REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)* 1/29/2010	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)* 8/27/2009 – 12/31/2009
4. TITLE AND SUBTITLE A comparison of approaches for tracking in naval environments		**5a. CONTRACT NUMBER**
		5b. GRANT NUMBER N66604-09-M-4141
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Margrit Betke		**5d. PROJECT NUMBER**
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Boston University, 111 Cummington St, Boston, MA 02215		**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Naval Undersea Warfare Center, Division Newport		**10. SPONSOR/MONITOR'S ACRONYM(S)**
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES

20100201279

14. ABSTRACT

Abstract We have investigated image analysis methods for tracking moving objects in marine environments. We focused on information-theoretic approaches that compare image regions of interest with the statistical models of the objects to be tracked. We evaluated tracking performance of the mean-shift and block-matching algorithms on videos of waterways. It is challenging to track naval vessels in these videos due to glare from the water surface, up and down movements of vessels, and occlusions. We found that the performance of the mean-shift tracking approach was superior to the performance of the block-matching approach in videos with low contrast between the naval vessels to be tracked and the surrounding water surface and where the scale and orientation of the vessels changed.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Margrit Betke
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**		7	**19b. TELEPHONE NUMBER** *(include area code)* 617 353 8919

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

A Comparison of Approaches for Tracking in Naval Environments

Margrit Betke
Technical Report on DOD/Naval Undersea Warfare Center grant
N66604-09-M-4141:
Object Detection in Naval Environments using Information-theoretic Approaches

Abstract We have investigated image analysis methods for tracking moving objects in marine environments. We focused on information-theoretic approaches that compare image regions of interest with the statistical models of the objects to be tracked. We evaluated tracking performance of the mean-shift and block-matching algorithms on videos of waterways. It is challenging to track naval vessels in these videos due to glare from the water surface, up and down movements of vessels, and occlusions. We found that the performance of the mean-shift tracking approach was superior to the performance of the block-matching approach in videos with low contrast between the naval vessels to be tracked and the surrounding water surface and where the scale and orientation of the vessels changed.

1 Introduction

Real-time large-area surveillance is increasingly performed in naval environments by unmanned vehicles (UxV) equipped with visual sensors. Imagery inputs are radio-transmitted to operators for analysis. Typical operator display devices report objects of interest at ranges at which the operator cannot recognize the type of object, i.e., a fixed installation, or a moving commercial fishing ship or naval vessel. The operator must decide whether or not to further investigate each detected object. Further investigation exposes the UxV to risks and is expensive, because it involves maintaining a continuous radio link, moving the UxV in potentially rough seas, and monitoring its reported imagery continuously until the object becomes recognizable. The goal of this research project was to investigate video-analysis approaches that can speed up and automate the recognition process. As a first step towards this goal, we identified techniques for tracking moving objects in marine environments. We

Margrit Betke,
Department of Computer Science, Boston University, Boston, MA 02215, USA, e-mail: betke@cs.bu.edu, www.cs.bu.edu/faculty/betke

focused on information-theoretic approaches that compare image regions of interest with the statistical models of the objects to be track,ed In particular, we applied the mean-shift algorithm to the problem of tracking histogram-based target representations as proposed by Comaniciu, Ramesh, and Meer (2003) and Bibby and Reid (2005), where the objects are represented by color histograms. We also implemented a block matching approach by Gyaourova, Kamath, and Cheung (2003) and compared the performance of the two methods.

2 Methods

2.1 The Mean Shift Algorithm

The mean shift algorithm is implemented by the comparison of color histograms. The histogram p of the object to be tracked is obtained from the reference frame and is compared to the histogram q in a subimage of a subsequent frame. We used the Bhattacharyya coefficient as a measure of similarity between the two histograms. We implemented a linearized version of the coefficient that uses a kernel that ensures that pixels near the center of the subimage are weighted more than pixels near the edge of the subimage (Bibby and Reid, 2005).

2.2 The Block Matching Algorithm

In the block matching algorithm, images are segmented into a number of regions or "blocks." Each block in the current image frame is matched with a block in the destination frame by shifting it over a predefined neighborhood of pixels in the destination frame. The blocks are compared with a similarity measure that computes the mean absolute difference (MAD) of corresponding brightness values in the two blocks (Gyaourova, Kamath, and Cheung, 2003). The search process over the predefined neighborhood is performed using a "two dimensional logarithmic search" (TDL) algorithm (Gyaourova, Kamath, and Cheung, 2003). The algorithm is described as follows:

1. Select an initial step size s.
2. Compare the current template block with the block at the center of the destination image and blocks at distance s above, below, left, and right of the center. Compute the similarity measure for the five block comparisons.
3. If the block at the center is most similar among the five, halve the step size: $s \leftarrow s/2$. If one of the other four blocks is most similar, select this block as a new center in the destination image and repeat step 2.
4. When the step size s becomes 1, compare the template block to all the nine blocks in the destination image around the currently chosen center block. The block

among these nine that best matches with the template block is selected as the image region that represents the tracked object.

3 Experimental Results

3.1 Experimental Results for the Mean Shift Algorithm

The white boat shown in Figure 1 has a sufficient level of intensity contrast to the water surface and can be tracked reliably with the mean-shift tracker. The darker row boat in the same video sequence is also tracked successfully with the mean-shift tracker (Figure 2). Note however that loss of track occurs when the row boat entered a region of the body of water where the reflection of a building created a background region with a similar intensity distribution.

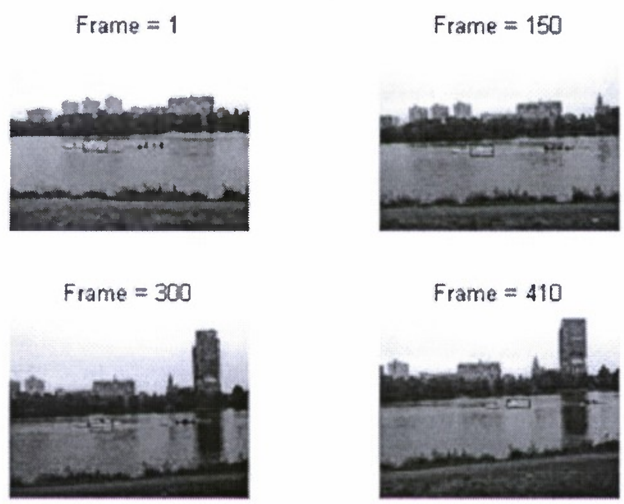

Fig. 1 Tracking a bright power boat with the mean-shift tracker.

An advantage of the mean-shift tracker is that it can handle frame-to-frame changes in scale of the object (Figure 3) and orientation.

The mean-shift tracker did not perform well when the illumination of the body of water changed (Figures 4 and 5). In our examples, loss of track occurred in frame 50 when we simulated an illumination change in frame 26.

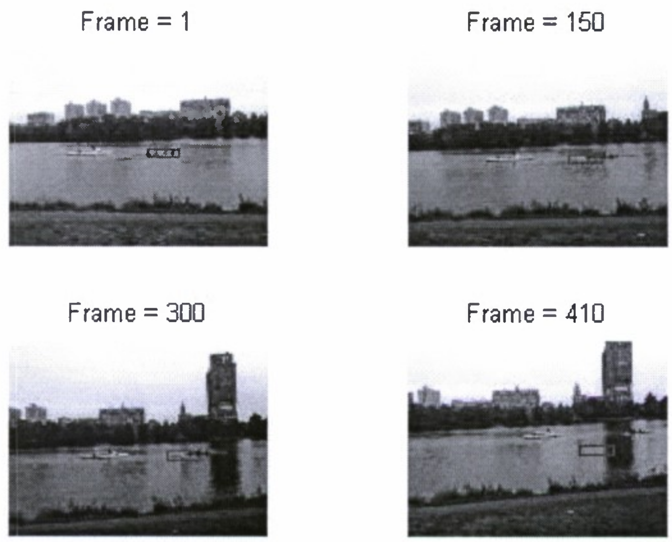

Fig. 2 Tracking a dark row boat with the mean-shift tracker.

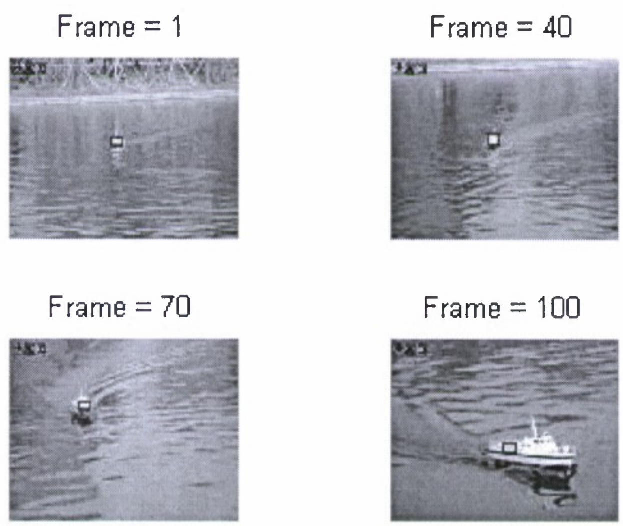

Fig. 3 Tracking a boat that is moving towards the camera with the mean-shift tracker.

3.2 Experimental Results for the Block Matching Algorithm

We tested the block-matching algorithm on the same videos as the mean-shift algorithm. The white boat shown in Figure 6 can be tracked reliably with the block-matching tracker. The darker row boat in the same video sequence is also tracked

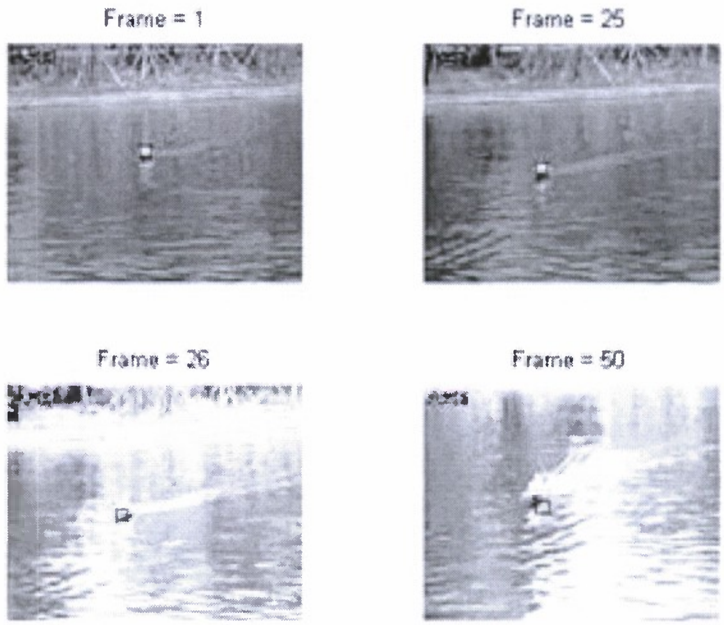

Fig. 4 Tracking a moving boat with the mean-shift tracker in an evironment with an increased level of brightness.

successfully with the block-matching tracker (Figure 7), but, as was the case for the mean-shift tracker, loss of track occurs when the row boat entered a region of the body of water with the building reflection.

The block-matching algorithm could not detect and track changes in object scale or orientation.

4 Conclusions and Future Work

For tracking of vessels moving in a marine environment, we found that the performance of the mean-shift tracker was superior to the performance of the block-matching tracker in videos with low contrast between the vessels and the surrounding water surface and where the scale and orientation of the vessels changed.

Future work includes building motion models of naval vessels that can be used to support tracking the vessel and recognition of the type of vessel. It also includes developing and testing approaches to cope with occlusions of tracked vessels.

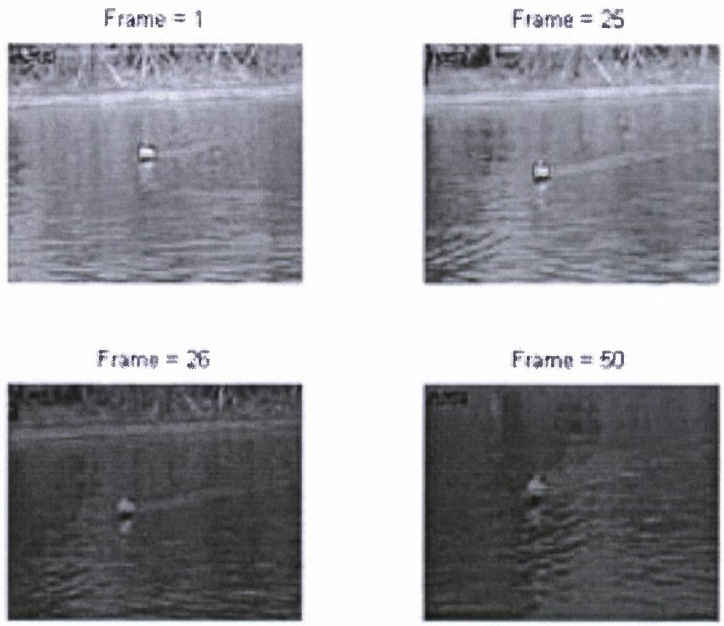

Fig. 5 Tracking a moving boat with the mean-shift tracker in an evironment with a decreased level of brightness.

Acknowledgements The tracking approaches were implemented and tested by Hari Mohan and Yun Wang under the guidance of the author.

References

Bibby C, Reid I (2005) Visual tracking at sea. In: Proceedings of the 2005 IEEE International Conference on Robotics and Automation (ICRA 2005), pp 1841–1846

Comaniciu D, Ramesh V, Meer P (2003) Kernel-based object tracking. IEEE Transactions on Pattern Analysis and Machine Intelligence 25(5):564–577

Gyaourova A, Kamath C, Cheung SC (2003) Block matching for object tracking. Tech. Rep. UCRL-TR-200271, Lawrence Livermore National Laboratory

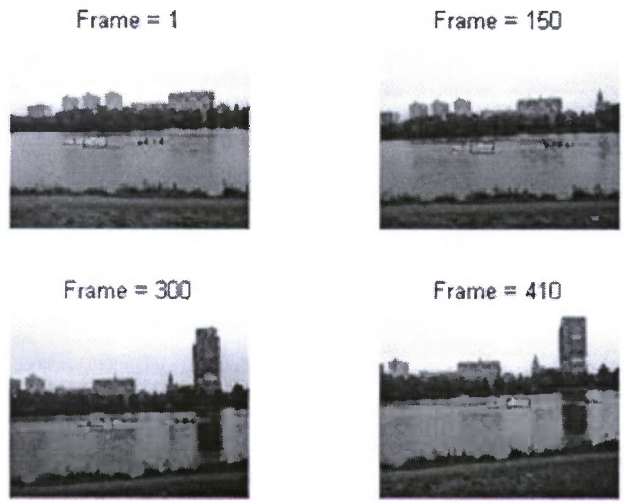

Fig. 6 Tracking a bright power boat with the block-matching tracker.

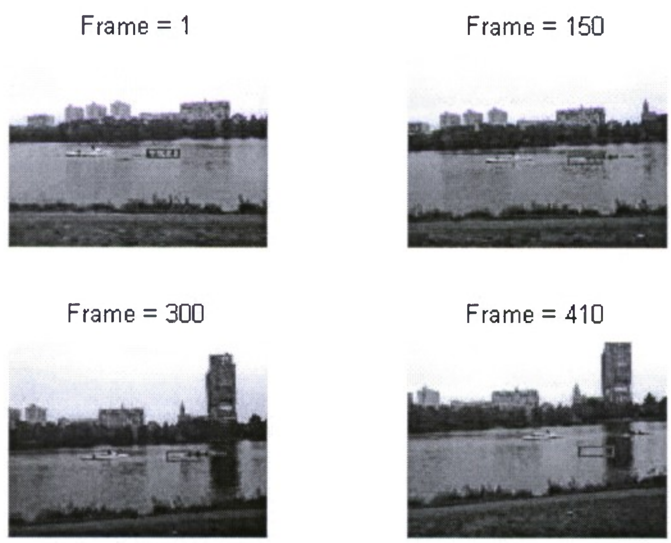

Fig. 7 Tracking a dark row boat with the block-matching tracker.