

Video smoke detection system

Description



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- 5 The invention is in the field of smoke detection using a video image. In residential and industrial buildings, warehouses, museums, churches and similar buildings, smoke detection is by smoke detectors which are fitted to the ceiling of the room, and are based, for instance, on the principle of light scattering or light reduction by smoke. On the other hand, in railway or road tunnels practically no smoke detectors are used, since here,
- 10 because of the air movement and air layering which are caused by the moving vehicles and trains, there is no guarantee that the smoke resulting from a fire would reach smoke detectors which are fitted to the roof within a useful time. Today, therefore, so-called linear heat detection systems, such as the FibroLaser system of Siemens Building Technologies AG, Cerberus Division, are used for fire monitoring in tunnels.
- 15 Very recently, there have been efforts to use the video systems, which are in any case present in tunnels for traffic monitoring, for smoke detection. Since the video images are very often uninteresting to an observer, and also since smoke causes only very small changes in the video image, there is no question of monitoring by personnel on the screens. Monitoring can only be done by automatic analysis of the video images, if at all.
- 20 In a known method for automatic investigation of video images for the appearance of smoke, the intensity values of the individual pixels of successive images are compared with each other. If intensity values which are typical of a brighter image caused by the presence of smoke are measured, the presence of smoke is assumed and the alarm is raised.
- 25 With this method, there is the problem, among others, that smoke in front of a bright background is not recognised, and even fire which generates little smoke is not detected. Additionally, changes of brightness such as are caused, for instance, by persons moving through the field of view of the camera, can trigger a false alarm. One attempt at solving this problem was to investigate an outer area as well as the actual area to be monitored,
- 30 and if there are changes in this outer area, to interrupt the observation of the area to be monitored. This method has the disadvantage that in some circumstances a fire is only detected after a certain delay, and that smoke sources in the outer area which is provided in addition to the area to be monitored are not detected.



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The present invention concerns a video smoke detection system with at least one device for taking video images, and with a signal processing stage, in which the brightness of individual pixels or groups of pixels of the video images is determined.

5 The object of the invention is to provide a video smoke detection system which makes quick, reliable detection of smoke possible, and is particularly suitable for use in road and railway tunnels. The smoke should be detected at as early a stage as possible of the origination of the fire, and false alarms should be practically impossible.

10 The video smoke detection system according to the invention is characterised in that the brightness of the pixels is determined by a process in which a value which represents the brightness is obtained, and that changes to this value over time are investigated for a change which is characteristic of the occurrence of smoke.

A first, preferred embodiment of the video smoke detection system according to the invention is characterised in that the brightness of the pixels is determined by an edge extraction process, in which an edge value is assigned to each pixel.

15 The video smoke detection system according to the invention is based on the recognition that the occurrence of smoke results in reduction of the contrast. In the determination of brightness by an edge extraction process, the edges are smeared or disappear. This process has the advantage that the edge value is insensitive to global lighting changes.

20 A second, preferred embodiment of the video smoke detection system according to the invention is characterised in that for each pixel the edge value is compared with a mean value, and that from this comparison a counter image, so called below, is obtained, and indicates the behaviour of the edge value over time relative to the mean value.

25 Preferably, the counter image, which indicates how often the brightness of the relevant pixel, on average over a specified period, has been above the stated mean value, is updated at every comparison of the edge value with the mean value.

The counter image is compared with a threshold, and if this threshold is exceeded an initialisation value is added to a current value.

30 A third, preferred embodiment of the video smoke detection system according to the invention is characterised in that in addition to the edge extraction process an investigation of the video images for movements, called movement detection below, takes place.

In road and railway tunnels, to monitor which the system according to the invention is primarily intended, the covering of the edges, insofar as it is not caused by smoke, will

occur almost exclusively because of moving objects between the relevant edge and the camera. Since such objects do not suddenly materialise, but almost always have moved to the place where they cover the edge, it can be assumed that in the case of an edge covering which is not caused by smoke, immediately previously a movement of the object covering the edge must have taken place. Movement detection thus provides a reliable criterion for distinguishing edges which are covered by smoke from those which are covered by objects.

Preferably, edge values are determined and movement is detected on the basis of counter images, which are continuously updated using a hysteresis algorithm. For movement detection, an algorithm based on normalised cross-correlation is preferably used.

The hysteresis algorithm preferably has a minimum value and a maximum value, and two thresholds between them. When counting upwards, the counter image jumps to the maximum value when the lower threshold is passed, and when counting downwards, it jumps to the minimum value when the upper threshold is passed.

This hysteresis algorithm makes it possible to use noisy images for the detection algorithms. Given hysteresis with suitable parameters, an edge which is caused by noise will not appear in the counter image, and an edge will not disappear because of a single noisy image.

A fourth, preferred embodiment of the video smoke detection system according to the invention is characterised in that three data structures are used, one data field with information about the edges which are present in the relevant image, one data field with a bit mask to exclude image areas which are not to be taken into account for smoke detection, and the observed image itself. The edges and the image are retained between successive iterations of the process, and the bit mask is re-initialised for each iteration.

A fifth, preferred embodiment of the video smoke detection system according to the invention is characterised in that the image and the edges are analysed pixel by pixel, and the bit mask is analysed for groups, called blocks below, of multiple pixels.

A sixth, preferred embodiment of the video smoke detection system according to the invention is characterised in that the data is processed on two paths, a first path for calculating the edges which are present in the image and updating the data which is already present about edges, and a second path for creating the bit mask. This second path includes the movement detection.

According to a seventh, preferred embodiment of the video smoke detection system according to the invention, the second path also includes checking the blocks for saturation of the device for taking the video images. Blocks with a specified number of saturated pixels are marked and not taken into account for the analysis of the counter image of the edges.

Another preferred embodiment of the video smoke detection system according to the invention is characterised in that by using a mask, arbitrary sections of the image can be excluded from the analysis. Preferably, the bit mask which is created on the basis of movement detection and the check for saturation is used to update the counter image to exclude image areas which are not to be taken into account for smoke detection.

Another preferred embodiment of the video smoke detection system according to the invention is characterised in that before the decision about the presence of smoke, there is a check for whether there are enough edges for such a decision.

Below, the invention is explained on the basis of embodiments and the drawings.

- Fig. 1 shows a block diagram of a video smoke detection system according to the invention,
- Figs. 2-4 each show a flowchart to explain the functioning of a first embodiment of a video smoke detection system according to the invention,
- Fig. 5 shows a flowchart to explain the functioning of a second embodiment of a video smoke detection system according to the invention.

The video smoke detection system according to the invention, according to Fig. 1, consists essentially of a number of video cameras 1 and a common processor 2, in which the signals of the video cameras 1 are processed and analysed. The video cameras 1 are installed, for instance, in a road tunnel, and are used for traffic monitoring, for instance to monitor conformity to traffic regulations and to detect formation of traffic jams, accidents, etc. The cameras are linked to a manned operation centre, in which traffic events in the tunnel are observed on monitors. The processors 2 are in a decentralised arrangement, in which a certain number, for instance 8 or 10 cameras, are assigned to a common processor 2.

In the processor 2, the video images are decomposed into pixels, brightness values are assigned to the individual pixels and/or groups of them, and the decision about the presence of smoke is made on the basis of a comparison of the brightness values of the pixels with a reference value. In the assignment of brightness values to the individual pixels or pixel groups, it is essential that this assignment should be independent of global

brightness changes, that is changes of the lighting of the whole image. This independence from the lighting can be achieved by assigning edge values, which are a derivation, to the pixels. Smoke detection is based on the assumption that the edges are weakened or disappear because of smoke.

- 5 The signal processing and analysis in processor 2 can be divided into two function blocks, which are called pixel brightness 3 and smoke detection 4 in Fig. 1. Corresponding to this division, the flowchart of Fig. 2 shows how the values which represent the brightness of the pixels (pixel brightness 3) are obtained, and that of Fig. 3 shows how they are further investigated for the presence of smoke (smoke detection 4). Fig. 4 shows a flowchart for
10 additional steps of the method according to Fig. 2, which are required for certain applications (smoke detection in interior spaces such as corridors, lobbies etc.).

The video images which are taken by each camera 1 are decomposed into pixels and digitised. For each pixel with co-ordinates i and j , its intensity value $I_{i,j}$, which can be, for instance, between 0 and 255, is determined. From the intensity values $I_{i,j}$, for a specified
15 group of, for instance, 3 by 3 or 5 by 5 pixels, the mean value $M_{i,j}$, or the median, or a value obtained by low pass filtering, is obtained. The median has the advantage that it can be calculated in 8 bits.

In parallel to the calculation of the mean value or median, an edge value is obtained from the intensity $I_{i,j}$ by derivation or frequency analysis (high pass filtering, for instance
20 wavelet transformation). The edge values $K_{i,j}$ of the individual pixels can be determined, for instance, by applying a Roberts or Sobel operator. However, it is of course possible to use a more complicated operator for the edge calculation, and to apply it to larger areas such as 5 x 5 or 7 x 7 pixels.

The edge value $K_{i,j}$ is then tested for whether it is above the mean value or median. If
25 YES, a number δ_{upp} is added to a value $Z_{i,j}$ and the old value $Z_{i,j}$ is replaced by the new one. If NO, a number δ_{low} is subtracted from a value $Z_{i,j}$ and the old value $Z_{i,j}$ is replaced by the new one. The value $Z_{i,j}$ is a number which indicates how often the edge value and thus the brightness of the relevant pixel has been on average above a specified threshold (mean value or median $M_{i,j}$) over a specified period. This number $Z_{i,j}$ is called the counter
30 image below. The value range of $Z_{i,j}$ is, for instance, 0 to 255, and the initial value of $Z_{i,j}$ when the system is initialised is 0. The numbers δ_{low} and δ_{upp} can be equal or different; for instance, they can both equal one.

The counter image $Z_{i,j}$ has a special advantage with respect to the effect of movements on the edge values. If an object moves through the image, at least one edge also moves

through it, and the result is that the pixel at the relevant position of the edge has a higher edge value, so that the counter image $Z_{i,j}$ is increased by δ . As soon as the edge has left the relevant pixel, the counter image $Z_{i,j}$ is reduced by δ_{low} , so that edges passing through the video image have no overall effect on the counter image $Z_{i,j}$ of the individual pixels.

- 5 The counter image $Z_{i,j}$ which is finally obtained is thus preferably a value which represents the brightness of the relevant pixel. In the investigation of the counter image $Z_{i,j}$, three timescales are used: the frequency with which the video images are taken, for instance 1/25 second, every 10 seconds after 255 images, and for instance every half hour.

According to Fig. 3, the counter image $Z_{i,j}$ is compared with a threshold S_z . If the counter
 10 image $Z_{i,j}$ is below the threshold S_z , nothing happens. If it is above the threshold S_z , a summation occurs, that is a value Σ_x is increased by 1 and replaced by this new value. The initialisation value Σ_x^0 is obtained by beginning at initialisation with $\Sigma = 0$ and summing. After a certain stable phase of a few seconds, the result is a stable value, which is then taken as the initialisation value Σ_x^0 . In normal circumstances, Σ_x should
 15 equal Σ_x^0 .

If Σ_x is significantly greater than Σ_x^0 , new edges have appeared, which can be caused by the presence of a standing object in the image area of the video camera. Such an object can be, for instance, a standing vehicle in a tunnel, or an object which has been put down in a corridor. In both cases, a certain image area is covered by the object, which is called
 20 covering in Fig. 3. In the case of covering, the initialisation value Σ_x^0 is redefined. The quotient Σ_x/Σ_x^0 is then formed and compared with a smoke threshold S_R . If this quotient is below the smoke threshold and therefore edges are weakened or have disappeared, the alarm is raised.

The comparison of the quotient Σ_x/Σ_x^0 with the smoke threshold S_R is absolutely sufficient
 25 for precise smoke detection with no false alarms, provided that sharp edges in the foreground move translationally, which as a rule is always the case in tunnels. For smoke detection in road or railway tunnels, therefore, a system with the functions shown in Figs. 2 and 3 will be used.

The circumstances are different in the case of smoke detection in interior spaces in which
 30 people stay. It has been established that people who stay in one place and converse with each other carry out a kind of oscillating or backward and forward movement on the spot, and in contrast to a translational movement, this never drops out of the counter image $Z_{i,j}$. Movements of textures or patterns are also a problem.

The result of these movements is that new edges appear, which could compensate for the weakening or reduction of edges by smoke, so that in some circumstances smoke would no longer be reliably detected. It is generally true that movement results in new edges and may also cover edges, and that smoke does not result in new edges, but weakens edges. An exception from this rule is smoke at a great distance, which may result in a new edge. Since the areas which are furthest removed from the camera are in the top part of the video image, this effect can be switched off by masking out this top part of the image, or it can be assumed that an edge which is formed by smoke will only move very slowly.

To prevent the interfering effect of movements, if required the subprogram which is shown in Fig. 4 is used to eliminate the movements, with the edges $K_{i,j}$ (Fig. 2) as the starting point. In principle the intensity $I_{i,j}$ could be the starting point, which however would be associated with the disadvantage of the presence of interfering direct current components. The difference $\Delta K_{i,j}$ of successive images is formed and compared with a movement threshold S_B . If $\Delta K_{i,j}$ is below this threshold, no movements are present. If $\Delta K_{i,j} > S_B$, the pixels which fulfil this condition are combined into sub-areas, from which the movement is masked out. This is achieved by not updating the counter image $Z_{i,j}$ and using the last counter image before the movement for these sub-areas.

The signal noise is removed by a morphological filter (erosion). This means the following: The difference image which supplies the number of changed pixels in the sub-areas is a binary image. This binary image is gone over with a pattern, and the pixels which correspond to the pattern are given the value "1". The end of the movement is indicated by the sub-areas disappearing from the image in succession and the edges decreasing.

Fig. 5 shows a flowchart of a second embodiment of the video smoke detection system according to the invention. This is outstanding in particular for high robustness against interference and high reliability of smoke detection. The image being observed is marked in Fig. 5 with reference A.

Here are some general explanations before the flowchart is described: Since the edges can be covered not only by smoke but also by objects between the camera and the relevant edge, an additional investigation of the observed image for movements takes place. It is assumed that an object which covers an edge has not suddenly appeared in this position, but has moved to it.

A further point to be noted for smoke detection is that of the various time frames which must both be taken into account and be distinguished from each other. There are very

fast effects in the sub-second range, such as trembling of the camera caused by a lorry moving past nearby, which can be eliminated by forming a sliding mean value. There are medium fast events, such as are caused by smoke for instance. These are approximately in the 10 second range, because the smoke takes about 10 seconds to reach the place where it is detected. There are slow effects in approximately the 10 minute range or even slower. These are, for instance, effects of the apparent movement of the sun. One possible way of distinguishing these time frames and identifying effects in the correct time frame is counter images with hysteresis.

A counter image is a series of values, normally of the size of an image which can be made larger or smaller. These values are usually used to count, for instance, events. Both the edge detection and the movement detection of the algorithm which is shown in the flowchart depend on counter images which are updated using a hysteresis algorithm. The hysteresis is characterised by four values, bottom, lower, upper and top, and bottom and top form counter limits which cannot be exceeded. The lower value is above the bottom value, and the upper value is between the lower and top values. If the counter value is between bottom and lower or between upper and top, counting is quite normal, i.e. the counter value is increased by one for each detected event. But if the counter value reaches the lower value and a further event is detected, it jumps to top. Similarly, when the counter value is decreasing and reaches the upper value, it jumps to bottom.

This hysteresis mechanism makes it possible to use noisy images for the detection algorithms. Given hysteresis with suitable parameters, an edge which is caused by noise will not appear in the counter image, and an edge will not disappear because of a single noisy image. The following relationships also apply: The difference between the lower and bottom values gives the number of successive individual images above which a feature or event, for instance an edge, must be present to be detected, and the difference between the top and upper values gives the number of successive individual images after which, if the counter value is decreasing, the event disappears. Since this number of individual images corresponds to a particular time span, these time spans represent a measurement for the reaction time of the algorithm.

The analysis which is shown in the flowchart begins with an edge detection 5, using a method which is based, for instance, on a Sobel operator. The algorithm analyses the brightness of each pixel of each individual image, and follows the history of the scene using the counter image 6, which is updated by the above-mentioned hysteresis algorithm. Two values are calculated for the environment of each pixel:

- A Sobel edge detection filter is applied to the environment, and supplies a value q_{Sobel}
- An average value q_{sum} is calculated for the pixels of the environment.

The two values are then compared using two scaling factors (DiffFac and SumFac):

5
$$f_{DiffFac} \cdot q_{Sobel} <?> f_{SumFac} \cdot q_{Sum}$$

If the left-hand side of this inequality is greater than the right-hand side, the counter 6 is raised, if not it is lowered. In both cases, the hysteresis mechanism is applied.

In parallel to the edge detection 5, movement detection 7 takes place. For this, for instance, an algorithm based on normalised cross-correlation is used, and runs broadly
10 as follows:

Normalised cross-correlation is:
$$\frac{|\bar{x} \cdot \bar{y}|}{\|\bar{x}\| \cdot \|\bar{y}\|} \quad (\text{Formula 1})$$

Small areas of the image, for instance of 4 by 4 pixels, are taken at time t , and these pixels are considered as vector $\bar{x}$. The same area of the subsequent image at time $t+1$ is designated vector $\bar{y}$. If the area has not changed at all, $\bar{x} = \bar{y}$ and the quotient
15 according to Formula 1 has the value 1. A change in this area would change the quotient, so that the degree of this change can be used as a measurement of the intensity of the change in the area.

For adaptation to the processor which is used, in Formula 1 the numerator and denominator are multiplied by factors, and the resulting products are noted analogously to
20 the normalised cross-correlation according to Formula 1. If the numerator is smaller, a movement has taken place and the corresponding area is marked. Sudden changes to the light or lighting conditions affect both sides of the inequality approximately equally, so that the described movement detection is immune to uniform changes in the image. In this way, a map of the current image in 4 by 4 pixel blocks is obtained.

25 The next step is the calculation of the blocks which should not be taken into account in the analysis of the counter image 6 of the edges. All blocks (of a certain number of pixels, for instance four by four, in the image) in which events which have a negative effect on the smoke detection algorithm have occurred should be detected. These blocks produce a bit mask 8, which is represented as a counter image of 1/16 the size of the full image.
30 The size of the blocks is determined by the blocks which are considered for movement detection, but can be changed.

A next stage is the correction of saturation of the video sensor. Such saturation can cause various problems:

- Normalised cross-correlation functions only if the pixels of the image are neither saturated nor completely black;
- 5 • The borders of a fully saturated image section appear as edges. A sudden change to the lighting would give the impression that the relevant edge has moved and then disappeared.
- In areas of saturated pixels, there are no edges. Edges which were originally detected disappear if the relevant area goes into saturation.

10 For this reason, in a saturation test 9, each area is tested by comparison with a limiting value for whether a specified number of pixels is saturated. If yes, the relevant block is also marked. To prevent moving objects showing "holes", because the movement detection only detects parts of a moving object, an extension operator 10 which fills any holes is applied to the bit mask 8.

15 The bit mask 8 which is calculated in the movement detection 7, saturation test 9 and extension operator 10 steps is now used to update the counter image for the exclusion process 11 (exclusion of image areas which are not to be taken into account for smoke detection). The hysteresis mechanism which is described above is applied again.

At this point of the algorithm, two counter images are present, the updated counter image 20 6 of all pixels where edges have been detected, and the updated counter image 11 of all blocks which are to be excluded. The latter counter image is now used, together with a parameter, to change the counter image 6 in such a way that reliable edge evaluation, which is not affected by anything which may interfere with smoke detection, becomes possible. Each block in the counter image 8 is compared with a threshold. If the value of 25 the block is above this threshold, all pixels in the counter image 6 are set to a minimum value. From the counter image 6 of the edges, two quantities which represent the number of edges at different times are now calculated. The first quantity is the number of pixels in the presently existing edges above a first threshold. The second quantity is the number of pixels above a second threshold. This second threshold can broadly be interpreted as the 30 number of pixels in edges which existed at a past point in time.

To calculate these two quantities, a function $\sum_l(c) = \sum_{i,j} (c_{i,j} > l)$, which counts the

number of pixels $c_{i,j}$ in the image of the counters with a value above a threshold l , is defined. Using this function, the two quantities can now be calculated. The number of

pixels which are now on an edge is estimated by putting l very close to the maximum value W_m which the pixels c_{ij} can reach. To take account of noise in image A, for l the value $(W_m - k)$ is usually chosen, where k means a number of frames and for instance for an ordinary fixed camera in a tunnel is about 250.

- 5 An "image height" parameter can be added to the subroutine for counting pixels. This has the effect that only the upper part, for instance the top half, of the image is taken into account for smoke detection. That is reasonable, because smoke usually rises. Additionally, arbitrary image sections can be excluded from the analysis using a mask.

- Before the decision on whether smoke is present, there is now a test in Step 12 for
10 whether enough edges are present for this decision to be possible. This test is necessary for the case in which, for instance, a large lorry is standing directly in front of the camera and the image shows no edges. Since in this case it is impossible to detect a fire, an interference signal should be triggered, indicating that the algorithm cannot work in present circumstances. To delay further action briefly and to be less sensitive to noise, an
15 interruption value, which can be either zero or greater than zero, is used. In the latter case, the absence of enough edges was detected just previously.

- If less than the number of pixels corresponding to a minimum number of edges are present, two actions can take place: If the interruption value is already not equal to zero, it is decreased, and if it reaches 1, an interference signal is triggered. On the other hand, if
20 the interruption value is zero, it is increased to a value greater than zero. If enough edges are present, the interruption value is set to zero and processing continues.

- If a number of edges which is sufficient for reliable detection of smoke is present, the decision about the presence of smoke takes place in Step 13, on the basis of the average sum and difference of the edges. The difference is multiplied by a parameter and
25 compared with the sum. If the sum is greater, there is no smoke; otherwise, the alarm is raised. In both cases, the processing of the current image ends and the processing of the next one begins.

- The alarm can be raised, for instance, by an appropriate alarm being indicated in a manned alarm or monitoring centre, to which the relevant camera is connected. This
30 causes the operating personnel to analyse the image which the camera supplies in more detail by eye. This centre can be, for instance, a police or fire brigade centre in a city or regional base, or the command centre of a road tunnel.

Patent claims

1. Video smoke detection system with at least one device (1) for taking video images, and with a signal processing stage (2), in which the brightness of individual pixels or groups of pixels of the video images is determined, characterised in that the brightness of the pixels is determined by a process in which a value which represents the brightness is obtained, and that changes to this value over time are investigated for a change which is characteristic of the occurrence of smoke.
2. Smoke detection system according to Claim 1, characterised in that the brightness of the pixels is determined by an edge extraction process (5), in which an edge value ($K_{i,j}$) is assigned to each pixel.
3. Smoke detection system according to Claim 1, characterised in that the brightness of the pixels is determined by a frequency analysis, preferably a wavelet analysis, in which an edge value ($K_{i,j}$) which is determined by high pass filtering is assigned to each pixel.
4. Smoke detection system according to Claim 2, characterised in that for each pixel the edge value ($K_{i,j}$) is compared with a mean value ($M_{i,j}$), and that from this comparison a counter image ($Z_{i,j}$, 6), so called below, is obtained, and indicates the behaviour of the edge value ($K_{i,j}$) over time relative to the mean value ($M_{i,j}$).
5. Smoke detection system according to Claim 4, characterised in that the counter image ($Z_{i,j}$, 6), which indicates how often the brightness of the relevant pixel, on average over a specified period, has been above the stated mean value ($M_{i,j}$), is updated at every comparison of the edge value ($K_{i,j}$) with the mean value ($M_{i,j}$).
6. Smoke detection system according to Claim 5, characterised in that the counter image ($Z_{i,j}$, 6) is compared with a threshold (S_z), and if this threshold (S_z) is exceeded an initialisation value (Σ_x^0) is added to a current value.
7. Smoke detection system according to one of Claims 4 to 6, characterised in that the video images (A) which have been taken are investigated for the presence of new edges, that the presence of new edges is concluded by means of a correlation calculation on counter images ($Z_{i,j}$, 6) which are separated in time, and that if new edges are present the initialisation value (Σ_x^0) is redefined.

8. Smoke detection system according to Claim 6 or 7, characterised in that a quotient is formed from the current value (Σ_x) and the initialisation value (Σ_x^0) and compared with a smoke threshold (S_R), and if it exceeds the latter, an alarm is raised.
- 5 9. Smoke detection system according to Claim 2, characterised in that in addition to the edge extraction process (5) an investigation of the video images (A) for movements, called movement detection (7) below, takes place.
- 10 10. Smoke detection system according to Claim 9, characterised in that edge values are determined and movement is detected (7) on the basis of counter images (6, 11), which are continuously updated using a hysteresis algorithm.
- 15 11. Smoke detection system according to Claim 10, characterised in that the hysteresis algorithm has a minimum value and a maximum value, and two thresholds between them, and that when counting upwards, the counter image jumps to the maximum value when the lower threshold is passed, and when counting downwards, it jumps to the minimum value when the upper threshold is passed.
- 20 12. Smoke detection system according to one of Claims 9 to 11, characterised in that for movement detection (7), an algorithm based on normalised cross-correlation is used.
- 25 13. Smoke detection system according to one of Claims 9 to 12, characterised in that three data structures are used, one data field with information about the edges which are present in the relevant image, one data field with a bit mask (8) to exclude image areas which are not to be taken into account for smoke detection, and the observed image itself. The edges and the image are retained between successive iterations of the process, and the bit mask (8) is re-initialised for each iteration.
- 30 14. Smoke detection system according to Claim 13, characterised in that the image and the edges are analysed pixel by pixel, and the bit mask (8) is analysed for groups, called blocks below, of multiple pixels.
15. Smoke detection system according to Claim 13 or 14, characterised in that the data is processed on two paths, a first path for calculating the edges which are present in the image and updating the data which is already present about edges,

and a second path for creating the bit mask (8). This second path includes the movement detection (7).

16. Smoke detection system according to Claims 14 and 15, characterised in that the second path also includes checking the blocks for saturation of the device for taking the video images. Blocks with a specified number of saturated pixels are marked and not taken into account for the analysis of the counter image (6) of the edges.
17. Smoke detection system according to Claim 16, characterised in that by using a mask, arbitrary sections of the image can be excluded from the analysis.
18. Smoke detection system according to Claim 17, characterised in that the bit mask (8) which is created on the basis of movement detection (7) and the check for saturation (9) is used to update the counter image (11) to exclude image areas which are not to be taken into account for smoke detection (13).
19. Smoke detection system according to Claim 18, characterised in that on the basis of the counter image (11) for exclusion of image areas which are not to be taken into account for smoke detection (13), the counter image of the edges (6) is changed so that the edge evaluation is largely immune to effects which may interfere with smoke detection (13).
20. Smoke detection system according to Claim 19, characterised in that before deciding about the presence of smoke, there is a test (12) for whether a sufficient number of edges for such a decision is present.