CLAIMS

1. Display device (1) ~~adapted~~ for displaying an image (2) ~~for~~ to a user having a visual impairment, the display device (1) comprising:

~~-~~a pixelated display (3) comprising a plurality of pixels (4), each pixel comprising a plurality of subpixels~~;~~;~~comprising an array of pixels (4), each pixel comprising a number of subpixels, and wherein the pixelated display (3) is operable to display the image (2) to an eye (5) of the user located at a viewing location relative to a position of the pixelated display (3);~~

~~- a processor (6) for operating the pixels (4) of the pixelated display (3) to display the image (2) on the pixelated display (3) wherein the processor (6) is operable to store information on the eye (5) of the user focal length of the eye;~~

~~-~~an eye-tracking system (7) ~~adapted for determining changes in the viewing location of the eye (5) of the user relative to the position of the pixelated display (3), wherein, preferably, the processor is configured for determining the change in viewing location of the eye of the user based on the change in viewing location detected by the eye-tracking system~~for tracking a position of an eye of a user relative to the pixelated display (3); ~~and~~

~~-~~a microlens array (8) provided on the pixelated display (3)~~, wherein the microlens array (8) comprises microlenses (9) that are arranged in a two-dimensional plane oriented parallel to the pixelated display (3), wherein the microlens array (8) covers, preferably completely covers, the pixelated display (3), and wherein the microlens array (8) is configured to project light emitted by the pixelated display (3) towards the eye (5) of the user in the viewing location~~; and

a processor (6);~~,~~

~~characterized in that~~

wherein the processor is configured to:

~~the processor (6) is configured for~~ determine, based on a focal length of the eye, ~~ing~~ a ~~first~~ location of a virtual image plane (10), the virtual image plane corresponding to a ~~first~~ viewing location of the eye (5) ~~of the user~~and comprising ~~,~~ a plurality of virtual pixels~~;by comparing the focal length of the eye of the user to the first viewing location, wherein a virtual image (11) is located on the virtual image plane (10) which virtual image (11) corresponds to an image (2) to be displayed on the pixelated display (3), wherein the virtual image (11) determines values of virtual pixels (12) of the virtual image plane (10),~~

wherein the processor (6) is configured for relate, foring a each subpixel (13) of the pixelated display (3), the subpixel to a corresponding first virtual pixel (14) of the virtual image plane (10) by determining a path of a light ray emitted by the subpixel (13) between the corresponding subpixel (13), the microlens array (8), the retina of the eye (5) of the user, and the firstto the corresponding virtual pixel (14) a light path (15) of a light ray emitted by the corresponding subpixel (13),

wherein the processor (6) is further configured for determiningdetermine, for each subpixel, a first value of the the corresponding subpixel (13) of the pixelated display (3) by comparing the a value of the corresponding subpixel (13) to the a value of the its first corresponding virtual pixel (14),

wherein the processor (6) is configured to operate each the corresponding subpixel (13) of the display (3) based on the respective determined first value when the eye (5) of the user is in the first viewing locationto display a corrected image on the pixelated display.,

2. Display device (1) according to claim 1, wherein the processor is further configured to:

determine, based on a detected change a change in a location of the eye to a second viewing location, a second location of the virtual image plane (10);

relate, for each subpixel (13), the subpixel to a second virtual pixel of the virtual image plane when the virtual image plane is in the second location;

determine, for each subpixel (13), a second value of the subpixel by comparing the value of the corresponding subpixel to a value of the second virtual subpixel;

operate each subpixel based on the determined second value to display an updated corrected image on the pixelated display.

wherein the processor (6) is configured for determining a second location of the virtual image plane (10), corresponding to a second viewing location of the eye (5) of the user, when the eye tracking system (7) determines a change in the viewing location of the eye (5) of the user from the first viewing location to the second viewing location,

wherein the processor (6) is further configured to relate the corresponding subpixel (13) of the pixelated display (3) to a second virtual pixel (16) of the virtual image plane (10) when the virtual image plane (10) is in the second location,

wherein the processor (6) is further configured for determining a second value of the corresponding subpixel (13) of the pixelated display (3) by comparing the value of the corresponding subpixel (13) to a value of the second virtual pixel (16); and

wherein the processor (6) is configured to operate the corresponding subpixel (13) of the display (3) based on the second value when the eye (5) of the user is in the second viewing location.

2. Display device (1) according to claim 1, wherein the processor (6) is configured for relating the corresponding subpixel (13) to the second virtual pixel (16) of the virtual image plane (10) by:

- determining, when the virtual image plane (10) is in the first location, a first pixel location relative to the pixelated display (3) of the corresponding first virtual pixel (14);
- comparing, when the virtual image plane (10) is in the second location and for one or more of the virtual pixels (12), a location of each of the virtual pixels (12) to the first pixel location; and
- relating the corresponding subpixel (13) of the pixelated display (3) to the virtual pixel (16) whose location corresponds to the first pixel location when the virtual image plane (10) is in the second location.

3. Display device according to claim 2, wherein the processor (6) is configured for determining:
- a parallel component of the first pixel location parallel to the pixelated display (3);
- a perpendicular component of the first pixel location perpendicular to the pixelated display (3); - parallel components of the locations of each of the virtual pixels (12) when the virtual image plane (10) is in the second location; and
- perpendicular components of the locations of each of the virtual pixels (12) when the virtual image plane (10) is in the second location, and

wherein the processor (6) is configured for, when the perpendicular components are equal, relating the corresponding subpixel (13) of the pixelated display (3) to the virtual pixel (16) whose parallel component is equal to the parallel component of the first pixel location.

4. Display device (1) according to claim 3, wherein the processor (6) is configured for relating the corresponding subpixel (13) of the pixelated display (3) to the virtual pixel (16) whose parallel component is equal to the parallel component of the first pixel location when the eye-

~~tracking system (7) does not detect a change of the eye (5) of the user in a perpendicular direction relative to the pixelated display (3).~~

~~5~~3. Display device (1) according to ~~one or more of the preceding claims~~claim 1 or claim 2, wherein the display device (1) is ~~adapted~~ configured to provide a feedback~~, e.g. a haptic feedback,~~ to the user to prompt ~~, e.g. prompting~~ the user to change ~~the~~ a position of the pixelated display (3).

~~6~~4. Display device (1) according to ~~one or more~~any of the preceding claims, wherein the eye-tracking system (7) is ~~further adapted for~~configured to track~~ing~~ a gaze of the eye (5) of the user ~~for determining~~to determine at which part of the pixelated display (3) the user is gazing.

~~7~~5. Display device (1) according to claim ~~6~~4, wherein the corresponding subpixel (13) is located in the part of the pixelated display (3) at which the user is gazing.

~~8. Display device (1) according to one or more of the preceding claims, wherein a microlens width and/or a microlens height is equal or smaller than a pitch of 8 subpixels (13) of the pixelated display (3).~~

~~9~~6. Display device (1) according to ~~one or more~~any of the preceding claims, wherein the display device (1) is further provided with an optical gap layer (17)~~, which is provided~~ between the pixelated display (3) and the microlens array (8), wherein the optical gap layer defines an optical gap between the pixelated display and the microlens array~~, wherein the optical gap layer (17) defines an optical gap (18) between the pixelated display (3) and the microlens array (8)~~.

~~10. Display device (1) according to claim 9, wherein an optical gap layer is present, wherein for each lens of the microlens array, the relation:~~

~~smaller (microlens width, microlens height) / optical gap –~~
~~pupil diameter – point projection diameter) / object distance~~

~~is minimized, wherein the smaller of the corresponding microlens width and microlens height is denoted by smaller(microlens width, microlens height), an estimate for the pupil size of the user is denote by pupil diameter, a size of a projection of an arbitrary point within a subpixel on the plane in which the pupil of the eye lies is denoted by point projection diameter, and a distance from the pixelated display to the eye of the user is denoted by object distance.~~

~~11~~7. Display device (1) according to ~~one or more of the claims 9-10~~claim 6, wherein the focal length of the microlenses (9) in the microlens array (8) is equal to the size of the optical gap (18).

~~12~~8. Display device (1) according to ~~one or more of the claims 9-11~~claim 6 or claim 7, wherein the optical gap (18) comprises a secondary microlens array.

~~13~~9. Display device (1) according to ~~one or more~~any of the preceding claims, wherein the microlenses (9) are rectangular or square microlenses (9).

~~14. Display device (1) according to one or more of the preceding claims, wherein the microlenses (9) are square microlenses (9).~~

~~15~~10. Display device (1) according to ~~one or more~~any of the preceding claims, wherein the display device (1) further comprises a protection layer (19) ~~which is placed~~ on top of the microlens array (8).

~~16~~11. Display device (1) according to one or more of the preceding claims, wherein the pixelated display (3) is provided in a smart phone case.

~~17~~12. Method for displaying an image (2) ~~for~~ to a user having a visual impairment, the method comprising: ~~wherein use is made of a display device (1) according to one or more of the preceding claims, wherein the display device (1) comprises:~~

determining, based on a focal length of an eye of the user, a location of a virtual image plane (10), the virtual image plane corresponding to a viewing location of the eye (5) and comprising a plurality of virtual pixels;

relating, for each subpixel (13) of a pixelated display, the subpixel to a corresponding virtual pixel (14) of the virtual image plane (10) by determining a path of a light ray emitted by the subpixel (13) to the corresponding virtual pixel (14),

determining, for each subpixel, a first value of the subpixel (13) by comparing a value of the subpixel (13) to a value of its corresponding virtual pixel (14),

operating each subpixel (13) based on the determined first value to display a corrected image on the pixelated display.

- a pixelated display (3) comprising an array of pixels (4), each pixel comprising a number of subpixels, and wherein the pixelated display (3) is operable to display the image (2) to an eye (5) of the user located at a viewing location relative to a position of the pixelated display (3);

- a processor (6) for operating the pixels (4) of the pixelated display (3) to display the image (2) on the pixelated display (3) wherein the processor (6) is operable to store information on the eye (5) of the user focal length of the eye;

- an eye-tracking system (7) adapted for determining changes in the viewing location of the eye (5) of the user relative to the position of the pixelated display (3), wherein, preferably, the processor is configured for determining the change in viewing location of the eye of the user based on the change in viewing location detected by the eye-tracking system; and

- a microlens array (8) provided on the pixelated display (3), wherein the microlens array (8) comprises microlenses (9) that are arranged in a two-dimensional plane oriented parallel to the pixelated display (3), wherein the microlens array (8) covers, preferably completely covers, the pixelated display (3), and wherein the microlens array (8) is configured to project light emitted by the pixelated display (3) towards the eye (5) of the user in the viewing location,

wherein the processor (6) is configured for determining a first location of a virtual image plane (10), corresponding to a first viewing location of the eye (5) of the user, by comparing the focal length of the eye of the user to the first viewing location, wherein a virtual image (11) is located on the virtual image plane (10) which virtual image (11) corresponds to an image (2) to be displayed on the pixelated display (3), wherein the virtual image (11) determines values of virtual pixels (12) of the virtual image plane (10),

wherein the processor (6) is configured for relating a subpixel (13) of the pixelated display (3) to a corresponding first virtual pixel (14) of the virtual image plane (10) by determining between the corresponding subpixel (13), the microlens array (8), the retina of the eye (5) of the user, and the first virtual pixel (14) a light path (15) of a light ray emitted by the corresponding subpixel (13),

wherein the processor (6) is further configured for determining a first value of the corresponding subpixel (13) of the pixelated display (3) by comparing the value of the corresponding subpixel (13) to the value of the first virtual pixel (14),

~~wherein the processor (6) is configured to operate the corresponding subpixel (13) of the display (3) based on the respective first value when the eye (5) of the user is in the first viewing location,~~

~~wherein the processor (6) is configured for determining a second location of the virtual image plane (10), corresponding to a second viewing location of the eye (5) of the user, when the eye tracking system (7) determines a change in the viewing location of the eye (5) of the user from the first viewing location to the second viewing location,~~

~~wherein the processor (6) is further configured to relate the corresponding subpixel (13) of the pixelated display (3) to a second virtual pixel (16) of the virtual image plane (10) when the virtual image plane (10) is in the second location,~~

~~wherein the processor (6) is further configured for determining a second value of the corresponding subpixel (13) of the pixelated display (3) by comparing the value of the corresponding subpixel (13) to a value of the second virtual pixel (16); and~~

~~wherein the processor (6) is configured to operate the corresponding subpixel (13) of the display (3) based on the second value when the eye (5) of the user is in the second viewing location.~~

~~18. Method according to claim 17, wherein the method comprises:~~
~~- determining a first location of a virtual image plane (10) by comparing the focal length of the eye (5) of the user to the viewing location, wherein a virtual image (11) is located on the virtual image plane (10) which virtual image (11) corresponds to an image (2) to be displayed on the pixelated display (3), wherein the virtual image (11) determines values of virtual pixels (12) of the virtual image plane (10);~~

~~- relating a subpixel (13) of the pixelated display (3) to a corresponding first virtual pixel (14) of the virtual image plane (10) by determining between the corresponding subpixel (13), the microlens array (8), the retina of the eye (5) of the user, and the first virtual pixel (14) a light path (15) of a light ray emitted by the corresponding subpixel (13);~~

~~- determining a first value of the corresponding subpixel (13) of the pixelated display (3) by comparing the value of the corresponding subpixel (13) to the value of the first virtual pixel (14);~~

- operating the corresponding subpixel (13) of the display (3) based on the respective first value when the eye (5) of the user is in the first viewing location;

- determining a second location of the virtual image plane (10), corresponding to a second viewing location of the eye (5) of the user, based on a change in the viewing location of the eye (5) of the user determined by the eye-tracking system (7);

- relating the corresponding subpixel (13) of the pixelated display (3) to a second virtual pixel (16) of the virtual image plane (10) when the virtual image plane (10) is in the second location;

- determining a second value of the corresponding subpixel (13) of the pixelated display (3) by comparing the value of the corresponding subpixel (13) to a value of the second virtual pixel (16); and

- operating the corresponding subpixel (13) of the display (3) based on the second value when the eye (5) of the user is in the second viewing location.

19. Method according to claim 18, wherein the method further comprises:
- determining a first pixel location relative to the pixelated display (3) of the corresponding first virtual pixel (14) with the virtual image plane (10) is in the first location;
- comparing, when the virtual image plane (10) is in the second location and for one or more of the virtual pixels (12), a location of each of the virtual pixels (12) to the first pixel location; and
- relating the corresponding subpixel (13) of the pixelated display (3) to the virtual pixel (16) whose location corresponds to the first pixel location when the virtual image plane (10) is in the second location.

20. Method according to one or more of the claims 17-19, wherein the method comprises:
- providing a feedback, e.g. a haptic feedback, to the user, e.g. prompting the user to change the position of the pixelated display (3).

21. Method according to one or more of the claims 17-20, wherein the method comprises:
- tracking the location of the eye (5) of the user by the eye-tracking system (7) in a direction perpendicular to the pixelated display;
- changing the first location of the virtual image plane (10) based on a change in a location of the eye (5) of the user in the direction perpendicular to the pixelated display (3).

~~22. Method according to one or more of the claims 17-21, wherein the method comprises:~~
~~- tracking a gaze of the eye (5) of the user by the eye-tracking system (7) for determining at which part of the pixelated display (3) the user is looking;~~
~~wherein the corresponding subpixel (13) is located in the part of the pixelated display (3) at which the user is gazing.~~

~~23. Processor (6) for operating a display device (1) adapted for displaying an image (2) for a user having a visual impairment according to one or more of the claims 1-16.~~

~~24~~13. A computer readable medium comprising instructions which, when executed, cause a processor to ~~Computer program for~~ perform~~ing~~ the method according to claim~~s~~ ~~17-22~~12.

~~25~~14. Smart phone case comprising a display device (1) according to ~~one or more of the~~any of claims 1-~~16~~ 11 and adapted for operating the display device (1) according to the method according to ~~to one or more of the~~ claim~~s~~ ~~17-22~~12.