture (); select_result_texture (); for(i = 0; i < num_strips; i++) { draw_strip(i + 1); read_strip_to_texture(i + 1); } disable_fragment_program(); draw_result_texture (); At the beginning of the pseudocode we simply draw the first strip, the texture associated with the tile pattern, as in figure 41-8a. We copy ribbon pixels to the result texture map (using glCopyTexSubImage2D to copy the region you just modified). Then we have a picture of the result, as shown in Figure 41-8b. Then we will enable the snippet app and determine the depth map, the result map, and the depth factor as parameters. We loop, drawing the remaining four strips from the picture of the result. For each strip we draw, we need to copy its pixels to the results texture map, because each new ribbon uses the image of the previous ribbon as a shortcut. Drawing the missing strips from figure 41-8b, we will copy the contents from the previous bar and displace the pixels horizontally to the current depth of the pixels. For example, if the given pixel depth is 0, we'll copy the exact color of the same pixel location in the previous bar. However, for other depth values, we will get a color from the previous strip in places on the same scan line, but proportionally transferred to its depth. Now consider the depth map and the results map images with coordinates from [0,0] to [1, 1]. A certain snippet with coordinates [x, y] uses the following calculations to find coordinates in the previous result map bar from where to get the color: 41.2.3 Creating animated single-image stereograms Since SIS images can be generated in real time using the capabilities of our GPU snippet program, we can now create an animated single-image stereogram (ASIS). We a normal 3D scene made of triangles and will use its z buffer as a depth of SIS depth means that we will make a certain opinion in the 3D scene and read the contents of the z-buffer to the texture of the depth map. Figures 41-9 Figure 41-9 Make animated SIS When we use the z-buffer from a real-time rendered scene as a depth map video source, we can interactively move the 3D scene (or have a predefined camera animation path) and stereogram to update each frame to reflect changes. This creates an animated stereogram in real time (one frame from the animation is shown in Figures 41-10). Figure 41–10 One animated stereogram frame It's hard to visualize an animated stereogram, so look at it first without animation, and when you have a clear image of it, turn on the animation. This is because you need to keep the eye crossing point at the right distance until the image animates so that you can visualize the animated stereogram. Stereograms will make it easier for strangers to search for the correct distance of the eye crossing point with a static view. Figure 41-11 Next image with different color tiles 41.2.4 fragment program list 41-1 shows the snippet program used to generate stereograms we discussed. Example 41-1. Fragment program for stereogram generation struct vert2frag { float4 pos : POSITION; float4 texcoord: TEXCOORD0; }; struct frag2screen { float4 color: COLOR; }; frag2screen main_frag(vert2frag IN, uniform sampler2D resmap, // result map uniform sampler2D depthmap, // depth map // [1.0/num_strips, 1.0/(num_strips + 1)] uniform float2 strips_info, // depth factor (if negative, invert depth) uniform float depth_factor) { frag2screen OUT; // texture coordinate from result map float2 uv = IN.texcoord.xy; // transform texture coordinate into depth map space // (removing first strip) and get depth value uv.x = (IN.texcoord.x/strips_info.y - 1.0) * strips_info.x; float4 tex = tex2D(depthmap,uv); // if factor negative, invert depth if (depth_factor < 0.0) tex = 1.0 - tex.x; // compute displace factor // (depthmap_value * factor * strip_width) float displace = tex.x * abs(depth_factor) * strips_info.y; // transform texture coordinate from result map into // previous strip translated by the displace factor uv.x = IN.texcoord.x - strips_info.y + displace; // assign output color from result map previous strip OUT.color = tex2D(resmap , uv); return; } Example 41.3 The application sample program uses OpenGL and Cg snippet to support the application. It's a simple Win32 program, and the source code is small. To start the program, run the pStereogram file.exe file. To browse the source code, open the pStereogram.dsw file in Microsoft Visual C++. The program uses the application GL_ARB_fragment and should run in any environment that supports this extension. Even the emulator-based snippet of program support will work slowly, but it will work. 41.3.1 Application options there are several options that allow you to generate new and custom-made stereograms. You can load new depth schemes (Ctrl+D), new tile patterns (Ctrl+T), and new 3D geometry (Ctrl +M). Supported video file formats are JPG and TGA. The program supports 3D geometry file formats for 3DS and P3D. On the View menu, you can choose the following options: Texture Filtering (Ctrl+F): This option allows smooth depth ranges. If disabled, the depth values will be continuous and you will clearly see the gaps between the depth levels (e.g. depth stairs). Flip depth (Ctrl+I): This option flips the depth values (1 - depth). It works by inverting the depth of the image values (white turns black and vice versa). Some people feel more comfortable watching stereograms with an eye crossing point in front of the video plane, some after it (as if looking at something inside the monitor). If you see 3D images that enter a video plane, use this option to get the correct image. Depth factor (<, >): This option selects the multiplication factor for depth values. Small factors lead to shallow images. High values make very deep images. The depth factor shall not exceed 1,0 or the artifacts will be generated if the entire available range (0.0 to 1.0) is used on the depth map. Number of strips (–, +): This option specifies the number of strips used. Small values generate fewer strips, but larger ones, while large values generate many smaller strips. This will change how close you are to the video plane you need to cross your eyes to get a 3D image. Generate stereogram: When you select this option, the snippet program is activated to see the stereogram. If disabled, the snippet program is disabled and all you see is the current depth scheme you choose. Depth from 3D grid: This option allows you to animate stereograms. When enabled, the depth map used by the application is acquired from the z buffer currently selected for the 3D eye object mapping. In this mode, you can navigate the 3D scene by viewing the resulting stereogram. Some 3D scenes may contain more than one camera, and some cameras may be animated, so replace the cameras with the number keys: 1, 2, . . You can interactively move around the scene using S, X and arrow keys. You can also rotate the image by clicking and dragging the image with the left-clicking and scrolling the image right-clicking. 41.4 Links TO THE SIRDS FAQ. singlis/sirds.html magic eye website. Thimbleby, Harold W., Stuart Inglis and Ian H. Witten. 1994.3D image display: Algorithms for single-image random pixel stereograms. Journal Computer 27(10), pp. 38-48. Available online copyright Many of the names that manufacturers and sellers use to distinguish their products, When those names are in this book and Addison-Wesley was aware of the trade mark's claim, the names were printed in initial capital letters or capital letters. The authors and publisher have taken care of the preparation of this book, but do not provide any express or implied warranty and assume no responsibility for any errors or misses. No liability shall be taken for incidental or consequential damages arising out of or arising from the use of the information or programmes contained herein. The publisher offers discounts for this book when ordered quantity for bulk purchases and special sales. 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