Implementing a real - time missile Tracker

A Design Lab Project Report Submitted
in Partial Fulfillment of the Requirements
for the Degree of

Bachelor of Technology

by

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<u>CERTIFICATE</u>

*This is to certify that the work contained in this thesis entitled "**Implementing a real - time missile Tracker**" is a bonafide work of* ***Karanam Dharneesh 2001EE25 Malraju Srivardhan Rao 2001EE30 Rushikesh Langde 2001EE57*** *, carried out in the Department of Electrical and Electronics Engineering, Indian Institute of Technology Patna under my supervision and that it has not been submitted elsewhere for a degree.*

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Acknowledgements

We thank Dr. Rajib Jha for his invaluable guidance throughout our work that it would not have been without him.

Contents

List of Figures

Chapter 1

Introduction

1.1 ABSTRACT

In this project we tried to implement a tracker using correlation and features of the target, The algorithm employs a primary correlation-based tracker based on phase correlation and a secondary feature-based tracker for support. In addition, a prescreener runs concurrently with the trackers to create a list of potential target centroids, increasing the tracker's level of confidence.

1.2 WORKING

The primary tracker and the secondary tracker are the two main parts of the tracker algorithm. A correlation tracker that first tracks a predetermined target serves as the main tracker. The secondary tracker assumes control if a set of specified conditions are not met. The secondary tracker is a feature-based tracker that extracts segments from the IR image that correspond to each target centroid and calculates various attributes linked to those segments. To determine the target's current location, these attributes are combined with prior knowledge of the target's position.

1.3 ORGANISATION OF THE REPORT

We described the correlation algorithm for image tracking and updating the reference image, then we described the optimised way to implement in frequency domain using the provided algorithm and then a better way to do it by using a phase correlation algorithm, then we describe the making of prescreener using edge detection and thresholding using OTSU, followed by the features used in the feature based tracker.

Chapter 2

REVIEW OF PRIOR WORKS

2.1 CORRELATION

Correlation is the process of moving a filter mask often referred to as kernel over the image and computing the sum of products at each location. Correlation is the function of displacement of the filter. we can extend the notion to 2-D which is represented. The

$$F \circ I(x,y) = \sum_{j=-N}^{N} \sum_{i=-N}^{N} F(i,j) I(x+i, y+j)$$

basic idea is the same, except the image and the filter are now 2D. We can suppose that our filter has an odd number of elements, so it is represented by a (2N+1)x(2N+1) matrix.

2.2 CONCLUSION

This chapter provided details of the some of the existing algorithms for correlation for image processing.

Chapter 3

CORRELATION BASED TRACKER

3.1 OUR ASSUMPTIONS

we consider this as a missile pov approaching the target so the target will mostly be in the centre of the frames, hence we need to focus our search window in the central part since we are approaching the target, we have to keep updating the reference image with processed frames ,because this tracker is based on present frames processed, if we get blurry frames we will lose the target hence we need another tracker. we shift our reference window over a search region present in the central part of the frame, in order to reduce calculations to cover all the frames, we also updated the reference images for every frame as we processed, in order to be precise with the tracking we run the prescreener in the background.

3.2 DIRECT IMPLEMENTATION

A section of the image that is additionally centred on the target and sizable enough to include the full target is taken away in order to create the first reference window. Depending on the distance to the target, the search window and reference window's sizes fluctuate from frame to frame. The target is surrounded by a rectangular area referred to as the search window, which must measure at least twice as big as the reference window. The guidance and control unit will steer the gimbal to that place once the minimal location matching to the target has been identified. The reference window utilised at each frame is a lag-filtered version of the previous reference window and the current window since the target's contrast varies consistently as an outcome of aspect and depression angle changes. In

$$MMSE(\hat{x},\hat{y}) = \min\left(\sum_{x,y}\left|\tilde{f}_{current}(x,y) - g_{history}(x+\hat{x},y+\hat{y})\right|^2 \Big/ N^2\right)$$

$$= \min\left(\sum_{x,y}\left(\tilde{f}^2{}_{current}(x,y) - 2\tilde{f}_{current}(x,y)g_{history}(x+\hat{x},y+\hat{y}) + g^2{}_{history}(x+\hat{x},y+\hat{y})\right) \Big/ N^2\right)$$

where

$\tilde{f}_{current}(x,y)$ = the current search window gated by a mask of ones the size of $g_{history}$

and

$g_{history}(x,y)$ = the reference window used in the correlation.

$$g_{history_i} = x * g_{current_i} + (1-x) * g_{history_{i-1}}$$

where

$g_{history_i}$ = the weighted reference window at frame i;

$g_{current_i}$ = a reference window size region centered on the target extracted from the current frame i,

$g_{history_{i-1}}$ = the reference window used for correlation in the previous frame i-1,

and

x = the reference window update rate (<1).

order to account for a potential change in the target signature brought on by turning, the value of x can be increased if the correlation value of the related minimal mean square error (MMSE) falls below a specific threshold . When doing this, the reference window gets updated with the most recent target signature data. To avoid overcompensating for momentary blurring and occlusion, the value of x is not increased too quickly; however, in this case, we kept it constant at a value that can support a sizable shift in angle.

3.3 OPTIMISING THE IMPLEMENTATION USING PROVIDED ALGORITHM

$$MSE(w_1, w_2) = F^2(w_1, w_2)M^*(w_1, w_2) - 2F(w_1, w_2)G^*(w_1, w_2) + G^2(w_1, w_2).$$

we tried to implement the above function for cross correlation to reduce the calculations but as we went on, we found out that the position of the reference image was not matching after some frames, this might be because of the M matrix and the relation between the w1 and w2 of the MSE and x and y, one of the possible reasons behind this failure of optimization can be inadequate information provided by the paper.

3.4 OPTIMISING USING PHASE CORRELATION IN THE FREQUENCY DOMAIN

However, we used the Fourier Transform to locate where the template is by using Phase Correlation instead. Basically, instead of computing the multiplication of the two spectra, we compute the cross power spectrum instead, to get the position of the required reference on the search window. Phase correlation is a method used to determine the relative translative offset between two similar images or data sets, known as digital image correlation. This approach is frequently employed in image registration and relies on a frequency-domain representation of the data, which is often calculated using fast Fourier transforms. Here

$$R = \frac{\mathbf{G}_a \circ \mathbf{G}_b^*}{|\mathbf{G}_a \circ \mathbf{G}_b^*|}$$

for the given two input images Calculate the cross power spectrum by taking the complex conjugate of the second result, multiplying the Fourier transforms together elementwise, and normalizing this product elementwise, given product is the Hadamard product (entry-wise product) and the absolute values are taken entry wise as well. Written out entry wise for element index Obtain the normalized cross correlation by applying the inverse Fourier transform and determine the location of the peak.

Obtain the normalized cross-correlation by applying the inverse Fourier transform.

$$r = \mathcal{F}^{-1}\{R\}$$

Determine the location of the peak in r.

$$(\Delta x, \Delta y) = \arg\max_{(x,y)}\{r\}$$

3.5 CONCLUSION

In this chapter, we proposed a better approach for the given algorithm to find the required correlation using phase correlation instead of using the given algorithm directly, because the described algorithm was not specific about the relation between x,y and w1,w2 and the value of matrix m was not discussed.

Fig. 3.1 Detection of tank

Chapter 4

FEATURE BASED TRACKER

4.1 MAKING THE PRESCREENER

The missile target detector, or prescreener, aids in the collection of frame characteristics. By using the Sobel operator, the prescreener's first phase estimates the image's strong edges. We identify the needed frame image's thick and thin edges. The sobel image was then thresholded and binarized using the otsu algorithm. Next, erosion was used to remove any unwanted thin edges caused by the environment or the ground. However, because the tank was small and other edges were comparable to it, we were unable to erode all the edges correctly, and this resulted in a lot of extra edges.

We had to work with several more centroids and there was noise in the sobel image. Once the Integrated image has been binarized and the target centroids are calculated using morphological erode operator. The output of prescreener will be used in the feature based algorithm.

4.2 FEATURES USED IN ALGORITHM

This algo works on the features of the reference image, here we have taken the mean and variance as a features. While the correlation tracker is operating, using the output

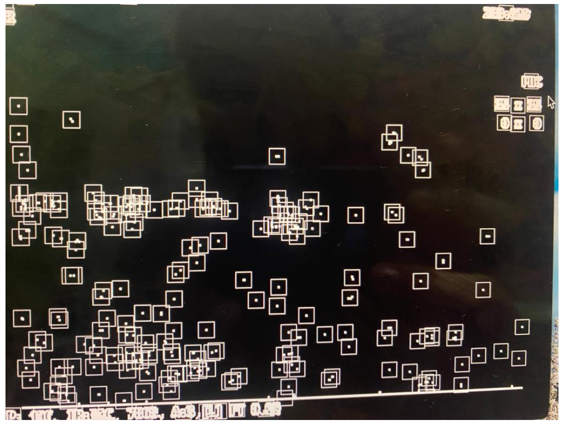

Fig. 4.1 Detecting the centroids

coordinates of correlation tracker a reference window has been made along with the window of each target centroids. Calculated the mean and variance of the reference window and target centroids. To use the data from prescreener, since we had less no. of features Xi = current feature's value of the target centroid. Yi = reference window's feature value. N = No of features. M = degree of similarity. The degree of similarity of a each target segment

$$M = \sum_{0}^{n} |X_i - Y_i|$$

Fig. 4.2 Degree of similarity

with the reference window segment is calculated. The target centroid whose features are almost similar to reference window, which gives minimum value of Mi is considered as a valid track.

4.3 PROBLEMS TO WORK ON

Unable to take more features of the reference window as we don't have the proper image of tank. During threshold and binarizing the sobel image, unable to decrease the target centroids by keeping the threshold to edge detection because tank size was too small that even with other small edges the tank was getting disappeared. In the video the tank size was too small, so we faced difficulties while taking it as reference window because it was just considering it as dark point.

4.4 CONCLUSION

In this chapter, we successfully implemented the prescreener using the provided method described above, the thresholding of the values requires more precision in order to get more accurate edges using OTSU hence the erosion and dialation is not perfected yet in order to get low no. of target centroids, we used only two features here in order to reduce the calculations since we had a lot of centroids.

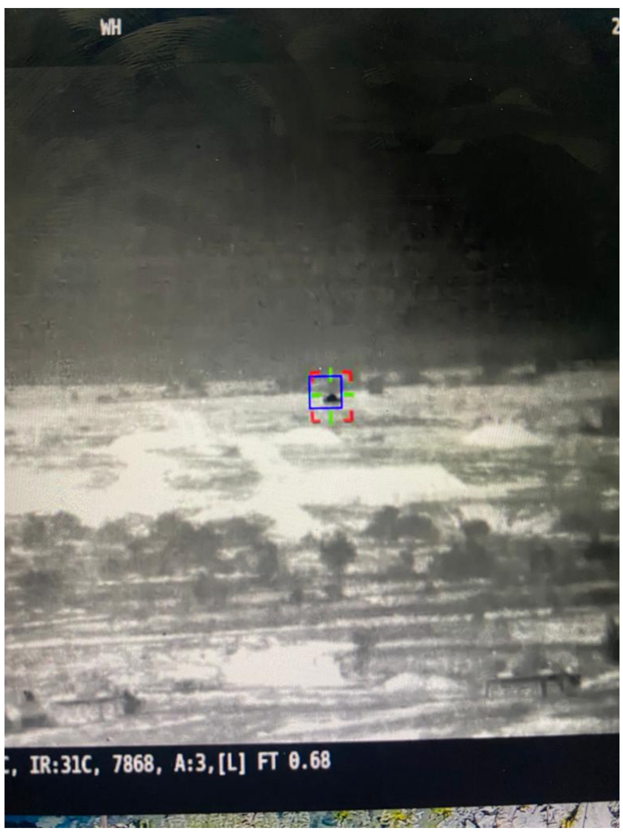

Fig. 4.3 Final tracking in action

Chapter 5

CONCLUSION

We have tried to implement the research paper and got results, as described above we have tried some variations in the algorithms according to our level of understanding, we implemented two to three algorithms out of which the ones described above served the best results

Chapter 6

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