

DESCRIPTION

TITLE OF THE INVENTION: AUTOSTEREOSCOPIC SCREEN, DEEMED TO BE OF PHOTOGRAPHIC QUALITY

5 1. Technical field of the invention

The invention relates to an autostereoscopic screen and a method for displaying an autostereoscopic image on such an autostereoscopic screen.

2. Technological background

10 Autostereoscopy is a technique enabling the three-dimensional display of images without requiring the wearing of special glasses by the viewer. This technique is known per se, in particular from the patents WO2006/024764, WO2014/041504, WO2013/140363, WO2014/016768, WO2019/063897, WO2019/207235, WO2022/175053 in the name of the applicant.

15 An autostereoscopic image is generally formed from a plurality of strips of interleaved elementary images, each corresponding to views of the same object or of the same scene from different viewpoints. A selecting device, typically formed by an array of cylindrical lenticules or a parallax barrier, is disposed in front of the display screen so as to enable the projection of a pair of elementary images corresponding to two different viewpoints of the scene, towards the two eyes of
20 the viewer respectively, which creates an impression of three-dimensionality in the viewer's brain.

25 The applicant has already proposed an autostereoscopic screen for displaying an image with N viewpoints, comprising a matrix of pixels arranged by rows and by columns, each pixel being composed of a plurality of sub-pixels of different colors. Furthermore, the screen is surmounted by an array of identical cylindrical lenticules each having a focal distance configured to be able to reflect to infinity the light rays coming from the screen. The pitch of the array of cylindrical lenticules is precisely calculated so that, at a predetermined distance from the screen, the viewer sees the images in succession by virtue of a

magnifying glass effect of the lenticule array.

This magnifying glass effect results from the fact that a lens placed at the correct distance (its focal distance) enlarges the sub-pixel(s) which is/are located in alignment with its optical axis and with the pupil of the eye of the viewer. If the lens enlarges N times, the sub-pixel(s) seen through the lens is/are perceived N times larger than it/they is/are in reality and masks for the eye which receives light therefrom through this lens the N-1 other sub-pixels which are not in the alignment described above.

Even the principle of the lenticular array does not make it possible to offer to the viewer a continuous parallax of the scene represented through an angle of 180°. The angle of observation is thereby subdivided into strips called “lobes”, within which, on the one hand, the parallax is discretized. In each lobe it is possible to see the N viewpoints in succession. When one lobe is exited, the succession of the N identical viewpoints is found in the following lobe, and so on across the whole width of the observation zone of the screen. The angular width of the lobes is defined both by the pitch of the lenticular array and by its focal distance.

Autostereoscopic screens necessitate the sub-division of the lobes into discrete sub-parts which are perfectly clear to see, the individual width of which in the lobe cannot exceed the average interpupillary spacing, which is 6.5 cm.

Therefore, one of the keys to the performance of the autostereoscopic screens currently proposed by the applicant is control of the resolving power of the optical components which are developed specifically for each panel of pixels.

For printed autostereoscopic photographs (and not autostereoscopic screens) it is possible to inscribe a maximum of printing points or dots, contiguous but well differentiated from each other, on media offering good dimensional stability. By virtue of the printing techniques currently used, the applicant manages to print 100 points per millimeter and sometimes even more, which equates to seeing points of 10 microns or less.

When the viewer moves in front of such a photograph, he sees the different elements of the scene moving with respect to each other in a continuous manner

and perfectly in accordance with the original physical volume as it would be perceived if it were seen at the same distance. The two eyes see two different viewpoints of the scene simultaneously, which enables the brain to recreate a perfectly natural feeling of three-dimensionality.

5 It is impossible, a priori, to find the quality of autostereoscopic photographs with screens insofar as these screens are formed from a matrix of pixels of greater or lesser resolution, composed of rows and columns aligned orthogonally and separated from each other by a black surround composed of opaque rows and columns of greater or lesser thickness according to the panels
10 and which form a grid pattern around the active zones of the pixels. The surface ratio between the black surround and the colored active sub-pixels has an impact on the luminosity and the contrast of the screen but also on its autostereoscopic resolving power.

 Throughout the text, the autostereoscopic screen is considered to have a
15 photographic quality when it makes it possible to eliminate discrete jumps during passage from one stereoscopic pair to another, in the parts of the image where the disparity is greatest.

 In other words, “photographic quality” is understood to mean a continuity in the three-dimensionality within the lobe, which seems, a priori, inaccessible to
20 an autostereoscopic screen without equipping it with a tracking system.

 The problems relating to moirage arise in addition to those relating to the resolving power. In fact, the lenticular array enlarges both the active zones of the panel of pixels and the black surround around them. This results in some sub-parts of the observation lobe being able to appear darker or lighter than others. These
25 variations in luminosity are generally perceptible at the transition between two neighboring viewpoints. The moirage effect of light intensity varies according to the particular structure of the panel and the orientation of the screen.

 The inventors have sought to overcome the technical bias of the person skilled in the art, according to which it would be impossible, a priori, to find the
30 quality of a photographic autostereoscopic image (characterized by continuity in the three-dimensionality within the lobe) with a screen having a panel of pixels.

3. Aims of the invention

The invention aims to provide an autostereoscopic screen deemed to be of photographic quality.

In particular, the invention aims to provide an autostereoscopic screen
5 which makes it possible to obtain a continuum of the parallax without perceptible discretization of the viewpoints.

Thus the invention aims to provide, in at least one embodiment, a screen which offers a continuous parallax feeling in each lobe.

The invention also aims to provide an autostereoscopic screen without
10 notable moirage or ghosting.

The invention also aims to provide a screen deemed to be of photographic quality irrespective of the structure of the sub-pixels of the panel of pixels of the screen (vertical or horizontal sub-pixels).

Finally, the invention aims to provide a method of displaying an
15 autostereoscopic image on a screen in accordance with the invention.

4. Description of the invention

In order to do this, the invention relates to an autostereoscopic display screen, deemed to be of photographic quality, for an autostereoscopic image with $M \times N$ viewpoints ordered from 1 to $M \times N$, N being an odd integer strictly greater
20 than 1 and M being an integer selected from 1, 2, 3 and 6.

The screen in accordance with the invention comprises a panel of pixels arranged by rows and by columns, each pixel being composed of a plurality of P active sub-pixels of different colors and opaque inactive zones forming a portion of black inter-row areas and/or inter-column areas of said panel.

25 The screen in accordance with the invention is characterized in that it further comprises an ordered array of cylindrical lenses mounted on said panel of pixels, each lens being inclined with respect to the columns of the screen by an angle equal to $\arctan(1/12)$.

Furthermore, said array has a pitch of $N/2$ pixels in width and makes it
30 possible to differentiate the even and odd lenses of said ordered array by distinct

distributions of the active zones of pixels and black zones of the panel arranged under each even and odd lens.

Furthermore, the array makes it possible to decode each of the $M \times N$ viewpoints distributed within N vertical blocks 6 pixels in height from M viewpoints (6/ M pixels per viewpoint), with a periodic iteration of each block on the axis of a lens every 12 rows if the sub-pixels of the panel are horizontal, and distributed within $P \times N$ vertical blocks 6/ P sub-pixels in height, from M/P viewpoints (6/ M sub-pixels per viewpoint), with a periodic iteration of each block on the axis of a lens, every 12/ P rows if the sub-pixels of the panel are vertical.

In other words, the screen has the feature of making it possible to encode on the panel extending under the lenses each of the $M \times N$ viewpoints with 6/ M different vertical pixels within N vertical blocks 6 pixels in height which are repeated, under each lens, every 12 rows if the sub-pixels of the panel are horizontal, and with 6/ M different vertical sub-pixels within $P \times N$ vertical blocks 6/ P sub-pixels in height which are repeated, under each lens, every 12/ P rows if the sub-pixels of the panel are vertical.

The array is configured to decode, by a magnifying glass effect, each of the $M \times N$ viewpoints encoded according to the principle set out above.

The screen in accordance with the invention also has the feature of being equipped with an array of cylindrical lenticules, each inclined with respect to the columns of the screen by an angle equal to $\arctan(1/12)$, i.e. by an angle of the order of 4.76° . The “arctan” function refers to the arctangent. The arctangent of a real number is the value of an oriented angle, the tangent of which equates to this number.

The screen also has the feature of having a lenticular array configured to make it possible to distribute, under each lens, the viewpoints over 12 consecutive rows if the sub-pixels are horizontal and 12/ P consecutive rows if the sub-pixels are vertical.

Throughout the following, and in order to simplify the terminology, “horizontal mode” or “horizontal version” of the screen refers to the screen formed of horizontal sub-pixels and “vertical mode” or “vertical version” of the

screen refers to the screen formed of vertical sub-pixels, it being understood that this does not indicate the portrait or landscape orientation of the screen. The horizontal mode and the vertical mode characterize only the orientation of the sub-pixels and not the portrait or landscape orientation of the screen.

5 Throughout the following and, unless stated to the contrary, in order to simplify terminology, “pixel” refers to the active zones of the pixel which make it possible to address the content and “black space” refers to the opaque inactive zones of the pixels which form the inter-row areas and/or inter-column areas of the screen.

10 In horizontal mode, with an inclination of 4.76° , each lens of the lenticular array traverses a group of elementary vertical blocks of 6 pixels, then a black space, before meeting a new group of elementary blocks of 6 pixels. It should be noted that all the matrices of pixels have a black opaque zone between each row of active pixels but this row, a constituent part of the pixel, makes it possible,
15 according to its percentage in the pixel, to benefit from a good resolving power.

 Since N is an odd integer, the ordered array of the screen has a non-integer pitch $N/2$, which makes it possible to differentiate the even lenses and the odd lenses by at least partially therein setting the distribution of the light zones (active zones of the pixels) against the distribution of the black zones (opaque zones of
20 the pixels) of the screen. In other words, if the lenses of the ordered array are numbered, from the left of the screen to the right of the screen, the panel of pixels under the even lenses has the same distribution of the zones of active pixels and of the black zones of the screen, and the panel of pixels under the odd lenses of the screen has the same distribution of the zones of active pixels and of the black
25 zones of the screen, the distribution of the even lenses being distinct from the distribution of the odd lenses of the screen. If the portion of the panel of pixels under an even lens were superimposed with the portion of the panel of pixels under an odd lens, it would thus be noted that at least a part of the dark zones of the panel under the even lens is facing at least a part of the active zones of the
30 panel under the odd lens and at least a portion of the active zones of the panel under the even lens is facing at least a portion of the dark zones of the panel under

the odd lens.

For an array of $11 \times M$ viewpoints (N is equal to 11), the lenses have a pitch of 5.5 pixels in width (in the non-simplified definition of the pixel). For an array of $7 \times M$ viewpoints (N is equal to 7), the lenses have a pitch of 3.5 pixels in width.

5 The array of the screen in accordance with the invention makes it possible to decode by a magnifying glass effect each of the $M \times N$ viewpoints distributed within N vertical blocks 6 pixels in height from M viewpoints ($6/M$ pixels per viewpoint), with a periodic iteration of each block on the axis of a lens every 12 rows if the sub-pixels of the panel are horizontal, and distributed within $P \times N$ vertical blocks $6/P$ sub-pixels in height, from M/P viewpoints ($6/M$ sub-pixels per viewpoint), with a periodic iteration of each block on the axis of a lens, every 10 12/ P rows if the sub-pixels of the panel are vertical.

15 In the horizontal version, the advantage of having vertical blocks (also referred to by the terminology of elementary blocks) of 6 pixels is that of offering the alternative of allocating the same viewpoint or even different viewpoints to each of these pixels.

20 When the scene represented is shallow, this poses little problem in displaying the same viewpoint, referred to as principal viewpoint, over the 6 consecutive pixels of an elementary block.

25 On the other hand, the perceived quality deteriorates when the disparity is greater. The perfect focusing of the arrays then brings about a clear perception of the discretization of the content at great depth or strongly protruding content and this impairs the photographic experience (continuous parallax) being targeted. When the horizontal translation of a contrasted detail in the image exceeds 2 or 3 lenses during a change in viewpoint, the discretization is excessive and it thus becomes indispensable to increase the number of viewpoints. Although this is effected to the detriment of the initial resolution of the principal viewpoints displayed, the improvement in the perceived quality is obvious.

30 If a slightly different viewpoint is allocated to each of the 6 pixels of each elementary block, the discretization disappears in the scenes with strong

disparity.

The screen in accordance with the invention thus makes it possible to display viewpoints, referred to as intermediate viewpoints, between the N principal viewpoints of the image to be displayed. These intermediate viewpoints
 5 are slightly shifted between each principal viewpoint in order to distribute them within each elementary block. The continuum between the successive principal viewpoints creates an effect of depth of photographic field in the far backgrounds and the strongly protruding foregrounds instead of an ostensible discretization.

In other words, the screen in accordance with the invention is remarkable
 10 in that it makes it possible to use groups 6 pixels in height per principal pixel (of which it forms part) in order to encode slightly different viewpoints in order to fill by a continuum the discrete succession of the principal viewpoints in order to come close to the quality of the autostereoscopic photographic images.

By virtue of this novel approach, which we refer to throughout the text as
 15 “tiling effect”, the objective being targeted of finding on a screen the continuity of the parallax of printed photographic images is achieved.

In particular, in a three-dimensional image, the disparity between viewpoints is accentuated as one moves away from the plane of the screen (also referred to as collimation plane). The overlap between common viewpoints,
 20 referred to as “crosstalk”, is identical over the whole screen and it affects the whole of the displayed image but is only revealed in the parts of the image where the disparity between viewpoints is great.

In particular, the inventors have realized that photographic blurring is potentially information associated with three-dimensionality, but also the
 25 materialization of the depth of field. The inventors have thus sought, contrary to the bias in the technical field, to cause the depth or protrusion in an image to materialize by progressive fade and not by discretization between viewpoints. The overall impression being targeted is that of a deep and continuous image, in which the fade between viewpoints is accentuated as the objects move away from the
 30 collimation plane, assimilated as the focusing plane.

The discretization between viewpoints thus materializes when identifiable

details in the image are repeated a number of times. When the disparity in a scene is great and the number of viewpoints insufficient to distribute it harmoniously between each, it is often the case that contrasted objects far from the collimation plane are degraded by the perception of ghosting.

5 A contrario, the deep details of a number of viewpoints can overlap simultaneously, with attenuation of the intensity and of the contrast in the redundancy perceived as one moves away from the central viewpoint, thus, a single object is reformed visually even if its image remains a little blurred.

10 The screen in accordance with the invention offers the possibility of adapting the number of viewpoints displayed (by modifying the value of M) according to the disparity in the image, both in depth and protrusion, with the ghosting of the details at the limits of the volume being the determining factor. This novel screen offers the viewer a continuous parallax within the lobe, without apparent discretization but with, instead, progressive fading of the details as the
15 limits of the volume are reached.

 This approach runs contrary to the screens proposed thus far, in which the aim was to seek perfect discretization of the viewpoints and this was considered to be the path to follow in order to provide a high-quality screen.

20 Advantageously and in accordance with the invention, each pixel of said panel of pixels is composed of a plurality of P horizontal sub-pixels of different colors juxtaposed on each other in the direction of the columns, so as to be able to encode each of the $M \times N$ viewpoints with $6/M$ different vertical pixels, which are repeated, under each lens, every 12 rows, M being equal to 1, 2, 3 or 6.

25 In other words, the screen in accordance with the invention makes it possible, in the horizontal version, to display as desired:

- N principal viewpoints, each encoded with 6 different contiguous vertical pixels (M being equal to 1 in this case),
- $2 \times N$ viewpoints each encoded with 3 different vertical pixels (M being
30 equal to 2 in this case),
- $3 \times N$ viewpoints each encoded with 2 distinct vertical pixels (M being

equal to 3 in this case),

- 6xN viewpoints each encoded with a single pixel (M being equal to 6 in this case).

5 Advantageously and in accordance with the invention, each pixel of said panel of pixels is composed of a plurality of P vertical sub-pixels of different colors juxtaposed one beside another in the direction of the rows, so as to be able to encode each of the MxN viewpoints with 6/M different vertical sub-pixels, which are repeated, under each lens, every 12/P rows, M being equal to 3 or 6.

10 In other words, the screen in accordance with the invention makes it possible, in the vertical version, to display as desired:

- 3xN viewpoints each encoded with 2 distinct vertical sub-pixels (M being equal to 3 in this case),
- 6xN viewpoints each encoded with a single sub-pixel (M being equal to 6 in this case).

15 Furthermore, the screen in accordance with the invention has narrower lobes than the screens previously proposed by the applicant. In order to do this, the optical components have relatively long focal distances in order to tighten up the lobe as much as possible without reducing the convenience with which the viewer positions himself. This makes it possible to increase the resolving power and angular continuity. Narrower lobes multiply the transition zones but they also divide the observation space in front of the screen into narrower strips, where a number of viewers can be positioned simultaneously and very comfortably, at different distances.

25 The invention thus runs contrary to a bias of the person skilled in the art who considers that a greater lobe width is indissociable from the quality of an autostereoscopic screen. Contrary to what might be assumed, the perceived image quality when the 6 pixels of an elementary block belong to the same high-resolution viewpoint is comparable to that which is obtained when, in this elementary block, intermediate viewpoints of lower resolution are “tiled” instead
30 of the principal viewpoint being spread. In other words, a display with very high

theoretical resolving power does not prove to be better than a display having partial overlap of intermediate viewpoints by a “tiling” effect. On the other hand, instead of the deep details discretizing when the resolving power is optimized, they spread out in the manner of a depth of field effect into a blur of circular appearance. The intermediate viewpoints spread horizontally and vertically at the same time, which makes possible this quasi-isotropic improvement in the resulting image.

Humans are used to depth of field blurring and it is physiologically inevitable to perceive blurring in the most remote planes of a three-dimensional image. The brain easily accepts that the blurring results from the distance of these planes and this does not adversely affect the feeling of general clarity which we otherwise perceive in the image.

According to one variant of the invention, the screen has the feature of being provided with a panel of pixels which, when it is oriented in horizontal mode (or vertical mode respectively), has columns (or rows respectively) each separated each other by black inter-column areas (or black inter-row areas respectively), the width (or height respectively) of which is close to that of the active zones of the pixels of the panel. These black surfaces form a black surround, the surface of which is close to the active surface of the screen. This makes it possible to have excellent levels of contrast.

Furthermore, according to this variant and in the case of the horizontal sub-pixels, the active and dark zones of the portions of the panel which are arranged under the even and odd lenses are opposite to each other. In other words, the active zones under the even lenses correspond to the dark zones under the odd lenses and the dark zones under the even lenses correspond to the active zones under the odd lenses.

Advantageously and in accordance with the invention, N is equal to 7 or 11.

The inventors have determined that finer lenticular arrays, which make it

possible to display only 7 or 11 principal viewpoints, make it possible to further marginalize the structure effect. This being the case, there is naturally nothing to prevent the use of a different number of viewpoints.

5 Advantageously and in accordance with the invention, P is equal to 3.

 According to this variant, each pixel of the matrix of pixels is composed, when said screen is oriented in the horizontal mode, of three horizontal sub-pixels of different colors juxtaposed on each other in the direction of the columns and said columns are separated from each other by a black inter-column space. Of
10 course, when this screen is oriented in a vertical mode, each pixel of the matrix is composed of three vertical sub-pixels of different colors juxtaposed one beside the other in the direction of the rows, and said rows are separated from each other by a black inter-row space.

 Nevertheless, there is nothing to prevent the use of panels of pixels where
15 each pixel is formed of four sub-pixels. In particular, there are panels in which a white sub-pixel is added to the three usual colors, red, green and blue.

 Advantageously and in accordance with the invention, said matrix of pixels is an 8K panel of pixels.

20 Such a panel of pixels makes it possible to use the highest resolutions currently available. Such a panel is, for example, a panel of 31.5'' resolution 7680x4320 pixels, which, oriented in portrait mode, has a matrix of pixels each formed of horizontal RGB stripes.

 In fact, the higher the resolution of the screen, the greater the possibility of
25 displaying a large number of viewpoints thereon simultaneously. It is thus possible either to use these additional viewpoints to enlarge the lobe by reducing the focal distance at constant pitch, or to reduce the width occupied by each viewpoint in the lobe by dedicating a sub-part of the narrower lobe thereto in order to come closer to a photographic effect.

30

 The invention also relates to a method for autostereoscopic display of

photographic quality of an autostereoscopic image with $M \times N$ viewpoints ordered from 1 to $M \times N$, N being an odd integer strictly greater than 1 and M being an integer selected from 1, 2, 3 and 6, characterized in that it comprises:

- 5 – the selection of an autostereoscopic display screen in accordance with the invention,
- the distribution under each lens of the $M \times N$ viewpoints distributed within N vertical blocks 6 pixels in height from M viewpoints ($6/M$ pixels per viewpoint), with a periodic iteration of each block on the axis of a lens every 12 rows if the sub-pixels of the panel are horizontal, and distributed within $P \times N$ vertical blocks $6/P$ sub-pixels in height, from M/P viewpoints ($6/M$ sub-pixels per viewpoint), with a periodic iteration of each block on the axis of a lens, every 12/P rows if the sub-pixels of the panel are vertical.

15 In other words, the method for autostereoscopic display in accordance with the invention makes possible the distribution under each lens of the $M \times N$ viewpoints of the image within N elementary blocks which are repeated every 12 consecutive rows if the pixels of the screen are formed of horizontal sub-pixels or within $N \times P$ elementary blocks which are repeated every 12/P consecutive rows if the pixels of the screen are formed of vertical sub-pixels.

20 The advantages and technical effects of the screen in accordance with the invention apply *mutatis mutandis* to a display method in accordance with the invention.

25 Advantageously and in accordance with the invention, each of the $M \times N$ viewpoints of the image are encoded, for a panel formed of horizontal sub-pixels, with $6/M$ different vertical pixels within the N elementary blocks 6 pixels in height, M being equal to 1, 2, 3 or 6.

30 Advantageously and in accordance with the invention, each of the $M \times N$ viewpoints of the image are encoded, for a panel formed of vertical sub-pixels,

with $6/M$ different vertical sub-pixels within the $P \times N$ elementary blocks $6/P$ sub-pixels in height, M being equal to 3 or 6.

When the screen in accordance with the invention is oriented in vertical sub-pixel mode, the pixels are located in a configuration in which the sub-pixels
 5 extend vertically and are P times taller than wide. In the case where each pixel is formed of three RGB sub-pixels (P being equal to 3 in this case), each square pixel is formed of three vertical sub-pixels juxtaposed horizontally.

The addressing of the content is no longer effected at the pixel as for the screen according to the horizontal variant but at the sub-pixel. The distribution of
 10 the viewpoints (also referred to by the term “mix”) can thus be effected over a group of 4 consecutive rows ($12/3$) instead of 12. With an equivalent number of viewpoints, the viewpoints are thus spread horizontally in proportions three times greater than the mix of the horizontal version.

Each viewpoint is encoded over at least two rows, which in this case
 15 additionally offers the possibility either of using fewer higher-resolution viewpoints or of “tiling” intermediate viewpoints depending on the depth of the three-dimensionality in the scene.

In the vertical sub-pixel version, the sub-pixel of the same viewpoint under the adjacent lens is located 4 rows lower down and on the following color. In the
 20 case where N is equal to 11, two encoding possibilities are thus obtained: 33 encoded viewpoints each with 2 different vertical sub-pixels (M being equal to 3 in this case) or 66 viewpoints each encoded with a single sub-pixel (M being equal to 6 in this case).

25 Irrespective of the version of the screen (horizontal or vertical), the method in accordance with the invention makes it possible to adapt the number of viewpoints displayed according to the disparity in the image, in depth and in protrusion, with the ghosting of the details at the limits of the volume being the determining factor.

30 It is possible either to use fewer higher-resolution viewpoints or to “tile” intermediate viewpoints depending on the depth of the three-dimensionality in the

scene.

The invention also relates to a display screen and a display method, which are characterized in combination by all or some of the features mentioned above or below.

5 **5. List of figures**

Other aims, features and advantages of the invention will become apparent upon reading the following description given solely in a non-limiting way and which makes reference to the attached figures in which:

- 10 – [figure 1] is a schematic view of a display screen in accordance with one embodiment of the invention,
- [figure 2] is a schematic view of a display screen in accordance with one embodiment of the invention with eleven principal viewpoints,
- 15 – [figure 3] is a schematic view of a display screen in accordance with another embodiment of the invention with seven principal viewpoints and oriented in portrait mode,
- [figure 4] is a schematic view of a display screen in accordance with another embodiment of the invention with seven principal viewpoints and oriented in landscape mode,
- 20 – [figure 5] is a schematic view of a display screen in accordance with another embodiment of the invention with forty-two viewpoints and oriented in portrait mode.

6. Detailed description of an embodiment of the invention

In the figures, for the purposes of illustration and clarity, scales and proportions have not been strictly respected.

25 Figure 1 schematically illustrates a screen 10 for displaying an autostereoscopic image with $6 \times N$ viewpoints comprising a matrix of pixels 20 arranged by rows and by columns. In other words, in the described embodiment, M is equal to 6.

30 The matrix of pixels is surmounted by an array of cylindrical lenses 30 (also referred to by the terminology of “lenticular array”) each inclined with

respect to the columns by an angle equal to $\arctan(1/12)$, i.e. an angle of 4.76° . In figure 1, the illustrated inclination is accentuated only for the purposes of illustration.

This array of cylindrical lenses 30 has a pitch of $N/2$ pixels in width, so
 5 that each lens of the array extends over a vertical block of six active zones of pixels of one column of the screen, referred to as elementary block, then a black inter-column space and a new elementary block of six active zones of pixels of the following column, and so on to the bottom of the screen.

As indicated above, each pixel is composed of a plurality of 3 active sub-
 10 pixels (P is equal to 3) of different colors and of opaque inactive zones forming a portion of black inter-row areas and/or inter-column areas of the panel. This being the case, (and for the sake of simplification) the term “pixel” refers to the active zones of the pixel which make it possible to address the content, and the term “black space” refers to the opaque inactive zones of the pixels which form the
 15 inter-row areas and/or inter-column areas of the screen.

The reference numeral 26 indicates a pixel in terms of the invention, in its non-simplified version, i.e. the group formed by the active zone of the pixel and the black zone which surrounds this active pixel zone.

The lenticular array is, for example, an array produced according to the
 20 method described in the application WO2020/178506 in the name of the applicant.

Figure 2 schematically illustrates a portion of a panel of pixels of a screen in accordance with one embodiment of the invention comprising horizontal sub-
 25 pixels and on which a lens 30 of the lenticular array is illustrated. This screen is designed to display an image with eleven principal viewpoints (i.e. N is equal to 11).

In order to do this, the panel of pixels (or matrix of pixels) comprises a plurality of pixels 26 arranged by rows and by columns. Each pixel 26 is formed
 30 of three horizontal sub-pixels of different colors and corresponding to the components R, G, B.

The columns of pixels are separated from each other by a black inter-column space 24 of a width substantially equal to the width of an active zone of the pixel 26 of the screen. In figure 2, these black columns are shown in white for the sake of clarity.

5 Each lens 30 of the array of cylindrical lenses is inclined with respect to the columns of the screen by an angle equal to $\arctan(1/12)$, i.e. 4.76° .

The array is designed so that its pitch is 5.5 pixels in width (11/2). Each lens of the array 30 extends over a group of vertical blocks 22 of six pixels of one column of the screen, referred to as an elementary block 22, then a group of black
10 inter-column spaces of equivalent height and a new group of elementary blocks of six pixels of the following column, and so on to the bottom of the screen.

Such a screen makes it possible to display $11 \times M$ viewpoints, M being an integer which may have a value of 1, 2, 3 or 6.

Figure 2 shows the eleven principal viewpoints using Roman numerals in
15 italics. Thus, for the elementary block referenced 22, the principal viewpoint of this block is the viewpoint *I*. The following elementary block of the same column encodes the viewpoint *II*.

It will be noted that under the illustrated lens 30, the first row of elementary blocks encodes the odd viewpoints (*I*, *3*, *5*, *7*, *9* and *11*) and the 2nd
20 row of elementary blocks encodes the even viewpoints (*2*, *4*, *6*, *8* and *10*).

The eleven principal viewpoints are thus interlaced, under the lens, over twelve consecutive rows in the horizontal version. If the screen is designed in vertical mode, the eleven viewpoints are thus interlaced over four consecutive rows (insofar as it is then possible to address the sub-pixels and not the whole
25 pixels).

As can be seen in figure 2, in order to find the same viewpoint under the illustrated lens it is necessary to shift by one column to the right and twelve rows downwards. It will thus be well understood that if the viewer sees the viewpoint *I* with one eye and if he shifts slightly to the left (the movement of the viewer is the
30 inverse of the horizontal shift of the viewpoints addressed to the eye owing to the presence of the lens), he will then see the viewpoint *2*, then the viewpoint *3*, and

so on to viewpoint 11. These eleven viewpoints are interlaced over twelve rows of the panel of pixels.

For each elementary block, intermediate viewpoints between said principal viewpoint of the block and the principal viewpoint of the following block can also
 5 be assigned to the other pixels of this elementary block (in other words, it is possible to display an image with $11 \times M$ viewpoints, with M selected from among 1, 2, 3 and 6).

The optical axis of the lenticular array 30 cuts the traversed pixels at an angle of 4.76° . This makes it possible to successively align each of the six
 10 traversed pixels of an elementary block with sub-parts of the solid angle occupied by each principal viewpoint.

Since a pixel is formed of three sub-pixels, each elementary block 22 of six pixels is thus formed of eighteen stacked horizontal sub-pixels. The traversing of an elementary block of six pixels is thus in reality the progressive traversing of
 15 these eighteen sub-pixels.

When a distinct viewpoint is assigned to each of the six pixels of an elementary block 22, eighteen cases of partial covering thus in fact occur.

The traversed sub-pixels must thus be assimilated with theoretical points located at the barycenter of the surface in question.

20 When the six pixels of an elementary block are allocated to six different viewpoints, the overlaps are obvious and mixing inevitable. However, the perceived quality is higher than that obtained with principal viewpoints of better resolution.

The screen in accordance with the embodiment of figure 2 thus makes it
 25 possible, as desired, to exploit contents with 11, 22, 33 or 66 viewpoints:

- 11 principal viewpoints, each encoded with six different contiguous vertical pixels (M is equal to 1),
- 22 viewpoints each encoded with three different vertical pixels (M is equal to 2),
- 30 - 33 viewpoints each encoded with two different vertical pixels (M is equal to 3),

- 66 viewpoints each encoded with a single pixel (M is equal to 6).

Figure 3 schematically illustrates a portion of a panel of pixels of a screen in accordance with another embodiment of the invention, oriented in horizontal sub-pixel mode and intended to display seven principal viewpoints (N is equal to 7).

The difference with respect to the screen of figure 2 is the lenticular array which has a pitch of 3.5 pixels instead of 5.5 pixels.

Each lens of the array 30 of cylindrical lenses is also inclined, each with respect to the columns of the screen by an angle equal to $\arctan(1/12)$, i.e. 4.76° .

The seven principal viewpoints are distributed under each lens over twelve consecutive rows, according to the same principle as that explained in relation to figure 2.

Figure 3 shows the different distributions of the active zones and of the opaque zones under the first two lenses, representative of the odd lenses and of the even lenses. In particular, the portion of the panel of pixels under the viewpoint 1 of the first lens corresponds to an opaque zone under the second lens, and the adjacent opaque portion of the viewpoint 1 under the first lens corresponds to the viewpoint 2 under the second lens.

It will be clearly observed that if the portion of the panel of pixels under the first lens (characteristic of an odd lens) were superimposed with the portion of the panel of pixels under the second lens (characteristic of an even lens), the active zones of the even lens correspond to the opaque zones of the odd lens and the opaque zones of the even lens correspond to the active zones of the odd lens.

Figure 5 illustrates the same screen as that of figure 3 with the sole difference that each pixel of the screen has been assigned a distinct image viewpoint. Thus, the screen makes it possible to display an image with 42 viewpoints (N is equal to 7 and M is equal to 6).

It will be noted that in the first elementary block of the first column illustrated, the viewpoints 42, 41, 40, 39, 38 and 37 are assigned to the six pixels

of the elementary block. In the adjacent elementary block of the second column, the viewpoints 12, 11, 10, 09, 08 and 07 are assigned to the six pixels of the elementary block. In the following elementary block of the third column, the viewpoints 24, 23, 22, 21, 20 and 19 are assigned to the six pixels of the elementary block, and so on for the 7 elementary blocks arranged under the first lens over the first 12 rows of the panel of pixels. The 7 elementary blocks are illustrated schematically by rectangles of dashed lines each surrounding six consecutive pixels in the direction of the columns.

In other words, for each of the 7 elementary blocks, one of the 42 viewpoints has been assigned to one of the pixels of the elementary block and one of the 5 following viewpoints in the series of the 42 viewpoints has been assigned to the other pixels of this elementary block. For the first elementary block of the first column, the viewpoint 37 can be considered to be the principal viewpoint and the viewpoints 38, 39, 40, 41 and 42 can be considered to be the intermediate viewpoints formed by the following viewpoints in the series of 42 viewpoints.

Under the first lens illustrated, the first twelve rows of the screen thus make it possible to display the 42 viewpoints of the image. It will be noted that the viewpoint 42 is located under the first lens, in the second column and in the 13th row. The viewpoint 12 of the first row and of the second column is located on the third column in the 13th row, and so on for each of the viewpoints. The same pattern is repeated for each lens and over the whole screen (not shown in the figure for the sake of clarity).

Figure 4 illustrates a screen designed to display a maximum of 42 viewpoints, but with an orientation with vertical sub-pixels. This screen thus also presents a lenticular array inclined with respect to the columns of the screen by an angle corresponding to 4.76° . The seven principal viewpoints are distributed, under the lenses, over four consecutive rows (instead of 12 for the horizontal sub-pixel version) insofar as it is thus possible to address the sub-pixels and not the whole pixels.

Thus, it will be noted that the viewpoint I is encoded by the white sub-

pixel of the first pixel at the top left of the figure. The viewpoint 1 is found in the 5th row and 2nd column of the screen, under this same lens, encoded by the light grey sub-pixel of the pixel and in the 9th row and 3rd column of the screen, encoded by the black sub-pixel of the pixel. The same applies for all the seven
 5 viewpoints of the image.

Following the example of the screen in horizontal sub-pixel mode, it is possible either to use fewer higher-resolution viewpoints, or to “tile” intermediate viewpoints depending on the depth of the three-dimensionality in the scene.

10 Irrespective of the embodiment, the lenticular array has an angle which makes it possible to distribute each viewpoint both vertically and horizontally. These viewpoints are said to be “principal” when the same viewpoint can occupy only the group of pixels of a vertical elementary block and they are said to be “intermediate” when a plurality of slightly shifted viewpoints are “tiled” in this
 15 same block and complete the principal viewpoint. The intermediate viewpoints can be considered as filler viewpoints which fill in the discrete parallax jumps between principal viewpoints so as to offer the viewer a continuous parallax feeling. They serve to smooth out the parallax jumps which may be perceptible between principal viewpoints.

20 The invention has been described with a fixed M within the image. In other words, the number of viewpoints is determined uniformly depending on the targeted disparity in the image. This being the case, it is possible to use the screen with a dynamic variation of the number of viewpoints (and thus of the integer M) within the same image depending on the disparity. For example, it is possible to
 25 make provision for M to be fixed at 1 or 2 for a low level of three-dimensionality and for M to be fixed at 3 or 6 for greater three-dimensionality. This makes it possible to limit only highly three-dimensional zones of an image, the need to generate 3D information with a large number of different viewpoints.

CLAIMS

- 5 **1.** Screen (10) for autostereoscopic display, deemed to be of photographic quality, of an autostereoscopic image with $M \times N$ viewpoints ordered from 1 to $M \times N$, N being an odd integer strictly greater than 1, and M being an integer selected from 1, 2, 3 and 6, said screen comprising a panel of pixels (20) arranged by rows and by columns, each pixel (26) being composed of a

10 plurality of P active sub-pixels of different colors and of opaque inactive zones forming a portion of black inter-row areas and/or inter-column areas of said panel,

characterized in that it further comprises an ordered array of cylindrical lenses (30) mounted on said panel of pixels, each lens being inclined with respect to

15 the columns of the screen by an angle equal to $\arctan(1/12)$, said array having a pitch of $N/2$ pixels in width so as to be able, on the one hand, to differentiate the even and odd lenses (30) of said ordered array by distinct distributions of the active zones of pixels (26) and of the black zones (24) of the panel arranged under each even and odd lens, and, on the other hand, to decode each

20 of the $M \times N$ viewpoints distributed within N vertical blocks 6 pixels in height from M viewpoints ($6/M$ pixels per viewpoint), with a periodic iteration of each block on the axis of a lens every 12 rows if the sub-pixels of the panel are horizontal, and distributed within $P \times N$ vertical blocks $6/P$ sub-pixels in height, from M/P viewpoints ($6/M$ sub-pixels per viewpoint), with a periodic

25 iteration of each block on the axis of a lens, every $12/P$ rows if the sub-pixels of the panel are vertical.
- 2.** Autostereoscopic display screen (10) as claimed in claim 1, characterized in that each pixel (26) of said panel of pixels is composed of a plurality of P

horizontal sub-pixels of different colors juxtaposed on each other in the

30 direction of the columns, so as to be able to encode each of the $M \times N$ viewpoints with $6/M$ different vertical pixels, which are repeated, under each lens, every 12 rows, M being equal to 1, 2, 3 or 6.

3. Autostereoscopic display screen (10) as claimed in claim 1, characterized in that each pixel (26) of said panel of pixels is composed of a plurality of P vertical sub-pixels of different colors juxtaposed one beside another in the direction of the rows so as to be able to encode each of the MxN viewpoints with 6/M different vertical sub-pixels, which are repeated, under each lens, every 12/P rows, M being equal to 3 or 6.
4. Screen as claimed in any one of claims 1 to 3, characterized in that N is equal to 11.
5. Screen as claimed in any one of claims 1 to 4, characterized in that P is equal to 3.
6. Screen as claimed in any one of claims 1 to 5, characterized in that said panel of pixels (20) is an 8K panel of pixels.
7. Method of autostereoscopic display of photographic quality of an autostereoscopic image with MxN viewpoints ordered from 1 to MxN, N being an odd integer strictly greater than 1 and M being an integer selected from 1, 2, 3 and 6, characterized in that it comprises:
 - ☞ the selection of an autostereoscopic display screen (10) as claimed in any one of claims 1 to 6,
 - ☞ the distribution under each lens (30) of the MxN viewpoints distributed within N vertical blocks 6 pixels in height from M viewpoints (6/M pixels per viewpoint), with a periodic iteration of each block on the axis of a lens every 12 rows if the sub-pixels of the panel are horizontal, and distributed within PxN vertical blocks 6/P sub-pixels in height, from M/P viewpoints (6/M sub-pixels per viewpoint), with a periodic iteration of each block on the axis of a lens, every 12/P rows if the sub-pixels of the panel are vertical.
8. Method as claimed in claim 7, characterized in that each of the MxN viewpoints of the image are encoded, for a panel formed of horizontal sub-pixels, with 6/M different vertical pixels within the N elementary blocks 6 pixels in height, M being equal to 1, 2, 3 or 6.
9. Method as claimed in claim 7, characterized in that each of the MxN

viewpoints of the image are encoded, for a panel formed of vertical sub-pixels, with $6/M$ different vertical sub-pixels within $P \times N$ elementary blocks $6/P$ sub-pixels in height, M being equal to 3 or 6.