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Safety Helmet Detection

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Abstract-Safety helmet wearing detection is very essential while traveling. We proposed a innovative and practical safety helmet wearing detection method based on image processing and machine learning. At first, the extract background modeling algorithm is exploited to detect motion object under a view of fix surveillant camera in power substation. After obtaining the motion region of interest, the Histogram of Oriented Gradient (HOG) feature is extracted to describe inner human. And then, based on the result of HOG feature extraction, the Support Vector Machine (SVM) is trained to classify pedestrians. Finally, the safety helmet detection will be implemented by color feature recognition. To ensure the safe operation of power equipments, more and more intelligent surveillance systems had been developed based on computer vision or image processing.

Keywords: Vibe; histogram of oriented gradient; support vector machine; color feature recognition

I. INTRODUCTION

Over the past decades, increasing accidents in power substation has raised many attention for safety monitor. In order to ensure the safe operation of power equipments, more and more intelligent surveillance systems had been developed based on computer vision or image processing [1]–[7]. This measure can not only address the problem of labour monitor, but also highlight the unsafe operation to avoid unexpected accidents. Safety helmet wearing detection is a very common and crucial task for surveillance in power substation. Whereas there are few researches for studying this problem by using image processing techniques. Most researches focus on the approach investigating of motorcyclists whether wearing or not safety helmets. Waranusast et al. developed an automatically detect system for motorcycle riders and was able to ascertain whether they are wearing helmets or not. This system extracts the motion objects and trains a K-Nearest-Neighbor (KNN) classifier for detection [8]. Silva et al. exploited the Hough circular transformation to determine the shape of safety helmet and use the extracted Histogram of Oriented Gradients (HOG) features to train a Multi-layer perceptron classifier, which can effectively and simply detect wearing helmet of motorcyclists [9]. In [10], the Kalman filtering and Cam-shift algorithm are used to track pedestrians and determine motion objects.

Meanwhile, the color information of safety helmets is used to detect safety helmets wearing.The objective of this paper is to present a novel and practical safety helmet wearing detection method based on image processing and machine learning in power substation. In order to reduce detection range of surveillance video, the ViBe background modelling algorithm is adopted to segment motion objects in foreground frame. After that, we extract Histogram of Oriented Gradient (HOG) feature of pedestrians in corresponding range and use Support Vector Machine (SVM) to classify the human.

II. LITERATURE REVIEW

Over the past decades, increasing accidents in power substation has raised many attention for safety monitor. In order to ensure the safe operation of power equipments, more and more intelligent surveillance systems had been developed based on computer vision or image processing [1]–[7]. This measure can not only address the problem of labour monitor, but also highlight the unsafe operation to avoid unexpected accidents. Safety helmet wearing detection is a very common and crucial task for surveillance in power substation. Whereas there are few researches for studying this problem by using image processing techniques. Most researches focus on the approach investigating of motorcyclists whether wearing or not safety helmets. Waranusast et al. developed an automatically detect system for motorcycle riders and was able to ascertain whether they are wearing helmets or not. This system extracts the motion objects and trains a K-Nearest-Neighbor (KNN) classifier for detection [8]. Silva et al. exploited the Hough circular transformation to determine the shape of safety helmet and use the extracted Histogram of Oriented Gradients (HOG) features to train a Multi-layer perceptron classifier, which can effectively and simply detect wearing helmet of motorcyclists [9]. In [10], the Kalman filtering and Cam-shift algorithm are used to track pedestrians and determine motion objects. Meanwhile, the color information of safety helmets is used to detect safety helmets wearing.

The objective of this paper is to present a novel and practical safety helmet wearing detection method based on image processing and machine learning in power substation. In order to reduce detection range of surveillance video, the ViBe background modelling algorithm is adopted to segment motion objects in foreground frame. After that, we extract Histogram of Oriented Gradient (HOG) feature of pedestrians in corresponding range and use Support Vector Machine (SVM) to classify the human. Finally, the color feature is exploited to determine whether the human wearing safety helmet or not. Our proposed method includes machine learning like extracting HOG features and training SVM, meanwhile includes image processing like color feature recognition in RGB color space.

[1]

Paper: Computer vision applications in power substations

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Power substations have an important role in the security and quality of supplies in a distribution system and it is necessary to pay particular attention to maintain a good system performance and to prevent the damage of equipment [1]–[3]. Furthermore, engineers in charge of the transmission network need to know not only the real-time status of power equipment but also the security and fire safety of the substation. In order to tackle fire safety and security requirements, the idea of remote vision for substation monitoring has been employed. Engineers and relevant staff are able to see on their remote display monitors the real-time scene of the indoor environment of the substation at different office locations or at home when they are standing by. Eight off-the-shelf CCTV cameras were installed at different locations of a power substation and the video signal from each camera was wired back to a "remote control and multiplexing box". Through this box, the lighting contactors of the eight locations can be controlled to ensure adequate illumination level. Such box is controlled by the on-site PC via the printer port and the video signal of anyone camera can be selected to an image grabber card on a time-multiplexing basis. Communication between the PC and the maintenance centre can be accomplished by Intranet or by a modem in the case of very old substations.

[2]

Paper: Towards automatic power line detection for a UAV surveillance system using pulse coupled neural filter and an improved Hough transform.

Author: Zhengrong LiEmail authorYuee LiuRodney WalkerRoss HaywardJinglan Zhang

Spatial information captured from optical remote sensors on board unmanned aerial vehicles (UAVs) has great potential in automatic surveillance of electrical infrastructure. For an automatic vision-based power line inspection system, detecting power lines from a cluttered background is one of the most important and challenging tasks. In this paper, a novel method is proposed, specifically for power line detection from aerial images. A pulse coupled neural filter is developed to remove background noise and generate an edge map prior to the Hough transform being employed to detect straight lines. An improved Hough transform is used by performing knowledge-based line clustering in Hough space to refine the detection results. The experiment on real image data captured from a UAV platform demonstrates that the proposed approach is effective for automatic power line detection.

[3]

Paper: intelligent detection of electrical equipment faults in the overhead substations based machine vision

Author: Abolfazl Rahmani Engineering Department, Sabzevar Tarbiat Moallem University, Iran

With regard to the development of the power industry and its importance and key role it plays in the development of our country, the problems of this technology should be profoundly investigated. The recent concern for increasing efficiency has made the experts in the field take measures to decrease the fault rate. Considering the wide distribution and spread of distribution networks that makes it difficult to access them, this issue is of much more significance.

[4]

Paper: A computer vision early-warning ice detection system for the Smart Grid

Author: Randy Wacha Manitoba HVDC Research Centre, Canada

Smart Grid" is a broad term used to describe how exchanging data in real time between utility resources and a central management system can enhance the efficiency, reliability and security of a power grid. Smart Grid devices include instrumented meters, thermostats, appliances etc. Other devices that are part of the Smart Grid include utility specific tools such as power line instrumentation, like the Manitoba Hydro Ice Detection System.

[5]

Visual, real-time monitoring system for remote operation of electrical substations.

Author: M. R. Bastos

CTEEP - Transmissão Paulista actually operates 105 substations geographically distributed across São Paulo State. These substations are remotely operated by two Operating Centers - Transmission Operating Center (COT - Centro de Operação da Transmissão), Bom Jardim - SP, and Back-end Operating Center (COR - Centro de Operação Retaguarda), Cabreúva - SP.

III. PROPOSED SYSTEM

Safety helmet wearing detection is a very common and crucial task for surveillance in power substation.Where as there are few researches for studying this problem by using image processing techniques. Most researches focus on the approach investigating of motorcyclists whether wearing or not safety helmets. Waranusast et al. developed an automatically detect system for motorcycle riders and was able to ascertain whether they are wearing helmets or not. This system extracts the motion objects and trains a K-Nearest-Neighbor (KNN) classifier for detection [8]. Silva et al. exploited the Hough circular transformation to determine the shape of safety helmet and use the extracted Histogram of Oriented Gradients (HOG) features to train a Multi-layer perceptron classifier, which can effectively and simply detect wearing helmet of motorcyclists. In power substation, the surveillance camera is installed on the fixed location. So the view of camera is fixed which can make sure that the background cannot change in frames. Consider this characteristic, we choose the ViBe background modelling algorithm. Moreover, this method is fast and effective to determine the motion objects. In order to detect the people in power substation whether wearing or not safety helmet, the second step is that obtaining the human location and image information. Thus, we extract the HOG feature of people and train the SVM classifier for people to classify pedestrian in power substation. When we know the human information in frames, we can utilize the color feature to detect safety helmet wearing situations

IV. SYSTEM ARCHITECTURE

Figure-1 System Architecture

PHASES OF THE SYSTEM

1. Vibe Background Modeling

ViBe algorithm converts moving object segmentation as pixel classification problem. One pixel can be divided into moving foreground pixels or background pixels.

There are n sample values $\{p1, p2, p3, ..., pn\}$ in each sample set $M(x)$. p is the pixel characteristic like gray values. $M(x)$ can be described as:

$M(x) = \{p1, p2, p3, ..., pn\}$. (1)

Generally, ViBe algorithm uses the first frame to initialize the background model. Although each sample set has n sample values, the only certain value for each pixel exists in image. For obtaining the sample value, the neighborhood pixel values of each pixel is randomly parted to sample set.

Assume that $vt(x)$ represents the characteristic value of pixel x in time t, $SR(pt(x))$ is denoted as a circular area with radius R and center $pt(x)$, a threshold Tth is set. As the Eqs. (2) and (3), by calculating the intersection operator of $SR(pt(x))$ and $M(x)$ to obtain the number $NUMc$ of samples with same sample value. If the $NUMc$ is bigger than the Tth, $vt(x)$ will be set as the background pixels, $vt(x)$ will be described as moving foreground instead.

$\{SR(pt(x)) \cap M(x)\} = NUMc$ (2)

$NUMc > T^{th}$, *background pixel*

$NUMc \leq T^{th}$, *foreground pixel*. (3)

The updating strategy of ViBe algorithm is conservative because the model updating needn't pixels detected as foreground in current frame. Each background pixel x can update a sample in sample set$M(x)$ with $1/\Phi$ probability. Furthermore, the neighborhood pixel also can update a sample in sample set $M(x)$ with $1/\Phi$ probability in same time. The probability of a sample both emerge at time $t0$ and $t1$ can be computed as

$p(t_1 - t_0) = e{-}\ln[(n-1)/n]^{(t1-t0)}$ (4)

The use of this update method can improve the accuracy of background pixel estimation.

2. HOG Extraction

The basic idea of HOG is calculating the histogram of oriented gradient in local image area. At first, we need to convert the color image into gray image, and then utilizing Gamma correction to normalize the origin image. Moreover, the edge extractor like Sobel is exploited to compute the gradient components of horizontal and vertical direction ofimage. This step can be written as:

$$Gx(x, y) = H(x + 1, y) - H(x - 1, y) \quad (5)$$

$$Gy(x, y) = H(x, y + 1) - H(x, y - 1) \quad (6)$$

where $H(x, y)$ is pixel value, $G_x(x, y)$ and $G_y(x, y)$ represent gradients at the vertical and horizontal direction of pixel (x, y) respectively. So the gradient magnitude $G(x, y)$ and gradient direction $\alpha(x, y)$ of pixel (x, y) can be denoted as:

$$G(x,y) = \sqrt{G_x(x,y)^2 + G_y(x,y)^2} \quad (7)$$

$$\alpha(x,y) = \tan^{-1}\left(\frac{G_y(x,y)}{G_x(x,y)}\right). \quad (8)$$

Finally, we divide image into a number of cells, calculate the histogram of oriented gradients of each pixel in cells, collect cells into blocks and convert those to a feature vector. After acquiring the feature description of human, we will train a Support Vector Machine (SVM) to solve the binary classification. Suppose that a given training sample set S includes n training samples, which can be written as:

$$S = \{(x_i, y_i)|x_i \in R_d, y_i \in \{-1, 1\}\}_{i=1}^{n} \quad (9)$$

where x_i is the feature vector of training samples, y_i is the label of training samples, $y_i = 1$ and $y_i = -1$ are defined as two types of results. We can train a SVM classifier to find an optimal hyper plane $h(x)$. The hyperplane can achieve large margin of separated discrimination plane. If the data is linear separable, we can define the hyperplane by:

$h(x) = sign(w^T x + b)$ (10)

where w is weight of feature vector and b is the bias. For the pedestrian classification, the data is obvious non-linear seperable. Therefore, we can design a feature transform to map the input vector x into a high dimensional space $\Phi(x)$. By calculating the kernel function $K(x_i,x_j)$, which can be written as $K(x_i, x_j) = \langle\varphi(x_i), \varphi(x_j)\rangle$, we can replace the dot production operation in x space. Here, we select the radial basis function (RBF) kernel function to train SVM. The radial basis kernel function can be represented as

$$K(x_i, x_j) = \exp(-\gamma\|x_i - x_j\|^2) \quad (11)$$

where γ denote the width of the kernel function. According to the given date (x,y), we can compute the SVM decision function as follow:

$$h(x) = sign(\sum_{i}^{N_s} a_i y_i K(s_i, x) + b) \quad (12)$$

where $a_i \geq 0$, the number of support vectors is N_s and the support vector is s_i.

3. Color Feature Recognition

By using pedestrian classification, we can acquire the more accurate human location and image information.This is used for to detect the helmet.by using helmet color helmet will be detected.

CONCLUSION

We have investigated a practical and novel method of safety helmets wearing detection in power substation which can real-time monitor the people whether wearing safety helmet or not. The image processing and machine learning techniques are employed in surveillance system of power substation. Firstly, ViBe background modeling algorithm was used to segment the moving objects under the view of monitoring camera. This trick could filter a lot of static objects. Moveover, the histogram of oriented gradient (HOG) feature extraction and support vector machine (SVM) classifier training were implemented to achieve human location per frame. Finally, we utilized color feature to recognize the safety helmet wearing situations. The overall method are verified by amount of experi ments on the surveillance video of power substation.

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