EECE575: Project Proposal
Effects of Post-processing on Background Subtraction Algorithms

Donovan Parks

September 30, 2007

1 Introduction

Background subtraction is a widely used method for identifying moving objects in a video stream. It is the first significant step in many computer vision applications, including video surveillance, human motion capture, and monitoring of traffic. The performance of these applications is dependent on the background subtraction algorithm being robust to illumination changes, small movements of background elements (e.g. swaying trees), the addition or removal of items in the background (e.g. parked car), and shadows cast by moving objects. Computational efficiency is also of high priority as these applications generally aim to run in real-time.

The most common paradigm for performing background subtraction is to build an explicit model of the background. Moving objects are then detected by taking the difference between the current frame and this background model. Typically, a binary segmentation mask is then constructed by classifying any pixel as being from a moving object when the absolute difference is above a threshold. Background subtraction algorithms differ in how they define and update the background model.

Despite the success enjoyed by background subtraction algorithms, it is becoming clear that post-processing is required in order to improve their performance. This post-processing can range from shadow detection algorithms operating at the pixel level to connected component labeling which identifies object-level elements. The results of post-processing can be used to directly improve the quality of the segmentation mask and fed back into the background subtraction algorithm in order to facilitate more intelligent updating of the background model.

2 Proposed Project

This project will consider the effects of different post-processing algorithms on the performance of several background subtraction algorithms:

- Simple frame differencing (as a baseline)
- Running Gaussian average [10]
- Gaussian mixture models [8]
- Gaussian mixture models with adaptive number of components [11]
- Gaussian kernel density estimation [3]
- Balloon kernel density estimation [11]
- Approximate median filtering [5]
- Mediod filtering [1]
- Eigenbackgrounds [6]

This list covers the most commonly used background subtraction algorithms along with recently developed state-of-the-art approaches. Each of these algorithms will then be combined with the following post-processing algorithms:

- *Noise removal*: due to camera noise and limitations of the background subtraction algorithms, the resulting binary segmentation masks typically contain numerous small foreground blobs[1]. For most applications, all blobs less than a certain size can be removed. This can be achieved by applying simple area thresholding.
- *Shadow detection*: it is common for shadows produced by moving objects to be erroneously detected by a background subtraction algorithm. Since shadows influence luminosity without significantly changing chromaticity, it is possible to distinguish shadows from the moving objects that produce them. This project will consider the shadow detection algorithm proposed by Elgammal [3]as a simple baseline and the more sophisticated algorithm proposed be Cucchiara et al. [2] which has been shown to give good results [7].
- *Blob detection and characterization*: since the most common applications for background subtraction involve tracking, it is usually necessary to perform connected-component labeling in order to identify object-level blobs in the segmentation mask. These blobs can then be characterized by their position, size, and other shape information. This project will consider the use of morphological operators to improve the quality of these blobs (e.g. filling holes using morphological closing). Detected blobs will be characterized as either moving or stationary by using an optical flow algorithm. This blob level information will then be fed back into the background subtraction algorithm in order to improve updating of the background model.

Evaluation will be performed using the Wallflower [9], Li [4], and VSSN06[2] test sequences.

3 Contributions

This project will result in the following contributions:

1. Extensive quantitative comparison of several popular and state-of-the-art background subtraction algorithms
2. Quantitative measure of how different post-processing methods affect the performance of these algorithms
3. Recommendations regarding which background subtraction and post-processing algorithms are most suitable for different tasks
4. A public repository consisting of all algorithms developed

4 Milestones

The following milestones will be used to track the progress of this project:

- October 21: complete implementation and testing of background subtraction algorithms
- November 7: complete implementation and testing of post-processing algorithms
- November 15: complete implementation and testing of evaluation software
- November 21: complete evaluation of background subtraction algorithms
- November 28: complete evaluation of background subtraction with post-processing

[1]for our purposes, a blob is defined as any set of connected pixels
[2]mmc36.informatik.uni-augsburg.de/VSSN06_OSAC

- December 7: complete written report and oral presentation

These milestones may require modification when the deadlines for the written report and oral presentation are announced.

5 Conclusion

Numerous computer vision applications depend on background subtraction in order to identify moving objects. This project will evaluate a number of popular and state-of-the-art background subtraction algorithms and determine how different post-processing algorithms can improve their performance. It is expected that this project will result in a list of recommendations that can be used to improve these computer vision applications.

References

[1] Rita Cucchiara, Constantino Grana, Massimo Piccardi, and Andrea Prati. Detecting moving objects, ghosts, and shadows in video streams. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 25(10):1337–1342, 2003.

[2] Rita Cucchiara, Constantino Grana, Massimo Piccardi, Andrea Prati, and Stefano Sirotti. Improving shadow suppression in moving object detection with hsv color information. pages 334–339, 2001.

[3] Ahmed Elgammal, David Hardwood, and Larry Davis. Non-parametric model for background subtraction. pages 751–767, 2000.

[4] Liyuan Li, Weimin Huang, Irene Yu-Hua Gu, and Qi Tian. Statistical modeling of complex backgrounds for foreground object detection. *IEEE Transactions on Image Processing*, 13(11):2004, 1459–1472.

[5] N.J.B. McFarlane and C.P. Schofield. Segmentation and tracking of piglets in images. *Machine Vision and Applications*, 8:187–193, 1995.

[6] Nuria Oliver, Barbara Rosario, and Alex Pentland. A bayesian computer vision system for modeling human interactions. pages 831–843, 2000.

[7] Andrea Prati, Ivana Mikic, Mohan M. Trivedi, and Rita Cucchiara. Detecting moving shadows: Algorithms and evaluation. volume 25.

[8] Chris Stauffer and W.E.L. Grimson. Adaptive background mixture models for real-time tracking. volume 2, page 252, 1999.

[9] Kentaro Toyama, John Krumma, Barry Brumitt, and Brian Meyers. Wallflower: principles and practice of background maintenance. page 1999, 255–261.

[10] Christopher Richard Wren, Ali Azarbayejani, Trevor Darrell, and Alex Paul Pentland. Pfinder: Real-time tracking of the human body. *IEEE Transactions on Pattern Analysis Machine Intelligence*, 19(7):780–785, 1997.

[11] Zoran Zivkovic and Ferdinand van der Heijden. Efficient adaptive density estimation per image pixel for the task of background subtraction. *Pattern Recognition Letters*, 27(7):773–780, 2006.