Analysis and Optimization of Computer Trajectory Based on Compound Eye Vision System

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Abstract. With the rapid development of science and technology, people have higher and higher requirements for target detection technology, which requires us to solve the disadvantages of traditional cameras, such as the difficulty of panoramic photography and continuous tracking motion. However, compound eye insects have a visual system composed of fewer neurons, which can achieve rapid detection and capture of objects of interest. Therefore, based on the principle of compound eye vision, a bionic compound eye panoramic detection system is designed in this paper, which can realize panoramic real-time detection through multiple sub eye cameras. Through the compound eye vision system, we can accurately locate the pan tilt controller, which can provide a comprehensive panoramic motion image. Through the principle of automatic windowing, we can acquire the image of moving area by multi-layer window. Then, through the relevant image processing methods, such as binarization, median filtering, spatial filtering, moving object detection, edge detection and other methods, we can get a relatively clear moving object contour and trajectory analysis, which can achieve full field of view, high sensitivity detection and tracking.

Keywords: Compound Eye Vision System, Computer, Trajectory Analysis

1. Introduction
With the rapid development of society, people have higher requirements for target detection and image acquisition. Panoramic 360° uninterrupted monitoring has become the requirement of many fields, which requires us to continuously improve camera technology\textsuperscript{[1]}. At the same time, moving object detection is an important part of computer vision, which is a method to extract the moving object from the image sequence. Therefore, the accuracy and speed of target detection is particularly important\textsuperscript{[2]}.

With the rapid development of bionic technology, compound eye vision theory has become the main research direction. Compound eye insects have a visual system composed of fewer neurons, which can quickly discover and capture objects of interest. In 1956, Reichardt and hanssentein found that the retinal ganglion cells of insects have a unique function of detecting light movement, which proposed a motion perception model based on optokinetic response, such as EMD model\textsuperscript{[3]}. Through the basic detector, we can measure the local motion signal, which will directly integrate and calculate the motion characteristics in different spaces. Through the detector principle, compound eye organisms can quickly identify and detect the object and motion information in the environment.
However, when the real image sequence is captured, the slight change of detector position will seriously affect the position change, which increases the difficulty of target detection. Based on the dual perspective, this paper can process the moving object detection, which will improve the accuracy and clarity of the image, through binarization, median filtering, spatial filtering, moving object detection, region reconstruction, noise reduction and so on. Based on the physiological characteristics of insect compound eye, this paper proposes a moving object detection algorithm based on the principle of compound eye, which can realize the rapid detection of moving objects.

2. Working principle of bionic compound eye vision system

2.1. Types of compound eyes

The types of compound eyes can be classified into overlap and juxtaposition, among which overlap can be classified into refraction, reflection and reflection overlap. The juxtaposed artificial compound eye is an independent imaging method for each sub eye. Finally, by pooling them into the nerves, organisms can integrate and judge changes in external motion and light intensity. The type of overlap is based on the fact that the overlap occurs in the receiving region, which is the integration of neurons. This paper lists the schematic diagrams of several kinds of compound eyes, as shown in Figure 1.

![Figure 1. Types of compound eyes.](image)

2.2. Physiological structure of compound eye

The surface of compound eye mainly has a layer of transparent cuticle, which can be divided into diopter, photoreceptor and optical isolator physiologically. In this paper, the physiological function of compound eye is simulated by optical lens, CCD detector and aperture diaphragm. At the same time, the compound eye has many sub eye structures, which can be simulated by multiple cameras. A refractor is a crystal structure used to bend light, which focuses light at the focus. The photoreceptor is made up of the retina and nerve fibers, which receive images of objects passing through the diopter. At the same time, through the conversion of photoelectric signals, nerve fibers can transmit electrical signals to the nerve center. Through CCD and video transmission cable, we can simulate the function of omentum and nerve fiber. The light barrier is composed of some pigment cells, which control the luminous flux according to the environmental changes, which can prevent the interference of light between adjacent eyes.

2.3. Fundamentals of visual system of compound eye

According to the theory of compound eye localization biological structure, the omentum under the microphthalmos cone is arranged according to a certain structure, which extends a nerve fiber through the basement membrane respectively. The sensory rods formed by the small omental cells are not fused with each other and arranged asymmetrically. The optical axes of these rods from the distal end to the proximal end do not coincide, which will form different directional sensitivity. According to
the visual information of each eyelet, we can treat it as a neural processing system, which can judge the position and speed of the object according to the strength of the information to perform different movements, as shown in Figure 2.

3. Principle of compound eye vision system

3.1. Local motion detector

In the 1940s, Werner Reichardt began to study insect movement detection. Werner Reichardt proposed a basic motion detector (EMD) based on Drosophila, which is also called Reichardt correlation detector. Through the integration calculation of EMD model, we can get the target information, as shown in Figure 3. The principle of the simplified model of EMD is as follows. The space interval between A and B channels is $\Delta$. If the target moves from A to B, the signal from channel A is multiplied by the signal from B after delay unit D, which will produce a positive output. However, the signal from B is multiplied by the signal from A after passing through the delay unit D, which can produce a negative output. Then the total output $y$ of the whole motion detector can be obtained by adding the two groups of signal outputs. When the motion speed matches the delay time, the output of EMD model is maximum.

3.2. Integrated local motion information recognition
By studying the large motor sensitive neurons in the brain of the green headed fly, the compound eye can collect local clues from a specific subset of EMD. By weighted processing, compound eye animals can recognize movement patterns, which define the location of the sensory field and the directional tuning of neurons. By combining the electrical inputs of multiple dendrites, the local fluctuations cancel each other, and finally, we can get a smooth and reliable output signal. For example, with the EMD array, we can project the signal input onto the leaflet, which will form an ordered spatial mapping of the field of view, as shown in Figure 4.

Figure 4. Integrated local motion information recognition.

4. Moving object detection algorithm

4.1. Optical flow method
Optical flow method gives each pixel a velocity vector, which will form a motion field of the image. According to the characteristics of the velocity vector of each pixel, we can analyze the image dynamically. There is no motion in the optical flow method. On the contrary, the target velocity vector is different from the background velocity vector, which can detect the moving target. The main problem of optical flow method is the poor real-time performance of most algorithms. The advantage is that it can simultaneously carry motion information and scene 3D structure information, which can detect moving objects without scene information.

4.2. Inter frame difference method
When the target moves in the scene, there will be obvious differences between frames. Through the absolute value of the brightness difference between the two frames, we can determine the moving target. The algorithm of inter frame difference method is relatively simple, which is not sensitive to the scene changes such as light. However, the inter frame difference method can only get the edge part, which is not a complete target. If the time interval is not selected properly, we may not be able to achieve target detection.

4.3. Background difference method
Background subtraction method detects moving objects by calculating the difference between the current frame of image sequence and background reference model, and the key is to obtain the background. Background difference method is more accurate and faster. However, in fact, it is difficult to get the static state background directly, which needs to estimate and recover the background through the inter frame information of the video sequence. Therefore, background difference method should be selective in updating background.

4.4. Moving object detection technology based on compound eye
In this paper, a fast moving object detection method based on the principle of insect compound eye is designed, which can divide the video image into regular hexagons. Through the similarity detection of adjacent frames and adjacent regions, we can get the algorithm flow chart, as shown in Figure 5.
5. Motion detection results
In different scenes, the moving target detection is not the same. Based on the background modeling method, we can extract the foreground results with pixel level accuracy. In this paper, Gaussian mixture model (GMM), general background clipping (vibe), pixel based adaptive segmentation (pbas) and compound eye vision system algorithm are analyzed respectively. The analysis results are shown in Table 1.

Table 1. The average performance of the algorithm is compared.

| No. | Method       | Recall   | Accuracy | F-measure |
|-----|--------------|----------|----------|-----------|
| 1   | GMM          | 81.26%   | 78.86%   | 0.8004    |
| 2   | Vibe         | 76.51%   | 86.53%   | 0.8121    |
| 3   | PBAS         | 80.79%   | 81.28%   | 0.8103    |
| 4   | Compound vision | 80.35% | 88.06%   | 0.8402    |

6. Conclusion
From the experimental results, we can see that the recall rate of compound eye vision system algorithm is average, and the precision and F-measure are ideal. Based on the physiological characteristics of insect compound eye, this paper proposes a moving object detection algorithm based on the principle of compound eye, which can realize the rapid detection of moving objects.

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