Stereogram Solver

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Introduction to Computational and Biological Vision project

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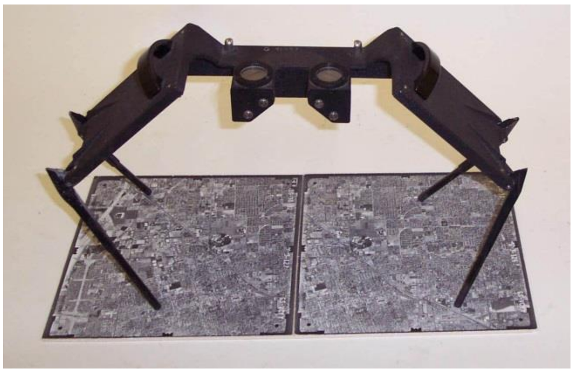
1. Introduction

1.1 What is stereogram image?

Stereogram is a regular two-dimensional image, though by using several technics, the one who observes it can get an illusion of depth, or in other words – see the image as three-dimensional picture.

Originally, stereogram referred to a pair of stereo images, which one could view, using a stereoscope. Nowadays there are many different ways to display stereoscopic images.

The stereogram was first discovered by Charles Wheatstone, in year 1838.
He found an explanation to binocular vision, and that explanation led him to invention of a stereoscope. Based on combination of mirrors and prisms, it enabled people to see three-dimensional images. In years 1849-1850, a Scottish scientist, David Brewster, improved Wheatstone's stereoscope by using lenses instead of mirrors, and by that he reduced its size.



Oliver Wendell Holmes invented a new and improved version of stereoscope, in 1861, that hadn’t   include mirrors at all, and wasn't expensive to produce. These devices were very popular for decades.

Salvador Dali produced some impressive stereograms, in his exploration in a variety of optical illusions. In early 1900, View-Master devices were developed, and gained moderate popularity.

Stereograms were popular again, due to invention of Auto Stereograms on computers. When inside two-dimensional image was in fact hiding three-dimensional object or image,

and the one who observed it, needed to focus his eyes in certain way to see it.
Magic Eye images are fine example to this matter.

1.2 How does it work?

Stereogram is, actually, an optical illusion of depth, in two dimensional images. Here is a little explanation of its creation:
The simplest stereogram is an auto stereogram that is in fact a horizontally repeating model. When viewed correctly, the object in the image seems floating above the background.

For example:

Our brain can almost immediately match hundreds of identical images; in different gaps one from other, and to combine them into one 3D image. In fact, as the gap between two images is smaller, as higher they will float above the background.
Another type of stereogram is Single Image Random Dot Stereogram, or SIRDS. Every single dot is computed based on the depth map, and projected against a series of random dots. Repeating patterns can be used instead of random dots. This way we will get a stereogram that if viewed correctly, will reveal the hiding image or object. There are two important things we need to consider though: the discussed pattern should not have large uncolored areas, and should be as much colorful as possible.

The subtle changes in the distance between stereogram dots can create the illusion of continuous passing in depth. Each color in the depth map is translated to a certain distance between the dots in the final image.
The depth map is very important in the process of producing a stereogram. We cannot create a neat stereogram without using a good depth map.
The mask should be black and white image, when the black area is the background, and different shades of gray dots, are points floating above it. As whiter are the dots, as closer they are to the observer.

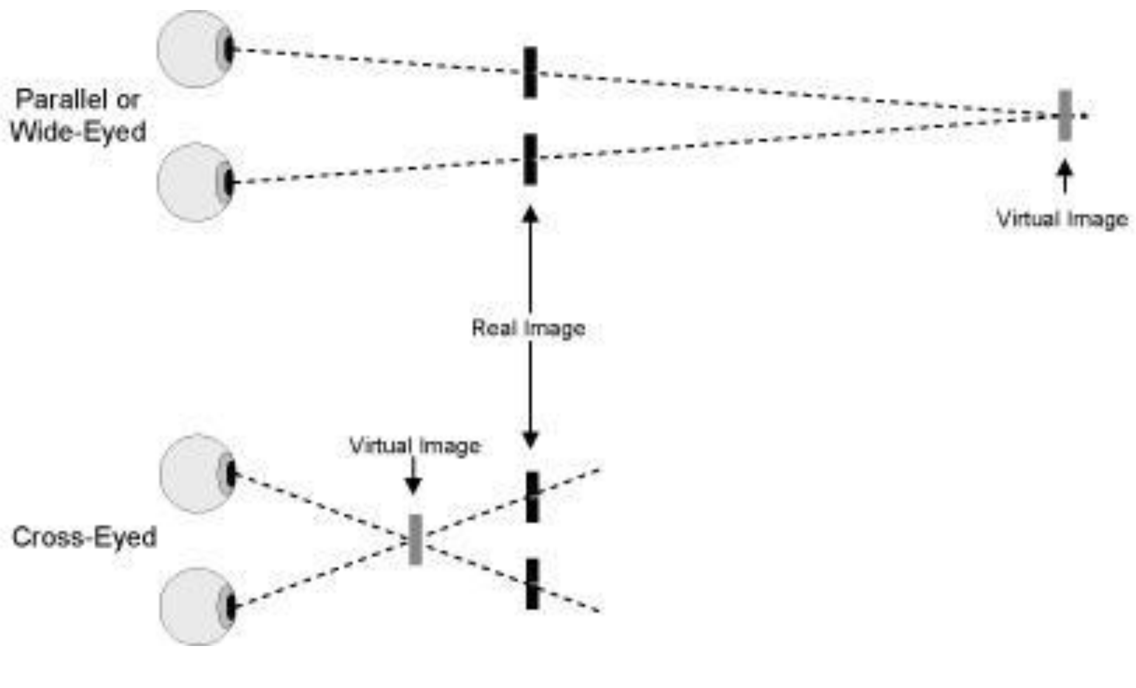
1.3 Methods of viewing stereogram images:

We have two eyes, the distance between them is approximately 15 cm. and that is why when we look at the real world, each eye sees a slightly different picture. The angle of the picture is a bit different through each eye.
Originally, the idea behind creation of stereogram was to project to each eye a slightly different image, our brain receives these two images, and translates them into one image with depth.

There are two methods to view a stereogram:
1. Parallel viewing.

2. Cross-eyed viewing.

Most of the stereograms were made to be viewed by the first, parallel, technique. This method requires that the eyes of the viewer take a relative parallel angle, and focus on some point behind the actual image. While the second, cross-eyed technique, assumes that the viewer focuses on some point in front of the actual image. The reason it is called this way, is because the one who uses it, would cross his eyes to focus them like that.



Not every person can see these illusions. People with some disabilities in one (or two) of their eyes, won't be able to see the 3D image. Some of us can easily find the hiding object in the stereogram, though most of the people have to train their eyes to see it.

2. Project

2.1 Goal:

Given a stereogram image, the solver will compute and output a two-dimensional image, with black background and colorful shape of the 3D object, hiding in the input image.

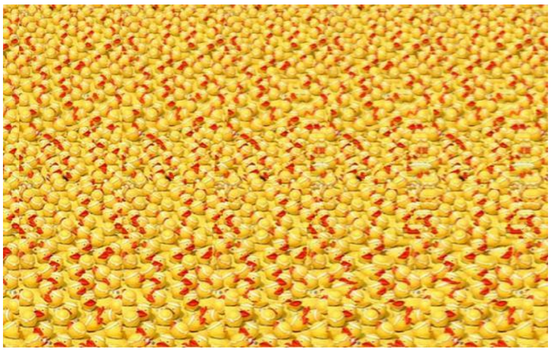
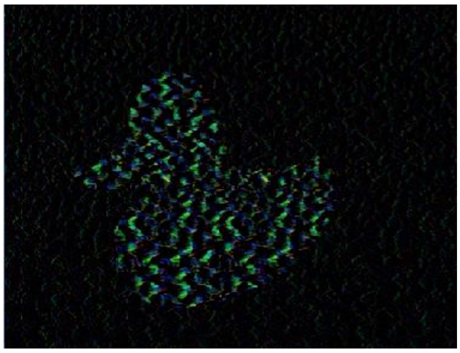
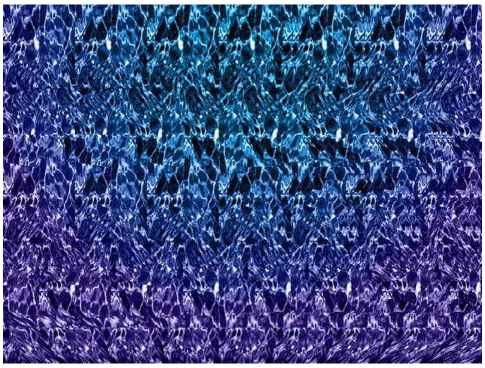
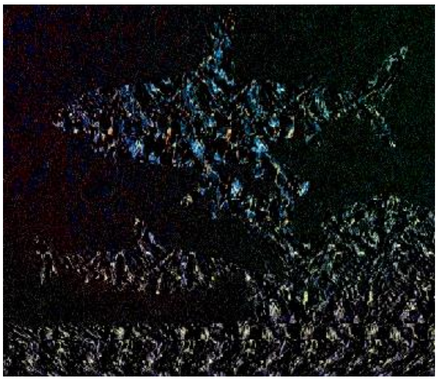
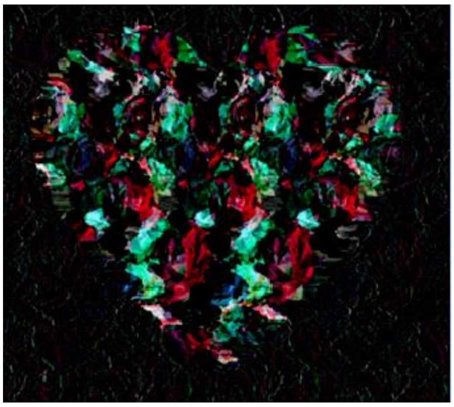
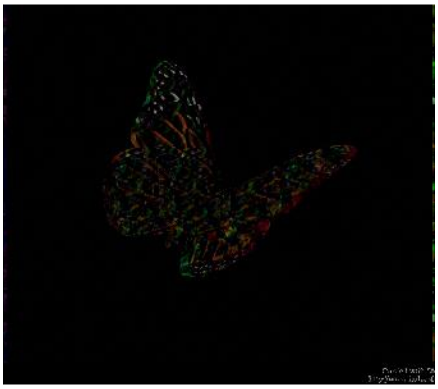
2.2 Approach and Method:

My approach was letting the program resemble the function of human eyes, in other words, perform the parallel viewing technique.
Presenting the main stages of the program:
1. Receives a stereogram image as input, and duplicates it once, to get two identical images, A and B.
2. Loops (n-0.35n +1)times: Takes k columns of pixels from the right side of image A, and the same amount of columns from the left side of B (k starting from 33% of the whole image to 98% of the image) and calculates |A – B|.
3. Filling up the array, that holds all the differences from the previous step, each difference itself is k columns of subtracted pixels.
4. Searches through the array of differences for the optimal difference m (which has the maximum of pixels, closest to black. Meaning pixels with value lower than 50, a threshold which I found fitting).
5. Restores the m's difference and displays it to the user (m – is actually the output image, in which was found maximum of black (or close to black (close to zero)) pixels, that represent the background of the 3D image).
* To run the program, Matlab should be installed.

2.3 Conclusions:

Human eyes go through a similar process, but much more complicated. For example, my solver won't be able to recognize continuous depths, because there is not only one focusing point in those stereograms and the iteration that returns the maximal m (as we discussed before) won't give concrete image, it would be blurry instead. Despite this, human eyes will be able to do it, because as we move our eyes through the image, they will continue focusing again and again.

2.4 Results:

3. References:

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