Tracking of Ballastic Missiles and Velocity Measurement using Frame Distance Manipulation

Vimal Kumar Mishra
Department of ECE
JIIT, Noida
Email: vimal.mishra34@gmail.com

Kumar Rajeev Ranjan
Department of ECE
JIIT, Noida
Email: rajeev.sharma_thesedate@yahoo.com

***Abstract*—In order to measure the velocity of a missile, several models have been discussed in this paper. It deals with the tracking and following of single/multiple missile in a sequence of frames and the velocity of the missile is determined. Algorithms have been developed for improving the image quality, segmentation, background subtraction, feature extraction and determining the velocity. Segmentation is performed to detect the object after reducing the noise from that scene. The object is tracked by plotting a rectangular bounding box around it in each frame. The velocity of the missile is determined by calculating the distance in the form of pixel that the object moved in a sequence of frames with respect to the frame rate and the total time of video is recorded. A simulink blockset has also been modeled to track the missile in this paper.**

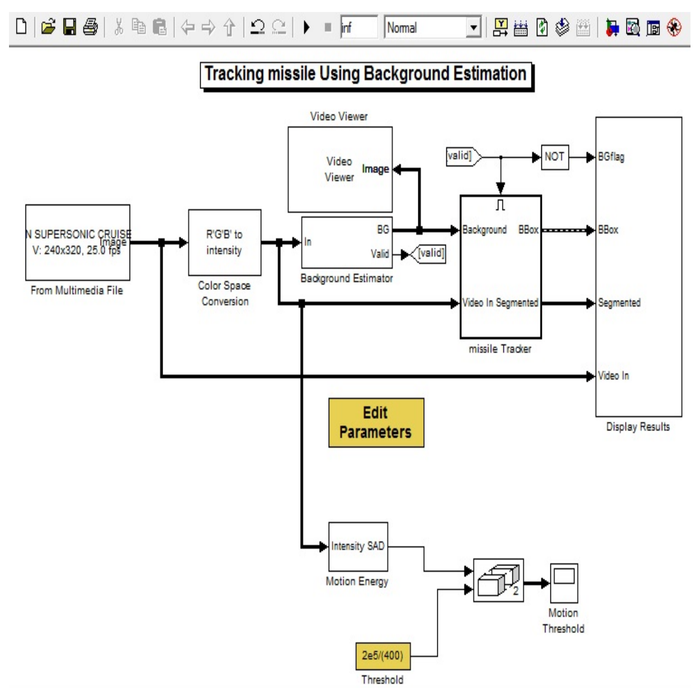
***Index Terms*—frame difference, missiles tracking, velocity measurement, motion detection, SAD, pixel in m using dpi.**

I. Introduction

It is very important for us to extract accurately moving missiles . In recent years, a great deal of practical and valuable algorithms are put forward and developed, which concern with the application of video processing techniques to automatic missile contour extraction. Currently, the background-difference algorithms are commonly used to detect moving missiles under the fixed scence. Viarani[1]. With this algorithm, the grey pixel information was used to detect vehicles. Literature[2] presented frame difference and self adaption threshold value approach to detect missile and extract the coordinates of missile. Literature[3] proposed a k-means clustering algorithms based on the image pixel to segment moving missiles. This algorithm can cancel noise and blur of image. However, the algorithm is sensitive to missile drive direction and large amount of calculation. When the cloud are moving missile direction of moving is not cleared through the detection region, the experimental results were not satisfied. In addition, time average, the median method, smooth detection[4][5][6], consistency criterion, otsu method, hidden Markov model method and the video redraw method are developed, that all these algorithms are mainly to consider the time and spatial characteristics of pixel to Initialize background, however these algorithms can not find the speed of missile it is difficult to meet real-time missiles flow testing requirements, The paper analyze the pixel and change into dpi system as a distance in cm/m for this find distance and divide by video time get speed of missile. The objective of this paper is to identify and track a moving missiles within a video sequence. The tracking of the missiles is based on background subtraction among video frames in contrast to image background-based detection.The velocity estimation can be either between two images or between current frame and Nth frame back. We set N to be one in our model. The proposed tracking and velocity estimattion method is straightforward and easier to implement and we assert has better performance.

II. Simulink Blockset for Missile Tracking

This simulink blockset works in 3 parts.In 1st part,a video is taken and this video is seperated into different frames having size 240x320 pixels.These RGB formet frames get transformed into gray level first .In 2nd part, background substraction is done for the object detection . Now the o/p is given to the missile tracker which tracks the missile 3rd part, shows that the foreground mask is tracked using SAD value to get the motion vector.The details of each step are described using simulink blockset shown below.



III. Methods and Algorithms

A. Background Elimination

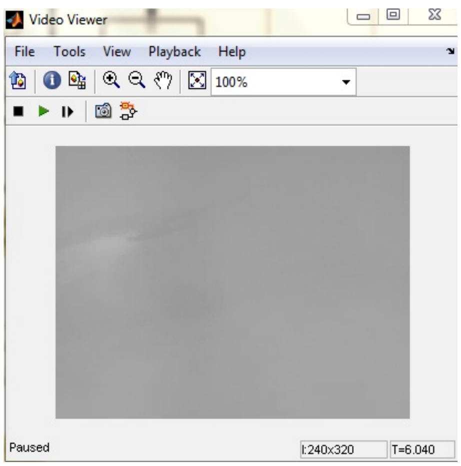
This algorithm removes all stationary objects from observation zone leaving only moving missiles and some details, which are changing from frame to frame. The latter are influenced usually by image noise and some background factors: light shadows, clouds, rain, snow etc. In real conditions time, season, weather and some others factors must be also taken into account. Background $B(p)$ is calculated as an average of each RGB values for the same image point p in the selected background frames:

$$B(p) = \sum_{K} \frac{I_B(k,p)}{n} \tag{1}$$

where $I_B(k,p)$ is pixel color value for point p in frame k. Background removal from moving missiles scene image $I(k,p)$ generates a color RGB image

$$D(k,p) = I(k,p) - B(p) \tag{2}$$

as an Euclidean distance . between $I(k,p)$ and $B(p)$. Fig. illustrates this result.



B. Noise and Blobs Filtration.

Image, as presented in our result has a lot of speckles caused by noise, which could be removed only by means of filtration. An effective method is threshold filtration just after background elimination. There are two main variations of this method:

1. Fixed threshold when it is determined empirically from the test sequence,
2. Histogram-derived threshold when the latter is selected from the brightness histogram of the segmented region.

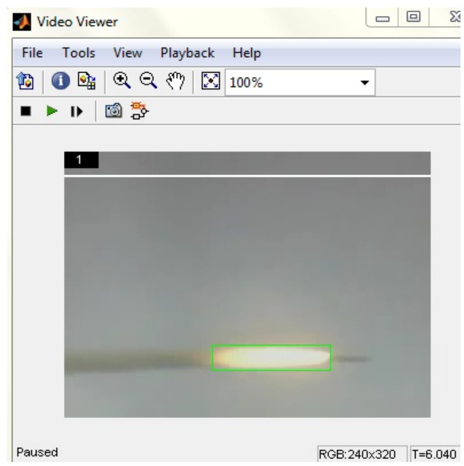
The first algorithm is more adaptive one and is generating an additional image:

$$M(k,p) = D(k,p) if D(k,p) > threshold \tag{3}$$

and

$$M(k,p) = 0 \tag{4}$$

for the rest. Next step removes isolated points and little blobs that remain after threshold filtration. The known idea is simple enough. If an image point p belongs to object then at least one of its eight adjacent points is a part of this object. If its adjacent points do not belong to object then so the point p does. This method was modified for the method under consideration by removing all points inside little $m \times n$ sliding rectangular window in case when its one pixel width contour has white color. In binary image it indicates the absence of points. Eight adjacent points for a pixel were considered here, instead of four adjacent points (as it is defined in many computer graphics algorithms). Such situation is caused by requirements for resolution, suitable for stable contour detection. Remaining noise can be effectively reduced by median filtration. Lets suppose there is a $m \times n$ mask applied to the area that surrounds original point $M(k,p)$. Forming up a sequence of $m \times n$ elements in the progressive order $I_1 < I_2 < \ldots < I_k$, where k = $m \times n$, an element I_J may be find from moving area which is the nearest to the center of this sequence. This pixel substitutes $M(p,k)$. These operations are the last in a frame preprocessing stage.



C. Edge Detection

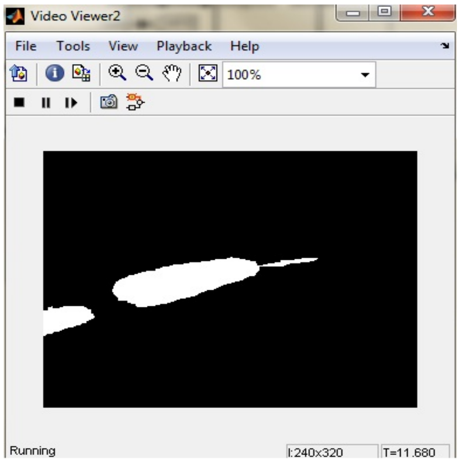
Now there is a need to locate a missiles in frame observation zone. It can be done by edge detection algorithm based on the calculation of image derivatives. They allow examining whether edge passes through a given pixel steep gradients are evidence of an edge, slow changes suggest the contrary. First derivative calculation is intended to detect the rate of intensity changes in frame images. Second derivative is used to determine the location of the maximum rate. To reduce derivative leaps within and near contour area initial image is smoothing. It is important to note that there is no universally detection technique that works equally well for all images. Therefore we have compared most widespread detection algorithms based on Prewitt, Sobel and Laplace methods[11,12] that are applied usually after median filtration. All methods mentioned are referring to mask (kernel) operations that provide the following results: gradient Sx in X direction, gradient Sy in Y direction and module M of gradient:

$$S_X = (a_2 + ca_3 + a_4) - (a_0 + ca_7 + a_6), \tag{5}$$

$$S_Y = (a_0 + ca_1 + a_2) - (a_6 + ca_5 + a_4), \tag{6}$$

$$M = \sqrt{{S_x}^2 + {S_y}^2} \tag{7}$$

where, $c = 2$and a_i pixels covered by 3×3 mask area. The designation $a_0, a_1, ..., a_7$ refers to the clockwise motion beginning from upper left corner of the mask. If $M > threshold$ then $M(k,p) = 1$ else $M(k,p) = 0$.

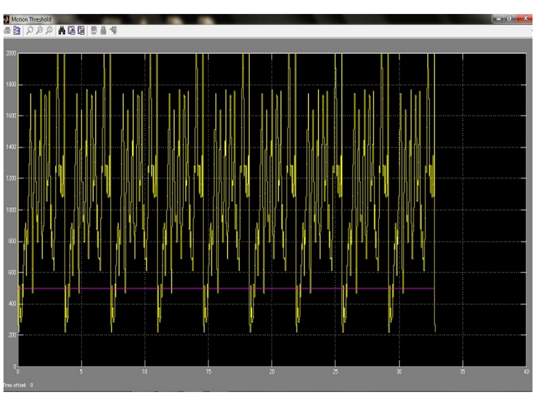


IV. SAD

Sum of absolute diffrence is the used for measuring the similarity between the image blocks.It takes the absolute diffrence between each pixel in the original blocks and corresponding pixel in the block which is being used for comparison.These differences are then summed to create a simple metric of block similarity The greater the similarity between the two matrices, the smaller the SAD values that result. Assume that input matrix I has dimensions (Mi, Ni) and the input matrix Template has dimensions (Mt, Nt). The equation for the two-dimensional discrete SAD is

$$\sum_{m=0}^{m-1} \sum_{n=0}^{n-1} absI(m+j, n+k) - T(m,n) \tag{8}$$

The figure shown below represents motion threshold of missile



V. Velocity Calculation.

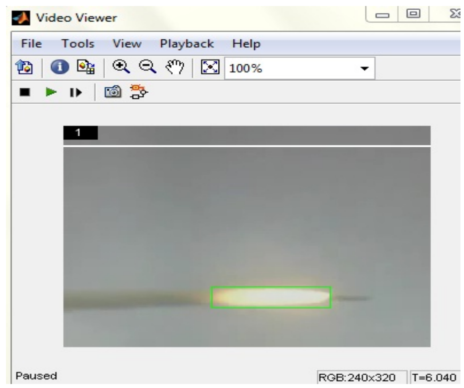
Missiles speed V was estimated using below described method.

$$V = X(pixel) \times F \tag{9}$$

TABLE I
VELOCITY MEASUREMENT FOR THE DIFFERENT FRAME SIZE

frame rate (f/s)	column frame size	velocity (m/s)
25	540	75
40	720	100
60	1080	360
80	1080	480
100	1080	600

where X is column pixel and F is frame rate
Then every video sequence was processed to get passed distance X depen- dence from frame number



In our experiments, the frame rate is 30f/s and the size of frames after projective transformation is 240x320 pixel. The length of a frame in the column pixel is 6 meters using dpi system. Combining with other information of trajectory, the velocity table of ballastic missile is calculated according to equation (9), which is shown in table 1

VI. Conclusion

This paper presents an approach for Tracking of ballastic missiles and velocity measuremmmt using pixel technique. The measuring velocity depends on the frame size as well as frame rate. So greater the frame size and higher the frame rate, more will be the velocity. With manual interaction, the velocity of the missile, including the missile trajectory and its speed, can be estimated more robustly and accurately. The background changes with the change in illumination so background should be updated. Experimental results show that the proposed approach can capture the missile tracking state accurately and meet the precision demand.

References

[1] E. Viarani,"Extraction of traffic information from image at DEIS,Proceedings," International Conference on Image Analysis and Processing, pp. 1073-1076, Sept. 1999

[2] Jianping Wu, Zhaobin Liu, Jinxiang Li," An algorithm for automatic vehicle speed detection using video camera," ICCSE. 2009: 193-6.

[3] Qing Liu Sun'an Wang etc. "Flame Recognition Algorithm Research under Complex Background," 2010 $IEEE$ 10th International Conference on Computer and Information Technology (CIT)," 2010 , Page(s): 503 - 510.

[4] C. Harris and M.J. Stephens. "A combined corner and edge detector. In Alvey Vision Conference," 1988: 147152.

[5] Blake A, Curwen R, Zisserman A. ”A framework for spatiotemporal control in the tracking of visual contours.“ Int J Comput Vis. 1993, 11(2):127146
[6] Alefs Bram, Schreiber David. ”Accurate speed measurement from vehicle trajectories using AdaBoost detection and robust template tracking.“ IEEE Conf Intell Transport Syst Proc ITSC. 2007. pp: 405- 412
[7] Beaudet, P R, ”Rotationally Invariant Image Operators, International Joint Conference on Pattern Recognition,“ pp. 579-583 (1987).
[8] V. T. Vu, T. K. Sjgren, and M. I. Pettersson, Integrating space time processing into time-domain backprojection process to detect and imaging moving objects, in Proc. $IEEE$ IGARSS, 2010, pp. 41064109
[9] R. P. Wildes, D. J. Hirvonen, R. Kumar, S. C. Hsu, W. B. Lehman, B. Matei, and W. Y. Zhao, Video georegistration: Algorithm and quan- titative evaluation, in Proc. 2001 $IEEEInt.Conf.ComputerVision, Vancouver$, BC, Canada, 2001, pp. 343350.
[10] A. C. Shastry, Airborne video registration and traffic flow parameter estimation in a multimedia GIS, M.S. thesis, Dept. Elect. Comput. Eng., Univ. Arizona, Tucson, 2002.
[11] L. G. Shapiro, G. C. Stockman. Computer Vision, Prentice Hall, 2001.
[12] L. A. B. Jhne, H. Hauecker, P. Geibler. Computer Vision and Applications, Academic Press, 1999.