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Description

The invention relates to an arrangement and a method for supporting surgical treatment of an eye.

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Before a surgical intervention on the eye of a patient, for example the implantation of an intraocular lens, it is currently usual to acquire biometric data about the eye, such as the anterior chamber depth, the lens thickness, the eye
10 length and/or the refractive power of the cornea, by means of a suitable diagnostic device. By using the acquired refractive power of the cornea, the axial position of an astigmatism can be calculated. On the basis of the data obtained within the context of the prior examination, markers are placed on the
15 eye, in particular the limbus, which are used by the surgeon during the intervention as positioning aids, for example when introducing incisions or when inserting the intraocular lens into the eye.

20 EP 2 184 005 A1 relates to an apparatus for computer-aided eye surgery, which permits an improvement to an intraocular surgical method by means of the direct linking of diagnostic and pre-operative planning results of a patient eye with the eye of the patient under the microscope of the surgeon. For
25 this purpose, a diagnostic device comprises a camera, which records a reference image. A data-processing device is set up to extend the reference image with visual contact information on the basis of the reference image and user inputs. Context information can contain, for example, an incision mark, a
30 cylinder axis, a pupil mark and/or a topography data set, or else a schematic representation of the limbus geometry in the form of angular marks matched to the limbus. A surgical microscope records live images of the patient eye. A superimposing unit superimposes the context information on the
35 live image against a transparent background.

US 2010/094262 A1 relates to a surgical method using imaging systems. An apparatus comprises an image recording module

fitted to a surgical microscope, in order to record real-time images and a pre-operative patient data set. The pre-operative patient data set comprises a still image of the surgical target area. In the still image, changes in the opacity can be made. Virtual surgical reference notes can be added directly on the pre-operative still image. These reference notes can be built up from visual components with different levels of transparency. The pre-operative still image is then linked with a real-time visualization of the surgical target area. For this purpose, the surgeon identifies at least one specific visible feature within the still image and uses this feature in order to align the pre-operative still image on the real-time visualization. The feature can be a blood vessel, a scleral feature, a unique network of vessels in the sclera or another identifying feature.

US 2006/116668 A1 relates to a system and method for corrective eye surgery, in which a pair of eye images recorded at different times are aligned. A reference data set comprises stored digital image data about a patient eye. For this purpose, the patient eye is photographed by recording a first video image with a camera. The reference data set is then manipulated by removing pixel data from all the pixels which are enclosed by a limbus, and from the region on the other side of the limbus, in order to obtain a first reduced reference data set. A real-time data set is collected during the intervention by using a second camera, which contains digital image data about the patient eye in a surgery position which differs from the pre-surgery position of the reference data set. A combined image is then displayed, which comprises the reference data set and the real-time data set, wherein either the reference data set or the real-time data set is displaced and/or rotated until accurately fitting registration is achieved.

The invention is based on the object of providing an arrangement and a method for supporting surgical treatment of an eye which make the positioning of incisions and/or implants

in the eye of the patient easier.

This object is achieved by an arrangement for supporting surgical treatment of an eye having the features of Claim 1.

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An arrangement according to the invention for supporting surgical treatment of an eye comprises a diagnostic device which is designed to record eye structure data. The eye structure data recorded by the diagnostic device are
10 characteristic image data of the eye or characteristic image data of individual regions of the eye. Furthermore, the diagnostic device can be designed to record further biometric data about the eye, such as the anterior chamber depth, the lens thickness, the eye length and/or the refractive power of
15 the cornea, on the basis of which the axial position of an astigmatism can be calculated. In the arrangement according to the invention for supporting surgical treatment of an eye, it is possible to use only one diagnostic device for recording the required eye structure data and biometric data. If desired
20 or necessary, however, a plurality of diagnostic devices can be provided for recording various eye structure data and biometric data.

The data processing unit of the arrangement according to the
25 invention for supporting surgical treatment of an eye is designed, on the basis of the eye structure data recorded by the diagnostic device, to generate a structural image which contains at least one representation of a characteristic eye structure and at least one position marking arranged relative
30 to the representation of the characteristic eye structure. The structural image generated by the data processing unit can be stored on a suitable storage medium and/or stored in a suitable database.

35 Furthermore, the arrangement according to the invention for supporting surgical treatment of an eye comprises an image data insertion device, which is designed to insert the structural image generated by the data processing unit into an

image generated by an operation microscope during the performance of a surgical treatment of the eye. In principle, it is possible to transmit the structural image generated by the data processing unit directly to the image data insertion unit, i.e. without intermediate storage. Preferably, however, as mentioned above, intermediate storage of the structural image generated by the data processing unit is carried out, so that the structural image of the image data insertion device is preferably transferred from a memory. The transmission of the structural image to the image data insertion device can be carried out via a cable connection or in a cable-free manner, for example via a WLAN connection. As an alternative to this, a mobile data carrier, such as a USB stick, having the structural image stored thereon can be connected to the image data insertion device.

During the insertion of the structural image generated by the data processing unit into the image generated by the operation microscope, image superimposition is carried out, i.e. the image generated by the operation microscope remains visible, at least in the regions which are not overlaid with the representation of the characteristic eye structure or the position marking. If desired, the representation of the characteristic eye structure and/or the position marking in the structural image generated by the data processing unit can also be displayed partially transparently, so that, during the insertion of the structural image into the image generated by the operation microscope, the regions of the image generated by the operation microscope overlaid with the representation of the characteristic eye structure and the position marking in the structural image remain partially visible.

As a result of the insertion of the structural image generated by the data processing unit into the image generated by the operation microscope, the arrangement according to the invention offers a surgeon, during the performance of a surgical treatment of an eye, information as to where the position marking is placed relative to a characteristic eye

structure. If the position marking, for example, marks the position of an incision to be introduced into the eye, the surgeon can thus gather from the structural image inserted into the image generated by the operation microscope where the insertion is to be placed relative to a characteristic eye structure. As a result, it is possible to dispense with the application of markers on the eye. Furthermore, the structural image permits very accurate placing of the position marking relative to the representation of the characteristic eye structure. As compared with a marker placed directly on the eye, the position marking in the structural image is thus distinguished by higher position accuracy.

According to the invention, the diagnostic device of the arrangement according to the invention for supporting surgical treatment of an eye is designed to record image data from iris structures, an iris edge and/or the limbus geometry as eye structure data. In principle, in the arrangement according to the invention for supporting surgical treatment of an eye, use can be made of a diagnostic device which is capable of recording selective image data from blood vessels, iris structures, an iris edge and/or the limbus geometry. As an alternative thereto, however, use can also be made of a diagnostic device which is only capable of recording an overview of the eye, from which then appropriate image data of blood vessels, iris structures, an iris edge and/or the limbus geometry can be gathered.

Preferably, the diagnostic device comprises a light source which is suitable to emphasize and highlight characteristic eye structures, such as blood vessels, iris structures, an iris edge and/or the limbus geometry. Alternatively or additionally, the operation microscope can also comprise a light source which is suitable to emphasize and highlight characteristic eye structures, such as blood vessels, iris structures, an iris edge and/or the limbus geometry. As a result of the irradiation with the light source, the characteristic eye structures are emphasized and can thus be

recorded and detected more easily and more accurately. The light source of the diagnostic device and/or the operation microscope is preferably a green light source.

5 The data processing unit of the arrangement according to the invention for supporting surgical treatment of an eye is designed, on the basis of the eye structure data recorded by the diagnostic device, to generate a structural image which contains image data from a selected iris structure, an iris
10 edge or the limbus geometry in front of a transparent background as a representation of a characteristic eye structure. The generation of the structural image in the data processing unit can be carried out with the aid of suitable image processing software which, in addition to the background
15 configuration, also permits suitable configuration of the representation of the characteristic eye structure, of the characteristic eye structure, for example with regard to the colouration, the transparency, etc.

20 The data processing unit can also be designed, on the basis of the eye structure data recorded by the diagnostic device, to generate a structural image which, as position marking, contains a marker in the form of a point, a line or an area, a grid and/or an axis indicating the position of an astigmatism.
25 Overall, it is thus possible for very many more items of position marking information to be contained in the structural image generated by the data processing unit than can be communicated by the application of markers directly to the
eye.

30 In principle, the image data insertion device can merely insert the structural image generated by the data processing unit rigidly into the image generated by the operation microscope. If he or she then desires, the surgeon can
35 manually then bring the representation of a characteristic eye structure, such as a blood vessel or the like, contained in the structural image into coincidence with the corresponding "real" eye structure in the image generated by the operation

microscope, for example by rotating the patient and/or by rotating a lying surface for the patient. The position marking in the structural image is then particularly simply and efficiently usable by the surgeon.

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However, a preferred embodiment of the arrangement according to the invention for supporting surgical treatment of an eye comprises a positioning device for positioning the inserted structural image relative to the image generated by the operation microscope. The positioning device can be integrated into the image data insertion device and can comprise a coarse matching function, i.e. a zoom function, and/or permit a displacement and/or rotation of the inserted structural image relative to the image generated by the operation microscope. The positioning device can be designed, for example, to be operable manually via actuators provided on the image data insertion device. As a result of equipping the arrangement according to the invention with a positioning device, the inserted structural image can be brought particularly simply and conveniently into coincidence with the image generated by the operation microscope without it being necessary to move the patient for this purpose.

The arrangement according to the invention for supporting surgical treatment of an eye can also comprise a device for detecting a selected eye structure in the image generated by the operation microscope. Furthermore, the positioning device can be designed to position the inserted structural image on the basis of the detected selected eye structure automatically relative to the image generated by the operation microscope. For example, the device for detecting a selected eye structure can comprise an eye tracker, which detects a pupil in the image of the eye generated by the operation microscope and the current position of the pupil. The positioning device can then, for example, be designed to position the inserted structural image automatically relative to the image generated by the operation microscope such that a grid contained in the structural image as position marking is centred on the centre

of the pupil.

Furthermore, it is conceivable, as a device for detecting a selected eye structure in the image generated by the operation microscope, to use a device which permits the detection of a "real" eye structure corresponding to the representation of the characteristic eye structure in the structural image in the image generated by the operation microscope. The positioning device can then be designed to automatically position the inserted structural image relative to the image generated by the operation microscope such that the representation of the characteristic eye structure in the structural image is brought into coincidence with the corresponding "real" eye structure in the image generated by the operation microscope.

The device for detecting a selected eye structure in the image generated by the operation microscope is preferably capable of operating continuously, i.e. continuously detecting a selected eye structure in the image generated by the operation microscope. Furthermore, the positioning device is preferably designed for continuous tracking of the structural image into the desired position relative to the image generated by the operation microscope.

In a method for carrying out surgical treatment of an eye, eye structure data are recorded. On the basis of the recorded eye structure data, a structural image is generated which contains at least one representation of a characteristic eye structure and at least one position marking arranged relative to the representation of the characteristic eye structure. The structural image is inserted into an image generated by an operation microscope during the performance of a surgical treatment of the eye.

The eye structure data reported can be image data from blood vessels, iris structures, of an iris edge and/or of the limbus geometry.

During the recording of the eye structure data, the eye can be irradiated by a light source which is suitable for emphasizing and highlighting characteristic eye structures, such as blood vessels, iris structures, an iris edge and/or the limbus geometry. Alternatively or additionally, the eye can also be irradiated during the performance of the surgical treatment of the eye by a light source which is suitable for emphasizing and highlighting characteristic eye structures, such as blood vessels, iris structures, an iris edge and/or the limbus geometry. Preferably, during the recording of the eye structure data and/or during the performance of the surgical treatment of the eye, the eye is irradiated with green light from a green light source.

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Preferably, on the basis of the recorded eye structure data, a structural image is generated which, as a representation of the characteristic eye structure, contains a representation of a selected blood vessel, a selected iris structure, an iris edge and/or the limbus geometry against a transparent background.

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Furthermore, on the basis of the recorded eye structure data, a structural image can be generated which contains a marker in the form of a point, a line or an area, a grid and/or an axis indicating the position of an astigmatism as position marking.

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In the method for performing a surgical treatment of an eye, the patient and/or a lying surface for the patient can be moved in order to position the image generated by the operation microscope relative to the inserted structural image, for example in order to bring the representation of the characteristic eye structure in the structural image into coincidence with the "real" eye structure in the image generated by the operation microscope. As alternative thereto, however, the inserted structural image can also be positioned relative to the image generated by the operation microscope. As a result, a change in the position of the patient during

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the surgical intervention becomes unnecessary.

Furthermore, a selected eye structure can be detected in the image generated by the operation microscope, and the inserted structural image can be positioned automatically relative to the image generated by the operation microscope, depending on the detected selected eye structure. For example, by means of an eye tracker, the position of a pupil can be detected in the image generated by the operation microscope, and the inserted structural image can be positioned relative to the image generated by the operation microscope in such a way that a grid contained in the structural image as position marking is centred on the centre of the pupil.

Furthermore, it is conceivable to provide the detection of a "real" eye structure corresponding to the representation of the characteristic eye structure in the structural image in the image generated by the operation microscope, and to position the structural image automatically relative to the image generated by the operation microscope in such a way that the representation of the characteristic eye structure in the structural image is brought into coincidence with the corresponding "real" eye structure in the image generated by the operation microscope.

If desired, continuous detection of a selected eye structure in the image generated by the operation microscope and continuous tracking of the positioning of the inserted structural image relative to the image generated by the operation microscope can be carried out, depending on the detected selected eye structure.

The invention will now be explained in more detail by using the appended schematic drawings, of which

Figure 1 shows a general illustration of an arrangement for supporting surgical treatment of an eye, and

Figure 2 shows a schematic illustration of an image generated by an operation microscope during the performance of a surgical treatment of an eye, into which image a structural image generated by a data processing unit has been inserted.

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Figure 1 shows an arrangement 10 for supporting surgical treatment of an eye 16. The arrangement 10 comprises a first diagnostic device 12, which is designed to record eye structure data. The first diagnostic device 12 comprises a green light source 14, with which the eye 16 of a patient can be irradiated with green light within the context of a prior examination. As a result of the green light irradiation, blood vessels 18 and iris structures 20 present in the eye 16 of the patient, and also the limbus geometry 21 (see Figure 2) are emphasized, so that the first diagnostic device 12 can record an image of the eye 16 in which the blood vessels 18 and iris structures 20 and the limbus geometry 21 can easily be seen.

A second diagnostic device 22 is used to record further biometric data from the eye 16, such as the anterior chamber depth, the lens thickness, the eye length and the refractive power of the cornea, on the basis of which the axial position of an astigmatism can be calculated. In the arrangement 10 illustrated in Figure 1, the second diagnostic device 22 is formed separately from the first diagnostic device 12. However, if desired, the functions of the first and of the second diagnostic device 12, 22 can also be integrated in a single diagnostic device.

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The image of the eye 16 recorded by the first diagnostic device 12 is transmitted to a first data processing unit 24. In the exemplary embodiment shown in Figure 1, the first data processing unit 24 takes the form of a personal computer, on which image processing software is installed. With the aid of the image processing software, on the basis of the image of the eye 16 created by the first diagnostic device 12, the first data processing unit 24 generates a structural image,

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which contains representations of blood vessels 18, iris structures 20 and of the limbus geometry 21 in the eye 16 of the patient as representations of characteristic eye structures.

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In a similar way, the further biometric data about the eye 16 recorded by the second diagnostic device 22 are transmitted to the second data processing unit 25. In a similar way to the first data processing unit 24, the second data processing unit 10 25 in the exemplary embodiment shown in Figure 1 is formed as a personal computer, on which suitable software for evaluating the recorded biometric data is installed. The biometric data prepared by the second data processing unit 25 are transmitted to the first data processing unit 24.

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Taking into account the biometric data transmitted to the first data processing unit 24 by the second data processing unit 25, position markings in the form of a grid 26 and in the form of an axis 28 indicating the position of an astigmatism 20 (see Figure 2) are then introduced into the structural image generated by the first data processing unit 24. The structural image has a transparent background and is stored in a database of the first data processing unit 24.

25 Furthermore, the arrangement 10 comprises an operation microscope 30 which supplies an image of the eye 16 during the actual surgical intervention. Also present is an image data insertion device 32. The image data insertion device 32 is controlled by a control device 34, likewise in the form of a 30 personal computer, which has access via a cable connection or a cable-free connection to the structural image stored in the database of the first data processing unit 24. Moreover, the control device 34 is supplied by the second data processing unit 25 assigned to the second diagnostic device 22 with the 35 biometric data about the eye 16 recorded by the second diagnostic device 22. The data transmission between the second data processing unit 25 and the control device 34 can likewise be carried out via a cable connection or a cable-free

connection.

As can be seen in Figure 2, the image data insertion device 32 is designed, during the performance of the actual surgical intervention, to insert the structural image generated by the first data processing unit 24 into the image of the eye 16 generated by the operation microscope 30. Here, image superimposition takes place, the regions of the image generated by the operation microscope 30 that are not overlaid with the representations of the blood vessels 18, the iris structures 20 and the limbus geometry 21 and also the grid 26 and the axis 28 continuing to remain visible through the transparent background configuration of the structural image. In particular, the pupil 35, the iris 36 and the regions 37 of the eye 16 surrounding the iris continue to remain visible.

From the structural image inserted into the image generated by the operation microscope 30 by the image data insertion device 32, the surgeon can gather where the astigmatism axis 28 is placed relative to the characteristic eye structures, i.e. the blood vessels 18, the iris structures 20 and the limbus geometry 21. On the basis of this information, the surgeon can determine, for example, in which position and attitude an intraocular lens is to be implanted into the eye 16.

In the exemplary embodiment shown in Figure 1 of an arrangement 10, there is also a device 38 for detecting a selected eye structure in the image generated by the operation microscope 30. The device 38 comprises an eye tracker, which detects the position of the pupil 35 in the eye 16. Data recorded by the device 38 are transmitted to the control device 34. Depending on the data recorded by the device 38, by means of a positioning device 42 the structural image inserted by the image data insertion device 32 into the image generated by the operation microscope 30 is automatically positioned relative to the image generated by the operation microscope 30 such that the grid 26 contained in the structural image is centred on the centre of the pupil 35.

Furthermore, the structural image can be displaced and/or rotated and zoomed manually relative to the image generated by the operation microscope 30 via appropriate actuators, not specifically illustrated in Figure 1. As a result, the representations of blood vessels 18, iris structures 20 and the limbus geometry 21 contained in the structural image can be brought into coincidence with the corresponding "real" eye structures in the image generated by the operation microscope 30, as shown in Figure 2. The axis 28 contained in the structural image then identifies the "real" axial position of the astigmatism and thus supplies the surgeon with important information with respect to the positioning of an intraocular lens to be implanted in the eye 16.

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In the arrangement 10 shown in Figure 1, the structural image is displaced, rotated and/or zoomed manually relative to the image generated by the operation microscope 30, in order to bring the representations of characteristic eye structures contained in the structural image into coincidence with the corresponding "real" eye structures in the image generated by the operation microscope 30. As an alternative thereto, the device 38 for detecting a selected eye structure in the image generated by the operation microscope 30 can also be a device which permits the detection of a "real" eye structure in the image generated by the operation microscope 30, corresponding to the representation of the characteristic eye structure in the structural image. The positioning device 42 then positions the inserted structural image automatically relative to the image generated by the operation microscope 30 such that the representation of the characteristic eye structure in the structural image is brought into coincidence with the corresponding "real" eye structure in the image generated by the operation microscope 30.

Patentkrav

1. Anordning (10) til understøttelse af en kirurgisk behandling af et øje (16) med:

- 5 - et operationsmikroskop (30), som er indrettet til under gennemførelsen af en kirurgisk behandling af øjet (16) at frembringe et billede med i det mindste en afbildning af en karakteristisk øjestruktur
- et diagnoseapparat (12), som er indrettet til at registre
10 øjestrukturdata, idet diagnoseapparatet (12) er indrettet til som øjestrukturdata at registrere billeddata af irisstrukturer (20), en iriskant eller limbusgeometrien,
- en databehandlingsenhed (24), som er indrettet til på grundlag af de af diagnoseapparatet (12) registrerede
15 øjestrukturdata at frembringe et strukturbillede, som indeholder i det mindste en afbildning af den karakteristiske øjestruktur samt i det mindste en i forhold til afbildningen af den karakteristiske øjestruktur placeret positionsmarkering, og
- 20 - en billeddataindføjningsenhed (32), som er indrettet til at indføre det af databehandlingsenheden (24) frembragte strukturbillede i det af operationsmikroskopet (30) under gennemførelsen af den kirurgiske behandling af øjet (16) frembragte billede,
- 25 kendetegnet ved, at strukturbilledet som afbildning af den karakteristiske øjestruktur indeholder billeddata af en udvalgt irisstruktur (20), en iriskant eller limbusgeometrien på en transparent baggrund.

30 2. Anordning ifølge krav 1, kendetegnet ved, at diagnoseapparatet (12) til registrering af øjestrukturdataene og/eller operationsmikroskopet (30) omfatter en grøn lyskilde (14).

35 3. Anordning ifølge et af de foregående krav, kendetegnet ved, at databehandlingsenheden (24) er indrettet til på grundlag af de af diagnoseapparatet (12) registrerede øjestrukturdata at frembringe et strukturbillede, der som

positionsmærkning indeholder en i form af et punkt, en linje eller en flade dannet markør, en raster (26) og/eller en akse (28), som viser positionen for en astigmatisme.

- 5 4. Anordning ifølge et af de foregående krav, kendetegnet ved en positioneringsenhed (42) til positionering af det indføjede strukturbillede i forhold til det af operationsmikroskopet (30) frembragte billede.
- 10 5. Anordning ifølge krav 4, kendetegnet ved, at der er tilvejebragt en enhed (38) til påvisning af en udvalgt øjestructur i det af operationsmikroskopet (30) frembragte billede, og at positioneringsenheden (42) er indrettet til automatisk at
15 positionere det indføjede strukturbillede afhængigt af den påviste udvalgte øjestructur i forhold til det af operationsmikroskopet (30) frembragte billede.

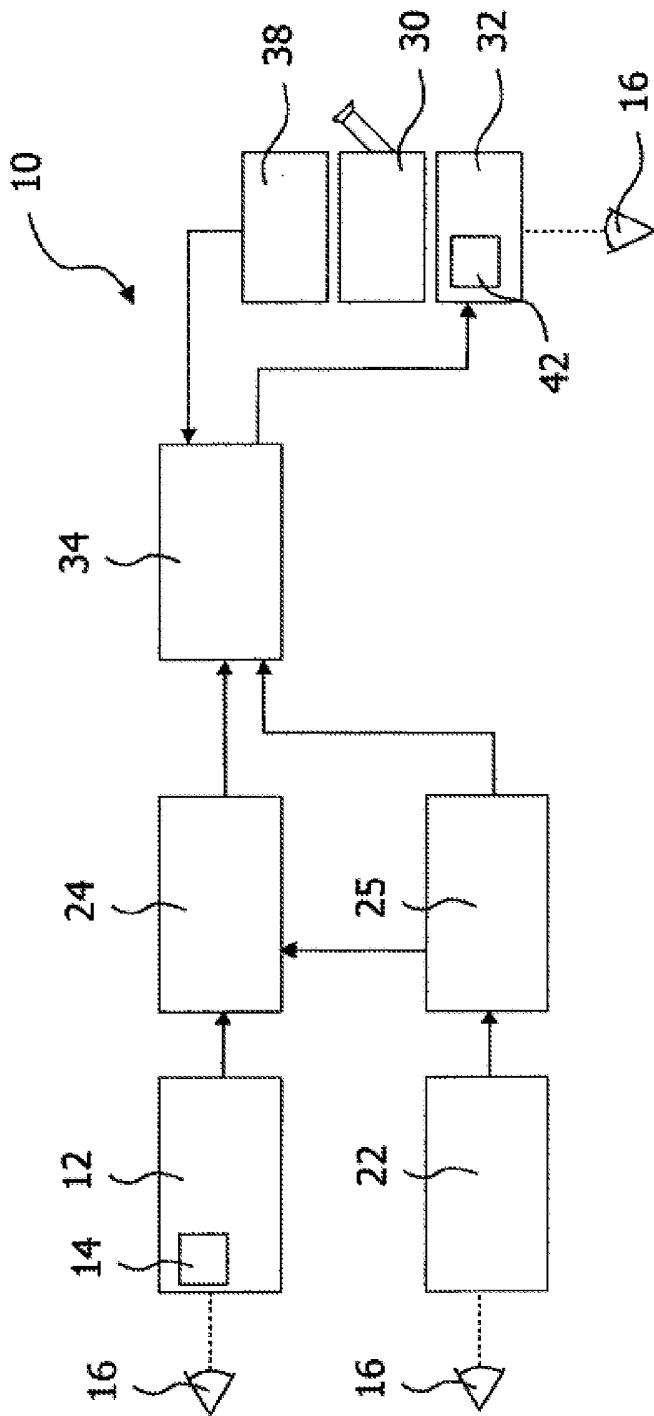


Fig. 1

FIG 2

