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A Review on Moving Target Detection Based On Edge Extraction

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ABSTRACT:
Moving target detection is a critical aspect in various fields such as video surveillance, autonomous vehicles, and military applications. This review explores the advancements and challenges in moving target detection with a focus on techniques based on edge extraction. Edge extraction plays a pivotal role in identifying and tracking moving targets by highlighting significant features in the image or video data. The paper begins by providing an overview of the significance of moving target detection in different domains and the role of edge extraction in enhancing the accuracy and efficiency of detection algorithms. Various edge extraction methods are discussed, including traditional techniques such as Sobel, Canny, and Prewitt, as well as more recent advancements like deep learning-based approaches. A comprehensive analysis of the strengths and limitations of different edge extraction methods is presented, considering factors such as computational complexity, robustness in different environmental conditions, and adaptability to real-time applications. The review also addresses the impact of noise, occlusion, and varying illumination conditions on the performance of edge-based moving target detection algorithms. Furthermore, the paper explores the integration of edge extraction techniques with other computer vision and image processing methods to enhance the overall moving target detection performance. It discusses the potential of combining edge information with motion analysis, object recognition, and machine learning algorithms to achieve more reliable and accurate results. The review highlights recent trends and emerging technologies in moving target detection, emphasizing the role of edge extraction in addressing contemporary challenges. Additionally, it identifies gaps in the current literature and suggests avenues for future research, such as the exploration of hybrid approaches and the development of edge-based algorithms suitable for dynamic and complex scenarios.

KEYWORDS: Moving Objects, Canny Edge Detection, Motion Segmentation

I INTRODUCTION

First step in visual surveillance system includes motion detection. Motion detection segments the moving foreground object from the rest image. Successful segmentation of foreground object helps in the subsequent process such as object classification, personal identification, object tracking and activity recognition in the video. Motion segmentation is done mainly with background subtraction, temporal differencing, and optical flow. Out of the three methods, background subtraction is the most popular method for detecting moving regions in an image by taking the absolute difference between the current image and the reference background image. A proper threshold is judiciously selected which segments foreground from the background. Edge detection is the concept for a set of mathematical methods whose aim is to identify the points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. In this paper, an improved canny edge detection algorithm is represented to obtain moving and robust edges. Compared with ordinary Canny method, there are four improvements to reduce computation time and ensure detection accuracy.Firstly,2-D Gaussian filter is decomposed into two independent 1-D filters,i.e.row filter and column filter, which allows calculate image gradient in parallel way. As a result, computation time is reduced highly. Secondly the method uses two thresholds, to detect strong and weak edges, and includes the weak edges in the output only if they are connected to strong edges. detection is a well developed field on its own within image processing Edges typically occur on the boundary between 2 regions[2]. Edge is defined as the boundary pixels that connect two separate regions [3] with changing image amplitude attributes such as different constant luminance and tristimulus values in an image. Edge detection is a well developed field on its own within image processing. Among the several textual properties in an image, edge-based methods focus on the 'high contrast between the text and the background'. The edges of the text boundary are identified and merged, and then several heuristics are used to filter out the non-text regions. Usually, an edge filters (e.g. canny operator) issued for the edge detection, and a smoothing operation. The Canny method finds edges by looking for local maxima of the gradient of I. The gradient is calculated using the derivative of a Gaussian filter [23]. The method uses two thresholds, to detect strong and weak edges, and includes the weak edges in the output only if they are connected to strong edges for x and y direction as shown in figure 2.2 (a), (b) [16].This method is therefore less likely than the others to be fooled by noise, and more likely to detect true weak edges.

The canny edge detection algorithm is easy to implement, and more efficient than other algorithms. From this edge detected images, text region is identified Features can be extracted from the edges of an image which significantly reduce the amount of data to be processed while preserving the important structural properties of an image[1].The example of an original image and image after edge detection are shown in Fig. 1 and Fig. 2 respectively below

II RELATED WORK

First step in visual surveillance system includes motion detection. Motion detection segments the moving foreground object from the rest image. Successful segmentation of foreground object helps in the subsequent process such as object classification, personal identification, object tracking and activity recognition in the video. Motion segmentation is done mainly with background subtraction, temporal differencing, and optical flow. Out of the three methods, background subtraction is the most popular method for detecting moving regions in an image by taking the absolute difference between the current image and the reference background image. A proper threshold is judiciously selected which segments foreground from the background. Edges are a reliable feature of text regardless of colour/intensity, layout, orientations, etc. Edge strength, density and the orientation variance are three distinguishing characteristics of text embedded in images, which can be used as main features for detecting text. Edge-based text extraction algorithm is general-purpose method, which can quickly and effectively localize and extract the text from both document and indoor/ outdoor images.

Wenbo Jing et.al. (2021) while traditional edge detectors concentrate on modifying the shape of the window function, we consider the edge detection problem from a new perspective, and an effective recurrent guidance filter is proposed in this letter. The proposed filter is elaborately designed for edge detection tasks and aims to remove the nonedge information including speckle noise and detailed texture and preserve edge information simultaneously. We first filter the image by the proposed filter and a filtered image is obtained. Then, by using the edge detector with the Gaussian-shaped window, which was previously proposed by us and performing the

post processing method, the edge response is extracted from the filtered image. Both objective and subjective experimental results on simulated and real synthetic aperture radar (SAR) images demonstrate that the edge detector based on the recurrent guidance filter yields better performance than the state-of-the-art edge detectors.
Yang Liu et.al. (2020) Edge detection is one of the most fundamental operations in the field of image analysis and computer vision as a critical pre-processing step for high-level tasks. It is difficult to give a generic threshold that works well on all images as the image contents are totally different. This paper presents an adaptive, robust and effective edge detector for real-time applications. According to the 2D entropy, the images can be clarified into three groups, each attached with a reference percentage value based on the edge proportion statistics. Compared with the attached points along the gradient direction, anchor points were extracted with high probability to be edge pixels. Taking the segment direction into account, these points were then jointed into different edge segments, each of which was a clean, contiguous, 1-pixel wide chain of pixels. Experimental results indicate that the proposed edge detector outperforms the traditional edge following methods in terms of detection accuracy. Besides, the detection results can be used as the input information for post-processing applications in real-time.
Giha Yoon et.al. (2021) in the last decade, deep neural network (DNN)-based object detection technologies have received significant attention as a promising solution to implement a variety of image understanding and video analysis applications on mobile edge devices. However, the execution of computationally intensive DNN-based object detection workloads in mobile edge devices is insufficient in fulfilling the object detection requirements with high accuracy and low latency, owing to the limited computation capacity. In this paper, we implement and evaluate a DNN-based object detection offloading framework to improve the object detection performance of mobile edge devices by offloading computation-intensive workloads to a remote edge server. However, preliminary experimental results have shown that offloading all object detection workloads of mobile edge devices may lead to worse performance than executing the workloads locally. This degradation is obtained from the inefficient resource utilization in the edge computing architectures, both for the edge server and mobile edge devices. To resolve the aforementioned problem with degradation, we devise a device-aware DNN offloading decision algorithm that is aimed to maximize resource utilization in the edge computing architecture. The proposed algorithm decides whether or not to offload the object detection workloads of edge devices by considering their computing power and network bandwidth, and therefore maximizing their average object detection processing frames per second. Through various experiments conducted in a real-life wireless local area network (WLAN) environment, we verified the effectiveness of the proposed DNN-based object detection offloading framework.
Ahmed H. Abdel-Gawad et.al. (2020) Genetic algorithms (GAs) are intended to look for the optimum solution by eliminating the gene strings with the worst fitness. Hence, this paper proposes an optimized edge detection technique based on a genetic algorithm. A training dataset that consists of simple images and their corresponding optimal edge features is employed to obtain the optimum filter coefficients along with the optimum thresholding algorithm. Qualitative and quantitative performance analyses are investigated based on several well-known metrics. The performance of the proposed genetic algorithm-based cost minimization technique is compared to the classical edge detection techniques, fractional-order edge detection filters, and threshold-optimized fractional-order filters. As an application for the proposed algorithm, a strategy to detect the edges of the brain tumour from a patient's MR scan image of the brain is proposed. First, Balance Contrast Enhancement Technique (BCET) is applied to improve the image features to provide better characteristics of medical images. Then the proposed GA edge detection method is employed, with the appropriate training dataset, to detect the fine edges. A comparative analysis is performed on the number of MR scan images as well. The study indicates that the proposed GA edge detection method performs well compared to both classical and fractional-order edge detection methods.

Longxin Zhang et.al. (2023) the current train image fault detection model does not consider detection accuracy and speed, and its parameters and calculation amount are large. Consequently, the model cannot easily satisfy the requirements of the actual edge computing scenario. Therefore, this study proposes a lightweight train image fault detection network (FDNet) under an edge computing environment. FDNet makes three improvements based on YOLOX. First, FDNet designs dual-path enhanced channel attention (DECA) module and fuses the path aggregation network (PAN) to form a DECA-PAN module to suppress background interference, highlight the object, and improve the feature fusion ability of the model. Second, focal loss and alpha-complete intersection over union (Alpha-CIoU) loss are used to optimize the loss function to alleviate the problem of small image samples and uneven fault categories. Third, the receptive field fusion block is added to the FDNet detection head, and three groups of detection heads are devised to detect objects at different scales to improve the detection ability of the model on multistage objects. Experimental results on the train image fault dataset demonstrate that the mean average precision (mAP) and speed of FDNet reach 94.82% and 103.4 frames per second (FPS), respectively, whereas its parameters and floating-point operations are less than one-sixth those of the well-known YOLOv4. The experimental results of FDNet, YOLOv5-s, YOLOX-s, YOLOv6-T, and YOLOv7-tiny in the public dataset COCO2017 show that FDNet achieves the highest mAP of 60.60% while maintaining a high detection speed among all lightweight models. The noise and illumination robustness tests show that FDNet has good anti-interference ability.

Table 1 summarizing the pros and cons of different edge detection techniques:

Edge Detection Technique	**Pros**	**Cons**
Sobel Operator	- Simple and computationally efficient.	- Sensitive to noise.
	- Effective for detecting vertical or	- May produce thick edges.
	Horizontal edges.	
Prewitt Operator	- Similar to Sobel but with a slightly	- Sensitive to noise.
	Different convolution kernel.	- May produce thick edges.
	- Simple implementation.	
Canny Edge Detector	- Low error rate: well-defined edges.	- Computationally more complex.
	- Localization: accurate edge locations.	- Requires careful parameter tuning.
	- Suppresses noise by smoothing.	
Laplacian of Gaussian (LoG)	- Good at detecting edges with varying widths.	- Sensitive to noise.
	- Smoothens the image before edge detection.	- Requires careful parameter tuning.
Marr-Hildreth (Zero Crossing)	- Good for detecting step edges.	- Sensitive to noise.
	- Provides accurate edge localization.	- Computationally more complex.

Kirsch Operator	- Multiple convolution masks for different orientations.	- May produce thick edges.
	- Can detect edges at different angles.	- Sensitive to noise.

Table 2 table summarizing different edge detection techniques along with their limitations and applications

Edge Detection Technique	Limitations	Applications
Sobel Operator	Sensitive to noise, may miss thin edges	General-purpose edge detection, real-time processing
Prewitt Operator	Sensitive to noise, may lose weak edges	Image analysis, computer vision
Canny Edge Detector	Computationally intensive, sensitive to parameters	Feature extraction, object recognition
Robert Operator	Less robust to noise,limited edge detection	Simple edge detection, real-time applications
Laplacian of Gaussian (LoG)	Sensitive to noise, computationally expensive	Fine detail extraction, medical imaging
Zero Crossing Detector	Sensitive to noise, requires precise parameter tuning	Object recognition, image segmentation
Marr-Hildreth (LoG with thresholding)	Sensitive to noise, computationally expensive	Edge localization, texture analysis
Frei-Chen Operator	Sensitive to noise, complex computation	Image processing, pattern recognition
Kirsch Operator	Sensitive to noise, limited to specific orientations	Medical imaging, shape analysis
Morphological Edge Detection	Sensitive to noise may not detect fine details	Object recognition, image segmentation

III CONCLUSION

In conclusion, the reviewed research works collectively underscore the pivotal role of motion detection and edge extraction in advancing visual surveillance systems. Motion detection serves as the foundational step for segmenting moving foreground objects, facilitating subsequent processes like object classification, tracking, and activity recognition in video streams. The predominant method of background subtraction, alongside temporal differencing and optical flow, plays a crucial role in this initial stage. Edge-based algorithms emerged as a common thread across the cited works, emphasizing their effectiveness in enhancing the precision of motion detection and subsequent tasks. These algorithms, focusing on characteristics such as edge strength, density, and orientation variance, provide a reliable means of extracting meaningful features from images, applicable to diverse scenarios.

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