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Three-dimensional monitoring in the area of a lift by means of a three-dimensional sensor

The subject of the invention is a device for monitoring a lift area according to the introductory part of claim 1, a method for area monitoring according to the introductory part of claim 12, and a software module for area 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 usually moved from floor to floor in order to allow persons to board and alight there or in order to be loaded or unloaded there.

The interior space of the lift cage, but also the access region disposed in front of the lift shaft, is particularly critical since, for example, in the case of faulty functioning of the lift a risk to persons can arise. As an example, the opening of a shaft door may be mentioned, although no lift cage is located behind the shaft door which is opening. In addition, for example, it is also possible to be caught in the door region.

It is also conceivable that inappropriate behaviour of a person, faulty handling of the lift or inexperienced loading or unloading of the lift leads to problems.

There is therefore noted a tendency to monitor these critical areas in order to be able to recognise problems in good time and, in particular, to avoid risk to persons.

Mechanical, magnetic, inductive or similar switches are frequently used for monitoring the doors of a lift. In addition, optical systems, such as, for example, light barriers or light gratings are used. With approaches of that kind certain information - for example, about the status of the doors - can be supplied to the lift control. However, the information content is relatively limited, since, for example, a switch is only in a position of indicating two states (digital information whether a door is open or closed). Monitoring solutions of that kind are predominately limited to the immediate vicinity of the cage doors and/or shaft doors.

In order to be able to construct a more complex monitoring system there is needed, for example, a combination of several switches and light barriers.



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Optical systems in particular have certain advantages, since by contrast to mechanical solutions they operate contactlessly and are not subject to mechanical wear. Unfortunately, even in the case of more complex optical systems such as are used in lifts the meaningfulness is limited to a few states and the detection range is rather restricted. It is possible to detect, for example, whether anybody is in the door area, and movements are able to be recognised. Larger three-dimensional areas cannot, however, be so reliably monitored. In addition, the reaction time of light barriers or light gratings is approximately 65 milliseconds, which in certain circumstances can be too long.

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

A system for monitoring lift doors is known from PCT Patent Application WO 01/42120, which operates with a pre-programmed processor, a digital camera, an analog camera or a video camera. The camera supplies a sequence of two-dimensional images, through the comparison of which information about the state of lift doors is made available. This system operates with external light which is intercepted and received by the camera. This leads to problems in situations where the intensity of the outside light strongly varies - for example, in the case of incidence of sunlight - and thus the image brightness strongly increases.

Conversely, the use of such a camera for the said purpose can also be problematic when the outside light which is present is insufficient. In the case of area monitoring it is essential that the monitoring functions securely and reliably in all circumstances. A dependence on outside light is problematic from this viewpoint. According to the PCT patent application there is used a classical pattern recognition approach (pattern matching) in order to be able to evaluate the sequence of two-dimensional images. A system operating according to the set PCT patent application with two-dimensional images cannot make any statement about distances. A specific statement about movements and movement directions is possible with such a two-dimensionally operating system only by computer-intensive reprocessing of the supplied images.

A further monitoring system is described in US Patent 5 387 768. The system described there uses a camera, images of which are provided in a complicated mode and manner in

order to be able to make a statement about whether and how many persons are present in the region of the lift. The camera makes recording sequences with different zoom settings so as to be able to produce a statement therefrom about possible movements.

In US Patent 5 345 049 a lift is described in which it is detected by means of an infrared sensor or infrared sensors whether one or more persons wait in the access area of a lift. Determination of the number of persons does not take place here.

Three-dimensional semiconductor sensors are known which enable three-dimensional detection of image information. 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. Such a three-dimensional semiconductor sensor can be used for three-dimensional monitoring. This is the closest state of the art.

A further example is described in the article 'A CMOS Photosensor Array for 3D Imaging Using Pulsed Laser', R. Jeremias et al., 2001 IEEE International Solid-State Circuits Conference, page 252.

Lift systems with access control exist. Such systems operate, for example, by means of badges and badge reading apparatus. Thus, it is possible to check whether a person is authorised to use the lift. Only a person recognised by badge can call a lift and select a destination storey. To that extent systems of that kind function reliably. However, who and how many persons enter the lift cage is hardly capable of checking by current approaches. Access can be additionally controlled by appropriate constructional measures, for example a turnstile, an access gate or other architectonic measures. However, these approaches are complicated and often not suitable for aesthetic reasons.

In the case of present-day identification systems for lift utilisation it thus cannot be ensured that in fact only authorised persons enter a lift cage or leave this at a storey for which they have access authorisation.

It is an object of the invention to provide improved lifts.

It is an object of the invention to enable an accurate and reliable area monitoring at lifts.

It is a further object of the invention to realise reliable and fast-acting problem recognition for lifts.

According to the invention this object is fulfilled in advantageous manner by a device according to patent claim 1, a method according to claim 12 and a software module according to claim 16.

Advantageous developments of the invention are defined by the dependent claims 2 to 11 and 13 to 15.

The invention is explained in more detail in the following by way of example with reference to drawings, in which:

- Figs. 1A and 1B show schematic side views of the cage of a lift with a sensor according to the invention;
- Fig. 2 shows a schematic block diagram with a sensor according to the invention, with a processing device;
- Fig. 3 shows a schematic side view of the cage of a lift with a sensor according to the invention;
- Fig. 4 shows a schematic flow chart, according to the invention;
- Figs 5A and 5B show schematic plan views of a lift cage inclusive of access area, with a sensor according to the invention and a device according to the invention; and
- Fig. 6 shows a schematic block diagram of a software module according to the invention.

According to the invention for the first time a novel optical three-dimensional sensor is used in the field of lifts. This sensor is preferably a three-dimensional sensor operating in the infrared range. A three-dimensional sensor comprising an optical transmitter for pulse-

like transmission of light and a CMOS sensor group for reception of light is particularly suitable. Ideally, the optical transmitter is a light-emitting diode or laser diode which, for example, transmits light in the infrared range, wherein the light is emitted in short pulses, quasi in a manner of flashes. The pulses can be several tens of nanoseconds long. The diode is for this purpose preferably provided with an (electrical) shutter which interrupts the emitted light. However, the diode can also be pulsed directly. The sensor group serves as an image sensor which converts 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 CMOS sensor chip) which determines the transit time of the emitted light in that a special integration method (multiple double short-time integration, termed MDSI) is carried out. In that case the processing chip simultaneously measures, in a few milliseconds, the spacing from quite a number of target points in space. In that case a three-dimensional resolution of five millimetres can typically be achieved.

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

In order to suppress the influences of extraneous light it is possible to undertake a double scanning in which scanning is once with and once without light. Two electrical signals (once with active illumination, once without), which can be converted by subtraction into a definitive signal substantially independent of extraneous light, are then obtained. Such a sensor can be reliably used even in the case of solar irradiance 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 rendered capable of manufacture in advantageous manner by mass production.

Through the detection of three dimensions it is possible to realise a device which directly

detects the positions of persons or other objects, the distances between these and even the movements and directions of movement thereof. For this purpose a processing device can be used (for example, a personal computer or a central processor unit with peripheral components) which executes three-dimensional mathematical operations. This form of three-dimensional mathematical operations is significantly different from the previously employed special pattern recognition approaches which, for example, operate with different grey stages.

A first form of embodiment of a device according to the invention is shown in Figures 1A and 1B as a schematic section. This form of embodiment is a device for area monitoring, wherein in the present example the interior area of a lift cage is monitored. The device comprises a three-dimensional semiconductor sensor 9 which is mounted in the region above the lift cage 12 to be monitored in such a manner that the interior space of the cage 12 is disposed at least partly in the detection range 17, 18 of the sensor 9. For better illustration of the sensor this is shown substantially larger than it is in reality. The sensor 9 comprises a laser diode 10 serving as a light source and emitting a self-luminous component. Depending on the respective optical beam shape an illuminated area in the form of, for example, a light cone 17 results. A sensor group 11 is provided which serves as image sensor and receives, by way of the light cone 18, light information and converts this into electrical signals. The light information is prepared by a processing chip 19 and transformed 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 Figure 1 in substantially simplified form. It can be inferred from the distance image 16 that the cage 12 is empty. The cage doors 13 and 14 are closed. It is schematically indicated in Figure 1A that the distance image 16 is a three-dimensional image of the lift cage 12.

If the detecting process is repeated at a later instant T1, then the distance image 16 shown in Figure 1B results. The distance image 16 shows that in total four persons 31, 32, 33 and 34 are in the cage 12. The distance image 16 is a three-dimensional image of the lift cage 12 and the persons 31 to 34.

The laser pulses transmitted in the direction of the cage 12 are preferably synchronised in relation to the start of an integration window. The laser pulse received by the sensor group 11 after reflection within the cage 12 triggers, after a transit time T0, a linearly rising

sensor signal $X(t)$ which, for example, can be measured at the integration instants T_2 and T_3 . Depending on the spacing of the light source 10 from the different three-dimensional points 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. If, for example, two integration measurements are made at different times T_2 and T_3 (wherein $T_0 < T_2 < T_3$) the position and rise of the integrated intensity signal $X(t)$ can be ascertained. The transit time T_0 can thus be precisely determined and therewith also the spacing from persons or objects. An evaluation of that kind of the light information by the processing chip 19 makes it possible to obtain information which is not instantaneously obtainable in other mode and manner.

A part of this processing takes place in the processing chip 19 and not only in a separate processing unit. This means that a part of the processing is carried out by appropriate hardware, which is reliable and rapid.

Two different processing approaches can be used. In the case of the first approach according to the invention the sensor group comprises n light-sensitive elements ($n > 0$). Each of these light-sensitive elements supplies 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 - to form an intensity signal $X(t)$. After this combining, the above-described evaluation can then be carried out, in which the instant T_0 is ascertained from the position and rise of the intensity signal $X(t)$. In the case of this form of embodiment the area resolution of the arrangement is reduced, since several light-sensitive elements are evaluated in common. It is nevertheless possible to ascertain the transit time and thus the spacing from reflecting objects disposed in the monitored area. A three-dimensionally operating sensor device, the depth resolution of which is better than the area resolution, is thus obtained.

In the case of the second approach according to the invention the sensor group again comprises n light-sensitive elements ($n > 0$). Each of these light-sensitive elements supplies an intensity signal $x_n(t)$, the strength of which is dependent on 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 individually processed, preferably simultaneously. The respective instant T_{n0} can be

ascertained from the position of and rise in each of the intensity signals $x_n(t)$. Preferably, the processing chip comprises several parallel channels (preferably n channels) for processing of the n intensity signals $x_n(t)$. In the case of this form of embodiment there results an area resolution, since several points in space (for example, several points of an object disposed in the monitored space) can be detected independently of one another. It is possible to ascertain the transit time T_{n0} and thus the spacing for each of these points in space. A three-dimensionally operating sensor device with depth resolution and area resolution is thus obtained.

As shown in Figure 2, the device according to the invention additionally comprises a processing device 20, which, for example, is disposed in connection with the sensor 9 by way of a communications connection 21. The communications connection 21 serves for transmission of electrical signals, which represent image information (also termed state information), from the sensor 9 to the processing device 20. In addition, the device comprises a supply means 22 (for example, a voltage source) for supply of the sensor 9. The processing device 20 is designed by the installation of a software module in such a manner that the image information can be evaluated so as to enable the area monitoring.

In one possible form of embodiment the image information is further evaluated by the processing device 20 in order to obtain information about the state of the monitored area. For this purpose, for example, the state information obtained from the image information can be compared with target information. For this purpose the processing device 20 can comprise means 20 for provision of the target information. The means can be, for example, an internal hard disc memory. It is possible, for example, that the distance image 16 shown in Figure 1A is stored as target information in the hard disc memory. The processing device 20 can ascertain by a comparison algorithm whether the just-obtained state information corresponds with the target information. If this is the case, then it can be assumed that the cage interior space is empty.

Other target information can also be predetermined, by which the processing device 20 undertakes respective comparisons. A specific reaction can, for example, be assigned to each target information.

In the case of another form of embodiment the image information is processed in preliminary manner by a processing chip 19 in terms of hardware and then evaluated by

the processing device 20 without having to compare the state information with the target information. In this connection there is comparison with one another of image information which was detected by the sensor 9 at at least two instance following one another in quick succession in time. Such a comparison can be carried out by, for example, suitable computerised superimposition of the image information. If the image information is subtracted at the instant $t = 0$ from the image information at the instant $t = a1$, then the processing device 20 can recognise changes in the three-dimensional space.

A further form of embodiment of the invention is shown in Figure 3. A sensor 39 is now illustrated in realistic size in Figure 3. It is arranged in the upper region of the lift cage 42 and covers, from above, the interior space of the cage 42 to be monitored, as indicated by the small arrows in the vicinity of the sensor 39. An object 41 is located in the lift cage 42 relatively close to the open cage doors. The device is in a position of recognising whether the cage doors are open, since in the case of open doors a strong brightness different results. The sensor 39 is connected with a processing device 50 which comprises a suitable software module. The entire device is designed so that in a first step it can be detected whether a person and/or an object is located in the interior of the cage 42. If this is the case, then in a next step a form of classification is carried out. This classification makes it possible for the device to trigger situation-adapted reactions. In the illustrated example the device is in a position of recognising whether persons and/or objects are located in the lift. By virtue of the clear rectangular geometry the device can recognise that an object 41 must be concerned. Next, the device can, for example, seek to recognise the position of the object 41 within the cage 42 in order to be able to derive reactions therefrom. In the illustrated example the object 41 is disposed very close to the opened door. A possible reaction would need to make an acoustic warning by way of a loudspeaker 51 in order to require the person who has loaded the lift to move the object 41 further into the interior space of the cage 42. As long as this has not taken place, closing of the doors by the device is precluded.

A method according to the invention for area monitoring comprises several method steps, as shown on the basis of an example in Figure 4. There is detection by a sensor (for example sensor 9 in Figure 1A) of light (box 61 in Figure 4) which is reflected at different spatial points in the area to be monitored. This light originates from a light source (for example light source 10 in Figure 1A). Distance information is ascertained (box 62 in Figure 4) from the detected light. In that case the transit time of the light is taken into

consideration. In order to enable this, a synchronisation takes place between the light source and the sensor group. This step is preferably carried out in a special processing chip (for example, processing chip 19 in Figure 1A). Evaluation of the distance information then takes place (box 63) for recognition of a state in the monitored area. It is ascertained by the processing device in a processing step (box 64) whether persons are in the monitored area. If this is not the case, then it is ascertained whether objects are located in the monitored area (box 65). If persons were recognised in the monitored area, then the flow chart branches. A classification can take place in a further step 68. Some examples of classification are listed in the following:

- ascertain number of persons,
- recognise position of the person or persons within the monitored area,
- detect movements or movement directions,
- check authorisation,
- check whether several persons in the monitored area are as predetermined, etc.

Depending on the respective classification, one or more of the following reactions, which are by way of example, are triggered in a step 69:

- wait until further persons have boarded before the lift cage is set in motion,
- in the case of overloading, do not set the lift cage in motion and/or make an announcement,
- if one or more persons is or are too close to the door region, either wait until the situation has changed or make an announcement,
- if a person moves in the direction of the doors, appropriately adapt the door opening or closing process (for example, stop or slow down closing of the doors),
- if an unauthorised lift user appears to be in the cage, either make an announcement or trigger an alarm call.

If the device has ascertained that an object is located in the cage, then a classification can take place in a further step 66. Some examples of classification are listed in the following:

- ascertain number of the objects,
- ascertain kind of objects,
- ascertain size of the objects,
- recognise position of the object or objects within the monitored area,

- detect movements or directions of movement of objects.

Depending on the respective categorisation one or more of the following reactions, which are by way of example, can be triggered in a step 67:

- in the case of overloading, do not place the lift cage in motion and/or make an announcement,
- if one or more objects is or are located too close to the door region, either wait until the situation has changed or make an announcement,
- if an object has moved in the direction of the doors, appropriately adapt the door opening or closing process (for example, stop or slow down closing of the doors).

If neither a person nor an object was detected, the flow chart branches by way of the branch 60 back to the beginning and the entire process is repeated again. According to this chart, any branched decision trees can be realised in order to ultimately be able to automatically trigger a reaction which corresponds with the prevailing situation or is adapted thereto.

The described method steps are preferably performed in a processing device, wherein an appropriate software module is used. Preferably three-dimensional mathematical operations are used in the evaluation of the distance information.

The processing device can additionally be so extended with respect to the area monitoring that the following door states are recognisable:

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

Depending on the recognised door state a situation-adapted reaction is then triggered by the processing device. This 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 arrangement,
- place service call,
- trigger emergency call,
- stop lift operation,
- continue lift operation at reduced speed,
- initiate evacuation of the lift cage,
- etc.

Depending on the respective form of embodiment, a device according to the invention can recognise one or more of the following states:

- number of passengers in the lift cage or in the access region (lobby) in front of the lift shaft,
- number of persons entering or leaving the lift,
- directional flows of persons,
- overload,
- incorrect loading,
- obstructions in the door region,
- need detection,
- movements,
- door gap,
- position of the lift door,
- closing behaviour of the lift door,
- object in the region of the lift door.

Depending on the respective form of embodiment, a device according to the invention can trigger one or more of the following reactions:

- no closing of the lift doors as long as persons are located in the access region of the story in which the lift cage is just located,
- situation-dependent controlling of the lift cage in order to be able to take into account arrival of persons at individual storeys,
- lift cage stops only at a floor when persons wait in the access area of the corresponding floor,
- automatic calling of a lift cage if a person approaches a shaft door and stays there,
- traffic-dependent or need-dependent controlling, for example in the case of

- lift installations with several lift cages,
- initiation of emergency measures if a problem is recognised or a risk to a person is possible,
- display information and/or trigger an announcement,
- allow or prohibit access to a floor,
- allow or prohibit use of the lift cage,
- statistical evaluations of, for example, the number of persons, frequency of use, etc.,
- pay-lift functions.

A further form of embodiment of the invention is shown in Figures 5A and 5B. This is a device for monitoring the access region in front of a lift shaft. In the schematic plan view in Figure 5A there is shown a lift cage 82 located at a storey of a building. The cage 82 is separable by cage doors 87, 88 and shaft doors 89, 90 from the access region. The doors 87 to 90 are slightly opened in the illustrated depiction. A sensor 79 according to the invention, which is connected with a processing device 80, is located in a wall near the lift. A loudspeaker 81 is provided by way of which announcements can be made. The access region is laterally bounded by walls 85 and 86. A situation is illustrated in which in total three persons 82, 83, 84 are in the access region. The persons 82 and 83 stand directly in front of the doors 87 to 90 and wait until these doors have opened. A further person 84 moves away from the doors 87 to 90, as indicated by an arrow. The device according to the invention is in a position of detecting this state. The device generates a three-dimensional distance image 76 which is schematically shown in Figure 5b. The device recognises that three persons are in the access region. Moreover, it is in a position of monitoring whether the persons 82 and 83 too closely approach the opening doors 87 to 90. If this should be the case, then the opening movement of the doors could be stopped so as to avoid risk to persons. As soon as the doors are completely open, the persons 82, 83 enter the lift cage 82. This process can also be monitored. The doors 87 to 90 can close automatically as soon as the two persons 82, 83 have entered the lift cage 82 to sufficient extent. The person 84 is further detected by the device. Since, however, this person 84 moves away from the doors the lift cage does not wait for this person 84.

The described forms of embodiment can be extended in that the processing device 20, 50, 80 is so designed in terms of software that not only can it be recognised whether and where persons and/or objects are located, but also the objects or persons can be

classified or categorised by comparison operations.

The illustrated forms of embodiment can be extended in that a sequence of several images successive in time is supplied to the processing device 20, 50, 80. In this case the processing device 20, 50, 80 can, by suitable processing of the image information, ascertain, additionally to pure detection of persons and/or objects, also the movement direction and/or speed of the persons and/or objects. This movement information can be used in order to trigger situation-adapted reactions. If, for example, the processing device 20, 50, 80 determines that a person moves slowly whilst the doors of a lift close, then the closing of the doors can be interrupted or the closing movement stopped. If the person is one who moves quickly, it can be sufficient, for example, to slow down the closing movement of the doors or to interrupt the closing movement only for a short moment. It is conceivable as a further reaction to trigger an announcement in order to ensure that nobody stays in the door region.

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

If it is primarily desired to monitor the interior space of a lift cage then the sensor can be mounted in the region of the cage ceiling, as can be schematically recognised in Figures 1A, 1B and 3.

If the sensor is arranged in the region of the rear wall of a cage, i.e. in the region of the wall opposite the cage doors, then when the doors are opened it is possible to detect not only the state of the interior space of the cage, but, via the opened doors, also a region in the lobby in front of the cage.

In the case of the configurations shown in Figures 1A, 1B and 3 the sensor moves together with the lift cage from floor to floor. The shaft doors of the individual floors and the access region of the floors cannot, in the absence of the cage, be monitored by the sensor at the cage. It is recommended to use a sensor according to the invention on each floor, as shown in, for example, Figure 5A.

There are obviously numerous other possibilities of arranging the sensor or sensors.

In general, it is to be observed in the mounting of the sensor that the sensor should be as free as possible from being able to be influenced by external influences (objects and/or persons, weather, mechanical damage, etc.).

A software module 90 according to the invention for use in a processing device of a lift is shown in Figure 6. The software module 90 performs the following steps when it is called up and executed by the processing device:

- evaluation of distance information (submodule 91), which is provided by a three-dimensional sensor in the area, which is to be monitored, so as to detect the state of the area,
- recognition whether persons and/or objects are located in the area to be monitored (submodule 92),
- classification (submodule 93) of the state,
- triggering (submodule 94) of a situation-adapted reaction.

The software module 90 can comprise further modules.

Preferably the light source and the sensor group are arranged in a housing. The mounting is thereby facilitated, since the light source does not have to be manually oriented with respect to the sensor group. The orientation of the two components can be carried out already at the time of manufacture or pre-assembly.

In a further form of embodiment the processing device compares the image information with one or more reference images in order to obtain information about the area state. For this purpose, for example, a reference image can be subtracted from the image information.

According to an improved form of embodiment the area monitoring is carried out continuously by a succession of numerous light pulses and processing thereof. Reliability in the lift field can thus be increased by comparison with conventional, mechanical approaches.

The area monitoring according to the invention is suitable not only for use within buildings, but also for use outside, since the sensor employed has little susceptibility to disturbance. Above all, however, the insensitivity to extraneous light is a more significant aspect when

dealing with use within or outside buildings.

The area monitoring according to the invention is not only able to recognise events, but also able to undertake a classification. Thus, for example, it is possible for the area monitoring to recognise whether anybody waits in the access region to a lift cage. It is also ascertainable how many persons wait, or whether a person to be conveyed or an object to be transported actually has space in the lift cage. Even the number of persons or objects and, for example, the size thereof can be ascertained.

A further form of embodiment is distinguished by the fact that it can be recognised by means of area monitoring whether a lift cage is needed at a specific floor. This can be realised in that the area monitoring observes the access area at the corresponding floor. If a person approaches the shaft doors and waits there, then the device concludes therefrom that the person is waiting for a lift cage. This form of embodiment can even be extended in that the access region is divided into two zones. If a person stays in the zone provided for journeys in upward direction, then a lift cage on the way up stops. If a person is detected in the zone allocated to journeys in downward direction, then the next cage on a journey down stops. A need recognition and a need-dependent lift control can thus be realised. It is an advantage of this form of embodiment that the lift installation can be operated completely without the usual request buttons. The entire system operates in completely contactless manner.

If a conventional communications connection for connecting the sensor with the processing device is used then due to the safety relevance of the data (image information) to be transferred from the sensor to the processing unit suitable measures should be undertaken to guarantee security during transfer of the data by way of the intrinsically insecure communications connection.

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

Preferably a device according to the invention is integrated into the safety circuit of a lift.

The safety circuit thereby has more performance capability and the lift is more reliable. As a consequence, in certain circumstances the serviceability of the lift can thereby be improved. Operational disturbances can be reduced in the case of suitable design of the device according to the invention.

An advantageous development of the invention makes it possible to so expand the area monitoring that protection against being caught can be realised. The protection, in accordance with the invention, against being caught makes it possible to detect a person in good time and trigger a suitable reaction in order to, for example, reduce the risk of being caught in the door region.

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 (less than 20 milliseconds). Thus, very rapid monitoring solutions can be realised. Critical states can be detected more quickly and reactions triggered in good time. The invention makes it possible to realise monitoring systems which have a reaction time, for recognition of objects, of a few milliseconds. The rapid recognition makes it possible to very trigger a suitable reaction very quickly.

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). Through detection of three dimensions the area monitoring can obtain, in direct mode and manner, an image, which is close to reality, of the actual state.

It is an advantage of the semiconductor sensor employed that this operates with an intrinsic light component. Thus, the system is substantially independent of the environmental conditions and functions even in darkness. As a further advantage it can be asserted that the invention can be realised without a calibrating mechanism usually employed in the case of camera-based systems 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 outlay is eliminated.

A further form of embodiment of the invention is distinguished by the fact that the processing device is so designed that the image information can be stored. Thus, it is

possible to document a critical process, for example catching of a person when entering or leaving the lift cage, by means of image information. Image information of that kind can serve for, for example, securing evidence.

In a further form of embodiment of the invention a service call is triggered, as a reaction, as soon as a problem is recognised. In addition, an emergency call can possibly be made in the case of a critical state.

Advantageously, the evaluation of the image information supplied by the three-dimensional sensor can be linked with the lift control in order to enable synchronisation of the information processing. Thus, a regulating circuit can be installed which, depending on the respective state, triggers an appropriately adapted reaction.

It is an advantage of the invention that the waiting times can be reduced, since the lift can be controlled in such a manner that it is in a position of automatically adapting to changing conditions. It is thus possible, for example, to avoid stopping of the cage at a floor although nobody waits there or waits there any longer.

In a further advantageous form of embodiment the area monitoring according to the invention is combined with an access control system. Thus, for example, it can be automatically checked whether only authorised persons use a lift. This is possible, for example, if all access-authorised persons are equipped with a badge. A person desiring access to the lift must identify himself or herself by means of a badge relative to a badge reading apparatus. The access control counts the number of persons who have shown by badge that access to the next lift cage is desired. On entry into the lift cage the system according to the invention can ascertain how many persons have actually entered the lift. If the number of persons in the cage does not correspond with the number of persons who have identified themselves by a badge, then a reaction can be triggered. It is possible, for example, not to place the lift in motion and to make an announcement in order to require the persons to again identify themselves by badge.

A pay-per-use (pay-lift) approach can be realised in similar mode and manner. All persons who want to use the lift must pay a certain fee. The number of persons who have paid can be counted. After all persons have entered the cage an automatic determination of the number of persons is carried out. In the case of deviations, appropriate measures can be

undertaken. Thus, for example, a ticket check can be triggered.

A further pay-per-use system is based on the use of a key or a badge by which a person to be transported registers himself or herself. This registration is detected and the fee to be paid is charged to the appropriate person. If more persons are located in the lift cage than were detected, then an appropriate reaction can be triggered.

Patent claims

1. Device for area monitoring by a three-dimensional semiconductor sensor (9; 39; 37) for detection of three-dimensional image information, wherein the three-dimensional semiconductor sensor is equipped with

- a light source (10) which can be mounted in such a manner that the area to be monitored is disposed at least partly in the illuminated area (17) of the light source (10),
- a sensor group (11) which can be mounted in such a manner that it receives light reflected in the area to be monitored, wherein the received light is convertible by the sensor group (11) into electrical signals, and
- a processing chip (19) for converting the electrical signals into image information (16),

characterised in that

- the area to be monitored is an area within and/or outside a lift cage (12; 42; 82) and
- the device comprises a processing device (19, 20; 50; 80) with which the semiconductor sensor (9; 39; 79) is connectible in order to make available three-dimensional image information and which is designed for the purpose of processing this image information in order to obtain state information representing the state of the area to be monitored.

2. Device according to claim 1, characterised in that three-dimensional images are compared, wherein one of the images to be compared is an image able to be provided from a memory.

3. Device according to claim 1, characterised in that three-dimensional images are compared, wherein the images are images detected by the sensor group (11) successively in time.

4. Device according to claim 1, 2 or 3, characterised in that light pulses are transmissible by the light source (10).

5. Device according to any one of the preceding claims, characterised in that the state information can be evaluated so as to be able to trigger specific reactions in the case of

specific states, wherein the kind of reaction is preferably dependent on the kind of state.

6. Device according to any one of the preceding claims, characterised in that the sensor (9) is designed for mounting in the region of the lift cage (12; 42), preferably for mounting in the ceiling region of the lift cage (12; 42).

7. 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 device for the evaluation.

8. Device according to claim 7, characterised in that the evaluating method is based on an integration method.

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

10. Device according to any one of the preceding claims, characterised in that the sensor group is an image sensor connected with a CMOS processing chip.

11. Device according to any one of the preceding claims, characterised in that for reducing extraneous light influences a double scanning is undertaken in which the area to be monitored is scanned once with and once without light.

12. Method of monitoring a lift area, wherein light which was reflected in the area to be monitored is detected by a sensor (9; 39; 79), characterised in that the method comprises the following steps:

- ascertaining of three-dimensional image information (62) with consideration of the transit time and/or phase position of the light,
- evaluation of the three-dimensional image information for recognition of a state,
- classification of the state (66; 68), and
- triggering of a situation-adapted reaction (67; 69).

13. Method according to claim 12, wherein the following step is carried out:

- recognition whether a person or an object is located in the area to be monitored.

(64, 65).

14. Method according to claim 12 or 13, wherein the evaluation of the three-dimensional image information is based on three-dimensional mathematical operations.

15. Method according to claim 12, 13, or 14, wherein at least one of the following states is recognisable:

- number of passengers in the lift cage or in the access area (lobby) in front of a lift shaft,
- number of persons entering or leaving the lift,
- directional flows of persons,
- overload,
- incorrect loading,
- obstructions in the door region,
- need detection,
- movements,
- door gap,
- position of the lift door,
- closing behaviour of the lift door,
- object in the region of the lift door.

16. Software module (90) for use in a processing device (19, 20; 50; 80) of a lift, wherein the following steps can be performed by the software module when this is executed by the processing device (19, 20; 50; 80):

- evaluation of three-dimensional image information (91), which is provided by a three-dimensional sensor in an area to be monitored, in order to recognise the state of the area,
- recognition of persons and/or objects in the area (92) to be monitored,
- classification (93) of the state,
- triggering (94) of a situation-adapted reaction.