

Door state monitoring by means of three-dimensional sensor

The subject of the invention is a device for door state monitoring according to the introductory part of claim 1, a method for door state monitoring according to the introductory part of claim 13 and a software module for door state monitoring according to the introductory part of claim 16.

Lift systems comprise at least one lift cage which is movable in a lift shaft or freely along a transport device. The lift cage is normally secured by a cage door and the lift shaft by a shaft door in each storey.

Mechanical, magnetic, inductive or similar switches are frequently used for monitoring the doors of a lift. In addition, optical systems, for example light barriers or light gratings, come into use. The lift control can be supplied with certain information - for example, about the state of the doors - by attachments of that kind. However, the information content is relatively limited, since a switch is only in a position to indicate, for example, two states (digital information whether the door is open or closed). In order to be able to build up a more complex monitoring system, there is needed, for example, a combination of several switches and light barriers.

For technical reasons, light barriers or light gratings no longer function reliably with a door gap less than 5 cm. This is a disadvantage of those kinds of solutions. In addition, the reaction time amounts to about 65 milliseconds which in certain circumstances can be too long.

Optical systems, in particular, have certain advantages since, by contrast with mechanical solutions, they operate in contactless manner and are not subject to any mechanical wear. Unfortunately, even with more complex optical systems such as used in the field of lifts the informational power is limited to a few states. For example, it can be detected whether anybody stands in the door region and movements can be recognised.

Certain optical photosensors even enable detection of three-dimensional images, wherein mechanically moved parts in the form of, for example, mirrors are used. These sensors are complicated and costly.



G00002



159159

A system for monitoring lift doors, which operates with a preprogrammed processor, a digital camera, an analog camera or a video camera, is known from PCT Patent Application WO 01/42120. This represents the closest state of the art. The camera delivers a sequence of two-dimensional images, through comparison of which information about the state of the doors is made available. This system operates with outside light which is captured and received by the camera. This leads to problems in situations where the intensity of this outside light changes very significantly - for example, in the case of incidence of sunlight - and thus strongly increases the image brightness. Conversely, the use of such a camera for the stated purpose can also be problematic when the outside light which is present is not sufficient. It is essential for door state monitoring that the monitoring functions safely and reliably in all circumstances. A dependence on outside light is problematic from this viewpoint. According to the PCT patent application a classic pattern recognition formulation (pattern matching) is used in order to be able to evaluate the sequence of two-dimensional images. A system operating in accordance with the said PCT patent application with two-dimensional images cannot make a statement about distances. A specific statement with respect to movements and movement directions is possible, in the case of such a two-dimensionally operating system, only by a calculation-intensive reprocessing of the supplied images.

Three-dimensional semiconductor sensors enabling three-dimensional detection of image information are known. Sensors of that kind are known from, for example, the article "Fast Range Imaging by CMOS Sensor Array Through Multiple Double Short Time Integration (MDSI)", P. Mengel et al., Siemens AG, Corporate Technology Department, Munich, Germany. A further example is described in the article "A CMOS Photosensor Array for 3D Imaging Using Pulsed Lasers", R. Jeremias et al., 2001 IEEE International Solid-State Circuits Conference, page 252.

It is an object of the invention to enable a comprehensive, accurate and reliable checking of doors, particularly of the state of the doors of a lift.

It is a further object of the invention to realise a reliable and quick-action protection, against being caught, for lift doors.

According to the invention these objects are met in advantageous manner by a device according to claim 1, a method according to claim 13 and a software module according to claim 16.

Advantageous developments of the invention are defined by the dependent claims 2 to 12, 14 and 15. The invention is explained in more detail in the following, by way of example, with reference to drawings, in which:

- Figs. 1A, 1B show schematic plan views of the doors of a lift with a sensor according to the invention;
- Fig. 2 shows a schematic block diagram of a sensor according to the invention, with processing equipment,
- Figs. 3A, 3B show schematic plan views of the doors of a lift with a sensor according to the invention;
- Fig. 4A shows a schematic plan view of the part of a lift with a sensor according to the invention;
- Fig. 4B shows a schematic view of a lift with a sensor according to the invention;
- Fig. 5 shows a schematic plan view of the doors of a lift with a sensor according to the invention;
- Fig. 6 shows a schematic flow chart according to the invention; and
- Fig. 7 shows a schematic block diagram of a software module according to the invention.

According to the invention there is used, for the first time, a novel optical three-dimensional sensor in the realm of lifts. The sensor is in that case preferably a three-dimensional sensor operating in the infrared range. A three-dimensional sensor comprising an optical transmitter for pulse-shaped transmission of light and a complementary metal oxide semiconductor sensor group for detection of light is particularly suitable. Ideally, the

optical transmitter is a luminescent diode or laser diode which transmits, for example, light in the infrared range, wherein the light is emitted in short pulses, i.e. in quasi flashing manner. The pulses can be of a length of several tens of nanoseconds. The diode is for this purpose preferably provided with a (electric) shutter which interrupts the emitted light. The diode can, however, also be directly pulsed. The sensor group serves as an image sensor converting light into electrical signals. The sensor group preferably consists of a number of light-sensitive elements. The sensor group is connected with a processing chip (for example a CM05 or complementary metal oxide semiconductor sensor chip), which determines the transit time of the emitted light in that a special integration procedure (multiple double short-time integration, termed MDSI) is carried out. In that case the processing chip simultaneously measures in a few milliseconds the distance to a large number of target points in space. In that case, depending on the respective number of light-sensitive elements, a spatial resolution of 5 mm can typically be achieved.

A further three-dimensional sensor which apart from other three-dimensional sensors is also suitable for use in connection with the present invention, is based on a distance measuring principle in which the transit time of transmitted light is detected over the phase of the light. In that case the phase position at the time of transmission of the light and at the time of reception is compared and the elapsed time or the spacing from the reflecting object is ascertained therefrom. For that purpose a modulated light signal is preferably emitted instead of short light pulses.

In order to suppress the influences of outside light, a double scanning can be undertaken in which scanning is once with and once without light. In that case there are obtained two electrical signals (once with active illumination, once without) able to be converted into a final signal, which is substantially independent of stray light, by subtraction. Such a sensor can even be reliably used in the case of solar radiation and in the case of changing light influences.

The three-dimensional sensor is preferably realised from semiconductor components, which leads to a high degree of reliability and robustness. In addition, such a three-dimensional sensor is particularly small and can be made advantageously producible by mass production.

Through the detection of three dimensions there can be realised a device which directly detects the positions of objects, the distances between these and even the movements and movement directions thereof. For this purpose processing equipment can be used (for example, a personal computer or a central processing unit with peripheral components) which executes three-dimensional mathematical operations. This form of three-dimensional mathematical operations substantially differs from the previously employed special pattern recognition formulations which operate with, for example, different gray steps.

A first form of embodiment of a device according to the invention is shown in Figure 1A. This is a device for simultaneous monitoring of the cage doors 12, 13 and shaft doors 14, 15 of a lift (the lift itself is not shown in Figure 1A). The device comprises a three-dimensional semiconductor sensor 9 which is mounted in the region of the doors 12 to 15, which are to be monitored, in such a manner that the doors 12 to 15 are disposed at least partly in the detection range 17, 18 of the sensor 9. The sensor comprises a laser diode which serves as a light source and transmits an intrinsic light component. An illuminated region, for example in the form of a light cone 17, results in dependence on the respective optical beam shape. A sensor group 11 is provided, which serves as an image sensor and which receives light information by way of the light cone 18 and converts it into electrical signals. The light information is prepared by a processing chip 19 and converted into image information 16 (for example, in the form of a three-dimensional distance image). An example of such a three-dimensional distance image 16 is illustrated in considerably simplified form in Figure 1A. It can be inferred from the distance image 16 that a gap exists in the door region, wherein the shaft doors 14, 15 are closed and the cage doors 12, 13 still slightly open.

If the detection process is repeated after a short interval in time, the distance image 16 shown in Figure 1B results. The door gap between the two cage doors 12 and 13 has almost closed. The distance image 16 therefore shows only a very narrow gap. The repetition of the detection process preferably coincides with the short-time integration time window of the three-dimensional sensor. The size T_1 of the time window can correspond with the repetition frequency of the light pulses transmitted by the light source 10.

The instant in time at which a laser pulse is transmitted in the direction of the doors 12 to 15 is preferably synchronised with respect to the start of an integration window. A laser

pulse received by the sensor group 11 after reflection at the doors 12 to 15 triggers, after a transit time T_0 , a linearly rising sensor signal $X(t)$ which, for example, can be measured at two different integration instants T_2 and T_3 (wherein $T_0 < T_2 < T_3$). Depending on the distance of the light source 10 from the doors 12 to 15 and from there to the sensor group 11, only a fraction of the original intensity of the light pulse is detected while the integration time window T_2 to T_3 is active. To the extent that two integration measurements are made at different times T_2 and T_3 , the position and gradient of the intensity signal $X(t)$ increasing from the time instant T_0 can be ascertained. For example, the transit time T_0 can be accurately determined and thus also the spacing of the doors 12 to 15 from the position and gradient. An evaluation of that kind of the light information by the processing chip 19 makes it possible to obtain information not instantaneously obtainable in any other mode and manner.

A part of this processing takes place in the processing chip 19 and not just in separate processing equipment. This means that a part of the processing is carried out by corresponding hardware which is reliable and fast-acting.

Two different processing expressions are usable. In the case of the first expression according to the invention, the sensor group n comprises light-sensitive elements ($n > 0$). Each of these light-sensitive elements delivers an intensity signal $x_n(t)$, the strength of which is dependent on the intensity of the light received by the respective light-sensitive element. These intensity signals $x_n(t)$ can be combined - for example by a form of superimposition - into intensity signals $X(t)$. After this combining, the above-described evaluation can be carried out, in which the time instant T_0 is ascertained from the position and gradient of the intensity signal $X(t)$. In this form of embodiment the area resolution of the arrangement is reduced, since several light-sensitive elements are evaluated in common. It is nonetheless possible to ascertain the transit time and thus the distance to the doors. There is thus obtained a three-dimensionally operating sensor device, the depth resolution of which is better than the area resolution.

In the case of the second expression according to the invention, the sensor group again comprises n light-sensitive elements ($n > 0$). Each of these light-sensitive elements delivers an intensity $x_n(t)$, the strength of which is dependent on the intensity of the light received by the respective light-sensitive element. These intensity signals $x_n(t)$ can then run through the above-described evaluation, wherein each of the intensity signals $x_n(t)$ is

processed individually (preferably at the same time). The respective time instant T_{n0} is ascertainable from the position and gradient of each of the intensity signals $x_n(t)$. The processing chip preferably has several parallel channels (preferably n channels) for processing the n intensity signals $x_n(t)$. An area resolution results with this form of embodiment, since several points in space can be detected independently from one another (for example, several points of the doors). It is possible to ascertain the transit time T_{n0} and thus the distance for each of these points in space. There is thus obtained a three-dimensionally operating sensor device with depth resolution and area resolution.

As shown in Figure 2, the device according to the invention additionally comprises processing equipment 20 which, for example, is connected with the sensor 9 by way of a communications connection 21. The communications connection 21 serves for transfer of image information (also termed state information) from the sensor 9 to the processing equipment 20. In addition, the device comprises current supply means 22 (for example, a voltage source) for supply of the sensor 9 with current. The processing equipment 20 is designed in such a manner through installation of the software module that the image information can be evaluated in order to enable monitoring of the lift doors 12 to 15.

In one possible form of embodiment the image information is further evaluated by the processing equipment 20 in order to obtain information about the door state. For that purpose, for example, the state information obtained from the image information can be compared with target information. For this purpose the processing equipment 20 can comprise means 23 for providing the target information. In that case such means can be, for example, an internal fixed-disc memory. It is possible, for example, that the distance image 16 shown in Figure 1B is stored in the fixed-disc memory as target information. The processing equipment 20 can ascertain by a comparison algorithm whether the state information corresponds with the target information. In this case it can be assumed that the doors 12 to 15 are closed. Other target information, with which the processing equipment 20 undertakes respective comparisons, can also be predetermined. A specific reaction can, for example, be associated with each item of target information.

In another form of embodiment the image information is preprocessed at the hardware side by a processing chip 19 and then evaluated by the processing equipment 20 without comparing the state information with target information. In that case, image data, which were detected by the sensor 9 at at least two time instants following one another at a short

interval, are compared with one another. Such a comparison can be carried out, for example, by appropriate computerised superimposition of the image information. If the image information at the time instant $t = 0$ is subtracted from the image information at the time instant $t = T1$, the processing equipment 20 can then recognise changes in the three-dimensional space. Details with respect to this form of embodiment can be inferred from Figures 3A and 3B. In Figure 3A there is shown a situation in which not only the cage doors 12, 13, but also the shaft doors 14, 15 are open to some extent at the time instant $t = 0$. At the time instant $t = T1$ (see Figure 3B), an object 31 is disposed in the door gap. The distance image 16 shown in Figure 3B shows in strongly schematic form that the object 31 was detected. The object 31 can be clearly detected by a superimposition of the two distance images 16, since there is obtained through the superimposition, for example, a three-dimensional height profile which substantially corresponds with the shape of the object. The penetration of the object 31 leads to a recognisable change in the height profile. As soon as an object has been detected in the region of the doors 12 to 15, the processing equipment 20 can trigger a corresponding reaction. The reaction can consist of, for example, interrupting the closing of the doors 12 to 15 so as to prevent the object 31 from being caught by the doors. Alternatively, the closing movement can be stopped and the doors reopened.

This form of embodiment can be extended in that the processing equipment 20 is so designed at the software side that it can not only be recognised whether an object is disposed in the door region, but the object can also be classified by comparison operations.

The form of embodiment shown in Figures 3A and 3B can be extended in that the processing equipment 20 is supplied with a sequence of several images succeeding in time. In this case the processing equipment 20 can, through suitable processing of the image information, also ascertain the movement direction and/or speed of the object 31 in addition to pure detection of the object 31. This movement information can be used for triggering situation-adapted reactions. If the processing equipment 20 determines that the object moves slowly, then the closing of the doors 12 to 15 can be interrupted or the closing movement stopped. If the object 31 is one which moves quickly, it can be sufficient, for example, to slow down the closing movement of the doors or to interrupt this only for a short moment. It is conceivable as a further reaction to trigger an announcement in order to ensure that nobody stands in the door region.

As shown in Figures 1A, 1B and 3A, 3B, the device according to the invention can be used for simultaneous monitoring of the cage doors and shaft doors.

If in the first instance it is desired to monitor the cage doors 42, 43, the sensor 39 can then be mounted in the region of the cage door cross member 41 as can be recognised, schematically, in Figure 4A (plan view) and Figure 4B. The cage door cross member 41 is disposed in the upper region of the lift cage 40. It can be recognised in Figure 4A that in the case of this form of configuration primarily the cage doors 42, 43 are able to be monitored. Since, however, the shaft doors 44, 45 follow, with an offset, the movement of the cage doors 42, 43, a particular statement about the closing and opening of the shaft doors 44, 45 can also be made. In the case of the configuration shown in Figures 4A, 4B, the sensor 39 moves from storey to storey in solidarity with the lift cage 40. The shaft doors of the individual storeys cannot be monitored by the sensor 39 in the case of absence of the cage 40. It is recommended to use monitoring means, for example conventional constrainedly opening contacts, on each storey at the shaft door side.

For simultaneous monitoring of the cage doors 52, 53 and the shaft doors 54, 55 the sensor 49 can be arranged between the cage doors and shaft doors 52 to 55 in the region of the cross member, as indicated in Figure 5. In that case the light source of the sensor 49 should be oriented so that it transmits light in the direction of the cage doors 52, 53 and the shaft doors 54, 55. The sensor group of the sensor 49 should be so oriented with respect to the light source that it catches light which was reflected by the cage doors 52, 53 and by the shaft doors 54, 55.

In general it should be noted in the case of mounting the sensor that the sensor itself should, as far as possible, be incapable of being influenced by external influences (objects and/or persons, weather, mechanical damage, etc.). In the case of centre doors, such as shown in Figures 1A, 1B, 3A, 3B, 4 and 5, the sensor is preferably arranged centrally with respect to the door. In the case of telescopic doors closing from one side or in the case of doors closing from above to below - for example in goods lifts - or in another mode and manner, the sensor can also be arranged differently.

A method according to the invention for monitoring the state of a lift door comprises several method steps. Light, which was reflected at various points in space in the

environment of the door to be monitored, is detected by a sensor (for example, sensor 9 in Figure 1A). This light originates from a light source (for example, light source 10 in Figure 1A). Distance information is ascertained from the detected light (box 62 in Figure 6). In that case, the transit time of the light is taken into consideration. In order to make this possible, a synchronisation between the light source and the sensor group takes place. This step is preferably undertaken in a special processing chip (for example, sensor chip in Figure 1A). The evaluation of the distance information (box 63) is then carried out for recognition of a door state. Preferably, this step is performed in processing equipment, wherein an appropriate software module comes into use. Three-dimensional mathematical operations preferably come into use in the evaluation of the distance information. The processing equipment categorises the state into one or more known states (box 64). The method according to the invention can be designed so that at least one of the following states is recognisable:

- door gap,
- position of the lift door or doors,
- closing behaviour of the lift door or doors and
- object in the region of the lift door or doors.

A situation-adapted reaction is then triggered by the processing equipment in dependence on the recognised state (box 65).

In that case, these can be one or more of the following reactions:

- stop door closing process,
- stop door opening process,
- slow down door closing process,
- slow down door opening process,
- trigger loudspeaker announcement,
- place a service call,
- trigger an emergency call,
- stop lift operation,
- continue lift operation at reduced speed,
- initiate evacuation of the lift cage,
- etc.

A software module 70 according to the invention for use in processing equipment of a lift is shown in Figure 7. The software module 70 performs the following steps when it is called up and executed by the processing equipment:

- evaluation of distance information (submodule 71), which is provided by a three-dimensional sensor in the region of a lift door, in order to detect the state of the lift door,
- categorisation (submodule 72) of the state and
- triggering (submodule 73) a situation-adapted reaction.

The software module 70 can comprise further modules.

The light source and the sensor group are preferably arranged in a housing. The mounting in or at the lift is thereby facilitated, since the light source does not have to be manually aligned with respect to the sensor group. The alignment of the two components can already be carried out during production or pre-assembly.

For realisation of shaft door monitoring it is recommended to provide a sensor in the region of the shaft door on every storey. Such a fitment is relatively expensive in terms of cost, since one sensor is used per storey. More favourable is a form of realisation in which there is used a sensor moving from storey to storey in solidarity with the lift cage.

In a further form of embodiment the processing equipment 20 compares the image information with one or more reference images in order to obtain information about the door state. For this purpose, for example, a reference image can be subtracted from the image information. According to an improved form of embodiment the door state monitoring is carried out continuously by a succession of numerous light pulses and processing thereof. Safety in the realm of lifts can thereby be increased by comparison with conventional, mechanical attachments.

The door monitoring according to the invention is suitable for detecting the door state (door position, door gap, course of the closing movement, etc.).

If a conventional communications connection for connecting the sensor with the processing equipment is used, then, due to the safety relevance of the data (image information) transferred by the sensor to the processing equipment, suitable measures are

undertaken in order to ensure safety in the transmission of data by way of the communications connection, which is not itself inherently secure.

The device according to the invention can be connected by way of a communications connection and/or by way of a network with a computer which further processes, prepares and optionally stores the image information delivered by the sensor. Thus, a monitoring system can be realised which, for example, monitors a lift installation with several lift shafts.

Preferably a device according to the invention is integrated in the safety circuit of a lift. The safety circuit thereby has greater performance capability and the lift is more reliable. As a consequence, in certain circumstances the serviceability of the lift can thereby improve. With a suitable design of the device according to the invention, operating disturbances can be reduced, whereby the trapping of persons in the lift cage occurs more rarely. Operational disturbances of that kind can be caused in conventional lifts by faultily functioning locking mechanisms, by contact problems at door locking check switches or by contaminations.

An advantageous development of the invention enables extension of the door state monitoring so that protection against being pinned can be realised.

The protection, in accordance with the invention, against being pinned allows a person to be detected in good time and an appropriate reaction to be triggered in order, for example, to reduce the risk of being pinned in the door region.

It is an advantage of the invention that neither the door state monitoring nor the protection against being pinned requires sensors and other means in or at the doors. Thus, the necessity of providing cable feeds in the door region is redundant.

A further advantage of a solution according to the invention by means of a three-dimensional sensor is to be seen in that sensors of that kind have a relatively short cycle time (< 20 ms). Very rapid monitoring solutions can thus be realised. Critical states can be detected more quickly and reactions triggered at the appropriate time. The invention enables realisation of monitoring systems which have a reaction time to recognition of objects of just a few milliseconds. The rapid recognition makes it possible to very rapidly

trigger a suitable reaction and, in particular and in contrast to known systems, before any contact between the doors and the detected object comes about.

The three-dimensional sensors employed enable evaluation of the third dimension, which is advantageous by comparison with one-dimensional systems (for example, light barriers) or two-dimensional systems (for example, light gratings or charge-coupled-device cameras). By virtue of detection of three dimensions the door state monitoring or the protection against pinning can be furnished in direct mode and manner with a reality-proximal image of the actual state of the door region.

It is an advantage of the semiconductor sensor used that this operates with an intrinsic light component. Thus, the system is substantially independent of environmental conditions and even functions in the dark. As a further advantage it can be put forward that the invention can be realised without a calibrating mechanism, which usually has to be used in the case of camera-based systems in order to take account of changed environmental conditions. In the case of a camera-based system, for example, the light sensitivity is adjusted by a calibrating mechanism. This complication is eliminated.

A further form of embodiment of the invention is distinguished by the fact that the processing equipment is designed so that image information can be stored. It is thus possible to document a critical process, for example the catching of a person when entering or leaving the lift cage, by means of image information. Image information of that kind can serve, for example, for safety evidence.

In a further form of embodiment of the invention a safety call is triggered, as a reaction, as soon as a detected door gap exceeds a minimum dimension, wherein in the case of a sub-critical door gap the operation of the lift is not interrupted. The lift is stopped only in the case of exceeding a critical value. In addition, an emergency call can possibly be placed.

Advantageously the evaluation of the image information delivered by the three-dimensional sensor can be linked with the door drive so as to enable synchronisation of the information processing. For this purpose the door drive can be equipped with an encoder. The information delivered by the door drive by way of the encoder to the processing equipment can be used in the comparison of the actual information with the target information.

In the case of a lift with wide doors, several sensors can be used, which are connected either with processing equipment or with several items of processing equipment.

The door monitoring according to the invention can either replace the conventional monitoring of door locking or be used to complement monitoring of door locking. The safety of the overall system can thus be improved.

The invention can, with respect to door monitoring, also be combined with the control of a lift which controls the door setting. Thus, a regulating circuit can be built up which triggers an appropriately matched reaction in dependence on the respective door state.

The inventive concept can be extended in that the sensor is used not only for monitoring lift doors, but also for room monitoring. In that case, with appropriate arrangement of the sensor it is possible to monitor, for example, the interior space of the cage or the foreground space in front of the cage.

Patent Claims

1. Device for monitoring a lift door (12, 13, 14, 15) with a sensor (9) for detecting image information and processing equipment (19, 20; 23) which is designed in such a manner that the image information of detected images can be evaluated in order to recognise a deviation between the images and thus to enable monitoring of the lift door (12, 13, 14, 15), characterised in that the sensor (9) is a three-dimensional semiconductor sensor (9) for detecting three-dimensional image information, with a light source (10) which can be mounted in the region of the lift door (12, 13, 14, 15), which is to be monitored, in such a manner that the lift door (12, 13, 14, 15) is disposed at least partly in the illuminated region (17) of the light source (10), and with a sensor group (11) able to be mounted in the region of the lift door (12, 13, 14, 15), which is to be monitored, in such a manner that it receives light reflected by the lift door (12, 13, 14, 15).
2. Device according to claim 1, characterised in that one of the images is an image able to be provided from a store.
3. Device according to claim 1, characterised in that the images are images detected successively in time by the sensor group (11).
4. Device according to claim 1, 2 or 3, characterised in that light pulses can be emitted by the light source (10).
5. Device according to one of the preceding claims, characterised in that a reaction can be triggered in the case of a deviation, wherein the form of the reaction is preferably dependent on the kind of deviation.
6. Device according to claim 5, characterised in that the reaction is triggered only when the deviation exceeds a threshold value or equates to a recognition pattern.
7. Device according to one of the preceding claims, characterised in that the sensor (9) is designed for mounting in the region of the cross member of a lift door, preferably for mounting in the region of the cage door cross member.

8. Device according to one of claims 1, 2 and 3, characterised in that an evaluating method preferably based on three-dimensional mathematical operations can be performed by the processing equipment for the evaluation.

9. Device according to claim 8, characterised in that the evaluating method is based on an integration procedure.

10. Device according to one of the preceding claims, characterised in that the light source radiates light in the infrared range, wherein the light source is preferably a luminescent diode or laser diode.

11. Device according to one of the preceding claims, characterised in that the sensor group is an image sensor with which a complementary metal oxide semiconductor processing chip is connected.

12. Device according to one of the preceding claims, characterised in that a double scanning, in which the lift door (12, 13, 14, 15) to be monitored is scanned once with and once without light, is carried out for reducing the influences of outside light.

13. Method of monitoring the state of a lift door, wherein light which was reflected in the environment of the door to be monitored is detected by a sensor (9), characterised in that the method comprises the following steps:

- ascertaining of three-dimensional image information with consideration of the transit time and/or phase position of the light,
- evaluation of the three-dimensional image information (63) for recognition of a state,
- categorisation of the state (64) and
- triggering of a situation-adapted reaction (65).

14. Method according to claim 13, wherein the evaluation of the three-dimensional image information is based on three-dimensional mathematical operations.

15. Method according to claim 13 or 14, wherein at least one of the following states is recognisable:

- door gap width

- position of the lift door
- closing behaviour of the lift door
- object in the region of the lift door.

16. Software module (70) for use in processing equipment (19, 20; 23) of a lift, wherein the following steps can be performed by the software module when this is executed by the processing equipment (19, 20; 23):

- evaluation of three-dimensional image information (71), which is provided by a three-dimensional sensor in the region of a lift door, in order to recognise the state of the lift door,
- categorisation (72) of the state and
- triggering (73) of a situation-adapted reaction.