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(54) Title: METHOD AND TEST CHART FOR TESTING OPERATION OF AN IMAGE CAPTURE SYSTEM

(57) Abstract: A method, test chart and system for testing operation of an electronic image capture system. The test chart is for determining whether resolvable detail of an image captured with the electronic image capture system exceeds a minimum operational value corresponding to a sufficient value for the electronic image capture system to be used for analysing microbial growth in a solid culture medium.

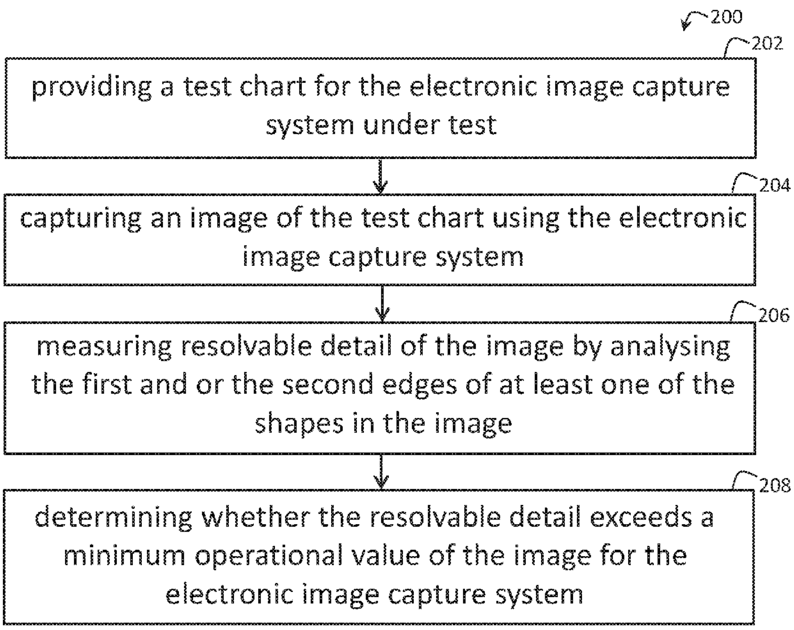

Figure 12

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METHOD AND TEST CHART FOR TESTING OPERATION OF AN IMAGE CAPTURE SYSTEM

Technical Field

[0001] The present invention relates to a method, test chart and system for testing operation of an electronic image capture system. Particularly, but not exclusively, the present invention relates a test chart for determining whether resolvable detail of an image captured with the electronic image capture system exceeds a minimum operational value corresponding to a sufficient value for the electronic image capture system to be used for analysing microbial growth in a solid culture medium.

Background of Invention

[0002] When capturing an image of an object, it is generally a goal to reproduce the features of the object as accurately as possible. This goal includes accurately reproducing features such as colour temperature, hue and saturation, and capturing the image at a sufficient resolution to allow for the identification and distinguishing of fine details.

[0003] In its simplest definition, resolution of an image captured with an electronic image capture system is defined by the system's ability to capture and process finely spaced details, e.g. resolvable detail. That is, the resolution indicates the highest spatial frequency that any image capture system can produce. However, measuring resolution in this way can be insufficient to test whether an electronic image capture system is operating correctly. A more accurate metric of measuring the resolvable detail of a captured image is to use the spatial frequency response (SFR) of the electronic image capture system. The SFR can be used to assess contrast loss as spatial frequency increases. Generally, as the distance between visual elements decreases (i.e. the spatial frequency increases), the contrast between those elements decreases to a point whereby the difference between the elements can no longer be distinguished.

[0004] The resolvable detail is dependent on several factors, including lighting, aperture, focus, lens quality, the number of photo-elements on the camera sensor, and any internal processing of the captured image such as compression and correction. Consequently, a reduction in resolvable detail of an image may indicate a change in any one of these factors.

[0005] In order to measure the resolvable detail for an electronic image capture system, a test chart such as that provided by the International Standard: ISO 12233:2014 Photography – Electronic still picture imaging – Resolution and spatial frequency responses. As will be appreciated by those persons skilled in the art, test charts include a series of visual elements which are analysed by an electronic image capture system to determine the SFR of a captured image of the chart. In order for a test chart to be successfully utilised, the chart needs to be accurately aligned relative to the image capture device so that the generated image can be processed in the correct orientation. Consequently, the commonly used test charts for determining resolvable detail for an image capture system are rotationally variant. For example, in the above referenced International Standard, the test chart is rectangular in shape and has visual elements that are required to be imaged in a particular rotational orientation. The rotationally variant nature of these existing test charts is generally is not problematic when the chart can be positioned in the required alignment relative to the camera by a user. However, in a situation where this is not convenient or possible, these charts are not suitable for measuring the resolvable detail for an electronic image capture system.

[0006] Before turning to a summary of the present invention, it must be appreciated that the above description of the prior art has been provided merely as background to explain the context of the invention. It is not to be taken as an admission that any of the material referred to was published or known, or was a part of the common general knowledge in the relevant art.

Summary of Invention

[0007] Accordingly, one aspect of the present invention provides a method of testing operation of an electronic image capture system, the method including: providing a test chart for the electronic image capture system under test, the test chart including: a background having a first colour; and at least one series of *n* number of shapes provided on the background, each of the shapes having an area with a second colour, and each of the shapes having at least a first edge adjacent to a second edge, wherein each of the *n* shapes in a series is provided on the background in an orientation such that either the first edge or the second edge of the at least one of the shapes has a rotation angle between 2 degrees and 88 degrees relative to a reference orientation of the test chart corresponding to the orientation of an image capture device of the electronic image capture system, and wherein *n* is at least 3; capturing an image of the test chart using the electronic image capture system; measuring resolvable detail of the image by analysing the first and or the second edges of at least one of the shapes in the image; and determining whether the resolvable detail exceeds a minimum operational value for the electronic image capture system.

[0008] Another aspect of the present invention provides a test chart for testing operation of an electronic image capture system, the chart including: a background having a first colour; and at least one series of *n* number of shapes provided on the background, each of the shapes having an area with a second colour, and each of the shapes having at least a first edge adjacent to a second edge, wherein each of the *n* shapes in a series is provided on the background in an orientation such that either the first edge or the second edge of the at least one of the shapes has a rotation angle between 2 degrees and 88 degrees relative to a reference orientation of the test chart corresponding to the orientation of an image capture device of the electronic image capture system, and wherein *n* is at least 3, whereby under test the electronic image capture system captures an image of the test chart, measures resolvable detail of the image by analysing the first and or the second edge of the shapes in the image to determine whether the resolvable detail exceeds a minimum operational value for the electronic image capture system.

[0009] Another aspect of the present invention provides a system for testing operation of an electronic image capture system, the system including: a test chart for the electronic image capture system under test, the test chart including: a background having a first colour; and at least one series of *n* number of shapes provided on the background, each of the shapes having an area with a second colour, and each of the shapes having at least a first edge perpendicular to a second edge, wherein each of the *n* shapes in a series is provided on the background in an orientation such that either the first edge or the second edge of the at least one of the shapes has a rotation angle between 2 degrees and 88 degrees relative to a reference orientation of the test chart, and wherein *n* is at least 3; an image capture device of the electronic image capture system capturing an image of the test chart, wherein the reference orientation corresponds to the orientation of an image capture device of the electronic image capture system; and a processor of the electronic image capture system for measuring resolvable detail of the image by analysing the first and or the second edges of at least one of the shapes in the image and determining whether the resolvable detail exceeds a minimum operational value for the electronic image capture system.

[0010] The test chart used for testing operation of the electronic image capture system is thus rotationally invariant and can be used in any orientation within 360 degrees of rotation. In an embodiment, the test chart is rotationally symmetric, such as a circle. For example, the test chart is disc shaped and the background and the shapes are provided on the circular planar surface of the disc. Also, the transition from the first colour to the second colour is preferably defined by at least one straight edge and this edge is slanted relative to either vertical or horizontal relative to the orientation of the image capture device.

[0011] In an embodiment, each of the *n* shapes in the series has at least the first edge perpendicular to the second edge, and each of the n shapes in the series is provided on the background in an orientation that is rotated by an angle of (90/n) degrees of rotation relative to a successive shape in the series, and wherein *n* is at least 4. In another embodiment, the *n* shapes are polygons as long as either the first edge or the second edge of the at least one of the shapes has a rotation angle greater than 2 degrees relative to the horizontal or vertical of the image capture device. It will be appreciated by those persons skilled in the art that shallow angles greater than 2 degrees representing near vertical and near horizontal can be used and preferably an angle closest to 5 degrees is used.

[0012] Preferably, the electronic image capture system under test is used for analysing microbial growth in a solid culture medium on a culture plate, and the minimum operational value is a sufficient value for the electronic image capture system to be used for this analysis.

[0013] In an embodiment, the system for testing operation of the electronic image capture system includes a support for supporting the test chart at a pre-determined location for the image capture device to capture the image, and wherein the system includes a frame for positioning the image capture device and the support relative to each other. Further, the pre-determined location corresponds to a location of a culture plate when the electronic image capture system is used for analysing microbial growth on a solid culture medium in the culture plate.

[0014] It will be appreciated by those persons skilled in the art that, with respect to the phrase “on a solid culture medium”, the word “on” is used to encompass microbial growth both upon the surface of the solid culture medium and within the solid culture medium. The term “solid culture medium” will hereinafter often be simply referred to as “medium” in the specification. For example, it will be appreciated that a microbiological sample, hereinafter often referred to simply as a “sample”, can be dispensed either upon the surface of the medium or within the medium so that microbial growth can be grown following the inoculation and incubation of the medium with the sample. That is, the microbial growth on the medium results from the inoculation and incubation of the sample, such as a urine sample, an enteric sample, a blood sample, a lymph sample, a tissue sample, a water sample, a food sample or other relevant sample, on the medium.

[0015] In addition, it will also be appreciated by those persons skilled in the art that the medium will usually be, for example, agar and will usually be contained in a container such as a plate, and, in a more specific example, a Petri dish, which may have a lid. The combination of the medium and the plate is hereinafter referred to throughout the specification as a “culture plate” which might sometimes be referred to in the art as an “agar plate”.

[0016] The electronic image capture system has been found, in an exemplary example, to provide sufficiently accurate images of microbial growth on the medium in order to provide a microbiological assessment. This assessment may be performed manually by a skilled laboratory technologist. Alternatively, the assessment may be automated and performed using a classifier that has been trained using a machine learning algorithm. Images obtained using the apparatus may be processed and used as input into the classifier. An example of an electronic image capture system, including such a classifier, is described in the Applicant's Australian patent 2012225196 titled "Method and Software for Analysing Microbial Growth", the contents of which are herein incorporated by reference.

[0017] Also, the image capture device may be a digital camera and lens. For example, a high resolution digital colour camera in combination with an appropriate lens has been found to provide quality images of the plates. Image capture devices having many different specifications are suitable for the purpose as would be understood by the skilled addressee.

[0018] The microbial growth may include, for example, one or more bacterial growths, fungal growths, viral plaques or protist growths and the growth may take the form of a colony, mycelium, hypha, plaque or other visible microbial structure. In some embodiments, each microbial growth may be growth that originates from a single microbe (such as where a sample is applied to a medium in a diluted manner such that individual microbes are separated).

[0019] The medium may include any medium which supports the growth of a microbe. As such, a medium may contain one or more microbial nutrients including, for example, a carbon source, a nitrogen source, essential elements and/or essential vitamins. The medium will also typically contain a gelling agent including, for example, gelatine, agar, gellan gum, agarose or agargel.

[0020] In an embodiment, the use of a ring light for diffusely illuminating one side of the culture plate assists a classifier in distinguishing between light reflected from the medium (which may be classified as background) and microbial growth. The reference to a "side" of the culture plate is to be taken to refer to any side including front, back, left, right, top or bottom side of the culture plate. In a preferred embodiment, the ring light diffusely illuminates the top of the culture plate, e.g. the surface of the medium on which microbial growth is present. The ring light also illuminates one side of the test chart for testing operation of the electronic image capture system.

[0021] The ring light may include a plurality of LEDs arranged in a circular array and a diffuser associated with the LEDs. Alternatively, the LEDs may themselves produce diffuse light and a separate diffuser may not be required. LEDs may be evenly spaced around the array in a single ring or in multiple rings. In one arrangement, the LEDs may be selectively illuminable so that, for example, only half or a smaller fraction of the ring light is activated at one time. This may provide angled lighting of the culture plate, and may be useful in highlighting surface topography of the medium. To ensure a uniform distribution of light intensity the number of LEDs in the array may be greater than 50, preferably greater than 180 so that a LED is spaced every 2 degrees. This is further assisted by the diffuser to smooth out the light distribution. In other alternatives, the ring light may be a fluorescent light or a plurality of fibre optic sources with a diffuser.

[0022] The ring light may be located relative to the support so that specular reflection of light from the ring light from a central surface of the medium or the test chart is at an angle that is not captured by the image capture device. For example, the ring light may have a width or diameter of between 120 and 250 mm and may be positioned between 30 and 50 mm above the support. As a culture plate or the test chart is typically circular, generally having a diameter of between 80 and 110 mm, light emitted from the LEDs will strike the central surface of the culture plate at such a low angle that it does not reflect into the camera lens. This prevents reflections of the LEDs from appearing in the image, producing a higher quality image for producing inputs to the classifier and hence a more accurate assessment and for measuring resolvable detail.

[0023] The support ideally positions the culture plate and the test chart immediately below the image capture device with its field of view directed to the culture plate or the test chart. As well as capturing the culture plate or the test chart in an image, the image capture device may also capture the area about the culture plate or the test chart. The apparatus may be arranged to include in the area about the culture plate or the test chart, in the field of view of the camera, various optical test features, such as a focus target, colour correction patches or alignment guides.

[0024] In an embodiment, the centre of the test chart is located by the support within a desired tolerance of the optical axis of the image capture device. Also, the shapes on the test chart are co-planar and the test chart is located by the support within a focal plane of the image capture device. The desired tolerance is, for example, 1mm.

[0025] That is, in an example of the system in use, the culture plate and the test chart to be imaged are positioned manually on the support by an operator, and the support includes a plurality of spaced apart fingers extending from a periphery of a circular hole supporting at least an edge of the culture plate or the test chart. The fingers thus define a position on the support such that the culture plate or test chart is precisely located in the field of view of the camera. In another example, the culture plate and the test chart to be imaged are positioned automatically, by a robotic placement device. In this case, the robotic device may be programmed to position the culture plate or the test chart in a predetermined position.

[0026] In addition, the frame may be a rigid structure that positions the image capture device, support and ring light relative to each other. The frame may be constructed in multiple parts that are connected together by bolts, screws or any suitable connection means. Alternatively, the frame may be formed in one piece by the use of suitable metal working techniques or moulds. The frame may play a part in light proofing the system.

[0027] Turning back to the above method of testing operation of the electronic image capture system using the test chart, the method further includes, in an embodiment, selecting the at least one of the shapes as having a desired orientation such that either the first edge or the second edge of the at least one of the shapes is within a range of rotation angles relative to a reference orientation of the test chart. Further, the range of rotation angles is between 2 and 90/*n* degrees of rotation relative to the reference orientation.

[0028] As described, the test chart is rotationally symmetric and, with reference to the above embodiment, the method further includes locating the reference orientation of the test chart by bisecting the test chart relative to the orientation of the image capture device.

[0029] In another embodiment, the method further includes determining a first region of interest of at least a portion of the first edge and a portion of the background adjacent the first edge. Also, the method further includes processing the first region of interest to characterise an edge Spatial Frequency Response (SFR) for the first edge, wherein the SFR is a SFR curve of spatial frequency values for pixel utilisation levels, and the SFR correlates to the resolvable detail for the electronic image capture system. It will be appreciated by those persons skilled in the art that methods of characterising an edge Spatial Frequency Response (SFR) are specified in the International Standard: ISO 12233:2014 Photography – Electronic still picture imaging – Resolution and spatial frequency responses. For example, the minimum operational value for the electronic image capture system correlates to a minimum utilisation level of 10 line pairs per pixel at a spatial frequency value of 0.5 relative to the SFR curve.

[0030] In addition, the method further includes determining a second region of interest of at least a portion of the second edge and a portion of the background adjacent the second edge, and processing the second region of interest to characterise an edge Spatial Frequency Response (SFR) for the second edge. In some embodiments, the method further includes averaging the edge Spatial Frequency Response (SFR) for the first and the second edges to generate an averaged SFR.

[0031] Turning back to the test chart more specifically, the shapes on the test chart are preferably squares having vertical edges corresponding to the first edge and horizontal edges corresponding to the second edge. Alternatively, the shapes are L shapes having perpendicular first and second edges. Indeed, as above, the shapes can be polygons with more than 2 edges.

[0032] In an embodiment, four series of n=4 squares are provided on the background of the test chart, and the method further includes processing eight first regions of interest to characterise the edge Spatial Frequency Response (SFR) for the vertical edges of the square and processing eight second regions of interest to characterise the edge Spatial Frequency Response (SFR) for the horizontal edges of the square. That is, four shapes across the four series of shapes have the desired orientation such that either the first edge or the second edge of the at least one of the shapes is within the range of rotation angles relative to the reference orientation of the test chart of between 2 and $90/n$ (22.5º where $n = 4$) degrees of rotation relative to the reference orientation. A person skilled in the art will also appreciate that edge SFR is a measure of the image transition across the edge rather than along it; accordingly it is preferable to have a near vertical and near horizontal edge greater than 2º.

[0033] In the embodiment, the electronic image capture system analyses both the first and the second edge of each of the exemplary four shapes in the image having the desired orientation to determine whether the resolvable detail exceeds a minimum operational value for the electronic image capture system. In other embodiments, one of either the first or the second edge of the shapes in the image can be analysed to determine whether the resolvable detail exceeds a minimum operational value for the electronic image capture system.

[0034] A person skilled in the art will appreciate that other configurations of numbers of series with $n > 4$ can be provided on the background to enable the test chart to test the operation of the electronic image capture apparatus. For example, 5 series of n=5 squares are provided on the background of the test chart. In this test chart, the range of rotation angles relative to the reference orientation of the test chart is between 2 and 18º of rotation relative to the reference orientation.

[0035] In another embodiment, the test chart includes a centrally-located visual marker for bisecting the test chart to locate the reference orientation of the test chart relative to the orientation of the image capture device. The centrally-located visual marker is a different colour to the background and is, for example, a circle that enables the system to bisect the test chart through the circle. Also, in the example, the circle enables the system to determine whether the image capture device is located centrally within a desired tolerance of the optical axis of the image capture device.

[0036] In another embodiment, the test chart includes a line provided on the background having a different colour than the first colour which bisects the test chart. Further, the test chart includes an orientation visual maker provided on the background to one side of the line. The orientation visual marker and the line enable the system to determine the orientation of the test chart.

[0037] In another embodiment, the test chart includes four planar-alignment visual markers provided equally distant from a centre of the test chart. Further, the four planar-alignment visual markers are provided on four of the squares that are equally distant from the centre of the test chart. The four planar-alignment visual markers are, for example, four dots in the corner squares of the test chart that can be used to check that the test chart is parallel to the imaging plane of the image capture device.

[0038] In an embodiment, the background is a light grey colour (e.g. 20% black) and the shapes are a dark grey colour (e.g. 80% black). That is, the colours of the test chart are monochromatic and in grey scale. The light grey colour can be used to detect irregularities in the electronic image capture system. The above mentioned four dots are white so as to be visible in the dark grey shapes and in the embodiment the line bisecting the test chart is also white. It will be appreciated by those persons skilled in the art that other colours can be used provided that the visual features are visible from the background by the electronic image capture system.

Brief Description of Drawings

[0039] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0040] Figure 1 is a top view of a test chart according to an embodiment of the present invention;

[0041] Figure 2 is a top view of a test chart according to another embodiment of the present invention

[0042] Figure 3 is a top view of the test chart of Figure 2 showing a series of shapes according to an embodiment of the present invention;

[0043] Figure 4 is a top view of the test chart of Figure 2 showing shapes in different series according to an embodiment of the present invention;

[0044] Figure 5 is a top view of a test chart with a 0º angle of rotation according to an embodiment of the present invention;

[0045] Figure 6 is a top view of a test chart with a 22.5º angle of rotation according to an embodiment of the present invention;

[0046] Figure 7 is a top view of a test chart with a 45º angle of rotation according to an embodiment of the present invention;

[0047] Figure 8 is a top view of a test chart with a 67.5º angle of rotation according to an embodiment of the present invention;

[0048] Figure 9 is a top view of a region of interest of a shape of a test chart according to an embodiment of the present invention;

[0049] Figure 10 is a graph of edge Spatial Frequency Responses (SFRs) for test charts under exemplary tests according to an embodiment of the present invention;

[0050] Figure 11 is a schematic diagram of an apparatus for use in analysing microbial growth on a solid culture medium in a culture plate according to an embodiment of the present invention; and

[0051] Figure 12 is a flow chart of a method of testing operation of an electronic image capture system according to an embodiment of the present invention.

Detailed Description

[0052] An embodiment of a test chart 1 for testing operation of an electronic image capture system is shown in Figure 1. The test chart 1 includes a background 12 having a first colour, and one series 14 of *n*=4 number of shapes provided on the background 12, each of the four shapes in the series 14 having an area with a second colour. In the embodiment, the first colour is a light grey and the second colour is a dark grey. Also, each of the shapes is a square with at least a first edge perpendicular to a second edge; the squares have two vertical edges and two horizontal edges.

[0053] Each of the four squares in the series 14 is provided on the background 12 in an orientation that is rotated by an angle of 22.5º of rotation relative to a successive square in the series 14. It can be seen that the first square 16 on the upper left hand side of the circular background 12 is rotated 85º from a horizontal axis of the test chart 1, the second square 18 on the lower right hand side of the circular background 12 is rotated 62.5º from the horizontal axis, the third square 20 on the upper right hand side of the circular background 12 is rotated 40º from the horizontal axis, and the fourth square 22 on the lower left hand side of the circular background 12 is rotated 17.5º from the horizontal axis.

[0054] Accordingly, under test conditions, the electronic image capture system captures an image of the test chart 1 using an image capture device of the system, measures resolvable detail of the image by analysing the vertical and the horizontal edges of the squares in the image to determine whether the resolvable detail exceeds a minimum operational value for the electronic image capture system. As mentioned above, in the embodiment, the electronic image capture system under test is used for analysing microbial growth in a solid culture medium on a culture plate, and the minimum operational value is a sufficient value for the electronic image capture system to be used for this analysis.

[0055] Also, it can be seen that the test chart 1 used for testing the operation of the electronic image capture system is rotationally invariant and is a circle. In the embodiment, the test chart is disc shaped, like the above mentioned culture plate, and the background and the shapes are provided on the circular planar surface of the disc. As mentioned, under the test of the electronic image capture system, at least one of the shapes has a desired orientation such that either the first edge or the second edge of the at least one of the shapes is within a range of shallow rotation angles relative to a reference orientation of the test chart of between 2 and 22.5º. In this embodiment, the square 22 with its 17.5º angle from the horizontal axis has the desired orientation. It can also be seen that at least one of the shapes 16 18 20 22 will have the desired orientation at any rotation of the circular test chart 1. That is, either the first edge or the second edge of the shapes has a rotation angle between the limits of 2º and 88º relative to the reference orientation of the test chart which corresponds to the orientation of the image capture device of the system. In the embodiment, the first and the second edges are straight and form the transition from the first colour to the second colour. Also, at least one of these edges is slanted relative to either the vertical or horizontal relative to the orientation of the image capture device as described above.

[0056] A centrally-located visual marker 24 is also shown in the test chart 1. As described, the centrally-located visual marker can be used for the electronic image capture system to bisect the test chart 1 to locate the reference orientation of the test chart relative to the orientation of the image capture device. The centrally-located visual marker 24 is a different colour (e.g. black) to the background 12 so that it can be identified by the electronic image capture system. The test chart also includes a line 26 on the background having a different colour than the background 12 which bisects the test chart 1 and an orientation visual maker 28 provided on the background 12 to one side of the line 26, also of a different colour to the background 12. As described, the line 26 and the marker 28 can be used by the electronic image capture system to determine the orientation of the test chart 1. The line 26 and the marker 28 are shown as white in the embodiment of the test chart 1.

[0057] Another embodiment of a test chart 10 for testing operation of an electronic image capture system is shown in Figures 2 to 8. This test chart 10 includes four further planar-alignment visual markers 30 provided equally distant from a centre of the test chart 10. These four planar-alignment visual markers 30 are provided on four of the squares that are equally distant from the centre of the test chart 10 as four white dots in the corner squares of the test chart 10 that can be used for the electronic image capture system to check that the test chart 10 is parallel to the imaging plane of an image capture device of the image capture system, which will be discussed in further detail below.

[0058] The test chart 10 also includes the background 12 having the first colour, as per the embodiment in Figure 1, and four series 14 32 34 36 of n=4 number of shapes provided on the background 12. Each of the four shapes in each of the series 14 32 34 36 has an area with a second colour, whereby the first colour is a light grey and the second colour is a dark grey. Each of the shapes is also a square with at least a first edge (e.g. vertical edge) perpendicular to a second edge (e.g. horizontal edge).

[0059] Each of the four squares in each of the series 14 32 34 36 is provided on the background 12 in an orientation that is rotated by an angle of 22.5º of rotation relative to a successive square in the series 14. Accordingly, under test conditions, the electronic image capture system again captures an image of the test chart 10, measures resolvable detail of the image by analysing the vertical and the horizontal edges of the four squares in the image to determine whether the resolvable detail exceeds a minimum operational value for the electronic image capture system.

[0060] Under the test of the electronic image capture apparatus, at least one of the shapes will again have a desired orientation such that either the first edge or the second edge of the at least one of the shapes is within the range of rotation angles between 2 and 22.5º relative to the reference orientation of the test chart. In this embodiment of the test chart 10, there are four squares across four different series with the same desired orientation and resolvable detail of the image is measured by analysing the first and the second edges of the four shapes in the image and determining whether the resolvable detail exceeds a minimum operational value for the electronic image capture system.

[0061] Figure 3 shows an embodiment of the test chart 10 with the squares of the series 14 highlighted. As with Figure 1, the it can be seen in this figure that the first square 16 on the upper left hand side of the circular background 12 is rotated 85º from a horizontal axis of the test chart 10, the second square 18 on the lower right hand side of the circular background 12 is rotated 62.5º from the horizontal axis, the third square 20 on the upper right hand side of the circular background 12 is rotated 40º from the horizontal axis, and the fourth square 22 on the lower left hand side of the circular background 12 is rotated 17.5º from the horizontal axis.

[0062] Figure 4 shows an embodiment of the test chart 10 with squares having the same orientation across the different series 14 32 34 36 highlighted. It can be seen that the square 16 of the first series 14 is rotated 85º from a horizontal axis of the test chart 10. The square 38 of the second series 32 is also rotated 85º from a horizontal axis of the test chart 10. The square 40 of the third series 34 is also rotated 85º from a horizontal axis of the test chart 10. The square 42 of the fourth series 36 is also rotated 85º from a horizontal axis of the test chart 10.

[0063] Figures 5 to 8 show the rotationally invariant test chart 10 being used across a number of orientations within 360 degrees of rotation. Figure 5 is at 0º of rotation, Figure 6 at 22.5º of rotation, Figure 7 is at 45º of rotation, and Figure 8 at 67.5º of rotation relative to a horizontal axis 44 of the test chart 10. When the test chart 10 at the orientation of Figure 5 is used for testing operation of the electronic image capture system, four squares across four series are selected as having a desired orientation such that either the first edge or the second edge is within the desired shallow range of rotation angles of 2 and 22.5º. These four squares here are: square 16; square 38; square 40; and square 42. When the test chart 10 at the orientation of Figure 6 is used for testing operation of the electronic image capture system, four different squares across the four series are selected as having a desired orientation. These four squares here are: square 22; square 46; square 48; and square 50. When the test chart 10 at the orientation of Figure 7 is used for testing operation of the electronic image capture system, four different squares across the four series are selected as having a desired orientation. These four squares here are: square 22; square 52; square 54; and square 56. When the test chart 10 at the orientation of Figure 8 is used for testing operation of the electronic image capture system, four different squares across the four series are selected as having a desired orientation. These four squares here are: square 18; square 58; square 60; and square 62.

[0064] As mentioned, the test chart 10 is rotationally invariant and, in an embodiment, is disc shaped with the background 12 and the squares being provided on the circular planar surface of the disc. The disc is shaped so as to be received by the electronic image capture system under test, which is used for analysing microbial growth in a solid culture medium on a culture plate having the same dimensions as the disc. Figure 11 shows an embodiment of a system 90 for testing operation of an electronic image capture system 100, the system 90 including at least the test chart 1 10, an image capture device 104 and a processor 138 of a computer 136 for measuring resolvable detail of the image captured with the electronic image capture system 100. The electronic image capture system 100 is generally used in analysing microbial growth on a solid culture medium in a culture plate 102. The system 100 is required to be tested at regular intervals to determine whether the resolvable detail exceeds a minimum operational value for the electronic image capture system corresponding to a sufficient value for the electronic image capture system to be used for analysing microbial growth.

[0065] Details of an embodiment of the electronic image capture system 100 for use analysing microbial growth on a solid culture medium in the culture plate 102 are provided below with reference to Figure 11. The electronic image capture system 100 further includes an image capture device 104 in the form of a high resolution digital camera 106 of machine vision quality with an appropriate fixed focal length lens 108. The camera 106 is positioned about 200mm above a ring light 110.

[0066] The ring light 110 has a large diameter relative to the diameter of the plate 102 (e.g. agar plate). In this example, the ring light 110 has a diameter of 180mm. The ring light 110 contains several hundred white LEDs arranged in a circular array and a diffuser. This light provides low angle, diffused side lighting to enable the plate to be uniformly illuminated. The ring light 110 is positioned around 40mm above an opaque cover 112 that forms part of the frame 118, and thus about 30mm above the plate 102. The positioning of the ring light 110 so that light from the white LEDs impinge on the surface of the agar plate 102 at a low angle prevents a specular reflection of the LEDs from a central surface of the solid culture medium being captured by the image capture device 104.

[0067] A lighting device 114 in the form of a flat panel light 114 based on an array of white LEDs behind a diffuser. The lighting device 114 is located about 150mm below the opaque cover 112. This distance is chosen so that light from the ring light 110 falls on the baffles rather than the light 114, to reduce rear illumination of the plate 102.

[0068] A support 116 for supporting the plate 102 in the direct field of view of the image capture device 104 is provided. The support 116 also supports the test chart 1 10 in the same manner. The support 116 is transparent to light and preferably includes a plurality of spaced apart fingers extending from a periphery of a circular hole supporting at least an edge of the culture plate 102. That is, the support 116 includes one or more positioning elements for positioning the plate 102 on the support 116 within the circular hole. Further, the support 116 includes a placement device configured to position the plate 102 in a position in the image capture system 100 to capture the image of the solid culture medium and any microbial growth. In another example, the support 116 is a transparent glass stage that is 3mm thick. The glass may be replaced if it becomes scratched over time. The support 116 includes, in another example, two or more triangle shaped transparent positioning elements for positioning the plate 102 on the support 116. The apexes of the triangles point towards the centre of the support for placement of the plate 102 so that the apexes touch the circumference of the plate 102.

[0069] A frame 118 positions the image capture device 104, support 116, ring light 110 and lighting device 114 relative to each other. The frame 118 is made of an opaque material, such as sheet metal or plastic, which reduces the amount of light entering the system 100. The internal surfaces of the system 100 are blackened where possible to reduce reflection of light from the internal surfaces into the lens 108.

[0070] The frame 118 includes a door 120 providing an access path for a human operator to place the plate 102 on the support 116. Alternatively, a robotic plate-handling device may use the access path to place the plate 102 precisely on the support 116 for imaging, and then to remove the plate to a designated output channel/slide. For example, the plate may be placed in an output channel representing one of up to four categories: 1. waste (the plate showed a clear negative result); 2. reincubation required; 3. identification of potentially pathogenic bacteria (the plate showed a positive result and requires review in accordance with regulations); or 4. for human review (the computer was unable to make a clear decision).

[0071] The opaque cover 112 is an aluminium plate that extends across the width of the frame 118 and effectively splits the frame 118 into a top enclosure 122 and bottom enclosure 124. The opaque cover 112 includes a hole 126 to allow light from the lighting device 114 to transmit through to the plate 102. The width of the hole 126 is just slightly larger than the width of the plate 102 (which is 90mm in this example and is typically between 80 and 110mm) and is less than the diameter of the ring light 110. This prevents light emitted from the ring light 110 from reflecting from the bottom surface 128 of the frame 118 or the surface of the flat panel light 114 and back through the culture plate 102.

[0072] The frame 118 also includes light baffles 130 positioned below the opaque cover 112.

[0073] Means 131 for changing the position of the ring light 110 relative to the support 116 are also provided in the form of a rack and pinion assembly.

[0074] The frame 118, opaque cover 112 and light baffles 130 define a cavity 132 such that the support 116 supports the plate 102 between the image capture device 104 and the cavity 132. The support 116 in the example of a glass stage seals the cavity 132 and prevents unwanted material from falling into the cavity 132. When the ring light 110 is illuminated and the lighting device 114 is off, the opaque cover 112 prevents light from the ring light 110 from illuminating visible areas of the cavity 132. In this configuration, the cavity 132 looks like a black background.

[0075] A side angle light 134 is used to illuminate the plate 102 from an angle to highlight any surface topography on the agar on the plate 102, such as dimples or a granular texture. An alternative to the side angle light 134 is to activate only some of the LEDs in the ring light 110, such that the plate 102 is illuminated from one direction only.

[0076] A processing means such as a computer 136 is connected to the image capture device 104, the ring light 110 and the lighting device 114 via a physical or wireless interface. The computer 136 may include a processor 138 and memory 140 storing software 142 for activating the different components, capturing raw data and processing the data.

[0077] A library of images, metadata and other information may be stored at the computer 136, or may be accessible at the computer 136 via a network. The library may be linked to a Laboratory Information Management System (LIMS) to access information about the patient and sample.

[0078] It will be appreciated that different components may be substituted for any of the above described components of the device, and that the distance between components and position of components may be adjusted. For example, although the camera 106 and lens 108 are shown inside the frame 118, in another example, they could be positioned outside the frame 118, with the lens 108 protruding through a hole in the top surface of the frame 118. Also, the width of the frame 118 could be decreased to reduce the overall size of the system 100.

[0079] An image acquisition process using the system 100 may be suitable for obtaining images for use in classifying microbial growth on the plate 102 using a trained machine learning classifier, or in training such a classifier. A manual process will be described, where many steps are performed by a human operator, but it will be appreciated that many of the steps of the process may be automated and performed in software or by a robotic device.

[0080] Firstly, an inoculated and incubated agar plate 102 is positioned on the support 116, within the spaced apart, by a user. Plates 102 are generally stored within a laboratory with the agar facing down (to prevent condensation on the lid from falling on to, and damaging, the agar surface), so positioning the plate 102 on the support may include removing a lid of the plate 102 and rotating the plate so that the agar is facing upwards.

[0081] The software 142 is activated to begin the image capture process. The software 142 requires the user to scan a barcode on the plate 102, or enter a number manually. The barcode links to a sample ID, which links the plate to a particular sample and, via the LIMS, to a particular patient. Once the barcode has been entered, a live video preview of the camera output appears in the window shown in Fig. 2(a). The user may adjust the location of the plate 102 or the focus or aperture of the lens 108 using the live video stream.

[0082] Returning back to Figures 9 and 10, an example is shown of the test chart 10 being used to test the operation of the electronic image capture system 100 to determining whether the resolvable detail exceeds a minimum operational value for the electronic image capture system 100. As described, an image of the test chart 1 10 is captured using the electronic image capture system so that resolvable detail of the image can be measured by analysing the first and or the second edges of at least one of the squares in the image. Further, the at least one square is selected as having a desired orientation such that either the first edge or the second edge is within a shallow range of rotation angles between 2 and 22.5º. Figure 9 shows a region of interest 64 of an edge 66 of one of the squares of the test chart 1 10 and it can be seen that the edge has a shallow angle relative to the horizontal axis. In an exemplary embodiment, the edge 66 is an edge of the square 40 of the test chart 10.

[0083] The region of interest 64 includes at least a portion of the first or the second edge and a portion of the background adjacent the first edge. In the exemplary embodiment, the edge 66 is an edge of the square 40 of the test chart 10 and the region of interest 64 is of the first (horizontal) edge of the square 40. In the embodiment where there are 4 series of 4 squares, there are 8 first regions of interest including at least a portion of the first edge and a portion of the background adjacent the first edge and 8 second regions of interest including at least a portion of the second edge and a portion of the background adjacent the second edge. These 16 regions of interest are processed to characterise an edge Spatial Frequency Response (SFR) for the first edge and the second edge, wherein the SFR is a SFR curve of spatial frequency values for pixel utilisation levels, and the SFR correlates to the resolvable detail for the electronic image capture system.

[0084] The method of characterising an edge Spatial Frequency Response (SFR) is provided by an SFR algorithm in the above mentioned ISO standard (ISO 12233:2014). This method allows measurement of the resolvable detail that a particular optical system, including the camera, can capture. The SFR method relies on the availability of at least two straight edges, with approximately 5 degrees to each axis, and the edges must transition from light grey to dark grey. Figure 9 shows the edge 66 of one region of interest 66 transitioning from light grey in the background 12 to dark grey in the square 40.

[0085] When the four squares in the test chart have been selected, the SFR algorithm is executed on each of the four sides, resulting in 16 measurements. These measurements are then combined and compared against a minimum utilisation level at a given spatial frequency value to obtain a pass or fail result for that test of the electronic image apparatus using the test chart 10. The measurements of the SFR are displayed as curves and are averaged to yield a single curve. That is, the edge Spatial Frequency Response (SFR) for the first and the second edges are averaged to generate an averaged SFR which is compared against the minimum operational value for the electronic image capture system 100 which correlates to a minimum utilisation level of 10 line pairs per pixel at a spatial frequency value of 0.5 relative to the SFR curve.

[0086] The SFR curves averaged in the above described way for six tests using the test chart 10 are shown in Figure 10 with respect to the minimum utilisation level of 10 line pairs per pixel at a spatial frequency value of 0.5. This minimum utilisation level of 10 line pairs per pixel at a spatial frequency value of 0.5 is a threshold value correlating to the designated minimum operational value for the electronic image capture system. The six tests of the electronic image capture system 100 are simulated tests with the camera 106 of the system 100 having its focussed changed to simulate it being out of focus. It can be seen that two tests displayed as the curves marked as “Focussed” passed the minimum threshold utilisation level of 10 line pairs per pixel at a spatial frequency value of 0.5. Accordingly, the resolvable detail for the electronic image capture system here exceeds the minimum operational value for the electronic image capture system. The tests marked with focus levels -1, -0.5, 1 and 0.5 fail the minimum threshold utilisation level of 10 line pairs per pixel at a spatial frequency value of 0.5.

[0087] In one embodiment, the code for the implementation of the testing operation to be implemented by the processor 138 of the computer 136 is broken into two separate pieces. A set of low-level functions is contained in a C++ class called SFRUtils. A set of higher-level functions is contained in a class called SFRChart. This class implements the square selection and region-of-interest (ROI) extraction for the test testing operation. Also, the ROIs are cropped from the image of the test chart taken using the electronic image capture system and passed down to SFRUtils.

[0088] The SFRUtils contains the low-level functions used to compute the SFR of a particular region. The key method in this class is processHorizontalROI which, when supplied an image of an ROI, produces the SFR for that region. The steps involved include: determining the location of the step between the two colours (e.g. light grey and dark grey) and fitting a line to it; using the line to straighten the edges and super-sample them, forming a 4x resolution 1D image of the transition from dark to light grey; differentiating the image to form an edge-spread-function (ESF); applying a hamming window to the differentiate function to weight samples in the centre more highly than those at the edges; and taking the absolute value of the discrete Fourier transform of the processed ESF to yield the SFR.

[0089] Each of the above steps can be broken down into an additional set of steps. In step 1, to locate the transition from dark to light grey, the image is differentiated to find edges. Within each column of the image, the maximum of the gradient is computed, which yields the position of the edge. Once the edge positions have been located, a linear fit is computed, which is then tuned via iteratively reweighted least squares (IRLS). IRLS requires solving a linear system of equations and currently uses a matrix inverse to determine the solution to the system.

[0090] In step 2, once the line has been computed, the image is straightened and super-sampled. This is achieved by using the line equation with each column index to determine a floating point y coordinate. The column is then shifted by the difference between y and the middle of the image. The shift is performed by multiplying the difference by 4, converting to an integer and then adding the entire column to a vector 4 times the height of the image. Every column in the image is added in this fashion, the end result being a vector containing a 4x sampled 1D copy of the edge. Each row is then divided by the number of samples which contributed to it.

[0091] In step 3, the 1D version of the image is differentiated. A simple numeric differentiation is used where the next element is subtracted from the previous element, and then divided by two to give the derivative of the current element.

[0092] In step 4, the edge-spread-function (ESF) is now weighted with a hamming window to reduce the influence of elements towards the edge of the ESF, and focus on the inner elements around the transition itself.

[0093] In step 5, the absolute value of the discrete Fourier transform is computed to yield the SFR itself.

[0094] In relation to the selection of the appropriate squares in the test chart 10, when the test chart 10 is processed, the set of appropriate squares to be used can be determined as follows. A list is constructed of every possible ROI for the test chart 10, leading to 64 entries. Each ROI is rotated by the test chart 10 orientation that is determined as described above. The angle between reference orientation and the four cardinal directions is then taken. If the angle is greater than 2º and less than 11.35º, a match has been found. The lower bound prevents the code from selecting squares which are close to horizontal or vertical.

[0095] If no match is found, the test is repeated with a threshold of 22.5º. Once the ROI list has been determined, the bounding box for each one needs to be determined. When the ROI list is determined, only the centre of each square is known, not the dimensions to be cropped from the original image. To compute the dimensions, four points are constructed which span the ROI. The points are then rotated to the angle of the ROI and the span of the points in X and Y is computed. If the X span is bigger than Y, some padding is added to the Y axis to ensure enough pixels are available. If the Y span is bigger than X, padding is added to the X axis. The image within this region is then extracted to form the ROI.

[0096] The edge pixels along the horizontal and vertical axis of the ROI are averaged together, to yield four averages. If the difference between the two horizontal edges is bigger than the two vertical edges, the image needs to be rotated. Similarly, if the middle pixel on the top row is brighter than the middle pixel on the bottom row, the image is upside down and needs to be flipped. Once the ROI has been cropped, it is fed to the SFR computation method.

[0097] In addition, the camera 106 alignment is checked. The centre of the test chart 10 is a black circle. Thus, the camera 106 alignment may be checked by ensuring the centre pixel of the image is black when the test chart 10 is loaded in the system 100. Black is defined as having an intensity of less than 0.2.

[0098] Also, the image captured for the test chart 10 should not be colour corrected. Thus, image must be prepared for use. The white balance is easily computed, since the test chart 10 is grey overall. The average grey of the test chart 10 is 0.31. Thus, the average colour of the area of the image covered by the test chart 10 is computed, and then mapped so that the average red, green and blue values are all 0.31.

[0099] The correct orientation of the test chart 10 can also be determined at this stage. The test chart 10 position in the system 100 can be used to determine the expected position of the white dot 28 in both possible orientations of the test chart 10 (the angle from the test chart 10 locating algorithm, and the same angle plus 180º). The angle which gives the highest brightness in the expected position should be chosen.

[0100] Turning now to Figure 12, there is shown a summary of a method 200 of testing operation of an electronic image capture system. The method 200 including the steps of: providing 202 a test chart for the electronic image capture system under test. The test chart 1 10 as per the above embodiments includes background 12 and at least one series of *n* number of shapes provided on the background 12, each of the shapes having an area with a second colour, and each of the shapes having at least a first edge perpendicular to a second edge, wherein each of the *n* shapes in a series is provided on the background in an orientation that is rotated by an angle of (90/*n*) degrees of rotation relative to a successive shape in the series, and wherein *n* is at least 4. The method 200 further includes capturing 204 an image of the test chart 1 10 using the electronic image capture system; measuring 206 resolvable detail of the image by analysing the first and or the second edges of at least one of the shapes in the image; and determining 208 whether the resolvable detail exceeds a minimum operational value for the electronic image capture system.

[0101] Further aspects of the method will be apparent from the above description of the electronic image capture system 100 for use in analysing microbial growth. Persons skilled in the art will appreciate that the method could be embodied in program code, executed by a processor, which could be supplied in a number of ways, for example on a computer readable medium, such as a disc or a memory, or as a data signal, such as by transmitting it from a server.

[0102] It is to be understood that various alterations, additions and/or modifications may be made to the parts previously described without departing from the ambit of the present invention, and that, in the light of the above teachings, the present invention may be implemented in a variety of manners as would be understood by the skilled person.

Claims

1. A method of testing operation of an electronic image capture system, the method including:

providing a test chart for the electronic image capture system under test, the test chart including:

a background having a first colour; and

at least one series of *n* number of shapes provided on the background, each of the shapes having an area with a second colour, and each of the shapes having at least a first edge adjacent to a second edge, wherein each of the *n* shapes in a series is provided on the background in an orientation such that either the first edge or the second edge of the at least one of the shapes has a rotation angle between 2 degrees and 88 degrees relative to a reference orientation of the test chart corresponding to the orientation of an image capture device of the electronic image capture system, and wherein *n* is at least 3;

capturing an image of the test chart using the electronic image capture system;

measuring resolvable detail of the image by analysing the first and or the second edges of at least one of the shapes in the image; and

determining whether the resolvable detail exceeds a minimum operational value for the electronic image capture system.

2. A method according to claim 1, wherein each of the *n* shapes in the series has at least the first edge perpendicular to the second edge, and each of the *n* shapes in the series is provided on the background in an orientation that is rotated by an angle of (90/*n*) degrees of rotation relative to a successive shape in the series, and wherein *n* is at least 4.

3. A method according to claim 2, further including selecting the at least one of the shapes as having a desired orientation such that either the first edge or the second edge of the at least one of the shapes is within a range of rotation angles relative to the reference orientation of the test chart.

4. A method according to claim 3, wherein the range of rotation angles is between 2 and 90/*n* degrees of rotation relative to the reference orientation.

5. A method according to claim 3 or 4, wherein the test chart is rotationally symmetric and the method further includes locating the reference orientation of the test chart by bisecting the test chart.

6. A method according to any one of claims 3 to 5, further including determining a first region of interest of at least a portion of the first edge and a portion of the background adjacent the first edge.

7. A method according to claim 6, further including processing the first region of interest to characterise an edge Spatial Frequency Response (SFR) for the first edge, wherein the SFR is a SFR curve of spatial frequency values for pixel utilisation levels, and the SFR correlates to the resolvable detail for the electronic image capture system.

8. A method according to claim 7, wherein the minimum operational value for the electronic image capture system correlates to a minimum utilisation level of 10 line pairs per pixel at a spatial frequency value of 0.5 relative to the SFR curve.

9. A method according to claim 7 or 8, further including determining a second region of interest of at least a portion of the second edge and a portion of the background adjacent the second edge, and processing the second region of interest to characterise an edge Spatial Frequency Response (SFR) for the second edge.

9. A method according to claim 8, further including averaging the edge Spatial Frequency Response (SFR) for the first and the second edges to generate an averaged SFR.

10. A method according to claim 9, wherein the shapes on the test chart are squares having vertical edges corresponding to the first edge and horizontal edges corresponding to the second edge.

11. A method according to claim 10, wherein 4 series of n=4 squares are provided on the background, and the method further includes processing 8 first regions of interest to characterise the edge Spatial Frequency Response (SFR) for the vertical edges of the square and processing 8 second regions of interest to characterise the edge Spatial Frequency Response (SFR) for the horizontal edges of the square.

12. A method according to any one of claims 1 to 11, wherein the minimum operational value is a sufficient value for the electronic image capture system to be used for analysing microbial growth in a solid culture medium.

13. A test chart for testing operation of an electronic image capture system, the chart including:

a background having a first colour; and

at least one series of n number of shapes provided on the background, each of the shapes having an area with a second colour, and each of the shapes having at least a first edge adjacent to a second edge,

wherein each of the n shapes in a series is provided on the background in an orientation such that either the first edge or the second edge of the at least one of the shapes has a rotation angle between 2 degrees and 88 degrees relative to a reference orientation of the test chart corresponding to the orientation of an image capture device of the electronic image capture system, and wherein n is at least 3,

whereby under test the electronic image capture system captures an image of the test chart, measures resolvable detail of the image by analysing the first and or the second edge of the shapes in the image to determine whether the resolvable detail exceeds a minimum operational value for the electronic image capture system.

14. A test chart according to claim 13, wherein each of the *n* shapes in the series has at least the first edge perpendicular to the second edge, and each of the *n* shapes in the series is provided on the background in an orientation that is rotated by an angle of (90/*n*) degrees of rotation relative to a successive shape in the series, and wherein *n* is at least 4.

15. A test chart according to claim 14, wherein the at least one of the shapes has a desired orientation such that either the first edge or the second edge of the at least one of the shapes is within a range of rotation angles relative to a reference orientation of the test chart.

16. A test chart according to claim 15, wherein the range of rotation angles is between 2 and 90/*n* degrees of rotation relative to the reference orientation.

17. A test chart according to claim 16, wherein the test chart is rotationally symmetric.

18. A test chart according to claim 17, wherein the test chart is a circle.

19. A test chart according to claim 17 or 18, wherein the test chart includes a centrally-located visual marker for bisecting the test chart to locate the reference orientation of the test chart relative to the orientation of the image capture device.

20. A test chart according to claim 19, wherein the test chart includes a line provided on the background having a different colour than the first colour which bisects the test chart.

21. A test chart according to claim 20, wherein the test chart includes an orientation visual maker provided on the background to one side of the line.

22. A test chart according to any one of claims 13 to 21, wherein the shapes on the test chart are squares having vertical edges corresponding to the first edge

and horizontal edges corresponding to the second edge, and 4 series of n=4 squares are provided on the background.

23. A system for testing operation of an electronic image capture system, the system including:

a test chart for the electronic image capture system under test, the test chart including:

a background having a first colour; and

at least one series of n number of shapes provided on the background, each of the shapes having an area with a second colour, and each of the shapes having at least a first edge perpendicular to a second edge, wherein each of the n shapes in a series is provided on the background in an orientation such that either the first edge or the second edge of the at least one of the shapes has a rotation angle between 2 degrees and 88 degrees relative to a reference orientation of the test chart, and wherein n is at least 3;

an image capture device of the electronic image capture system capturing an image of the test chart, wherein the reference orientation corresponds to the orientation of an image capture device of the electronic image capture system; and

a processor of the electronic image capture system for measuring resolvable detail of the image by analysing the first and or the second edges of at least one of the shapes in the image and determining whether the resolvable detail exceeds a minimum operational value for the electronic image capture system.

24. A system according to claim 23, wherein the system includes a support for supporting the test chart at a pre-determined location for the image capture device to capture the image, and wherein the system includes a frame for positioning the image capture device and the support relative to each other.

25. A system according to claim 24, wherein the pre-determined location corresponds to a location of a culture plate when the electronic image capture

system is used for analysing microbial growth on a solid culture medium in the culture plate.

26. A system according to claim 24, wherein the centre of the test chart is located by the support within a desired tolerance of the optical axis of the image capture device.

27. A system according to claim 24, wherein the shapes on the test chart are co-planar and the the test chart is located by the support within a focal plane of the image capture device.

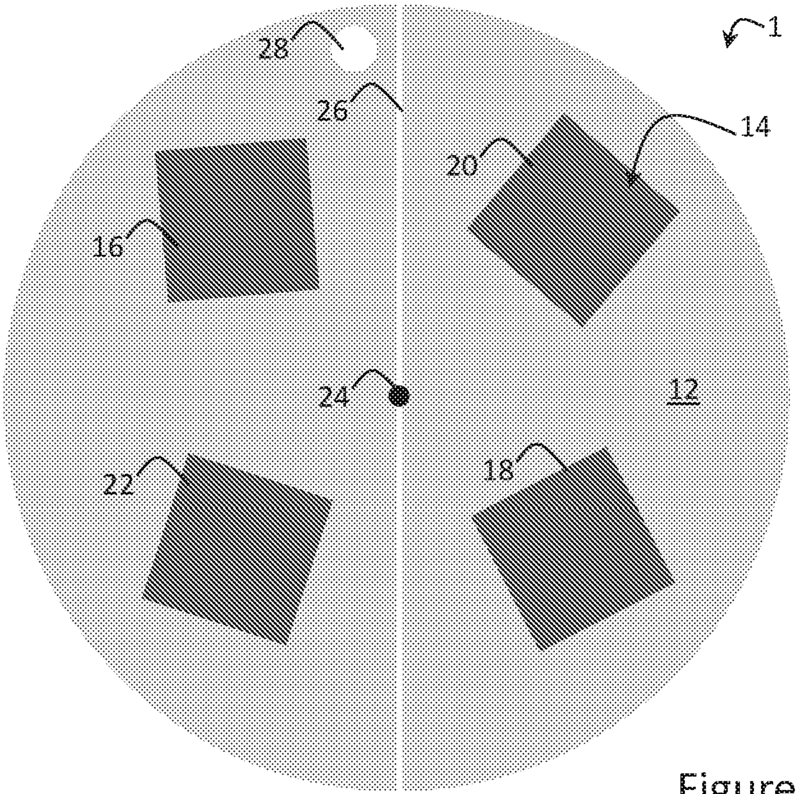


Figure 1

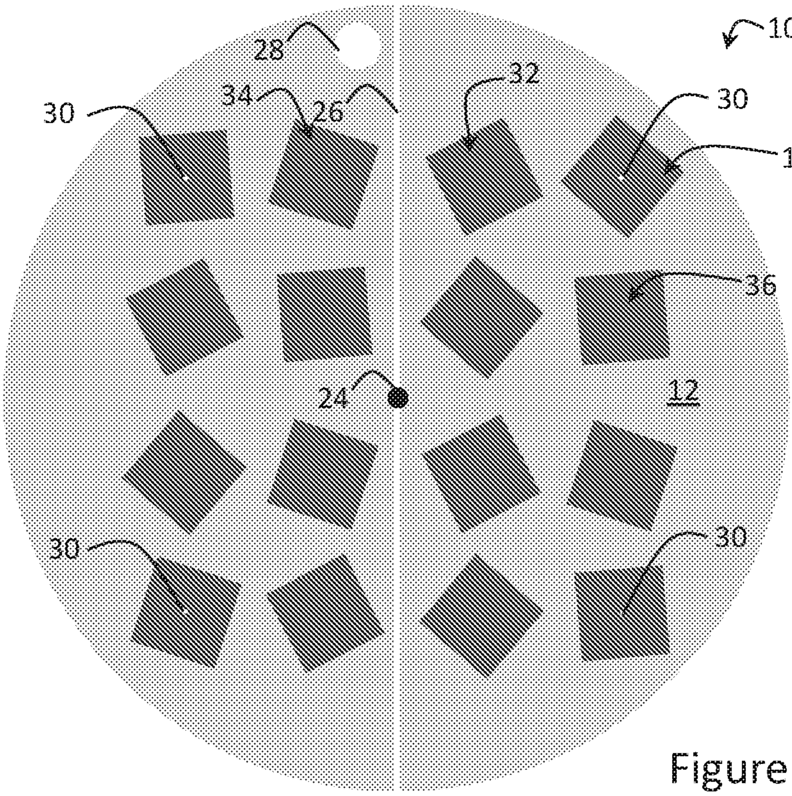


Figure 2

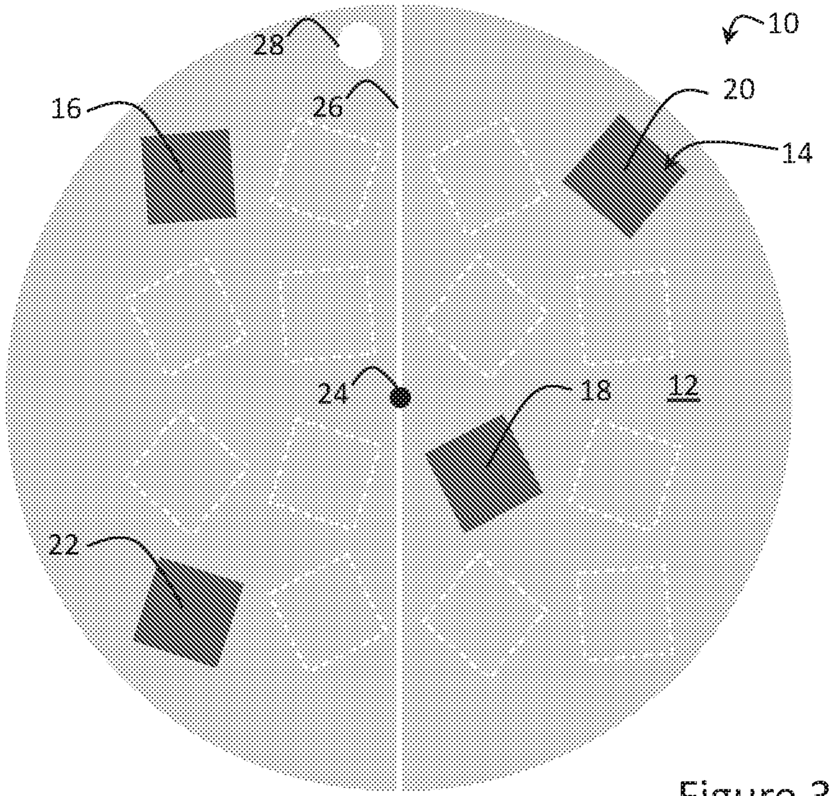


Figure 3

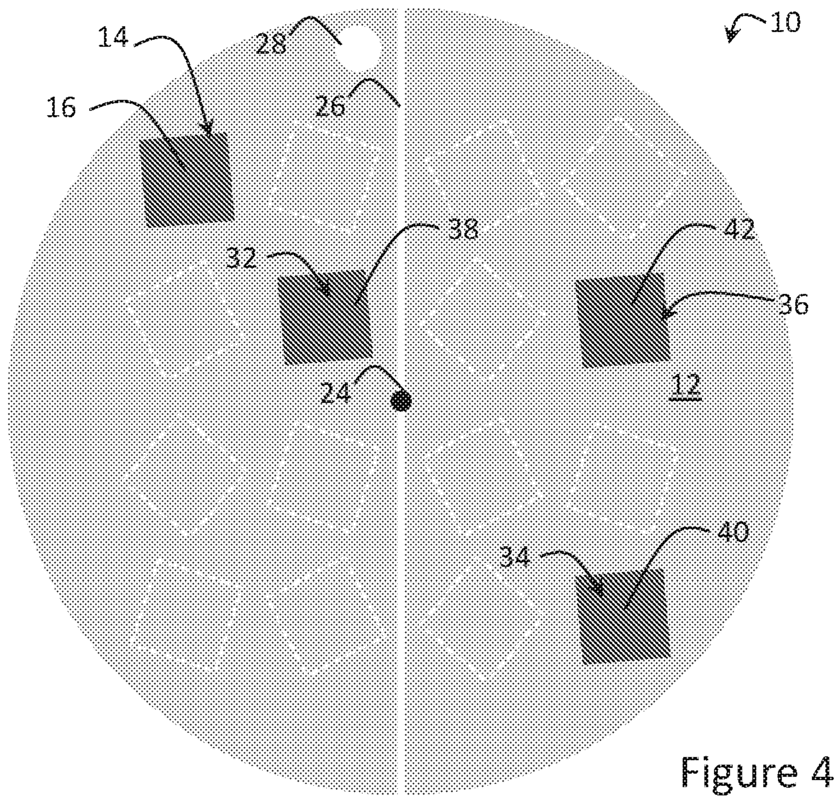
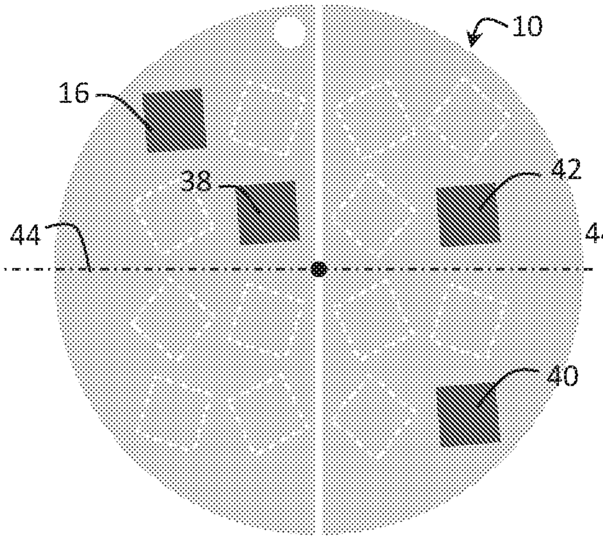
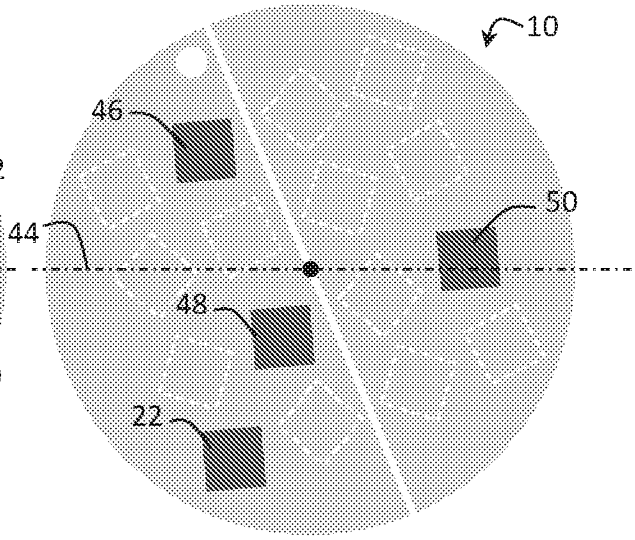


Figure 4



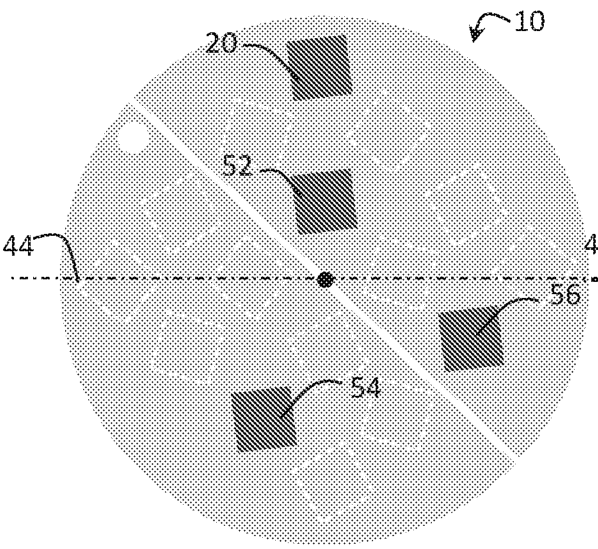
0° of rotation

Figure 5



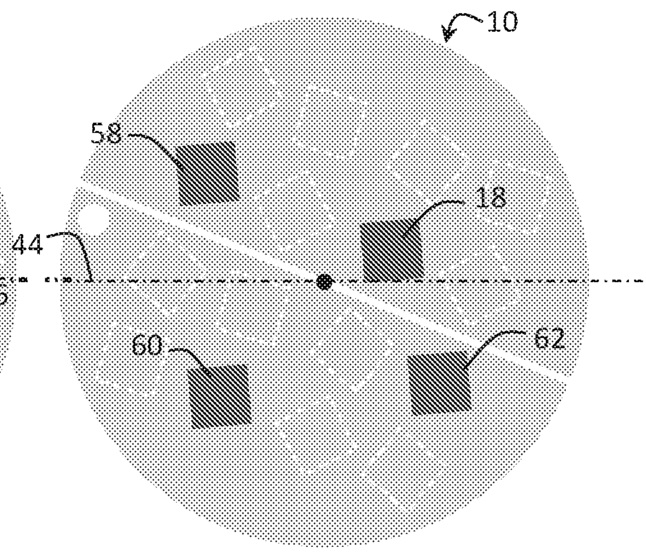
22.5° of rotation

Figure 6



45° of rotation

Figure 7



67.5° of rotation

Figure 8

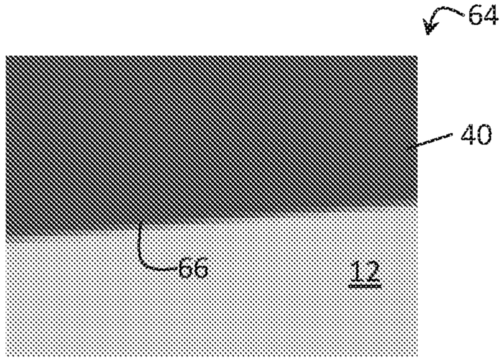


Figure 9

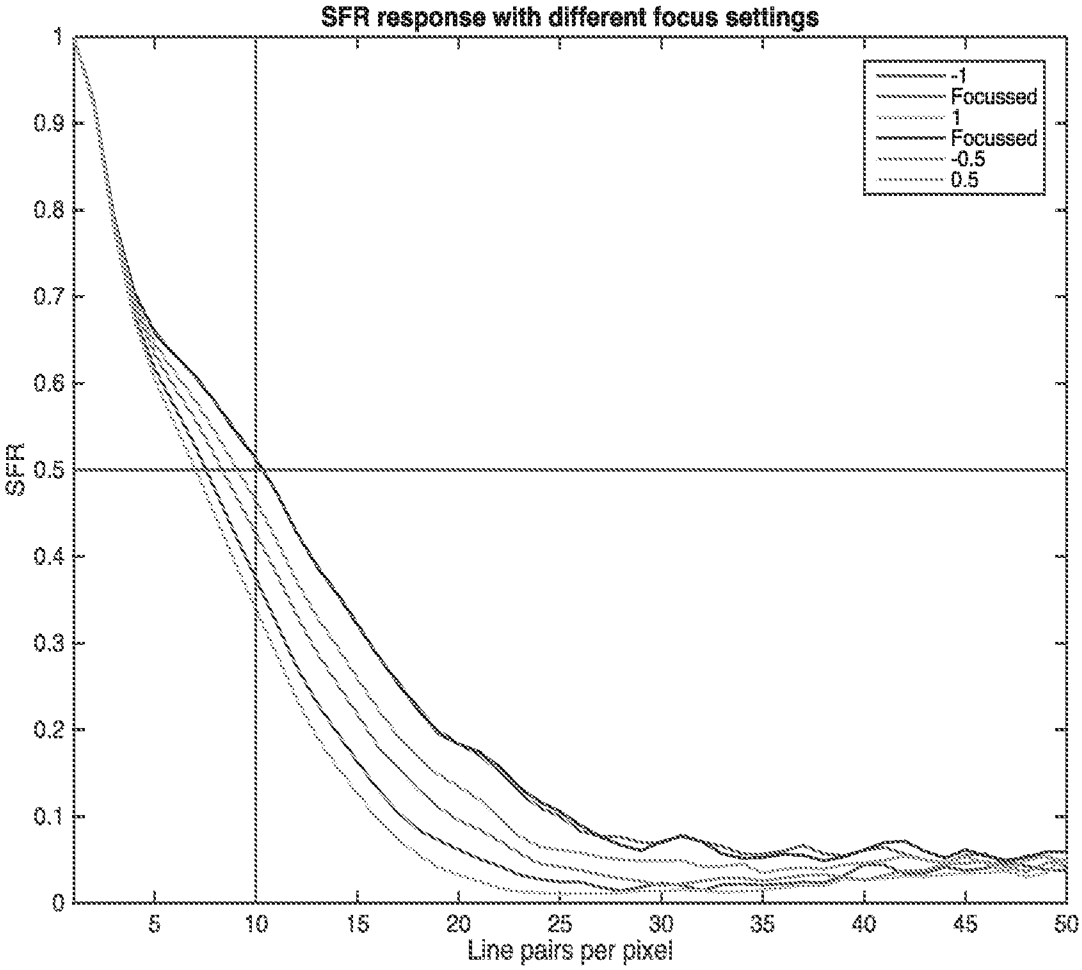
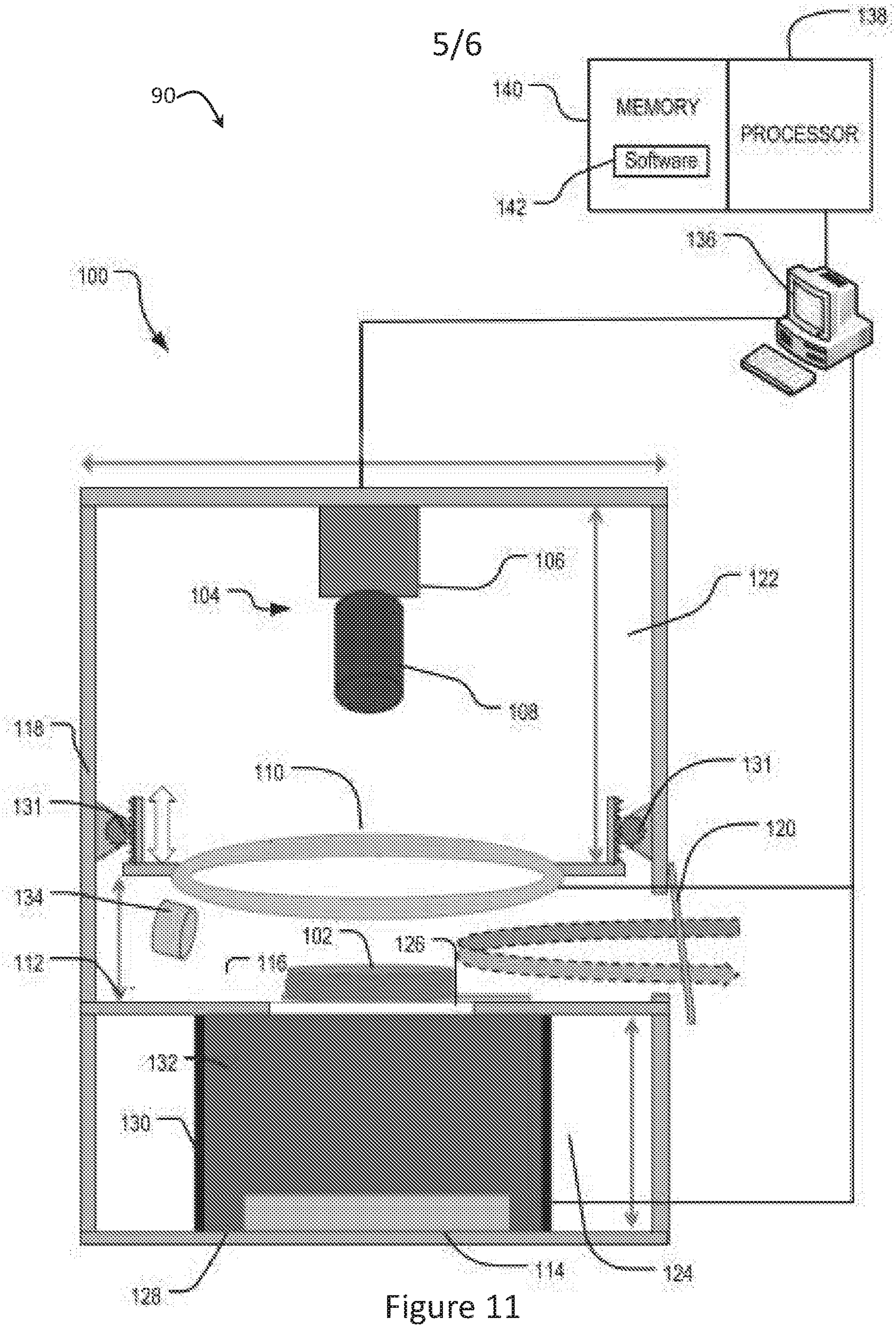


Figure 10



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138
140
MEMORY
Software
PROCESSOR
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136
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Figure 11

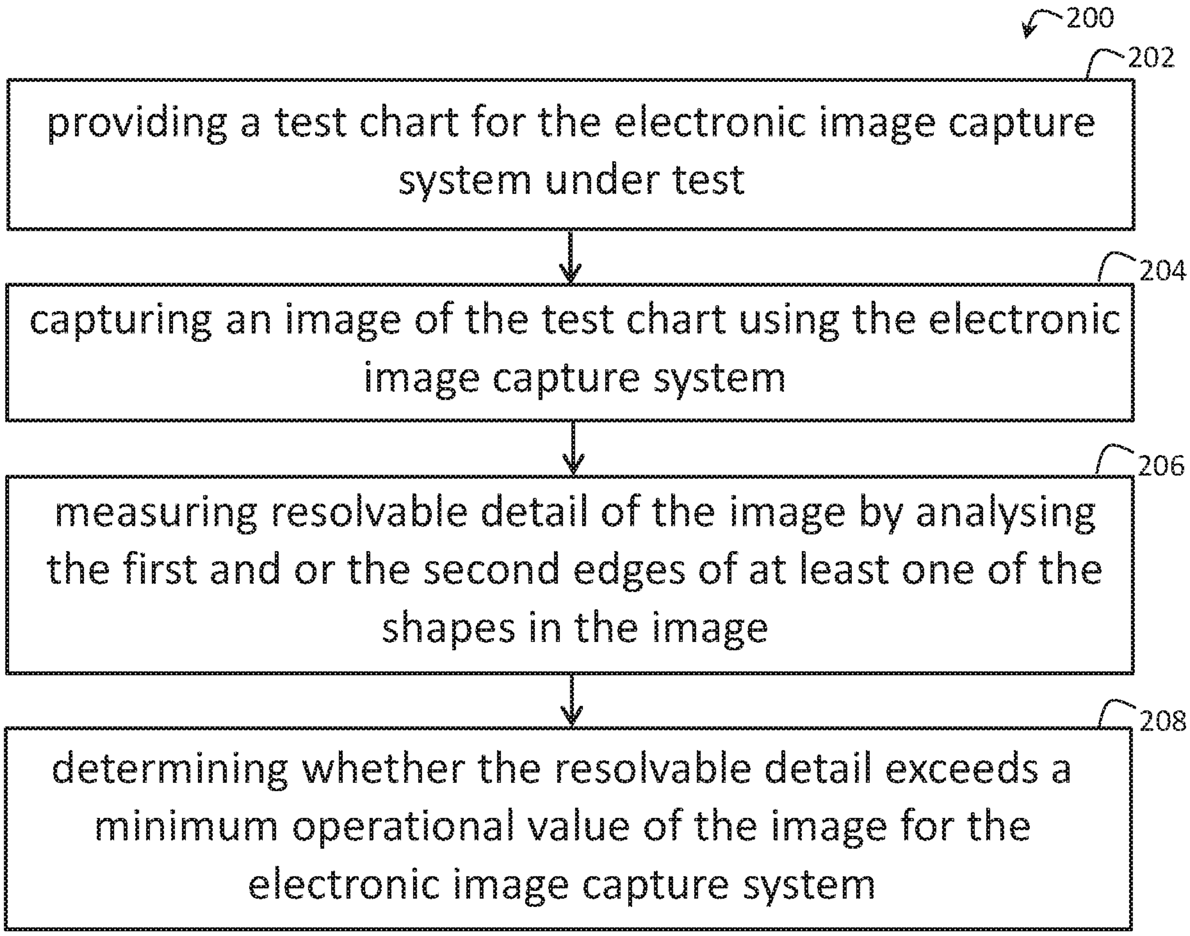
200
202
providing a test chart for the electronic image capture system under test
204
capturing an image of the test chart using the electronic image capture system
206
measuring resolvable detail of the image by analysing the first and or the second edges of at least one of the shapes in the image
208
determining whether the resolvable detail exceeds a minimum operational value of the image for the electronic image capture system

Figure 12

INTERNATIONAL SEARCH REPORT	International application No. **PCT/AU2017/050305**

A. CLASSIFICATION OF SUBJECT MATTER

G06T 7/80 (2017.01) H04N 17/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PATENW: IPC/CPC Marks:G06T7/80/LOW; Keywords: ISO 12233, EGA, ROTATE, ANGLE, ORIENTATION, SLANT, TILT, OBLIQUE, DEGREE, RESOLVE, RESOLUTION (and similar terms).
Google Patents Keywords: Capturing, image, determine, ISO 12233, details, camera, resolution, test, procedure, edge gradient, Spatial Frequency Response, color, transition, calibration, chart, digital, slanted edge (and similar terms).
Google Scholar Keywords: Digital, camera, resolution, test, ISO 12233, procedures, capturing, image, determine, details, chart, slanted edge (and similar terms).
Google Keywords: Digital, camera, resolution, test, operation, measure, resolvable, detail, operational, value, ISO 12233, chart, capture, method, standard (and similar terms).
Espacenet and AU internal databases: Applicant and inventor name search.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 June 2017	26 June 2017
Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Rafiq Uddin AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262256172

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2017/050305
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/0013760 A1 (PARODI-KERAVEC et al.) 19 January 2012 Paragraphs: [0026], [0051] - [0052], [0055] - [0056], [0063] - [0064], [0092] - [0094]; Fig. 1, 22.	1 - 27
A	US 2013/0016222 A1 (JIANG et al.) 17 January 2013 Whole document.	1 - 27
A	Zhang, Zhengyou. "A flexible new technique for camera calibration." IEEE Transactions on pattern analysis and machine intelligence 22.11 (2000): 1330-1334. Whole document.	1 - 27
A	Boiangiu, Costin-Anton, and Alexandru Victor Ştefănescu. "Target validation and image calibration in scanning systems." Proceedings of the 1st International Conference on Image Processing and Pattern Recognition (IPPR'13), Budapest, Hungary. 2013. Whole document.	1 - 27

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2017/050305**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 2012/0013760 A1	19 January 2012	US 2012013760 A1	19 Jan 2012
		GB 2482022 A	18 Jan 2012
US 2013/0016222 A1	17 January 2013	US 2013016222 A1	17 Jan 2013
		US 8730329 B2	20 May 2014
		CN 103688537 A	26 Mar 2014
		EP 2732632 A1	21 May 2014
		JP 2014521263 A	25 Aug 2014
		KR 20140044899 A	15 Apr 2014
		WO 2013009434 A1	17 Jan 2013

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.