

Automatic Monitoring Of Motionless Object And Animate Body

Field of Invention

[0001] The present invention relates to a method and system for monitoring motionless object or animate body, for example, in a surveillance or health care system.

Background

[0002] Security monitoring system is not only useful for crime prevention; it is also useful for ensuring safety of passengers, for example, in a lift where some one may be injured or fallen ill, in a train station or under-ground passage-way when one has fallen ill or lost unconsciousness. Monitoring of patients in a health care facility is also equally useful; for example, elderly patients in a nursing home may need to be monitored closely, especially in wash-rooms where elderly people are more likely to fall and injure themselves; thus, quick response is expedient.

[0003] A conventional security system often uses cameras to monitor a specific area. These cameras transmit images of the monitored area to video screens at a security post. However, the effectiveness of such monitoring relies on the attention and alertness of the security personnel at the security post. More attention is required to detect a motionless object, especially when human traffic is heavy. A motionless object may become a security scare if it is intentionally or mischievously planted.

[0004] US Patent No. 5,043,705 describes a sonar system for detecting a motionless body in a pool. For example, a bottom layer of a swimming pool is continuously scanned at known time intervals to generate successive frames of images of objects exceeding a threshold size. Successive image data are compared; a contour which remains substantially motionless for longer than a predetermined time interval can thus be detected. The contour may represent a person in distress and an alarm can be timely activated in response.

[0005] Due to high security concern in recent events, it can thus be seen that there exists a need for a different method of detecting motionless object/body to ensure safety and security in public places.

Summary

[0006] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[0007] In one embodiment, the present invention provides a method for detecting a motionless object or body in a surveillance system. The method comprising: capturing an image of an area to be monitored, including a background image; converting the image into a grey scale format; computing a background correlation coefficient (bCp) between a captured image and the background image; capturing a predetermined number, p of changed images if the background correlation coefficient is less than a first threshold value; computing a change correlation coefficient (cCp) between two of the predetermined numbers p of changed images, and treating each of such pair of changed images to include a motionless object/body when the change correlation coefficient (cCp) is less than a second threshold value; and sending an alert signal when a motionless object/body is detected.

[0008] In another embodiment of the method, the change correlation coefficient is computed by comparing two successive changed images or by comparing a changed image with each of the other p-1 changed images. Preferably, the correlation coefficient is performed along a predetermined line or area.

[0009] In another embodiment, the method further comprises deciding whether a range of the changed correlation coefficient (ΔCp) is greater than a dynamic range, and if the decision is positive, meaning that the captured images are moving, repeating the image capturing step in claim 1.

[0010] In another embodiment of the present invention a system for monitoring a motionless object or body is provided. The system comprises: a camera; an image processor; and a data-storage unit; wherein with the image processor is connected to the camera and an output unit and wherein the image processor is operable to execute an algorithm according to any one of method claims 1-13.

[0011] In another embodiment of the system, the camera is operable with white, infra-red or ultra-violet light. Preferably, the system comprises a microphone input to the image processor.

[0012] In an embodiment of the data-storage unit, the data-storage unit comprises flag switches. Preferably, each flag switch is connected to a relevant emergency service.

[0013] In an embodiment of the output unit, the output unit comprises a video console and an alarm panel at a monitoring station. In another embodiment, the monitoring station is a security station. In yet another embodiment, the monitoring station is a nursing station in a health-care ward.

Brief Description of the Drawings

[0014] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0015] FIG.1 illustrates a system for monitoring the security and safety of an area A according one embodiment of the present invention;

[0016] FIG. 2 illustrates a process for determining an image with a moving object or body in the area A in accordance with another embodiment of the present invention;

[0017] FIG. 3 illustrates a sub-process for determining an image with a motionless object or animate body in accordance with another embodiment of the present invention; and

[0018] FIG. 4 illustrates a sub-process for differentiating a motionless animate body from a motionless object.

Detailed Description

[0019] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals or series of numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0020] FIG. 1 shows a system 10 for detecting motionless object and body in according with one embodiment of the present invention. As shown in Fig. 1, the system 10 has a camera 20 for monitoring an area A. The camera 20 is connected to an image processor 30, a data-storage 40 and an output unit 60. The data storage 40 includes flag switches 50, such as a motionless flag switch 52. In another embodiment, the system 10 also includes a microphone input 25 to the image processor 30.

[0021] FIG. 2 shows an algorithm or process 100 for use with the motionless detection system 10 according to another embodiment of the present invention. As shown in FIG. 2, the camera 20, when in use, sends a stream of frames of images H of the area A to the image processor 30, for example, at 30 frames/s. As shown in FIG. 2, the algorithm/process 100 starts with step 105.

[0022] From step 105, the process 100 prompts a security guard, who is on site duty or is connected remotely to the system 10, to set some initial parameters in step 110. As shown in FIG. 2, the initial parameters include, for example, a start timer and a select

interval n of image frames captured by the camera and sent to the image processor 30. For example, when $n=5$, every 5th image captured by the camera is stored in the data storage 40 and analysed by the image processor 30. In addition, the system 10 also sets a captured image counter, m and changed image counter, p both to zero in step 110.

[0023] The image H captured by the camera 20, in step 120, may be in colours, for example, in a RGB format. The selected frames of the images captured by the camera 20, including the background image are then converted by the image processor 30 to grey scale format, in step 125. Each grey scale image, $I_{m,p}$ is identified by counters m and p . For example, the grey scale background image or template is identified as $I_{m=0,p=0}$ and is hereafter identified as I_0 for easier reference. Obviously, images H_m and $I_{m,p}$ are related by the image counter m .

[0024] In step 130, the image processor 30 generates a correlation coefficient bCp for the current image in relation to the background image I_0 . A decision is then made in step 135 whether the correlation coefficient bCp is less than a threshold value. In one embodiment, the correlation coefficient bCp is a cross-correlation coefficient. If the grey-scale image I is normalized, for example, by subtracting an intensity of each pixel of the grey-scale image I by a mean value of an intensity of the entire image before comparing it with a similarly normalized background image I_0 , the resulting cross-correlation coefficient is appropriately called a normalized cross-correlation coefficient (NCC). The NCC is a useful tool as it is less sensitive to variations in luminance level of the captured images. In another embodiment, the normalization factor is a variance of intensity of the image. In yet another embodiment, other correlation coefficients are obtained by dividing the above coefficients by the standard deviation of intensity of the respective images. For example, if the NCC is less than 0.75, it means that there is a significant change in the current image when compared with the background image/template; if the NCC is greater than the threshold value, it is considered that there is no object or animate body above a predetermined size coming into view of the camera 20.

[0025] If the decision in step 135 is “yes”, the process 100 proceeds to step 140. In step 140, the image processor 30 stores the changed image $I_{m,p}$ in the data storage 40 and

identifies the changed image by the counters m and p . From the image counter m and select image interval n , the capture time of an image that requires attention can be determined. Counter p is used to track the number of successive changed images. In another embodiment of step 140, the background image correlation coefficients bC_p are additionally stored and sorted in an ascending or descending order; after executing step 140, the highest and lowest bC_p s are known.

[0026] From step 140, the process 100 proceeds to step 145. In step 145, a decision is made whether counter p has reached a predetermined number. For example, the predetermined number may be set between 3 and 8. As shown in FIG. 2, if five successive images change significantly from the background image/template I_0 and the decision in step 145 is positive, the process 100 proceeds to process Y. If the decision in step 145 is “no”, the process 100 proceeds to step 150. In step 150, each counter, m and p , is incremented by 1 count before the process 100 reverts to step 120 for the camera 20 to continue monitoring the area A.

[0027] Capturing a predetermined number p of successive changed images in a loop from steps 140, 145, 150, 120 to 135 is to ensure that new object/body detected in the changed images is not caused by external and transient environmental factors, such as, the flickering of lighting in area A, for instance, due to flicker in the power supply; lightning; and so on. By capturing p successive images, there is a time lag between the images; the time elapse between the images takes care of a new animate body staying still within the time period.

[0028] If the decision in step 135 is “no”, meaning that an image captured by the camera 20 is not significantly different from the background image/template, the process 100 proceeds to step 190. In step 190, the image counter m is incremented by 1 count before reverting to step 120 for the camera 20 to continues monitoring the area A. At the same time, the changed image counter p is re-initialised to one in step 190.

[0029] In the process 100, the image processor 30 stores only the changed image if the change in an image is significantly different from the background image/template. By so doing, the algorithm/process 100 helps to keep the size of the data storage 40 to a

reasonable size. In one embodiment, the changed image includes both the unprocessed image $H_{m,p}$ and the grey-scale image $I_{m,p}$.

[0030] In another embodiment of process 100, a step 115, as shown in FIG. 2, is added after step 110. In one embodiment of step 115, a sub-area of an image captured by the camera 20 corresponding with an image of a known moving part, such as a clock, escalator, and so on, has a pixel intensity of the sub-area being changed to a fixed intensity, for example, from variable intensity values ranging from 0 to 128 to a lower but fixed intensity value, for example, of 0 or 8. This is to ensure that the correlation calculations contributed by the image data corresponding to known moving parts are insignificant; hence, the detection of motion of unknown objects or animate bodies is more reliable with the use of the process 100 according to the present invention.

[0031] FIG. 3 shows a sub-process starting with point Y or step 155 in accordance with another embodiment of the present invention. From step 155, the process 100 executes step 158. In step 158, the changed image counter p is set to one before proceeding to step 160.

[0032] In step 160, a decision is made whether the difference between the highest and lowest correlation coefficients or ΔC_p of the changed image calculated in step 130 is greater than a dynamic range. For example, in one embodiment, the dynamic range is 0.2. If ΔC_p of p successive changed image is greater than the dynamic range, it means that the change in the changed images $I_{m,p}$ is caused by a moving object or animate body. If the decision in step 160 is “yes”, the process control jumps back to point X in FIG. 2 for the process 100 to continue monitoring area A.

[0033] If the decision in step 160 is “no”, a counter c is initialized to zero in step 162 before executing step 164. In step 164, the image processor 30 calculates the correlation coefficient cC_p of a current changed image $I_{m,p}$ with a previous one. For example, in a first process loop, the first changed image $I_{m,p=1}$ is compared with the background image I_0 and a first correlation coefficient $cC_{p=1}$ is calculated by the image processor 30; in the

second process loop, the second changed image is compared with the first changed image and a second correlation coefficient $cCp_{=2}$ is calculated, and so on.

[0034] During each of such process loop, a decision is made in step 166 whether each changed image is different from the previous changed image, ie. by determining whether the changed image coefficient cCp is less than a threshold value. In one embodiment, the changed image threshold value in step 166 is the same as the background image threshold value in step 135. In another embodiment, the changed image threshold value in step 166 is different from the background threshold value in step 135.

[0035] If the decision in step 166 is “yes”, meaning that the current changed image is different from the previous changed image, for example, due to it including an image of a moving object or animate body. The image processor 30 then makes a decision in step 168 whether all the predetermined numbers p of changed images have been compared with each previous changed image. As shown in FIG. 3, the predetermined number p is 5.

[0036] If the decision in step 168 is “no”, the p counter is incremented by one count in step 170 before the image processor 30 reverts to step 164. If the decision in step 168 is “yes”, meaning that all the changed images have been compared with each previous respective changed image and that all the changed images are considered to include an image of a moving object or animate body, the image processor 30 control jumps back to point X in FIG. 2.

[0037] If the decision in step 166 is “no”, meaning that two successive changed images are considered to include an image of a non-moving or motionless object or animate body, the image processor 30 control reverts to step 164 and repeats calculating the correlation coefficient cCp of the changed image again. Before doing so, the image processor 30 increments counter c by one count in step 172. The value of c is predetermined, for example, $c=2$ as shown in FIG. 3. As shown in FIG. 3, a decision is made in step 174 whether the value of c has reached the predetermined number.

[0038] If the decision in step 174 is “no”, the image processor 30 executes steps 175 and 176 before the control jumps back to step 164. Step 175 is similar in function as that in step 168, whilst step 176 is similar in function as step 170. If the decision in step 174 is “yes”, a successive negative decision in step 166 is taken to confirm that an image of a motionless object or animate body has been captured by the camera 20. The process 100 then sends an alert signal, in step 178, to the security guard, who is monitoring the area A and sets the motionless flag 52.

[0039] A decision is then made in step 180 whether action is taken by the security personnel in response to the alert signal in step 178. If the decision in step 180 is “no”, the process 100 sets a time delay in step 182 before re-activating the alert signal in step 178. If the decision in step 180 is “yes”, the motionless flag 52 is re-set in step 185 before the process 100 control jumps back to point X in FIG. 2 to continue processing the images captured by the camera 20 for motionless object/body.

[0040] In another embodiment of the process in step 164, all the changed images are compared with one another and a respective correlation coefficient cCp is stored in the data storage 40, instead of the earlier embodiment where successive changed images are compared. Hence, if the number p of changed image is predetermined in step 145, the number of changed image comparison is known. For example, if $p=5$, the number of comparison and number of correlation coefficients is 10; for example, $cCp1$ is obtained by comparing image $I_{m,p=1}$ with image $I_{m,p=2}$; $cCp2$ is obtained by comparing image $I_{m,p=1}$ with image $I_{m,p=3}$, and so on. If $p=8$, the number of comparison is 28. Accordingly, the value of p in step 168 is the number of comparison of the changed images.

[0041] In another embodiment of the process 100, a decision step 183 is additionally made after step 182. In step 183, a decision is made whether the process 100 is to continue processing the images for motionless detection in the area A after an alert signal is activated. If the decision in step 183, for example by the security guard on duty, is “No”, the process 100 control reverts to step 178 to re-activate another alert signal after another time delay in step 182. If the security guard has verified that the alert situation is harmless and decision in step 183 is “yes”, the process 100 control jumps back to point

X in FIG. 2 and continues processing the images of area A for any motionless object/body.

[0042] In another embodiment of the process in step 178, a motionless flag switch 52 in the data storage 40 is additionally activated once an alert signal is raised in step 178. The motionless flag switch 52 may be used to trigger a data-logger to record details of the alert situation, for example, identification of area A, time of occurrence, and so on. In another embodiment, the motionless flag switch 52 activates an emergency service, such as, an ambulance service. Accordingly, before the process control returns to point X from steps 180 and 183, the motionless flag switch 52 is reset in steps 185 and 186.

[0043] FIG. 4 shows a sub-process 200 for checking whether a motionless body detected in the sub-process shown in FIG. 3 involves an animate body. For a motionless animate body, the life of the body, for example, a human being or animal, may in danger and quick rescue may be required. As shown in FIG. 4, the sub-process 200 starts with step 210.

[0044] In step 210, the image processor 30 calls out the corresponding unprocessed image $H_{m,p}$ and grey-scale image $I_{m,p}$ captured by the camera 20 in steps 120 and 125. In the following process in step 220, the image processor 30 executes a sub-routine to determine the colour spectrum of the motionless object/body that is detected; for example, the colour spectrum of the motionless object/body is obtained by converting the unprocessed image $H_{m,p}$ into HSV and/or HIS colour formats. In another sub-routine, an outline of the motionless object/body is determined and a further sub-routine is executed to determine the aspect ratio and/or area of the motionless object/body. Predetermined data on the colour spectrum, aspect ratio, outline area of human being; pets, such as dogs, are stored in the data storage 40 to differentiate such animate body from other motionless objects that may be commonly found in public places; for instance, such motionless object may be a piece of luggage, bag, box, discarded newspaper, and so on.

[0045] After executing step 220, a decision is made in step 230 whether the motionless object/body detected is an animate body. The decision in step 230 is made by comparing

the colour spectrum, aspect ratio and outline area of the motionless object with such characteristic data of animate bodies stored in the data storage 40. If the decision in step 230 is “yes”, the sub-process 200 executes a voice recognition sub-routine in step 240.

[0046] In step 240, the voice recognition sub-routine enables a microphone 25 input from the area A and records for a predetermined period a sound spectrum emitted by the motionless animate body. A decision is then made in step 250 whether the recorded sound spectrum level is above a background noise level. If the decision in step 250 is “yes”, the sub-process 200 executes the following step 260.

[0047] Various situations could lead the positive decision in step 260; for example, the motionless person might be injured and the person’s view is blocked by an escalator. In order to minimize false alarm, the sub-process 200 activates the voice recognition sub-routine in step 260 and analyses the sound spectrum recorded in step 240. A decision is then made in step 270 whether any part of the recorded sound is above a threshold intensity of some one shouting for “help”. If the decision in step 270 is “yes”, the sub-process 200 sends out a first type of alert signal in step 178a. In one embodiment, the first type of alert signal is to additionally call for an ambulance service.

[0048] If the decision in step 250 or 270 is “no”, it may mean that a motionless animate body is detected by the camera 20; accordingly, a second type of alert signal is raised in step 178b. In one embodiment, the second type of alert signal is to call the security guard, who is on site duty to verify the alert situation.

[0049] If the decision in step 230 is “no”, it may mean that the motionless outline detected by the camera 20 is an in-animate object, and a third type of alert is raised in step 178c. In one embodiment, the third type of alert is to call the security guard who is on duty and/or a civil defence squad to check on the in-animate object.

[0050] In the above description, a camera 20 is described. However, other types of camera are also suitable for use with the present invention; for example, the camera 20 can detect infra-red or UV light instead of white light. In addition, the system shown in FIG. 1 may be one of several separate channels of the image processor 30; these separate

channels may operate concurrently to monitor other areas. These separate channels are connected through the output unit 60 to a central monitoring station or console 70, where a person on duty can view all the monitored areas through video screens. In another embodiment, the monitoring station includes an alarm panel with a mimic board and alarm indicators.

[0051] Also in the description, image correlation coefficient is used to illustrate the use of the present invention. Other techniques can be used in addition to image correlation for their faster change detection; such other techniques are, for example, multi-scale normalized cross correlation, cross correlation along selected lines or area across an image, image subtraction, and so on.

[0052] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the invention. For example, the decision points and correlation threshold values in FIGs. 2 and 3 may be changed and the principle disclosed in this invention can be used to monitor motion or lack of movement of elderly or stroke patients in a high-dependency ward in a hospital.

CLAIMS:

1. A method for monitoring a motionless object or body in a surveillance system, said method comprising:
 - capturing an image of an area to be monitored, including a background image;
 - converting the image into a grey scale format;
 - computing a background correlation coefficient (bCp) between a captured image and the associated background image;
 - capturing a predetermined number, p of changed images if the background correlation coefficient is less than a first threshold value;
 - computing a change correlation coefficient (cCp) between two of the predetermined numbers p of changed images, and treating each of such pair of changed images to include a motionless object/body when the change correlation coefficient (cCp) is less than a second threshold value;
 - deciding whether a range of the change correlation coefficients (ΔCp) is greater than a dynamic range, and if the decision is positive, meaning that the captured images are moving, repeating the image capturing step; and
 - sending an alert signal when a motionless object/body is detected.
2. A method according to claim 1, wherein the change correlation coefficient is computed by comparing two successive changed image.
3. A method according to claim 1, wherein the change correlation coefficient is computed by comparing a changed image with each of the other $p-1$ changed images.
4. A method according to claim 2 or 3, wherein the change coefficient is performed a predetermined c number of times for confirmation.
5. A method according to any one of the preceding claims, further comprising determining whether a motionless detected object/body is an animate body.
6. A method according to claim 5, wherein said determination comprises determining colours of the animate body.

7. A method according to claim 5, wherein said determination comprises determining an outline of the animate body.
8. A method according to claim 7, wherein said determination comprises determining an aspect ratio or a size of the animate body from its outline.
9. A method according to any one of claims 5-8, further comprising detecting sound/voice.
10. A method according to any one of the preceding claims, wherein the correlation coefficient is performed along a predetermined or selected line across each image.
11. A method according to any one of the preceding claims, wherein the correlation coefficient is performed over a predetermined or selected area of each image.
12. A method according to any one of the preceding claims, further comprising reducing resolution or an intensity level of a sub-image that is known to move.