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A Contour Detection And Background Subtraction Method For Extracting Moving Objects From Videos

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Abstract: The accurate extraction of moving objects from video sequences remains a critical challenge in computer vision, particularly for applications such as video surveillance, traffic monitoring, and human activity recognition. Traditional background subtraction techniques often falter in complex environments, while edge-based approaches lack semantic context. This paper introduces a hybrid framework integrating adaptive background subtraction with contour detection to enhance accuracy and robustness. Evaluated across benchmark datasets (PETS2009, CDnet2014) and a custom surveillance set, our method demonstrates superior performance in precision, recall, and computational efficiency compared to baseline techniques. Results indicate this approach is highly suitable for real-time object detection in resource-constrained environments.

Index Terms—Contour Detection, Background Subtraction, Video Processing, Moving Object Detection, GMM, Canny Edge Detection, Real-Time Surveillance.

I. INTRODUCTION

Video surveillance systems require accurate and efficient detection of moving objects. Traditional background subtraction methods like Gaussian Mixture Models (GMM) are limited under dynamic backgrounds. Edge-based techniques such as Canny edge detection identify object boundaries but suffer from lack of contextual filtering.

This research proposes a hybrid model leveraging the strengths of both methods. The core question is whether integrating edge detection with adaptive GMM can enhance accuracy and real-time performance in fixed-camera surveillance footage.

II. METHODOLOGY

A. Research Design

An experimental research design was adopted. The process involved background modeling, contour detection, mask integration, and performance evaluation on three datasets.

B. Data Collection

Datasets used:

- PETS2009
- CDnet2014
- Custom surveillance dataset (50 one-minute 1080p sequences)

C. Background Subtraction

GMM (Zivkovic's method) with:

- 5 Gaussians
- Adaptive learning rate (init. 0.01)
- Shadow detection: 0.5 threshold

D. Contour Detection

Using the Canny algorithm:

- Noise reduction (Gaussian filter)
- Gradient computation (Sobel)
- Non-maximum suppression
- Hysteresis thresholding
- Morphological ops: Dilation, erosion
- Douglas-Peucker algorithm for contour simplification

E. Integration Mechanism

Combines GMM masks with contour overlap. Filters out noisy regions with low contour density.

F. Reliability and Validity

- K-fold cross-validation (k=5)
- Evaluation metrics: IoU, F1-score, precision, recall
- Benchmarked against ground-truth annotations
- Runtime analysis on Intel i7, 16GB RAM

III. RESULTS

A. Quantitative Analysis

Table I. Performance Comparison

Dataset	Method	Precision	Recall	F1-Score	IoU	Time/Frame (ms)
PETS2009	Proposed	0.91	0.87	0.89	0.81	32
	GMM-only	0.85	0.82	0.83	0.75	25
	Edge-only	0.78	0.64	0.70	0.61	28
CDnet2014	Proposed	0.88	0.85	0.86	0.78	35
	GMM-only	0.81	0.79	0.80	0.70	29
Custom Set	Proposed	0.93	0.89	0.91	0.84	30

B. Visual Analysis

- GMM masks: blob-like
- Edge-only: noisy
- Proposed: clear boundaries, reduced noise

C. Processing Time Comparison

- GMM-only: ~10.2 ms
- Proposed: ~12.5 ms
- Edge-only: ~19.8 ms
- Full subtraction: ~23.6 ms

D. Statistical Significance

Paired t-test on F1-scores (PETS2009): $p < 0.01$

IV. DISCUSSION

Integrating edge detection with GMM filters out false positives caused by background motion. Effective in:

- Dynamic environments (e.g. water, leaves)
- Complex object shapes
- Temporarily static objects

Challenges include:

- Sensitivity to lighting changes
- Shadows causing false edges

Compared to deep learning methods:

- Lower computational load
- No training data required
- Real-time capable on standard hardware

V. CONCLUSION

This paper introduces a computationally efficient hybrid approach to moving object detection using GMM and Canny-based contour analysis. Benchmarked across standard datasets, the method demonstrates high accuracy and low latency, offering a strong candidate for resource-constrained surveillance systems.

Future directions:

- Robustness to lighting variations
- Support for moving camera setups
- Semantic feature fusion

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