Claims

1. An apparatus for assembling a lens module and an image sensor to form a camera module, the apparatus comprising:

a positioning system for adjusting a relative arrangement between the lens module and the image sensor; and

an inspection system operative to view fiducials of the lens module and the image sensor,

wherein the positioning system is operative to align the lens module and the image sensor based on a relative alignment of the respective fiducials of the lens module and the image sensor as viewed by the inspection system.

2. The apparatus of claim 1, wherein the inspection system comprises a first inspection device positioned for viewing the fiducials on a surface of the lens module from a first direction, and a second inspection device positioned for viewing the fiducials on a surface of the image sensor from a second direction, the second direction being opposite to the first direction.

3. The apparatus of claim 1, wherein the positioning system comprises a gripper for gripping the lens module.

4. The apparatus of claim 3, wherein the gripper is configured to actuate the lens module to move in six degrees of motion defined by translational motion along each of three orthogonal axes in a three-dimensional space and rotational motion about each of the three orthogonal axes.

5. The apparatus of claim 3, wherein the gripper is configured to actuate the lens module to rotate relative to the image sensor about an axis defined by both the lens module and the image sensor, to align the respective fiducials of the lens module and the image sensor.

6. The apparatus of claim 1, wherein the positioning system comprises a unit transporter on which the image sensor is mountable for moving the image sensor within the apparatus.

7. The apparatus of claim 1, further comprising a test chart for use in testing optical characteristics of the lens module and the image sensor.

8. The apparatus of claim 7, further comprising an image testing device operative to obtain images of the plurality of regions of interest of the test chart.

9. The apparatus of claim 8, wherein the image testing device comprises a magnification lens assembly.

10. The apparatus of claim 9, further comprising an optical diffuser for evenly distributing light from a light source to provide a diffuser background light, wherein the positioning system is operative to align a centre of the image sensor with a centre of the diffuser background light as obtained by the image sensor.

11. The apparatus of claim 9, wherein the test chart has length and width dimensions of not more than 15cm.

12. The apparatus of claim 9, wherein the distance between the test chart and the imaging testing device is between 0.4m and 5m.

13. The apparatus of claim 1, further comprising a dispenser for dispensing UV glue onto the image sensor.

14. The apparatus of claim 13, wherein the apparatus is configured to cure the UV glue for fixing the relative arrangement between the lens module and the image sensor.

15. A method of assembling a lens module and an image sensor to form a camera module, the method comprising the steps:

viewing fiducials of the lens module and the image sensor; and

aligning the lens module and the image sensor based on a relative alignment of the respective fiducials of the lens module and the image sensor.

16. The method of claim 15, wherein the step of viewing fiducials of the lens module and the image sensor comprises:

viewing the fiducials on a surface of the lens module from a first direction using a first inspection device, and

viewing the fiducials on a surface of the image sensor from a second inspection using a second inspection device, the second direction being opposite to the first direction.

17. The method of claim 15, wherein the lens module is gripped by a gripper, and the step of adjusting the relative arrangement between the lens module and the image sensor includes the step of actuating the gripper in any one of six degrees of motion defined by translational motion along each of three orthogonal axes in a three-dimensional space and rotational motion about each of the three orthogonal axes.

18. The method of claim 17, further comprising active alignment of the lens module with the image sensor, the active alignment including the steps of:

obtaining a plurality of images of a test chart using the image sensor at different heights of the lens module relative to the image sensor;

analysing the plurality of images of the test chart in respect of their clarity; and

actuating the gripper in any one of the six degrees of motion to move the lens module relative to the image sensor to an optimal position that provides higher consistency of image clarity among corresponding sections of the plurality of images.

19. The method of claim 18, wherein the active alignment step further comprises the step of aligning a centre of the image sensor with an image centre of a diffuser background light, the diffuser background light being produced on an optical diffuser which evenly distributes light from a light source.

20. The method of claim 15, wherein the lens module comprises a lens and a lens holder, the lens module being supported by a turn head operative to rotate the lens relative to both the lens holder and the image sensor, the method further comprising an active alignment of the lens with the image sensor, the active alignment including the steps of:

obtaining a plurality of images of a test chart using the image sensor at different angular displacements of the lens relative to the image sensor;

analysing the plurality of images of the test chart in respect of their clarity; and

rotating the turn head to move the lens until the lens is arranged at a particular angular displacement relative to the lens holder and the image sensor, wherein the particular angular displacement of the lens relative to the lens holder and the image sensor is based on the clarity of the plurality of images as analysed.

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Claims

1. An apparatus for assembling a lens module and an image sensor to form a camera module, the apparatus comprising:

a positioning system for adjusting a relative arrangement between the lens module and the image sensor;

a test chart for use in testing optical characteristics of the lens module and the image sensor, the test chart comprising a plurality of regions of interest;

a magnification lens assembly arranged between the test chart and lens module; and

an inspection system operative to view fiducials of the lens module and the image sensor,

wherein the positioning system is operative to align the lens module and the image sensor based on a relative alignment of the respective fiducials of the lens module and the image sensor as viewed by the inspection system, and also based on a clarity of each of the regions of interest of the test chart as imaged by the image sensor.

2. The apparatus of claim 1, wherein the inspection system comprises a first inspection device positioned for viewing the fiducials on a surface of the lens module from a first direction, and a second inspection device positioned for viewing the fiducials on a surface of the image sensor from a second direction, the second direction being opposite to the first direction.

3. The apparatus of claim 1 or claim 2, wherein the positioning system comprises a gripper for gripping the lens module.

4. The apparatus of claim 3, wherein the gripper is configured to displace the lens module to move in six degrees of motion defined by translational motion along each of three orthogonal axes in a three-dimensional space and rotational motion about each of the three orthogonal axes.

5. The apparatus of claim 3 or claim 4, wherein the gripper is configured to displace the lens module to rotate relative to the image sensor about an axis defined by both the

lens module and the image sensor, to align the respective fiducials of the lens module and the image sensor.

6. The apparatus of any one of the preceding claims, wherein the positioning system comprises a unit transporter on which the image sensor is mountable for moving the image sensor within the apparatus.

7. The apparatus of any one of the preceding claims, further comprising an optical diffuser arranged between the lens module and the image sensor for evenly distributing light from a light source to provide a diffuser background light, wherein the positioning system is operative to align a centre of the image sensor with a centre of the diffuser background light as obtained by the image sensor.

8. The apparatus of any one of the preceding claims, wherein the test chart has length and width dimensions of not more than 15cm.

9. The apparatus of any one of the preceding claims, wherein the distance between the test chart and the imaging testing device is between 0.4m and 5m.

10. The apparatus of any one of the preceding claims, further comprising a dispenser for dispensing UV glue onto the image sensor.

11. The apparatus of claim 10, wherein the apparatus is configured to cure the UV glue for fixing the relative arrangement between the lens module and the image sensor.

12. A method of assembling a lens module and an image sensor to form a camera module, the method comprising the steps:

viewing fiducials of the lens module and the image sensor;

the image sensor imaging a test chart having a plurality of regions of interest, wherein a magnification lens assembly is arranged between the test chart and the lens module; and

aligning the lens module and the image sensor based on a relative alignment of the respective fiducials of the lens module and the image sensor, and also based on a clarity of each of the regions of interest of the test chart as imaged by the image sensor.

13. The method of claim 12, wherein the step of viewing fiducials of the lens module and the image sensor comprises:

viewing the fiducials on a surface of the lens module from a first direction using a first inspection device, and

viewing the fiducials on a surface of the image sensor from a second inspection using a second inspection device, the second direction being opposite to the first direction.

14. The method of claim 12 or claim 13, wherein the lens module is gripped by a gripper, and the step of adjusting the relative arrangement between the lens module and the image sensor includes the step of actuating the gripper in any one of six degrees of motion defined by translational motion along each of three orthogonal axes in a three-dimensional space and rotational motion about each of the three orthogonal axes.

15. The method of claim 14, further comprising active alignment of the lens module with the image sensor, the active alignment including the steps of:

obtaining a plurality of images of a test chart using the image sensor at various heights of the lens module relative to the image sensor;

analysing the plurality of images of the test chart in respect of their clarity; and

actuating the gripper in any one of the six degrees of motion to move the lens module relative to the image sensor to an optimal position that provides higher consistency of image clarity among corresponding sections of the plurality of images.

16. The method of claim 15, wherein the active alignment step further comprises the step of aligning a centre of the image sensor with an image centre of a diffuser background light, the diffuser background light being produced on an optical diffuser which evenly distributes light from a light source.

17. The method of any one of claims 12 to 16, wherein the lens module comprises a lens and a lens holder, the lens module being supported by a turn head operative to rotate the lens relative to both the lens holder and the image sensor, the method further comprising an active alignment of the lens with the image sensor, the active alignment including the steps of:

obtaining a plurality of images of a test chart using the image sensor at various angular displacements of the lens relative to the image sensor;

analysing the plurality of images of the test chart in respect of their clarity; and

rotating the turn head to move the lens until the lens is arranged at a particular angular displacement relative to the lens holder and the image sensor, wherein the particular angular displacement of the lens relative to the lens holder and the image sensor is based on the clarity of the plurality of images as analysed.

18. The apparatus of any one of the preceding claims, wherein the positioning system is operable to locate the lens module at a plurality of positions relative to the image sensor along an axis along which the lens module and the image sensor are arranged, and the image sensor is operable to obtain images of respective ones of the regions of interest of the test chart at each of the plurality of positions along the axis.

19. The method of any one of claims 12 to 18, further comprising the step of locating the lens module at a plurality of positions relative to the image sensor along an axis along which the lens module and the image sensor are arranged, wherein the step of the image sensor imaging the test chart comprises the image sensor obtaining images of respective ones of the regions of interest of the test chart at each of the plurality of positions along the axis.