System and method for spray paint image synthesis in surveillance camera anomaly detection

FIELD OF THE INVENTION

[0001] The present invention relates to a system and method for constructing an anomaly surveillance image dataset, in particular, a system and method for synthesizing spray paint on surveillance images, for training a surveillance camera anomaly detection deep neural network model.

BACKGROUND OF THE INVENTION

[0002] While surveillance camera systems are commonly used nowadays for security monitoring. Their maintenance is always an issue since it can be more than thousands of cameras installed in one surveillance camera system. Besides, most of these cameras are installed in remote locations that are difficult to access. Recent advances in machine vision technologies enable many smart surveillance applications which make use of surveillance videos for event or person identifications. The performance of these applications highly depends on the quality of the videos. It imposes a further demand on the efficiency and effectiveness of the maintenance scheme to ensure the surveillance cameras are operating in their best possible condition.

[0003] An effective fault detection mechanism is the prerequisite of any maintenance scheme. The most effective way to detect anomalies in surveillance cameras is to directly assess the quality of the videos they capture. Traditional surveillance camera systems mainly use a manual approach to monitor the operation of the system. Such an approach becomes implausible for the current surveillance camera systems since they can easily scale up to contain thousands of cameras. It requires a huge number of workers and a large space for installing the monitoring equipment, which makes the cost of the system extremely high. Besides, the monitoring needs to be performed all the time, 24/7. Human beings often make errors when working in such a condition. An automatic approach using machinery is thus more viable.

[0004] Due to the nature of the surveillance systems, two different kinds of automatic surveillance camera anomaly detection systems are needed. For the surveillance systems that send the captured videos to a central server for processing, the surveillance camera anomaly detection system should be implemented as a computing process in the server. Since anomaly detection is only an auxiliary function, its complexity and computing resource requirements should be kept as low as possible to avoid affecting the main function of the surveillance system. On the other hand, there are also surveillance systems that directly process the captured videos on the edge using an embedded system close to the camera. The surveillance camera anomaly detection system should then also be implemented in the embedded system or an additional embedded system attached to the original one. The complexity and computing resource requirements of the system become even more stringent to allow it to be installed in low-cost embedded devices.

[0005] However, automatic surveillance camera anomaly detection is a difficult task since the operation of surveillance cameras can be affected by many internal and external factors. All of them can degrade the quality of the captured surveillance videos. For example, the visibility of surveillance videos may be affected by extreme weather conditions such as heavy rain, snow, fog, dust, et cetera, since these surveillance cameras mostly operate outdoors. The video quality may also degrade due to the aging of the camera itself or caused by dirt on the camera lens. This is especially common for safety monitoring or at the tool booths and roadside for car plate recognition or vehicle speed detection.

[0006] Surveillance videos can also be tampered with by intruders for those cameras accessible by the general public. Said intruders may manually change the camera focus setting to blur the camera view or spray paint onto a surveillance camera with the intention to block the camera view. It is particularly difficult to detect the spray paint situation since it can be totally opaque, semi-transparent, and transparent with a blurring effect. There are also clean regions having completely no spray paint so that the background can be clearly seen. Moreover, the spray paint pattern is diverse with irregular shapes.

[0007] There is a need to have a system and method that provide a low-cost, real-time, and efficient surveillance camera anomaly detection system. The system should automatically alert, in real-time, the surveillance camera network or the smart application to the kind of blur anomaly in the surveillance video. Accordingly, suitable actions can be carried out for different blur types. Such a system not only reduces the maintenance effort but is also crucial to the smart surveillance application to ensure the accuracy of their smart decisions. For developing such a system, data-driven approaches are widely known to be the most effective. However, datasets are needed for their training. These datasets, in particular, the spray paint surveillance image datasets, are difficult to find. Although we can use synthesized images for training, the system for synthesizing surveillance images is also rare. There is a need to develop a system and method of synthesizing spray paint on surveillance images for training a surveillance camera anomaly detection network.

[0008] United States Patent No. 8964030 B2 discloses a surveillance camera system having a camera malfunction detection function to detect types of failure via block and entire image processing. The surveillance camera system includes an entire feature extraction unit to extract each entire feature from an input image and a reference image; a block feature extraction unit to extract block features being features of each block from images after the block division of the input image and the reference image divided into blocks by a block division unit. A malfunction determination unit to calculate a first variation between the entire features of the reference image and the entire features of the input image, and a second variation between the block features of the reference image and the block features of the input image, to determine a camera malfunction by using a threshold, and output information indicating a type of the camera malfunction for each block. Accordingly, the surveillance camera system determines the camera malfunction by using an arbitrary or a random threshold, the detection accuracy could be sub-optimal or far from sub-optimal. Also, the surveillance camera system needs to perform background modeling or keep track of the background image using the previous frames as the reference to compare with the current input image. Such a reference approach also may not be accurate. Therefore, there is a need to have a no-reference surveillance camera system wherein handcrafted features, handcrafted thresholds, and information from the previous frames are not required. For training such a no-reference system, there is a need to have a dataset that contains the required anomaly images. In particular, a spray paint surveillance image synthesizing method is needed as real spray paint surveillance images are difficult to find.

[0009] China Patent No. 106203501 A discloses a video image fuzzy anomaly detection method based on machine learning. The machine learning-based video image fuzzy anomaly detecting method of the invention comprises the steps: converting a high-definition video color image into a grayscale image; dividing the grayscale image into two categories according to the fuzzy and non-fuzzy artificial, and the gradient histogram feature is calculated for each image. The gradient histogram feature is used as the classification feature, and the support vector machine is used for training to save the parameters after training. The gradient histogram features are also calculated for the new input image by using the trained parameters, and then the output parameters of the support vector machine are calculated by using the trained parameters; the support vector machine is positively determined as the video image blur, and the support vector machine is negative to determine that the video image is not blurry. However, the anomaly detection method is only able to detect and classify the video image as blurry or not blurry. There is a need to have an anomaly detection system that could detect and classify different types of blur scenarios for taking necessary action to overcome the anomaly issue and access different levels of security assessment, hence enabling timely intervention. For training such a system, there is a need to have a dataset that contains the required anomaly images. In particular, a spray paint surveillance image synthesizing method is needed as real spray paint surveillance images are difficult to find.

[0010] China Patent No. 103491340 A discloses a method and apparatus for the detection of tampering with a surveillance camera. The surveillance equipment comprises an image-generating unit, a rotating unit, an interference detection unit, a past image storage unit, and a rotate period interference detection unit. The rotating unit rotates the angle of described image-generating unit between a plurality of precalculated positions; the interference detection unit includes high frequency filter and violate-action determining unit, and said high frequency filter extracts high frequency component from image, and the high frequency component of the violate-action determining unit based on extracted determined and had violation-action; the past image storage unit stores is in the situation that described image-generating unit is directed to the image that first direction is caught; the rotate period interference detection unit will be pass by image and new images and be compared to detect the violate-action in the period of described image-generating unit rotation; wherein, described new images is in the situation that described image-generating unit is directed to first direction is hunted down, described image in the past was hunted down before described first direction rotates at described image-generating unit, and described new images is hunted down when described image-generating unit turns back to described first direction. Said method and apparatus for detection of tampering with a surveillance camera may lack surveillance image datasets that cover different types of anomaly scenarios for training deep learning models. Therefore, there is a need to have an anomaly detection method and system that could detect and classify different types of blur scenarios for taking necessary action to overcome the anomaly issue and access different levels of security assessment, hence enabling timely intervention. For training such a system, there is a need to have a dataset that contains the required anomaly images. In particular, a spray paint surveillance image synthesizing method is needed as real spray paint surveillance images are difficult to find.

[0011] China Patent No. 107979753 A discloses a method for detecting the image abnormality category of photographic devices. The method for detecting a picture abnormal type of a photographing device proposed by the invention comprises starting a picture detection of a photographing device; activating the photographing device to photograph a test film X; loading a reference image; intercepting X from the test film; comparing the X test images with the reference images respectively to generate an image test sequence with X abnormal image features, and; judging an abnormal picture type of the photographing device according to the image test sequence. The picture abnormality type of the photographing apparatus is divided into four types comprise a redirect (RD) abnormal picture, a defocus (DF) abnormal picture, a spray (SR) abnormal picture, and a block (Blockage, BK) abnormal screen. However, the method of detecting image abnormality is merely based on the obtained abnormality images and comparison with reference images to judge the type of picture abnormality wherein such reference approach may not be accurate. Therefore, there is a need to have a no-reference surveillance camera system wherein handcrafted features, handcrafted thresholds, and information from the previous frames are not required. For training such a no-reference system, there is a need to have a dataset that contains the required anomaly images. In particular, a spray paint surveillance image synthesizing method is needed as real spray paint surveillance images are difficult to find.

[0012] Yong Sun Kim, Yongwan Kim, et al, Computer Animation and Virtual Worlds

27(2) discloses an interactive digital painting system that allows a user to draw graffiti on a virtual 2D canvas with a digital spray can. The digital graffiti system provides a sensation similar to painting real graffiti on a wall, by incorporating paint simulation with a pressure-controllable digital spray can, stereo visualization, and a tracking device. The system is merely an application of graffiti on a virtual 3D canvas with a digital spray can for VR application. There is a need to have a system and method of synthesizing spray paint on surveillance images for training a surveillance camera anomaly detection network.

SUMMARY OF THE INVENTION

[0013] It is an objective of the present invention to provide a low-cost surveillance camera anomaly detection system and method that can give real-time notifications to a surveillance camera network or smart surveillance application on the blur anomalies in the captured surveillance images for taking necessary action.

[0014] It is also a further objective of the present invention to provide an image dataset that includes normal, natural blur, defocus blur, dirt blur, and spray paint blur surveillance images for training, validating, and testing deep learning models for surveillance camera blur anomaly detection.

[0015] It is also a further objective of the present invention to provide a system and method for synthesizing spray paint on surveillance images to construct a spray paint blur dataset.

[0016] Accordingly, these objectives may be achieved by following the teachings of the present invention. The present invention relates to a method for synthesizing spray paint on surveillance images, comprising the steps of: estimating a spray density map to represent the thickness of spray paint; preparing a Gaussian kernel with variance varied at each image location depending on the spray density map; synthesizing the blurring effect given by the spray paint by mathematically convolving a surveillance image with the spatial-varying Gaussian function; estimating a spray alpha map to decide the color intensity appears on the surveillance image at each location; performing an element-wise weighted sum of the spray paint blur image and the spray paint color image with the weight depending on the spray alpha map; randomizing the design parameters to generate spray paint images of different spray paint patterns, thickness, and colors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The features of the invention will be more readily understood and appreciated from the following detailed description when read in conjunction with the accompanying drawings of the preferred embodiment of the present invention, in which:

[0018] **Fig. 1** illustrates two variants of the surveillance camera anomaly detection system in the present invention;

[0019] **Fig. 2** illustrates a process flowchart of the surveillance image blur anomaly detection method.

[0020] **Fig. 3** illustrates examples of normal and anomaly image data in the dataset developed in the present invention;

[0021] **Fig. 4** illustrates a process of spray paint blur image synthesis.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0022] For the purposes of promoting and understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and described in the following written specification. It is understood that the present invention includes any alterations and modifications to the illustrated embodiments and includes further applications of the principles of the invention as would normally occur to one skilled in the art to which the invention pertains.

[0023] The present invention teaches a system for detecting anomalies in a surveillance camera network comprising: one or more surveillance cameras to generate image data of an environment in a surveillance camera network; a computing device including one or more processing devices and one or more memory devices communicatively coupled to the one or more processing devices storing programmed instructions thereon, which when executed by the processor causes the instantiation of: a spray paint images synthesizer to construct an anomaly surveillance image dataset for training a surveillance camera anomaly detection deep neural network model; a blur classifier to: apply, to a neural network, an image data; and compute, using the neural network and based on the image data, the image data with compromised visibility; and a control component to perform one or more operations using the image data based on the compromised visibility.

[0024] In a preferred embodiment of the present invention, the system further comprising: a classifier to compute, using the neural network, a blur classification corresponding to each image data, wherein the performing the one or more operations is further based at least in part on the blur classification.

[0025] The present invention further teaches a method for detecting anomalies in a surveillance camera network, comprising the steps of: applying, to a neural network, an image data of a surveillance camera; determining, using the neural network, and based on the image data, the image with compromised visibility; and computing, using the neural network and based on the image data, a blur class with compromised visibility.

[0026] In a preferred embodiment of the present invention, the method further comprising, computing, using the neural network, at least one blur attribute corresponding to the at least one blur class, wherein the performing the one or more operations is further based at least in part on the blur attribute. Said blur classes comprise normal, natural blur, defocus blur, dirt blur, and spray paint blur; and the blur attributes include normal, natural, defocus, dirt, and spray paint.

[0027] In a preferred embodiment of the present invention, the method further comprising the constructing of a blur anomaly surveillance image dataset for training the neural network. Said dataset comprises normal surveillance images, blurry surveillance images due to natural environmental interference, defocusing, dirt, and spray paint on the surveillance camera, as well as the labels of the images.

[0028] In a preferred embodiment of the present invention, the method further comprising the steps of training the neural network: retrieving an image data of the dataset corresponding to one blur class; retrieving the attribute of that image data; and training, using multiple image data and the corresponding blur attributes, a neural network to optimize its internal parameter to classify image data with the compromised visibility.

[0029] The present invention further teaches a method for synthesizing spray paint on the surveillance images for the construction of the said blur anomaly surveillance image dataset.

[0030] In a preferred embodiment of the present invention, the method further comprising, estimating a spray density map to represent the thickness of spray paint; preparing a Gaussian kernel with variance varied at each image location depending on the spray density map.

[0031] In a preferred embodiment of the present invention, the method further comprising: synthesizing the blurring effect given by the spray paint by mathematically convolving the surveillance image with the spatial-varying Gaussian function; estimating a spray alpha map to decide the color intensity appears on the surveillance image at each location.

[0032] In a preferred embodiment of the present invention, the method further comprising: performing an element-wise weighted sum of the spray paint blur image and the spray paint color image with the weight depending on the spray alpha map.

[0033] In a preferred embodiment of the present invention, the method further comprising: randomizing the design parameters to generate spray paint images of different spray paint patterns, thickness, and colors.

[0034] The system in the present invention automatically evaluates the quality of the videos captured by a surveillance camera to determine the working condition of the camera. The system is optional to add in a computer server and attach to a surveillance camera. The system has two variants depending on the application, as shown in **Fig. 1**. For applications wherein the surveillance videos are sent to one or more servers on the cloud for centralized processing, the system can be an add-on computer process in the servers. For applications wherein the captured surveillance video needs to be directly processed on edge, the system can be an embedded system attached to a surveillance camera.

[0035] Said quality evaluation refers to the detection of different types of blur anomalies in the surveillance images such as natural blur, defocus blur, dirt blur, and spray paint blur, wherein said spray paint blur refers to the blurring effect caused by the paint spray on the camera lens or the front lid of the camera enclosure.

[0036] The system can automatically alert, in real-time, the surveillance camera network or the smart application about the blur anomalies in the surveillance video. A different action can be taken based on the blur type. For instance, the camera should be inspected, cleaned, repaired, or even replaced if there is spray paint blur in the captured images. It is because the blurring effect is permanent. However, the smart system should be alerted if the surveillance images taken with the natural blur anomalies are suitable for the designated smart applications. Certainly, no alert should be generated if a camera operates normally and the background scene is highly visible.

[0037] As shown in **Fig. 1**, the system reads in the compressed video captured by a surveillance camera and decompresses it with a video decoder into image frames. They are then sent to a deep neural network model for blur anomaly detection.

[0038] As described herein, compared with traditional approaches that often use handcrafted features and thresholding techniques to detect the camera anomaly, the present method and system use the deep learning model blur detection method to detect and classify blur anomalies in real time. A blur anomaly detection is formulated in the present invention as a deep learning-based image classification problem, i.e. $\hat{y} = F(I, \theta)$ where I is the surveillance image input to the network, F is the deep neural network with learned parameters θ, and $\hat{y}$ is the predicted label generated by the network. A predetermined dataset is developed to facilitate the training, validation, and testing of the network.

[0039] The deep neural network model comprises a ResNet18 structure **100** as the backbone, as shown in **Fig. 2.** The model further comprises an attention operator **102** and a blur type classifier **104**. It is further simplified to reduce the network size and computational complexity so that it can be realized even on embedded platforms, such as the STM32 microcontrollers. To improve the classification accuracy, the network is modified via color feature attention by a color histogram generator **106** and a color feature attention vector estimator **108**. Color is an important cue for boosting the accuracy of the model. It is based on the observation that many blur anomalies will introduce a bias to the color histogram of the image. For instance, natural blur images often have the grayish sky appearing at the top. Dirt blur images usually have dirt of darker color appearing within the image. Also, spray paint blur often makes a large part of the image be covered by the spray color. Inspired by the success of the attention method in improving the classification accuracy of deep neural networks, the color histogram is used in the network as extra information to attend to the features to boost the accuracy of the detection model.

[0040] The said learning-based blur detection approaches require a large amount of image data to train the said deep learning model for achieving a satisfactory level of accuracy. Accordingly, 10,000 surveillance images of five classes are collected to form a dataset for training the said deep learning model in the present invention. Said five classes of collected surveillance images include but are not limited to normal, natural blur, defocus blur, dirt blur, and spray paint blur images. Examples of normal and anomaly image data in the dataset developed in the present invention are shown in **Fig.3**. **Fig.3a** is normal image data. The natural blur image comprises images affected by adverse weather conditions as shown in **Fig.3b**, including foggy, heavy rain, heavy snow, and strong wind. The defocus blur images as shown in **Fig.3c**, dirt blur images as shown in **Fig.3d**, and spray paint blur images as shown in **Fig.3e** comprise images resulting from the aging, misuse, and intentional tampering of the surveillance camera. They cover the diverse blur anomalies caused by intentional camera tampering, unintentional factors, and environmental changes. Without loss of generality, other numbers of surveillance images and classes are also possible, as long as the number of images of each class is the same for class balancing. The machine learning model may be trained to attend different classes without departing from the scope of the present invention.

[0041] Each class of the said dataset has 1400, 400, and 200 images for training, validating, and testing, respectively, the deep neural network model. Each image has one corresponding label of the class normal, defocus blur, natural blur, dirt blur, or spray paint blur. The resolutions of the images are diverse, from the range of 238×158 to 5184×3456, and with diverse background scenes. They simulate the images taken by a wide range of surveillance cameras installed at different locations.

[0042] The images in the dataset are obtained by different approaches. Since surveillance images with the spray paint blur are difficult to find, the training and validation images are synthesized by using the spray paint blur synthesizer in this invention. The testing images are real images taken by a single-lens reflex camera Canon EOS 650D at surveillance-like viewing angles at various locations.

[0043] For the spray paint blur synthesizer developed in the present invention, it is designed based on the assumption that the higher of spray density, the more color pigment particles are dyed onto the camera lens. Hence, the more color pigment particles at a particular image location, the blurrier and higher spray color density will result at the particular image location. Accordingly, the spray paint blur synthesizer has two stages which comprises a first stage of blurring an image according to the spray density and a second stage of coloring the image according to the normalized spray paint density.

[0044] It is known that an image can be blurred by convolving it with a Gaussian kernel H_σ, where σ is the standard deviation and controls the blurriness of the image. Therefore, the blurring effect given by the spray paint can be synthesized by convolving the image H_σ and setting σ to be varied at each image location (x, y) depending on the spray density as follows:

$$(x - x_0, y - y_0) = \exp\left(-\frac{(x-x0)^2 + (y-y0)^2}{z'^2}\right), \ldots\ldots\ldots\ldots(1)$$

where

(x_0, y_0) is the spray origin

$p'=p/z^2$

$z'=sz$

z is the thickness of the paint

p represents the pressing force on the nozzle of a spray paint container

s represents the size of the nozzle that sprays the paint

[0045] Thus, by randomizing (x_0, y_0), p', and z', spray shots can be synthesized at different image locations, with different spray nozzle sizes and different pressing forces. Moreover, as spray painting is known to a person skilled in the art that it is a continuous process wherein user would normally hold the press button to spray continuously, therefore it is approximated as the sum of consecutive spray paint shots. In particular, a spray paint process is approximated in T time units by T spray paint shots. For blurring and coloring an image, a spray density map **202** is first estimated to represent the thickness of spray paint after T shots. Said spray density map, S_T, **202** after T time units, is the sum of spray density maps **202** at time instants t from 1 to T:

$$S_T = \int_{t=0}^{T} S_t dt \approx \sum_{t=1}^{T} S_t, \quad \ldots\ldots\ldots\ldots\ldots(2)$$

where

$S_t \in R^{W\times H}$ is the spray density map **202** representing the $\sigma_t(x, y)$ at every pixel (x, y) at time t:

$$S_T = \begin{bmatrix} \sigma_t(0,0) & \cdots & \sigma_t(W-1,0) \\ \vdots & \ddots & \vdots \\ \sigma_t(0, H-1) & \cdots & \sigma_t(W-1, H-1) \end{bmatrix}, \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where W and H are the width and height of the image, respectively.

[0046] In (2), S_T is the superposition of T 2D Gaussian distributions. Consequently, at the first stage of the spray paint blur synthesis, an image I **200** is blurred by convolving it with a spatial-varying Gaussian kernel H_{ST}. It is equivalent to the following weighted-sum operation applied to every pixel (x, y) of the image I **200**:

$$I_{Blu}(x, y) = \frac{1}{N_H} \sum H_{ST(x,y)} I_{N(x,y)}, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

where

$N(x, y)$ is the neighborhood pixels at (x, y)

N_H is the size of the kernel $H_{S(x,y)}$

The standard deviation σ of $H_{S(x,y)}$ is obtained from S_T. It is a spatial-varying function following the density of the spray, as shown in (3).

[0047] After blurring the image, the image is colored at the second stage of the spray paint blur synthesis. Firstly, a spray alpha map **206** $A_T \in R^{W\times H}$ is estimated to decide how strong the color appears on the image at each location. It in turn defines the transparency of the background at each location following the spray paint process for T time units. As aforementioned, the higher the spray density, the more color pigment particles are dyed onto the camera lens. A_T is the weighted sum of T normalized spray density map $\hat{S}_t$ **202**:

$$A_T = clip(\sum_{t=1}^{T} w_t \hat{S}_t, 0, 1), \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

where

w_t is a weighting parameter representing the number of color pigment particles for the shot at time t

$\hat{S}_t$ is the normalized spray density map **202** of S_t by dividing the maximum value of S_t, i.e. $\hat{S}_t = S_t/\max(S_t)$

$clip(x, 0, 1)$ is a clipping function to limit the value of x to within the range 0 to 1

[0048] Finally, the spray paint blur image I_{Spray} **208c** is the element-wise weighted sum of the blurred image I_{Blur} **204b** and the spray color map C_{Spray} **208b**:

$$I_{Spray} = (1 - A_T) \otimes I_{Blur} + A_T \otimes C_{Spray}, \ldots\ldots\ldots\ldots\ldots\ldots..(6)$$

where

$\otimes$ is element-wise multiplication

$C_{Spray} \in R^{W \times H}$ is the 3-channel RGB color map representing the color of the spray paint.

I_{Spray} is the synthesized spray paint blur image with spatial-varying blurry **204a** and color effects **208a**.

[0049] The spray paint blur synthesis process is summarized in **Fig. 4**. It is noted that the above image synthesis process can be easily modified for synthesizing spray paint on surveillance videos.

[0050] The present invention explained above is not limited to the aforementioned embodiment and drawings, and it will be obvious to those having an ordinary skill in the art of the prevent invention that various replacements, deformations, and changes may be made without departing from the scope of the invention.

CLAIMS

WHAT IS CLAIMED:

1. A method for detecting anomalies in a surveillance camera network, comprising the steps of:

   applying, to a neural network, an image data of a surveillance camera;

   determining, using the neural network, and based on the image data, the image with compromised visibility; and

   computing, using the neural network and based on the image data, a blur class with compromised visibility.

2. The method for detecting anomalies in a surveillance camera network of claim 1, further comprising, computing, using the neural network, at least one blur attribute corresponding to the at least one blur class, wherein the performing the one or more operations is further based at least in part on the blur attribute.

3. The method for detecting anomalies in a surveillance camera network of claim 1, wherein the blur class comprise normal, natural blur, defocus blur, dirt blur, and spray paint blur.

4. The method for detecting anomalies in a surveillance camera network of claim 2, wherein the blur attribute includes normal, natural, defocus, dirt, and spray paint.

5. The method for detecting anomalies in a surveillance camera network of claim 1, further comprising constructing of a blur anomaly surveillance image dataset for training the neural network, wherein the dataset comprises normal surveillance images and blurry surveillance images.

6. The method for detecting anomalies in a surveillance camera network of claim 5, the training of the neural network, further comprising the steps:

   retrieving an image data of the dataset corresponding to one blur class;

   retrieving the attribute of the image data; and

   training, using multiple image data and the corresponding blur attributes, a neural network to optimize its internal parameter to classify image data with the compromised visibility.

7. The method for detecting anomalies in a surveillance camera network of claim 5, the constructing of the blur anomaly surveillance image dataset further comprising the step of: synthesizing spray paint on the surveillance images.

8. The method for detecting anomalies in a surveillance camera network of claim 7, the synthesizing of spray paint, further comprising:

estimating a spray density map to represent the thickness of the spray paint; and

preparing a Gaussian kernel with variance varied at each image location depending on the spray density map.

9. The method for detecting anomalies in a surveillance camera network of claim 8, further comprising:

synthesizing a blurring effect given by the spray paint by mathematically convolving the surveillance image with the spatial-varying Gaussian function; and

estimating a spray alpha map to decide the color intensity appears on the surveillance image at each location.

10. The method for detecting anomalies in a surveillance camera network of claim 9, further comprising, performing an element-wise weighted sum of the spray paint blur image and the spray paint color image with the weight depending on the spray alpha map.

11. The method for detecting anomalies in a surveillance camera network of claim 10, further comprising, randomizing the design parameters to generate spray paint images of different spray paint patterns, thickness, and colors.

12. A system for detecting anomalies in a surveillance camera network, comprising:

one or more surveillance cameras to generate image data of an environment in a surveillance camera network;

a computing device including one or more processing devices and one or more memory devices communicatively coupled to the one or more processing devices storing programmed instructions thereon, which when executed by the processor causes the instantiation of:

a spray paint images synthesizer to construct an anomaly surveillance image dataset for training a surveillance camera anomaly detection deep neural network model;

a blur classifier to:

apply, to a neural network, an image data;

compute, using the neural network and based on the image data, the image data with compromised visibility; and

a control component to perform one or more operations using the image data based on the compromised visibility.

13. The system for detecting anomalies in a surveillance camera network of claim 12, further comprising:

a classifier to compute, using the neural network, a blur classification corresponding to each image data,

wherein the performing the one or more operations is further based at least in part on the blur classification.

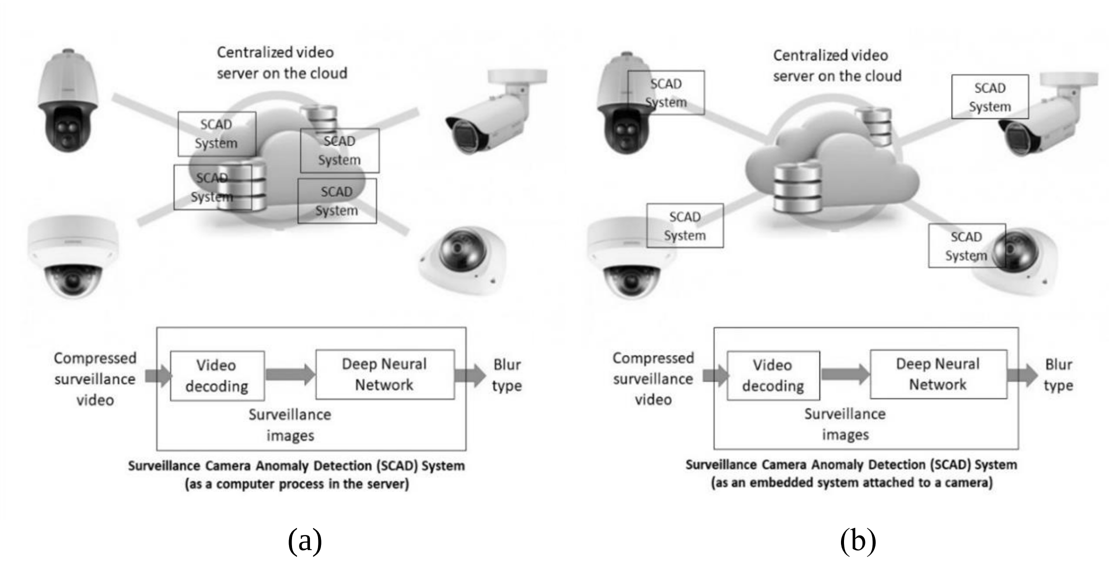

Figure 1

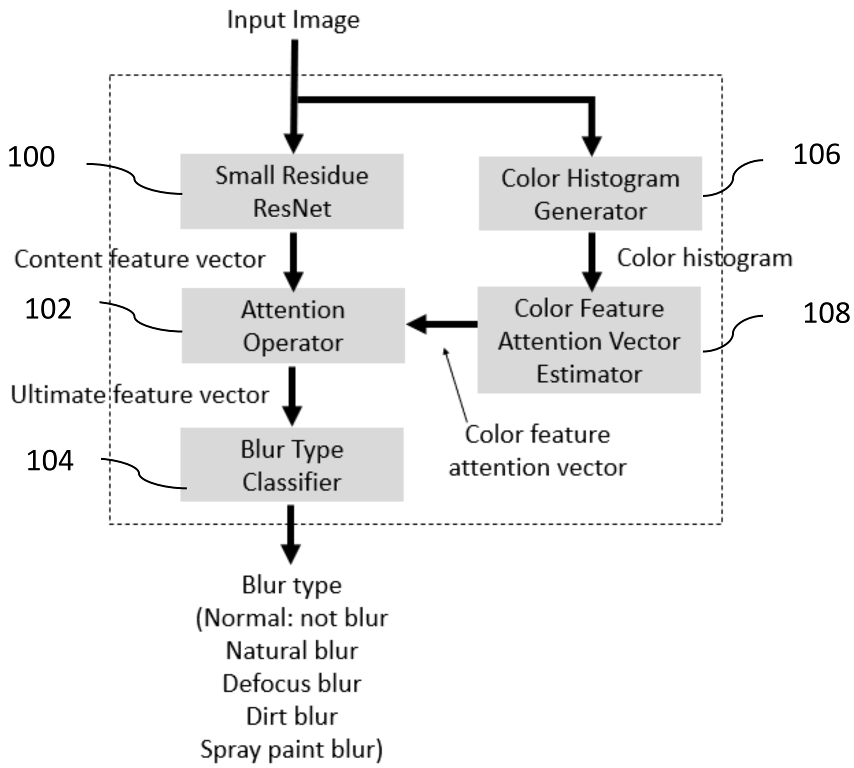

Figure 2

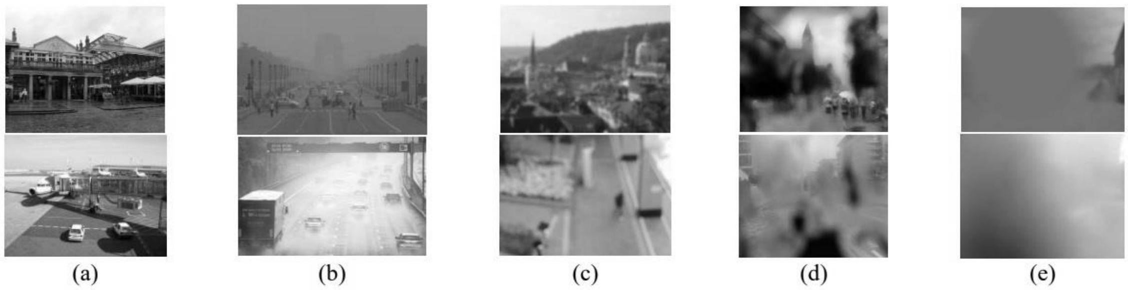

Figure 3

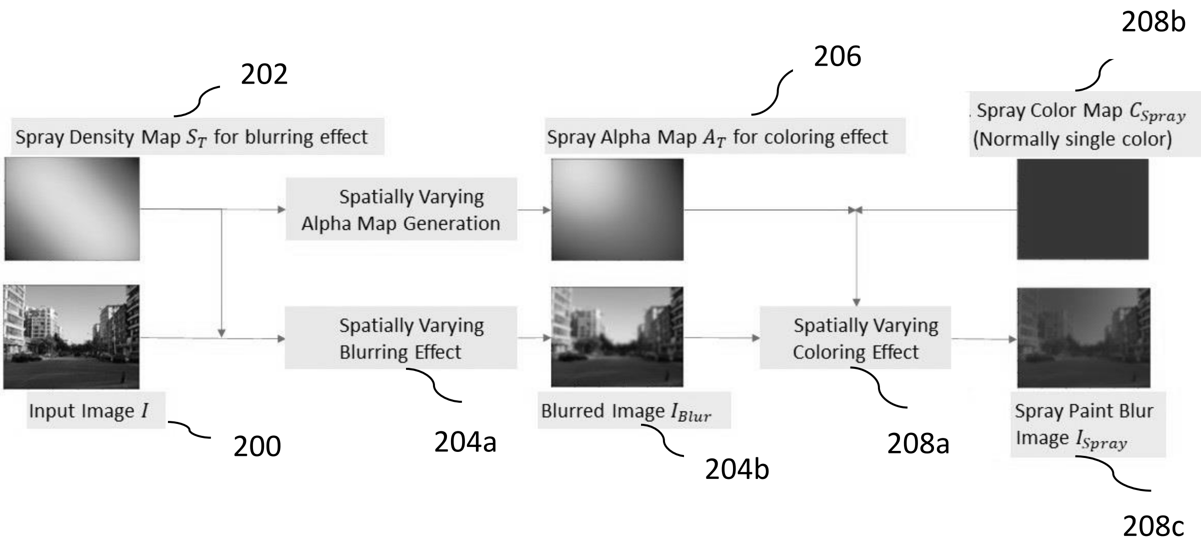

Figure 4