Popims 3D Video

PATENTED TECHNOLOGY

February 21. 2011

I) Abstract

Popims 3D Video technology combines a standard RGB screen with an array of spherical lenses that are organized as a honeycomb. The innovation stands in the organization of red, green and blue sub-pixels constituting the RGB structure of the electronic screen.

It brings three major advantages to auto-stereoscopic 3D video (3D without glasses).

1. Higher perceived resolution

   For N points of view (N different images displayed simultaneously by the electronic screen), the original resolution of the screen is not divided by N as it is with conventional cylindrical lens arrays, but by N/2. This is made possible by the fact that spherical lenses are focusing on a smaller surface than cylindrical ones.

   The improvement is so important that it is no more necessary to remove the lenses array for 2D vision.

2. Superior image discrimination

   Cross-talking is completely eliminated, as sub-pixels focused by the spherical lenses all belong to the same image (cross talking happens when one eye is viewing at least partly some pixels belonging to another image than the ones strictly belonging to the image to be viewed).

3. Pivot function

   The same electronic screen produces the 3D effect in the landscape and in the portrait modes. Tilting the device 90° is sufficient to switch from one mode to the other. This does not require any mechanical component, as spherical lenses work in all directions.

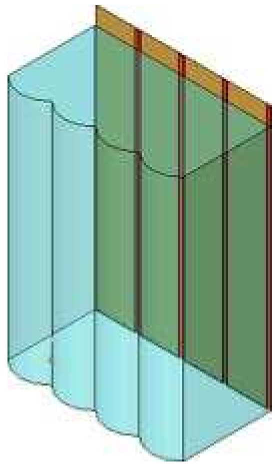
Optionally, a very simple mechanical device can restore the original resolution of the RGB screen when viewing 2D images or videos (necessary for large size screens).

II) Prior art

The basis of auto-stereoscopic 3D display (without glasses) consists in hiding some pixels of the electronic screen to one eye, and some others to the other eye, so that each eye of the spectator sees a different view of the scenery.

In the prior art the hiding device is constituted either by cylindrical lenses or by parallax barriers that may be electronic (liquid cristal).

A. Cylindrical lenses



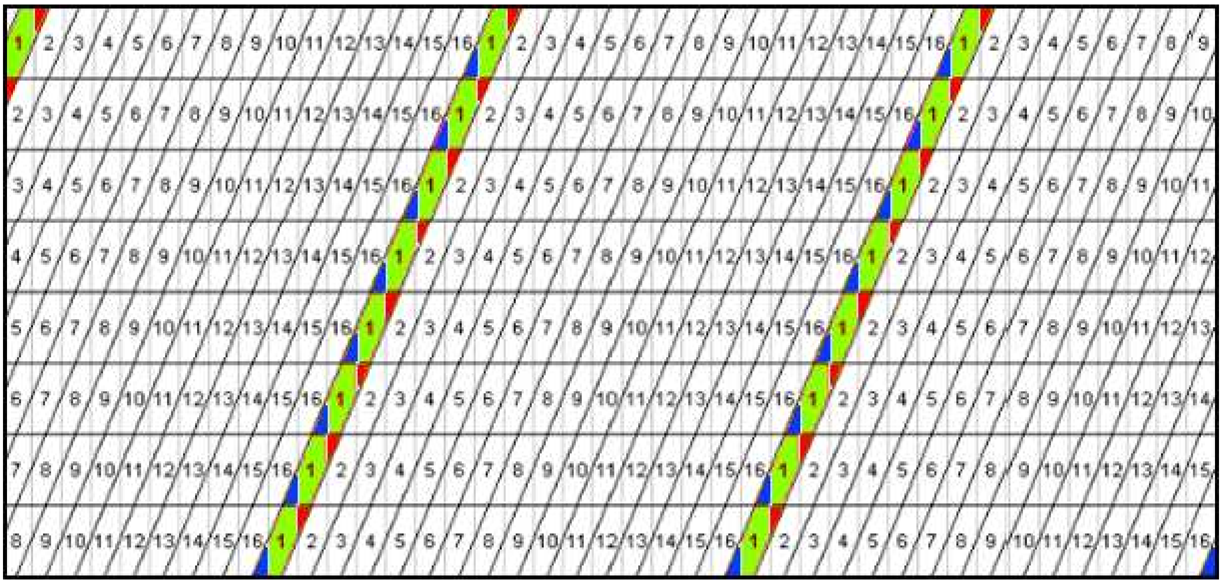
The principle of lenticular display, usually attributed to Gabriel Lippmann, can be applied to RGB screens.

It has been improved by Pierre Allio who had the idea to focus lenses not on whole RGB pixels but on one a third of their surface, a red, green or blue sub-pixels, each image proposed to the viewer being composed of successive red, green and blue columns of sub-pixels constituting colored triplets that are valid for additional color synthesis.

A second improvement was brought by Philips who proposed to slant the cylindrical lenses with respect to the underlying pixel grid, with the result of increasing the perceived resolution.

This solution, which is now used by nearly all 3D screen manufacturers, has an important disadvantage: the focusing line of a slanted cylindrical lens crosses sub-pixels that are horizontal and/or vertical neighbors of the targeted one, except in a unique position when that line crosses the pixels separations at the rectangle sub-pixel angles. This is possible for only a very limited number of the spectator's position, and it must be seen that slanting the cylindrical lenses leads to cross-talking (mixing images corresponding to different points of view).

The diagram below shows in red and in blue the zones that are visible through slanted cylindrical lenses and that do not belong to the image which is to be seen from a specific direction (here image 1). Zones colored in red belong to image 2 and zones colored in blue to image 16.



Focusing zones are enlarged on the diagram to show better the different zones, but it is clear that a thinner focusing zones do lead to the same disadvantage.

Cylindrical lenses arrays have another disadvantage, which is that the 3D resolution of a screen (the one which is perceived by the spectator) is much lower than the one of the original 2D screen. If N is the number of images to be viewed successively when moving around the screen, the number of visible sub-pixels is divided by N.

One can see on the above diagram that the resolution is determined by the horizontal distance between two lenses. For a given number of images, this distance is lower when the lenses are slanted, but the 3D resolution R_{3D} (expressed in dots per inch DPI or in pixels per cm) remains quite low as determined by the following formula: $R_{3D} = R_{2D} / (N \times \cos(A))$ where R_{2D} is the 2D resolution **N** the number of images, and **A** the angle between the vertical and the cylindrical lenses axis.

The best possible value of the **A** angle is ATAN(1/3) which has a cosine equal to 0.95. This means the advantage of slanting the angle remains limited. For a stereoscopy (2 images), the best possible value of R_{3D}, which the resolution perceived by the viewer, is given by this formula as 53% of R_{2D}. For 4 images, it is lowered to 26% of R_{2D}.

B. Electronic barriers

The principle of the parallax barrier has been invented by Auguste Berthier.

Using elongated barriers have the same disadvantages as those described above for these types of lenses.

Electronic barriers can be created electronically with liquid crystals; and have the advantage that one can switch the barrier on and off. Sharp has manufactured 3D screens based on this principle.

More recently, Eun Song improved this idea by suggesting using electronic barriers that could be coded in two different ways, for maintaining the barriers as vertical lines (or slightly slanted equivalents) when the screen is moved from the landscape or portrait position to the other one.

There is another disadvantage which is that all types of barriers transform light into heat. This limits the final luminosity of the device and/or increases the electricity consumption. It is not adapted to portable devices as, for a given required luminosity, it shortens very significantly the duration of the batteries.

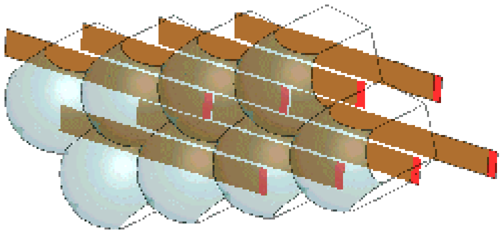
III) Popims 3D Video

The basis of our technology is explained in our WO9820392 patent : the screen comprises a plurality of juxtaposed optical elementary devices, each of said optical elementary devices comprising an elementary lens and an elementary image situated in register with said elementary lens so that a spectator can see at least a portion of the elementary image through said elementary lens, the portion of the elementary image seen depending on the position of said spectator relative to the elementary lens.

This is the exact claim 1 of this patent which is already delivered in many countries including the United States of America.

Some patented 3D video devices based on electronic barrier cannot be made without infringing this patent.

Lenses are no more cylindrical but spherical, which leads to three very important advantages:



1. All the advantages of lenses compared to parallax barriers, in terms of luminosity and electric consumption.
2. A much greater number of images than with cylindrical images, which leads to more 3D power for a given perceived resolution, or a better perceived resolution for a given 3D power (On the diagram on the right, the width of each lens is similar to the one of the cylindrical lenses shown above, at the prior art description, and for this reason, the resolution perceived by the viewer is also the same, but the number of images that can be

seen is much greater, as it is proportional to the width of each brown line located behind each lens).

3. The possibility to use the same screen, without any mechanical transformation, in the portrait and landscape modes.

IV) How it works

Our method can be implemented using spherical lenses arrays or equivalent parallax barriers (a mix of transparent and opaque surfaces) that may be painted or electronic (this enables the suppression of the barrier in case of 2D vision).

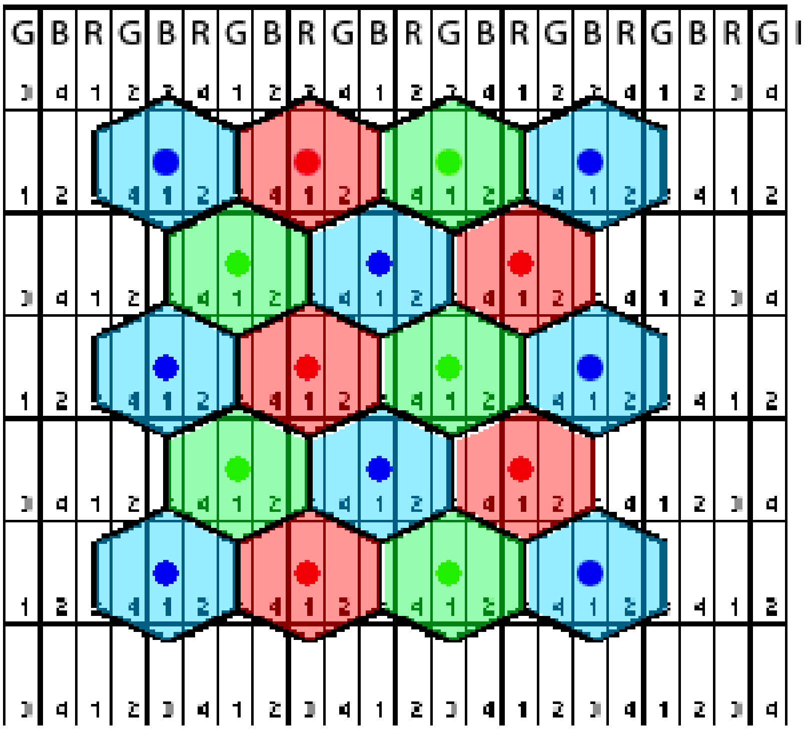
In all cases, the distance between lenses that are located at the same height is equal to the width of a red, green or blue sub-pixel, multiplied by the number **N** of different images produced by the display.

The best 3D resolution is obtained when the next horizontal line of lenses is offset horizontally by the distance between **N/2** sub-pixels, as shown below. In that case, the number of lenses in register with a sub-pixels column is the double of the number of lenses in the prior art, which doubles the perceived resolution.

Spherical lenses have the advantage of focusing on one point (while cylindrical ones focus on a line). As a consequence, all focused points belong to only one image corresponding to only one point of view. This is the end of cross talking.

Pivot function is obtained naturally because spherical lenses work the same way in all directions. The method requires a specific geometry of lenses which is described below.

Here is an example called “HEXA 4” because it enables viewing 4 different images when sub-pixels are vertical rectangles, which is the case for an iPad or a standard PC, and for the portrait mode of an iPhone.



The viewer, when moving from right to left, views successively images 1 to 4, constituted by dots noted 1 to 4 on the above diagram.

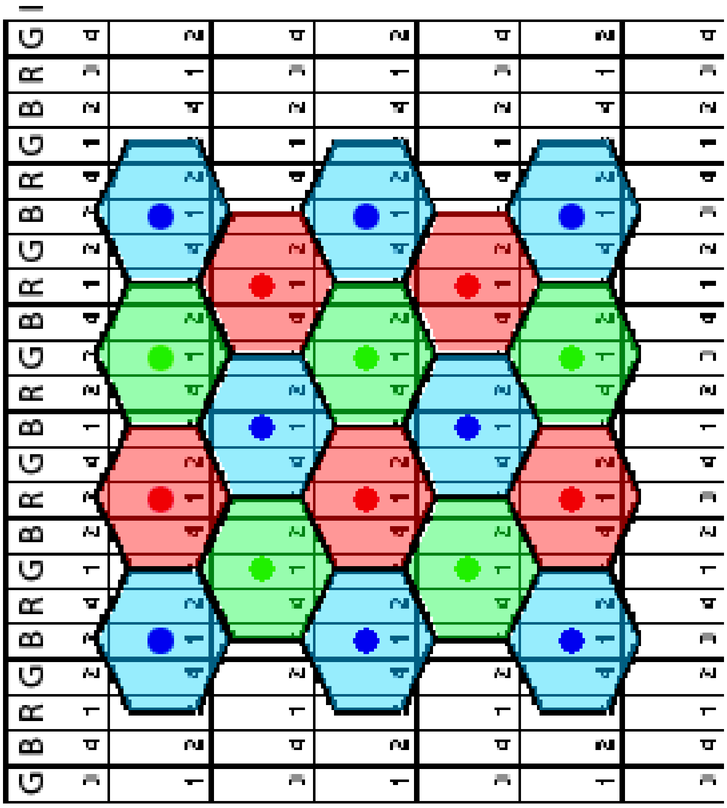
At the distance for which the device has been conceived, two eyes may view the following stereoscopic couples: 1+3, 2+4, 3+1 or 4+2. Two of these couples are correct and two are inverted.

The distance between lenses that are located at the same height is equal to the width of a red, green or blue sub-pixel, multiplied by 4 as **N = 4**.

The next horizontal line of lenses is offset horizontally by the distance between **N/2 = 2** sub-pixels. One can see that the number of lenses columns is the double of the number of cylindrical lenses in the prior art, which effectively doubles the perceived resolution.

Darker colored discs show the focusing zones of lenses. All discs belong to only one image corresponding to only one point of view.

Pivot function is obtained naturally by rotating the whole product up to the position shown below, which corresponds to the portrait mode for an iPhone and to the landscape mode for an iPad or a standard PC.



This situation corresponds to the landscape mode for an iPhone and to the portrait mode for an iPad or a standard PC, enables displaying a stereoscopy. There are only two different images displayed: one with sub-pixels 1 and 2, and the other with sub-pixels 3 and 4. At the distance for which the device has been conceived, two eyes may view the following stereoscopic couples: 1+3, 2+4, 3+1 or 4+2. Two of these couples are correct and two are inverted.

In that recommended implementation, the display algorithm may be the same for both modes: displaying one image with pixels 1 and 2, and the other with pixels 3 and 4.

In both cases, a very important advantage of this organization is that red, green and blue sub-pixels constitute pixels having the shape of triangles that are almost equilateral. There are two ways for coding an image with such triangular pixels : either coding a pixel with three chosen sub-pixels, or coding each pixel as a whole pixel, forgetting two color components of each pixels.

This seems mysterious, but it does work extremely well. To be convinced, one may have a look at the animation on the Popims web site : http://www.popims.com/images/data/hello.gif. It shows the same image viewed with standard pixels and with “HEXA” pixels using this method.

We recommend the second method, which gives birth to a very high number of uncompleted pixels: ¾ of the original number of pixels of the 3D screen, 75% of **R_{2D}** (to be compared with the 26% which is the value corresponding to cylindrical lenses) : <u>3 times better</u> !

With such a performance, viewing 2D images is perfect even with the lenses array remaining present. In fact, the 2D perceived resolution (with the two eyes), remains at least equal to the one of the one of the electronic screen without the lenses array.

To view correctly the stereo, the viewer has to stand right in front of the display, and HEXA 4 is appropriate only for small screens (phones, tablets, camera, etc.).

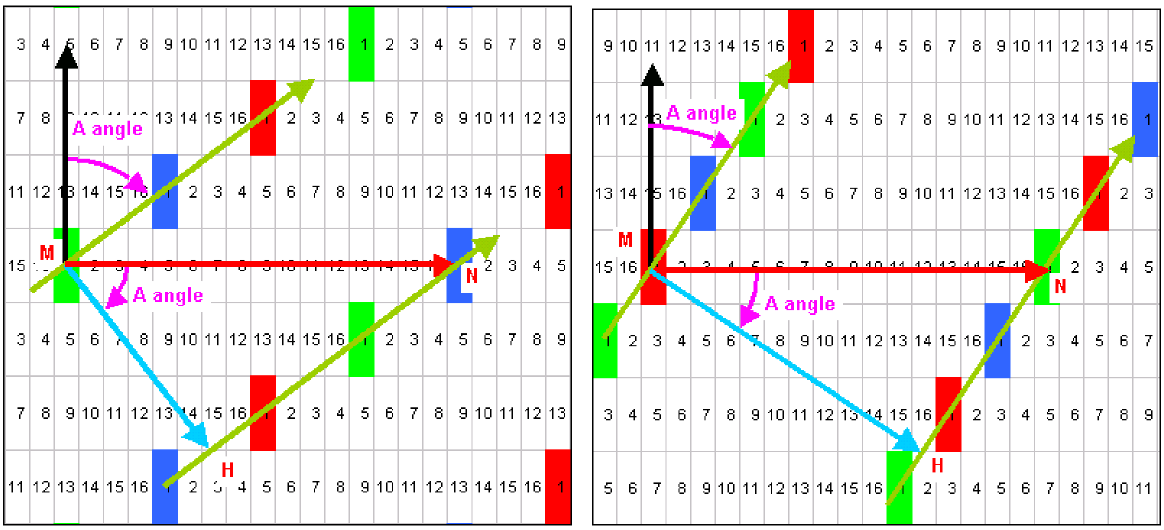
HEXA 4 constitutes therefore a very good solution for these products, and we strongly believe it will become the standard for all small screens.

For wider screens, the method works all the same, but with different lenses sizes as it is then necessary to display more different points of view.

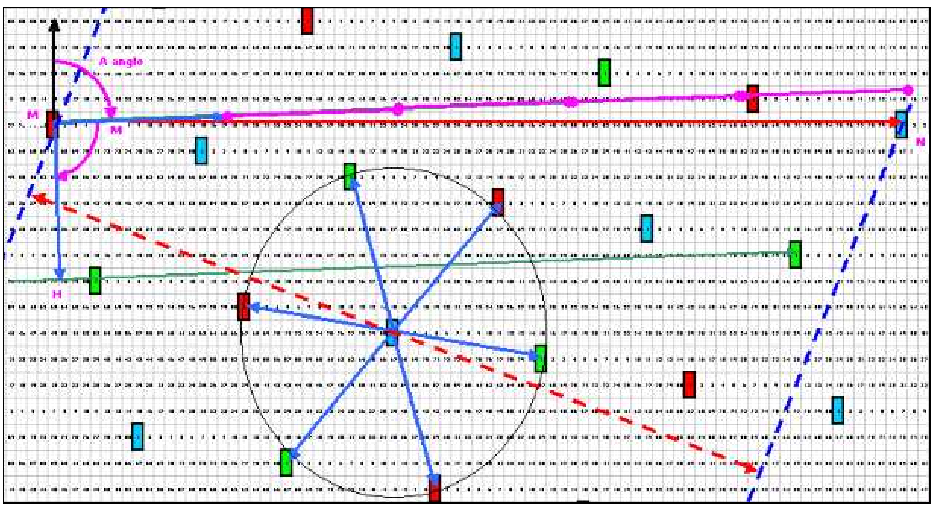
Below are two examples showing how lenses can be arranged for 3D television screens proposing a high number of different points of view.

On the left diagram, the A angle is high and the resolution also high, Another advantage of such a high A angle is that the screen can here also be tilted from the landscape mode to the portrait mode without having to modify the lenses array.

On the right diagram, the A angle is less. It can be lowered to ATAN(1/3) as for cylindrical lenses.



The following diagram shows how keeping the HEXA organization for very high numbers of images.



A slight modification of the position or of the structure of the lenses array is sufficient to eliminate its effect, i.e to push it closer to the electronic screen, which prevents the lenses to converge on a sub-pixel. This becomes necessary when the number of displayed images is high, which is the case for large size screens.

V) Manufacturing

All that is necessary is to use a lenses array in place of the electronic screen protection window. Lenses may be located on the front part or on the rear part of the window. This means that the cost for a 3D screen is nearly the same as for a standard 2D screen.

Many techniques are known that can be used to produce such lenses arrays, including injection molding, or embossing.

Popims team has developed a complete new technology which allows to create glass arrays, that are more adapted than plastic ones to large size screens, as glass has a better dimensional stability in case of heat or humidity variations. This technology consists in printing lenses with varnish (visit http://wwww.popims.com to get more information about this).

VI) Applications

There are many applications including 3D photography and video, medicine, office work and presentations, 3D games, amusement, enhanced reality.

VII) Industrial property

Bidirectional auto-stereoscopy devices are protected by WO9820392 which is issued in several countries, and by FR/10-04144 (22-10-2010).

VIII) Licensing

Popims proposes worldwide non-exclusive patent, know-how and software exploitation licenses to all manufacturers of products comprising an electronic screen, such as television sets, personal computers, tablets, cell phones, cameras, medical equipments, displays, etc., and to software companies.

Who we are

Popims is an independent international R&D team, involved since 2001 in display and lighting technologies, including:

- SphericalLenses: a patented video and still image coding system using spherical lens arrays (WO9820392), injection molding of such lenses arrays,
- LensPrinter: a 3D/animations direct printing technology (lenses may be printed together with coded images)
- Micro-Lenses: micro-lenses manufacturing technology for LCD screens,
- OptoElectronic Boards: printed optical elements such as micro-lenses, optical fibers, optical fiber layers, beam concentrators, beam re-orienters, switches and connectors, etc.,
- Projection Screens: printed micro-lenses that reflect the light in specific directions,
- Retro-projection Screens that filter the light of the sun when used outside,
- Light Collimators: a complete new method which diminishes dramatically the space used by a light collimator and allows a much more efficient beam concentration,
- Micro-mirrors lighting: the light is introduced into a light guide along the backside of the guide through Popims light collimators assembled in parallel, and then divided by micro-mirrors into multiple beams that are in turn concentrated by one or more convergent lenses. It is the collection of these organized micro-beams that is used to send the light exactly where required – applications are retro-lighting devices and lighting apparels,
- Stable Image Acquisition: a new method for acquiring all types of still images or video, including using a telephoto objective without any tripod, and/or creating panorama images from multiple pictures,
- 3D Video : the future standard for 3D video screens without glasses,
- Software: 3D imaging software: free & prof. versions of Popims Animator, instant 3D portraiture, Popims RIP, Popims 3DMoiré generator).

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Keywords

Flat panel displays : 3D TV; 3D imaging ; autostereoscopic ; multi-view ; pivot ; tridimensional image ; luminance ; Landscape ; portrait ; liquid crystal displays ; optical elements ; display equipment ; three-dimensional displays ; stereoscopy ; tablet ; phone ; camera ; pc ; iPhone ; iPad ; Popims.