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AN ADAPTIVE MORPHOLOGICAL FILTER FOR MOVING OBJECT SEGMENTATION

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ABSTRACT

This work presents a system that combined well-known morphological filters in order to find true moving regions from a sequence of images. For localizing the changed region, a block-based change segmentation process is proposed. This change region is naturally a coarse region and also contains some holes. To compensate this, we used an edge-based dilation to get an anisotropic expansion of the coarse image. Then the segmentation is generated using watershed algorithm. To prevent over segmentation, we used a specially weighted gradient image to achieve segmentation. Also, we removed some local minima from that gradient image. Finally, a fusion is applied on morphological filters. Furthermore, we calculated the coverage ratio of edge pixels of each segmented region. Comparing with a converge threshold, we determined whether the segmented region is truly belongs to a moving region or not. In the end, the experimental result demonstrated the validity of our proposed method.

Keywords: *Moving Objects, Morphological Filter, Erosion, Dilation, Edge Detection, Watershed Segmentation*

1. INTRODUCTION

In naturalistic scenarios, the segmentation of regions/objects plays a fascinating role in now a days' research. Because most of the images were taken in dynamic applications like healthcare, in which some objects need to be segmented such as tumor in brain MR or CT images. Similarly, some other imperative domains such as video scrutiny, inaccessible distinguishing, medical analysis etc. Many researchers have been proposed to segment objects in such ambiguous. For such purpose, a well-known optical flow-based method [1] has been proposed to detect autonomously moving objects in the presence of camera motion. Comparatively, they achieved better detection rates. However, computational wise, most of optical flow-based methods are much expensive [2]. Moreover, these methods may not employ in real world for full-frame video streaming without particular hardware [2].

The authors of [7] proposed a method in order to detect and track a moving object from the video. They utilized saliency map model for detecting the moving object, while, for tracking, they employed Kalman filter and claimed better accuracy. However, the salient object is not preserved when utilizing large blocks [8]. Moreover, most of the salient-based method are heuristics due to which it degrades their performances in real time detection [8]. The authors of [9] detected different objects in complex scenarios using sparse robust principal component analysis, and claimed better accuracy rate. However, this method produces too many nonzero coefficients due to which it is not acceptable for such applications having high dimensional [10]. Similarly, some background subtraction methods [12–14] have been proposed based on Gaussian mixture model to detect the moving objects; however, their accuracy degraded against complex background scenarios [13].

Furthermore, an integrated method has been proposed for detecting moving objects in dynamic environments that is the integration of deep neural network (for prediction) and optical flow (for getting contextual information) [15]. They achieved better accuracy; however, this work independently tracks the objects that ignore the interactions among

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the objects because they estimate the contextual information and data integration for a single object at one time [16]. The authors of [17] utilized deep learning in order to detect the moving objects in naturalistic application, and claimed higher accuracy in real time. However, deep learning is very much complex and might not be applicable in real time and complex scenarios. In one of the recent studies [18], the authors proposed a fast method for object detection that was based on Caffe method and convolution neural network and they tested their method in real time scenario. However, convolution neural network completely depends on the initial parameter tuning in order to avoid the local optima due to which it requires initialization according to the problem in hand. So, for such purpose it requires expert domain knowledge [19]. A robust method based on binary scene modeling was proposed by [20] in order to detect the moving objects. In this work, a weighted auto encoder was considered that was based on deep learning scheme which further adaptively generate a vigorous feature depiction. Nevertheless, binary scene prototype seizures the spatio-temporal division circulation evidence in the Hamming planetary, that guarantees the high efficacy of objects detection in dynamic scenarios [21].

Therefore, in this study, we designed a system that combined temporal information as well as spatial information to find true moving regions from a sequence of images. For localizing the changed region, a block-based change segmentation process is proposed. This change region is naturally a coarse region and also contains some holes. To compensate this, we used an edge-based dilation to get an anisotropic expansion of the coarse image. The spatial segmentation is generated using watershed algorithm. To prevent over segmentation, we used a specially weighted gradient image to achieve segmentation. Also, we removed some local minima from that gradient image. Finally, a fusion is applied on temporal information and spatial information. For this, we calculated the coverage ratio of edge pixels of each segmented region. Comparing with a converge threshold, we determined whether the segmented region is truly belongs to a moving region or not.

We already described some related works about the moving object segmentation. The remaining article is ordered as follows: Section 2 describes the proposed algorithm. The implementation environment has been presented in Section 3. Furthermore, Section 4 presents results. Finally, the article has been concluded with some future directions.

2. PROPOSED METHOD

In this study, we selected a series of images having identical scenario and the images were taken in various times under diverse environmental factors. Then every method is utilized individually that are described as below.

2.1 Edge-based Object Segmentation

Edge detection is one of the robust methods that is employed to decrease the total volume data and diminish the unwanted details by employing an interacting window that move from left to right pixel by pixel due to which the edges of the entire image have been determined. There are two approaches that are commonly utilized for the identification of the edges. The first one is called Gradient method, which distinguishes the edges through seeing the extreme and least values within the entire image after employing the first derivative. There are some well-known filters such as Sobel, Prewitt, Canny, Robert, Cross, and Smoothing that might be used in this method in order to robustly perform such task. On the other hand, the second method is called Laplacian technique that finds for zero crossings in the whole image after employing the second derivative in order to get the edges through Marr-Hildreth mask.

In this method, the color images have been converted to grey scale images to get the robust performance. After getting grey scale image, a 3×3 interacting window has been utilized in order decrease the total volume data. For instance, '*I*' is a grey scaled image and '*W*' is an interacting window that finds the edges of the entire image (as represented in Figure 1).

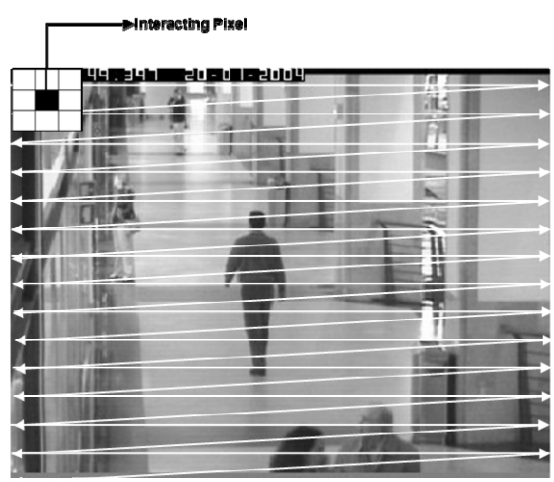

Figure 1: Image scanning

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The middle pixel of this window interacts with every pixel in order to get edges from the corresponding image. After getting the edges from the image, another technique named raster scanning has been utilized to link and combine the points of the edges in the form of pair coordinates. In which, an edge intersection is met till at the end of finished and a new list is created for the entire branches. Mathematical it is modelled as

$$I \square W = I - (I * W)$$
$$= I \cap (I * W)^c$$
$$\{W\} = \{W^1, W^2, W^3, \ldots\ldots W^n\} \quad (1)$$
$$I \square \{W\} = (((I \square W^1) \square W^2) \square \ldots\ldots\ldots \square W^n)$$

2.2 Erosion-based Object Segmentation

Generally, erosion is utilized for diminishing the unwanted or hidden details from grey scale images to binary images, which means the color images have been converted to grey scale and then to binary images to get the robust performance. The corresponding image has been divided into two categories through image segmentation module i.e., object and background. The binary image I of the object category is eroded via an interacting element. In order to do this, an interacting element (window for erosion) having size 3×3. The middle pixel of this window interacts with every pixel in order to get edges from the corresponding image. So, by this way we can remove the unwanted details, which is described as below.

$$I \ominus W = \{z | (W)_z \cap I^c \neq \phi\} \quad (2)$$

Equation (2) represents the erosion of I by W that is the set of the entire corresponding pixels z such that W transformed by z that is attained in resultant A. Generally, set W is stated as the interacting element coupled with other morphological processes. Erosion has been indicated by well-known function as shown in eq. (3).

$$W = inter\ (element, factor) \quad (3)$$

where '*inter*' is a morphological interacting element. The '*element*' is used for which the shape is 'diamond' and '*factor*' is 'eye (7)' that is employed to connect the interacting element with pixels.

2.3 Dilation-based Object Segmentation

Dilation is one of the well-known morphological filters that can be utilized for the purpose of diminishing the unwanted or hidden details from grey scale images to binary images, which means the color images have been converted to grey scale and then to binary images to get the robust performance. Furthermore, dilation enriches the size of the object that is gained by the amalgamation of numerous objects. In this operation, the corresponding image is prolonged to binary image first. Then an interacting element (window) has been utilized to complete lattices, which further might be employed for enlarging the outlies confined in the initial image. Based on multiple experiments, the size of the interacting element (window) has been selected from various sizes such as 3×3, 5×5, 7×7, and 9×9. The odd number of rows and columns are selected for the interacting window because throughout the dilation procedure, only the center pixel is connecting with every pixel of the entire image. The attentive pixels based one the locality is considered by the interacting window in the dilation procedure, which applied the suitable scheme to the entire pixels in the locality and allotted a value to the conforming point in the resultant image. Similarly, in the dilation procedure, the interacting window is moved on the conforming image, in which the window performs matching like if the pixels' value of the background is exactly matched with that of the center pixel of the window, then the pixel value of the resultant image at the same position will becomes 1, otherwise 0. This process enlarges the image. This matching will be repeated for the entire pixels of the image. The method is utilized the following interacting window for enlarging.

$$\begin{pmatrix} \textbf{True} & \textbf{False} & \textbf{True} \\ \textbf{False} & \textbf{False} & \textbf{False} \\ \textbf{True} & \textbf{False} & \textbf{True} \end{pmatrix}$$

2.4 Watershed-based Object Segmentation

Segmentation is the procedure of separating a corresponding image into various areas (i.e., groups of pixels). The main purpose of segmentation is to make simpler and make changes in the representation of the corresponding image into somewhat which is much meaningful and calmer to examine. Generally, the method of segmentation is utilized in order to discover objects and boundaries in the corresponding images such as

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lines and curves. We applied segmentation with the purpose that we will check each individual segment with the information of temporal mask and conclude whether this segmentation is a true moving region or not. To do segmentation we apply watershed segmentation – a very popular and robust segmentation algorithm.

On the other hand, the watershed method is an allegory that is based on the comportment of water in a landscape. It means that when there is a rain the water drops are falling on various areas and then direct the landscape plain sailing. The water runs out at the bottommost of valleys, which further might not be considered the depth of the corresponding meres in the basins. There will be a specific area for every region from where the entire water will controlled and collected. In simple words, there will be every region is connected with a collector (basin) and every point of the landscape is associated exactly one identical basin. Segmentation using traditional watershed segmentation may generate an over segmented image. So, to minimize the over segmentation problem, we eliminate some local minima of the gradient image.

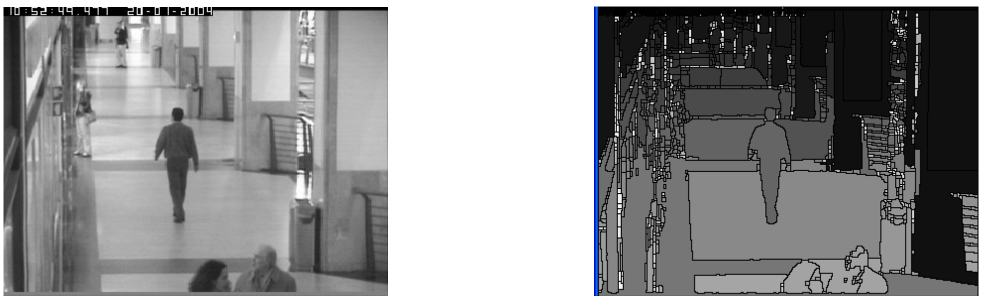
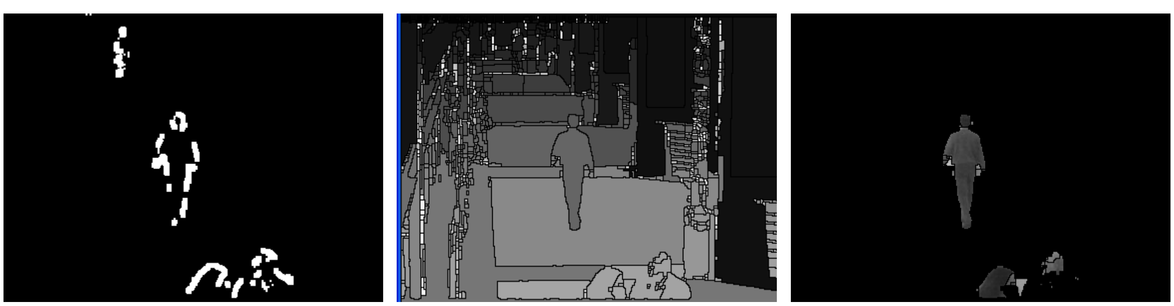


Figure 2: Illustration of watershed segmentation on weighted gradient image.

2.5 Integration of Morphological Filters

The objective of this section is to combine all of the filter to generate a fused filter that has the capability to robustly segment an object in complex images. The purpose is to detect the group of points which are expressively different amongst the resultant image of the series and the preceding images and these points include the corresponding window change. The window change might be the outcome of the integration of fundamental parameters as well as the objects presence or absence, objects movement against the background, or changes in the objects shape. Furthermore, stable objects might suffer modifications in color or contrast. The main concern is that the change in window should not comprise insignificant or annoyance arrangements of change like those encouraged through movement of the camera, sensor noise, illumination distinction, or distinctive fascination. The concepts of suggestively diverse and insignificant fluctuate through application. Assessing the window change is often the initial stage in the direction of the more determined objectives of change empathetic: segmenting and recognizing changes through semantic type that commonly involves implements personalized to a specific application. Applying all these procedures we finally get the moving objects.



Erosion coupled with Dilation | Watershed Result | Resultant Moving Objects

Figure 3. Sample detection result of the entire methodology.

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3. IMPLEMENTATION ENVIRONMENT

The proposed method for detection moving regions from a sequence of images is implementd using MTES image processing develeopment tools with Microsoft Visual C++ 6.0 programming language. There are seven user defined functions, two MTES builin functions, add operator and loop are used to develop the system.

The MTES workspace contains the following function module:

- MTES built in Read Image function
- MTES built in Write Image function
- MTES built in iRGBToUint8 function
- User defined GenarateFileName Module
- User defined BlockBasedMotionDetection Module
- User defined EdgeBasedDialation Module
- User defined CannyEdgeExtraction Module
- User defined Gradient Module
- User defined ThresholdOnGradient Module
- User defined VincentInt16 Module
- User defined SegmentWiseFillInt Module
- User defined ShowOriginalObject Module

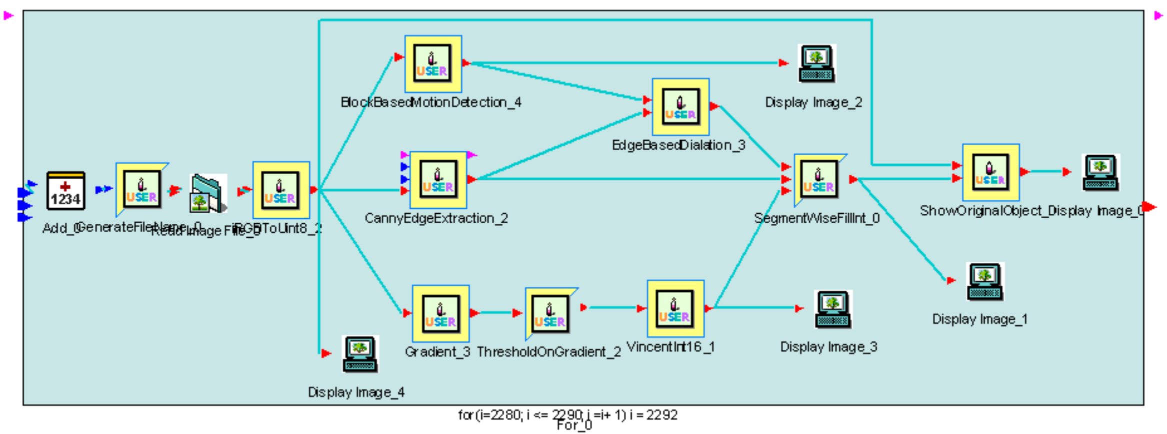

Figure 4. MTES Workspace for the proposed methodology

4. EXPERIMENTAL RESULTS

The developed algorithm is tested and validated against different situations in various situations. These test cases fall under either outdoor or indoor environments. All the data is collected from some standard image change detection databases. We use four sequences of images taken from three databases to test the performance and performance reliability of our method. These databases are presented as below.

4.1 CAVIAR Database

We take two image sequences from CAVIAR Database [4]. In this sequence, a person is walking through by a straight line and return in an indoor room where a lot of external daylight comes and reflected through the glasses. In another sequence, a couple is moving along with looking, persons moving inside and coming out of supplies.

4.2 PETS Database

PETS 2007 database [5] contains a sequence of images at an airport luggage collection rail. Some peoples are stationary at that location and some other passengers are walking by in the scene.

PETS 2001 database [6] contains a sequence of images at road adjacent by a parking lot. There are some cars which are parked. Cars are passing through the road while some are newly parked at the parking lot. At the same time some pedestrian also passed through the scene.

In all of these four image sequences, the moving objects covered a small portion compared to total image area. Moving object detection method can lead to poor result when moving regions covers a large area of the current frame. To Test this scenario, we collect an image sequence generate in ubiquitous computing lab, Kyung Hee university. In this image sequences almost half of the image area is moving region.

This all image sequences are tested with our developed system. The system is developed using MTES – an image processing tool with the Microsoft Visual C++ 6.0 programming tool. The system is tested on a Pentium 4 CPU with 2.4 GHz processor speed. The system memory was one gigabyte.

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The test result of all five-image sequence is shown in Figure 5. For simplicity we show one image from every sequence of images.

CAVIAR 1 (Frame No 390)

CAVIAR 2 (Frame No 2280)

PETS 2007 (Frame No 390)

PETS 2001 (Frame No 600)

Captured Image

Image Sequence Description | Current Frame | Detected Moving Region

Figure 5. Detected Moving Region using several image sequences.

5. CONCLUSION

In this study, we proposed moving object segmentation process by fusing spatial information and temporal information together. A combined morphological algorithm such as erosion coupled with dilation is utilized to diminish the unwanted information from the grey scaled and binary images respectively. In erosion, the corresponding image has been divided into two categories through image segmentation module i.e., object and background. The binary image *I* of the object category is eroded via an interacting element. In order to do this, an interacting element (window for erosion) having size 3×3. The middle pixel of this window interacts with every pixel in order to get edges from the corresponding image. Similarly, dilation enriches the size of the object that is gained by the amalgamation of numerous objects. In this operation, the interacting window is moved on the conforming image, in which the window performs matching like if the pixels' value of the background is exactly matched with that of the center pixel of the window, then the pixel value of the resultant image at the same position will becomes 1, otherwise 0. This process enlarges the image. This matching will be repeated for the entire pixels of the image. Then the segmentation is generated using watershed algorithm. To prevent over segmentation, we used a specially weighted gradient image to achieve segmentation. Also, we removed some local minima from that gradient image. Finally, a fusion is applied on morphological filters. Furthermore, we calculated the coverage ratio of edge pixels of each segmented region. Comparing with a converge threshold, we determined whether the segmented region is truly belongs to a moving region or not. In the end, the experimental result demonstrated the validity of our proposed method against the existing techniques.

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