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Video Smoke Detection System and Method for Testing the Same

Description

The present invention relates to a video smoke detection system with a camera for recording video images and a signal processing stage in which the brightness of the individual pixels or group of pixels of the video images is determined, wherein a value that is representative of the brightness of the pixels is obtained and its behaviour over time is investigated to detect the occurrence of changes characteristic of smoke.

Smoke detection systems of this type, such as are described for example in WO 00/23959 and in EP patent application no. 00 128 606.1, are preferably used in tunnels, since in the latter, it cannot be ensured on account of the air movement and air stratification generated by the moving vehicles and trains, that the smoke formed in the event of a fire would reach in good time the smoke detectors mounted on the roof of the tunnel.

The operator of a tunnel who employs such a smoke detection system wishes not only to comply with the specified or agreed specifications, but also to be able to carry out function tests *in situ* so as to check the operational readiness of the system at any time. The obvious possible way of carrying out such function tests using a smoke generator is very complicated however, since the relevant tunnel has to be closed for this purpose. The manufacturer of the smoke detection system is for their part interested in checking, within the framework of quality control during manufacture or after installation of the systems, the compliance with the specifications and in calibrating the system, in which connection this calibration should be able to be carried out as simply as possible. Here too the use of smoke generators is very complicated.

The invention now provides a video smoke detection system by means of which a function check or calibration can be carried out quickly and without great effort and expenditure *in situ*, i.e. at the installation site directly in the tunnel as well as at the place of manufacture or indeed any other arbitrary place. These two processes (calibration and function check) hereinafter termed test/testing should be able to be carried out simply and reliably and should yield reproducible results.

The video smoke detection system according to the invention is characterised in that in order to test the system the signal from the camera can be influenced so that a change in



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the video signal that is characteristic of the occurrence of smoke is simulated at the signal processing stage.

5 A first preferred embodiment of the video smoke detection system according to the invention is characterised in that means are provided for reducing the contrast of the video signal.

10 A second preferred embodiment of the video smoke detection system according to the invention is characterised in that the aforementioned means are formed by an optical filter that can be positioned in front of the camera lens. Preferably the optical filter has a plurality of variously strongly scattering diffusers that can be positioned as desired in front of the camera lens.

A third preferred embodiment of the video smoke detection system according to the invention is characterised in that the aforementioned means comprise a decoder with adjustable contrast.

15 A fourth preferred embodiment of the video smoke detection system according to the invention is characterised in that the aforementioned means are formed by an electronic filter that can be connected between the camera and signal processing stage.

A fifth preferred embodiment of the video smoke detection system according to the invention is characterised in that the filter has a transfer function with vertical and horizontal filtering.

20 A sixth preferred embodiment of the video smoke detection system according to the invention is characterised in that the aforementioned means have a device for adjusting the focal length of the camera. Preferably the aforementioned means can be actuated by remote control.

25 The present invention also relates to a method for testing a video smoke detection system that comprises a camera for recording video images and a signal processing stage, in which the brightness of the individual pixels or groups of pixels of the video images is determined and a value that is representative of the brightness of the pixels is obtained and its behaviour is investigated over time to detect the occurrence of changes that are characteristic of smoke.

30 The method according to the invention is characterised in that in order to test the system the signal from the camera is influenced so that a change in the video signal that is characteristic of the occurrence of smoke is simulated at the signal processing stage.

A first preferred embodiment of the method according to the invention is characterised in that the contrast of the video signal is reduced.

In the video smoke detection system according to the invention and in the method according to the invention for testing a video smoke detection system, an optical filter in front of the camera is therefore swivelled in order to simulate smoke, or the video signal at the output of the camera is electronically isolated so that it reacts to the smoke algorithm, or the focal length of the camera is adjusted to such an extent as to simulate an image fuzziness caused by smoke.

In all cases a reduction of the contrast of the video signal is thus effected, whereby it "appears" to the signal processing stage as if smoke were actually present. In this way the smoke detection algorithm can be tested under realistic conditions without having to produce a test fire or activate a smoke generator, which would not be feasible in practice in a tunnel on account of the associated traffic congestion (closure of the tunnel).

The invention is described in more detail hereinafter with the aid of examples of implementation and with reference to the following drawings, in which:

Fig. 1 is a diagrammatic representation of a first embodiment of a video smoke detection system according to the invention,

Fig. 2 is a diagrammatic representation of a first variant of the system of Fig. 1, and

Fig. 3 is a diagrammatic representation of a second variant of the system of Fig. 1.

The video smoke detection system according to the invention consists according to Figs. 1 to 3 essentially of a plurality of video cameras 1 and a common processor 2, in which the signals from the video cameras 1 are processed and evaluated. The video cameras 1 are installed for example in a road tunnel and serve to monitor the traffic flow, for example to monitor the observance of traffic regulations and to detect the build-up of dust, accidents and the like. The cameras are connected to a manned control point in which the traffic in the tunnel can be observed via monitors. The processors 2 are decentrally arranged, a certain number of for example 8 to 10 cameras being associated in each case with a common processor 2. Each video camera 1 is arranged for example in a housing 3 that serves to protect the camera against external influences such as damage, spray water, condensation water or dust. The front side of the housing 3 has a transparent window 4 and the upper side of the housing has a cover 5 that can be moved in the longitudinal direction. A housing of this type is known for example from the International Design Registration No. DM/049 356.

In addition to monitoring the traffic, the system consisting of the video cameras 1 and the processors 2 serves for fire warning purposes by detecting the smoke that is thereby formed. In the processor 2 the video images are decomposed into pixels, brightness values are allocated to the individual pixels and/or groups of pixels, and by comparing the
5 brightness values of the pixels to a reference value it is decided whether or not smoke is present. In the allocation of the brightness values to the individual pixels or groups of pixels it is essential that this allocation is independent of global changes in brightness, i.e. changes in the illumination of the overall image. This independence from the illumination can be achieved by allocating to the pixels edge values that in fact represent a derivation.
10 The recognition of smoke is based on the assumption that the edges disappear or are attenuated by smoke. This means in other words that, due to the smoke, the contrast in the video signal, which is the output signal of the camera 1, is reduced.

The details of the smoke detection algorithm are not described in more detail here; reference may be made in this connection to European patent application no.
15 00128606.1 filed by Siemens Building Technologies AG on 28.12.2000, to which reference is hereby expressly made.

The aforescribed video smoke detection system is equipped with a test device for function testing and/or calibration, which enables the compliance with the specifications to be tested and a function test to be carried out at any arbitrary site, in particular at the
20 place of use of the system, under realistic conditions without having to produce a test fire or activate a smoke generator. The test device is based on the fact that the signal from the camera 1 is influenced in such a way that a change in the video signal that is characteristic of the presence of smoke is simulated at the processor 2. Figs. 1 to 3 each illustrate an embodiment of the test device.

25 According to Fig. 1 the test device is formed by an optical filter 6 that can be swivelled in front of the lens of the video camera 1. The filter may in the simplest case be a type of signalling disc that can be held by an operator in front of the camera 1, or it may be formed as a motor-actuable swivelling arm or may even be part of a motor-driveable disc as illustrated in Fig. 1. The disc includes, in addition to the filter 6 acting as diffuser, an
30 optically completely transparent region that in normal operation is swivelled in front of the lens of the video camera 1. The filter 6 may be a surface diffuser or a volume diffuser, or there may also be used a so-called diffusing screen, as is employed in photography to reduce the contrast, as filter 6. The disc together with its drive 7 may either be arranged

in the interior of the housing 3 as shown in the diagram, or may also be arranged outside the latter.

When a test is to be carried out, the drive 7 of the disc receives a corresponding signal via a line 8 connected to the control point and swivels the optical filter in front of the lens.

5 The signal to the line 8 may be generated manually or also automatically in the control point, by for example switching the video smoke detection system periodically to a test mode. Due to the scattering effect of the filter 6 the image recorded by the camera 1 undergoes a reduction in contrast, which has a corresponding effect on the output signal of the camera 1 and thus on the input signal of the processor 2 and is interpreted by the
10 processor as indicating the presence of smoke. If no alarm signal is triggered by the processor 2, the operating staff in the control point recognise that a fault has occurred.

In the smoke detection algorithm described in the aforementioned EP patent application no. 00128606.1 only those pixels whose contrast lies above a certain threshold value are involved in the evaluation. These pixels are investigated and an alarm is triggered if,
15 within a certain specified time, the contrast in sufficiently many of the said pixels is reduced by a specific amount. In other words a contrast threshold is set and in this way the sensitivity of the system is adjusted to a practicable value. If a histogram of the contrast distribution with the contrast frequency is constructed compared to the contrast height (in percent), then at a contrast threshold of N% all pixels with a contrast height
20 below the contrast threshold would be disregarded.

The testing/calibration of the system can now be carried out in a similar way and here too this contrast threshold can be used by designing the disc illustrated in Fig. 1 in such a way that it has three or four transparent regions, a fully transparent region and two or three regions with variously strongly scattering diffusers. For example, diffusers of the
25 same material but with different thicknesses can be used.

Three diffusers may for example be chosen as follows:

- the contrast reduction produced by the first diffuser is so slight that only a small percentage of for example 10% of the observed pixels are below the threshold;
- the contrast effect produced by the second diffuser is such that an average
30 proportion of for example 15 to 20% of the observed pixels is below the contrast threshold;

- the contrast effect produced by the third diffuser is such that a relatively large proportion of for example at least 30% of the observed pixels is below the contrast threshold.

When swivelling the first diffuser the system must not trigger an alarm, when swivelling
 5 the second diffuser the system may trigger an alarm, and when swivelling the third
 diffuser the system must trigger an alarm. In this way the operator knows for certain that
 the system is adjusted to the selected contrast threshold. The use of several, variously
 strongly scattering diffusers is advantageous particularly in older tunnels with relatively
 dark walls.

10 The processor 2 of the video smoke detection system contains *inter alia* a decoder, in
 which connection decoders can be obtained in which the contrast can be adjusted. When
 using such a decoder the testing/calibration procedure just described may be carried out
 electronically by for example visualising the said histogram on a screen and then reducing
 15 the contrast at the decoder until the curve shown in the histogram falls below the contrast
 threshold and thereby triggers an alarm.

This procedure would correspond exactly to the swivelling of the various diffusers. The
 displacement of the histogram curve on the screen when reducing the contrast of the
 decoder is carried out using an appropriate software tool.

In the embodiment illustrated in Fig. 2 the video signal between the output of the camera
 20 1 and the input of the processor 2 is passed through a filter 9 and is electronically
 isolated. For this purpose the filter 9 has a pulse response such that the smoke detection
 algorithm reacts. For example the filter 9 may comprise a transfer function with horizontal
 and vertical low-pass filtering. The switching of the video signal to the filter 9 is effected
 by means of a lead 10 connected to the control point.

25 In the embodiment illustrated in Fig. 3 a camera 1 with a motor-adjustable focal length is
 used, the focal length adjustment being identified by the reference numeral 11. In order
 to carry out a function test or a calibration the focal length adjustment 11 receives a
 control signal via a line 12 connected to the control point, which signal effects a
 corresponding adjustment of the focal length. The fuzziness produced thereby
 30 corresponds to a contrast reduction in the video image of the camera 1.

Obviously the test device illustrated in Figs. 1 to 3 may also be used by the manufacturer
 of the video smoke detection system to test compliance with the specifications, in which
 connection such a test may also be carried out at the factory within the framework of the

quality control. A further possible way of using the test device consists in temporarily removing the system after it has been installed. In this case the test device enables the functional integrity of the installed system to be demonstrated to the customer.

Patent Claims

1. Video smoke detection system with a camera (1) for recording video images and a signal processing stage (2) in which the brightness of the individual pixels or groups of pixels of the video images is determined, wherein a value that is representative of the brightness of the pixels is obtained and its behaviour over time is investigated for the occurrence of changes characteristic of smoke, characterised in that in order to test the system the signal of the camera (1) can be influenced so that a change in the video signal that is characteristic of the occurrence of smoke can be simulated at the signal processing stage (2).
2. Video smoke detection system according to claim 1, characterised in that means are provided for reducing the contrast of the video signal.
3. Video smoke detection system according to claim 2, characterised in that the aforementioned means are formed by an optical filter (6) that can be positioned in front of the camera lens.
4. Video smoke detection system according to claim 3, characterised in that the optical filter (6) comprises a plurality of variously strongly scattering diffusers which can be positioned as desired in front of the camera lens.
5. Video smoke detection system according to claim 2, characterised in that the aforementioned means comprise a decoder with adjustable contrast.
6. Video smoke detection system according to claim 2, characterised in that the aforementioned means are formed by an electronic filter (9) that can be connected between the camera (1) and signal processing stage (2).
7. Video smoke detection system according to claim 6, characterised in that the filter (9) comprises a transfer function with vertical and horizontal filtering.
8. Video smoke detection system according to claim 2, characterised in that the aforementioned means comprise a device (11) for adjusting the focal length of the camera (1).
9. Video smoke detection system according to one of claims 2 to 8, characterised in that the aforementioned means can be actuated by remote control.

10. Method for testing a video smoke detection system that comprises a camera (1) for recording video images and a signal processing stage (2), in which the brightness of the individual pixels or groups of pixels of the video images is determined and a value representative of the brightness of the pixels is obtained and its behaviour over time is investigated for the occurrence of changes characteristic of smoke, characterised in that in order to test the system the signal of the camera (1) can be influenced so that a change of the video signal characteristic of the occurrence of smoke is simulated at the signal processing stage (2).
11. Method according to claim 10, characterised in that the contrast of the video signal is reduced.
12. Method according to claim 11, characterised in that the contrast reduction is effected by arranging a diffuser in front of the camera (1).
13. Method according to claim 11, characterised in that the contrast reduction is effected by electronically influencing the output signal of the camera (1).
14. Method according to claim 11, characterised in that the contrast reduction is effected by adjusting the camera (1) to give a fuzzy image.