ASSESSMENT OF HANDLING QUALITIES OF LIGHT COMBAT AIRCRAFT (LCA-TEJAS) IN AIR-TO-AIR ATTACK MODE BY ANALYSIS OF HEAD-UP DISPLAY (HUD) VIDEO OF THE CHASE AIRCRAFT

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ABSTRACT

This Paper is intended to assess the handling quality of LCA-Tejas during air to air attack mission. In this paper handling quality of LCA in air-to-air attack mode is being assessed using image processing techniques. As a part of flight test program of LCA Tejas we have presented a methodology to assess the handling quality of LCA by detecting the target aircraft in every frame of the HUD video of the chase aircraft during an air-to-air attack mission. Based on the detection of the aircraft in every frame of the HUD video, percentage of time the aircraft is being targeted during a given test point is arrived at. This percentage is an indicator of the handling quality of the aircraft and is used to assess the ease with which the pilot can aim at the enemy aircraft while in close combat.

INTRODUCTION

LCA-Tejas is undergoing an extensive flight test before induction into the Indian Air Force. Air-to-air attack is one of the major missions where the handling quality of the aircraft has to be evaluated. In an air-to air attack mission, the main objective is to chase an enemy aircraft and maintain aim on an enemy aircraft. Head-up display in the cockpit is utilized by the pilots to aim at the enemy aircraft. To help the pilots to aim at the enemy aircraft, circle appears at the centre of HUD when the aircraft is in air-to-air attack mode. The pilot is required to chase the aircraft in such a way that the enemy aircraft is always maintained within the circle of attack. Figure 1) shows a sample HUD frame of the chase aircraft and Figure 2 shows HUD frame when the enemy aircraft is being targeted by the chase aircraft (both aircrafts being LCA-Tejas in this case). In figure 2 it can be seen that the enemy aircraft is being targeted and thus is inside the circle of attack as shown in the HUD frame.

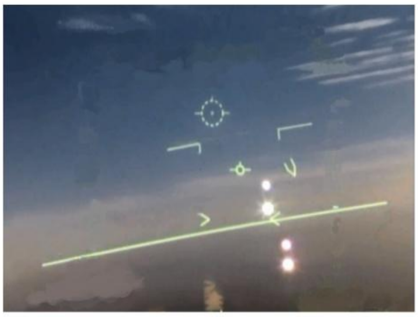


Fig 1(a): A sample HUD frame of LCA **Fig 2: A HUD frame with target**

The efficient tracking of the enemy aircraft in this case is largely dependent on two factors: a) The skill of the pilot, and b) The ease of handling the aircraft when carrying out various maneuvers by test pilot. To take the first factor out of consideration these tests are conducted with very experienced set of test pilots. Finally, the best out of the set of tests is used for evaluating the handling quality of the aircraft. This method takes the piloting skill out of consideration. In order to evaluate the handling quality of the aircraft, it is required to find out the percentage of time the enemy aircraft was kept within the targeting circle of the chase aircraft's HUD display. The major challenge in evaluating this was to detect the position of enemy aircraft of chase aircraft's HUD and to verify its presence within the targeting circle. Once all the frames of the HUD video from the start to the end of the test point is analyzed, total percentage for which the enemy aircraft is within the targeting circle can be arrived at. A higher percentage indicates the ease of handling of the aircraft.

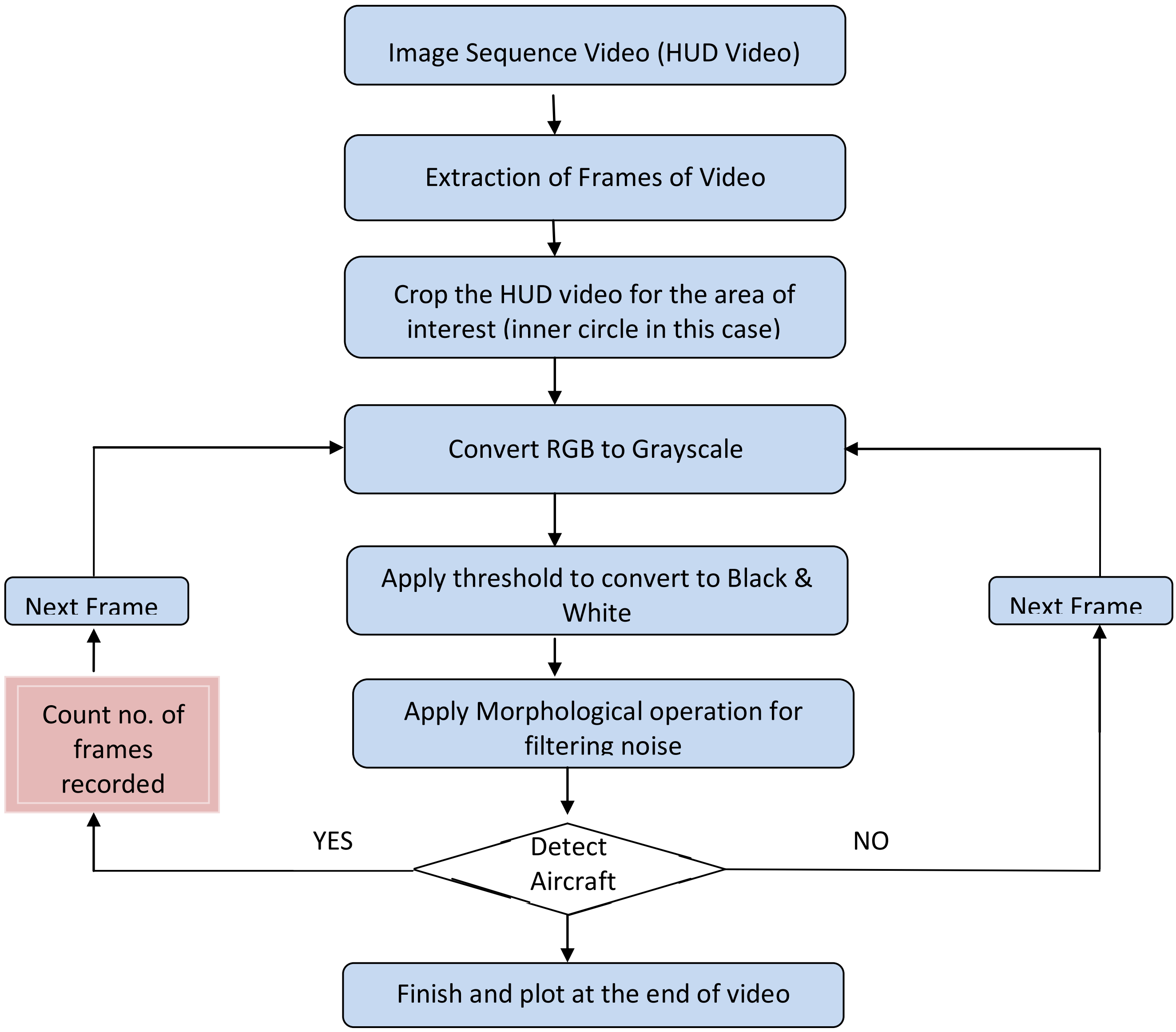
DESCRIPTION

1. System description.

Algorithm used in tracking an enemy aircraft and evaluating the presence of the aircraft within the firing circle is carried out using morphological image analysis used in image processing application. Once we are able to extract frames of HUD video we apply cumulative image analysis to locate the aircraft within the firing circle which is inner circle as shown in the Fig 2 in the HUD frame. The detection of aircraft in a specific frame is based on the assumption that the aircraft will be darker than the background. To cater for lower contrast when the aircrafts are diving and ground objects are in background, threshold is adjusted accordingly which is explained in detail in section 4 of the body of this paper. Morphological image analysis is then carried out to detect the aircraft in the frame.

2. Process flow.

A flow chart of the algorithm used to analyze the video is shown in Fig 2(a) .is shown below:



3. Overview of the method:

Once the flying sortie is over and HUD video is recovered from VDR recorder, we look for the timings of the test point when this particular test was carried out. Then that particular portion of video is extracted for evaluation. The video is then loaded in matlab workspace and the region is interest is cropped. A sample cropped frame is shown below.

Figure 3: Cropped rectangular region in a HUD video frame.

All the frames of the video are cropped for this area of interest. The region outside the circle of attack in the cropped frame is then masked as the area of interest lies within the circle. Cropping followed by circular masking is done to achieve this. A sample result of this operation is shown in figure4.

➡ Figure 4: Rectangular cropped image after masking

After this the RGB image is converted it to grayscale. A sample image is shown in figure 5.

➡ Figure 5: Gray Scale image.

Then the grayscale image is converted to a black and white image with an experimentally determined threshold. A sample black and white image is shown in figure 6 below.

➡ Figure 6: Figure shows post application of threshold

After this image erosion and dilation are applied successively to remove the noise if any.

4. <u>Experimentally determining Threshold:</u>

Determining the threshold and carrying out morphological analysis for filtering noise are the core operations of this tool which help us in aircraft detection with greater accuracy. Different thresholds are used during different missions as the process of edge detection is solely dependent on the threshold which can differentiate between the background and the aircraft. Threshold has to be selected carefully to make sure that the value lies between the pixel intensity of the background and the aircraft in a grayscale image. For example if a grayscale image is converted to binary with 0.6 as threshold, the command replaces intensity of the pixel greater than 0.6 with white and less than 0.6 with black as shown in figure 6. When the tool was being analyses in a non-dive mission where the background was fairly light sky, it was observed that if the threshold luminescence limit is lower more edges were being detected which resulted in fair increase in noise from background pixel where threshold was kept near 0.3,0.4. However, a high threshold may miss the subtle edges when kept around 0.7, 0.8. We observed wrong patters of blob (pixels accumulated together) were detected. The images below describe the effect of under-thresholding and over-thresholding.

Under-thresholding-

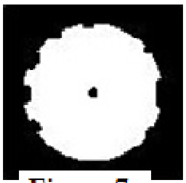


Figure 7

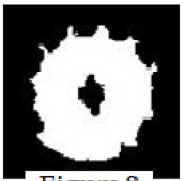


Figure 8

Figure 7 and 8 shows 0.3 threshold and 0.4 thresholds.

Over-thresholding

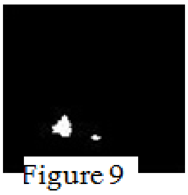


Figure 9

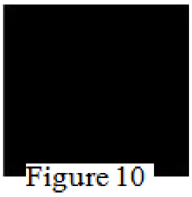


Figure 10

Figure 9 and 10 shows thresholding around 0.7 and 0.8.

It is clearly visible when we use 0.3 and 0.4 limit of threshold in-correct pixels are detected and when using 0.7 small portion of pixels are getting detected which are considered as noise during filtering, while at 0.8 threshold the aircraft is not getting detected in the frame. Hence, for lighter sky-like backgrounds 0.6 threshold limit was concluded to be optimum. Also for dive attacks where ground objects are seen in the background resulting a low contrast 0.4 threshold limit was concluded to be optimum.

5. Morphological image analysis:

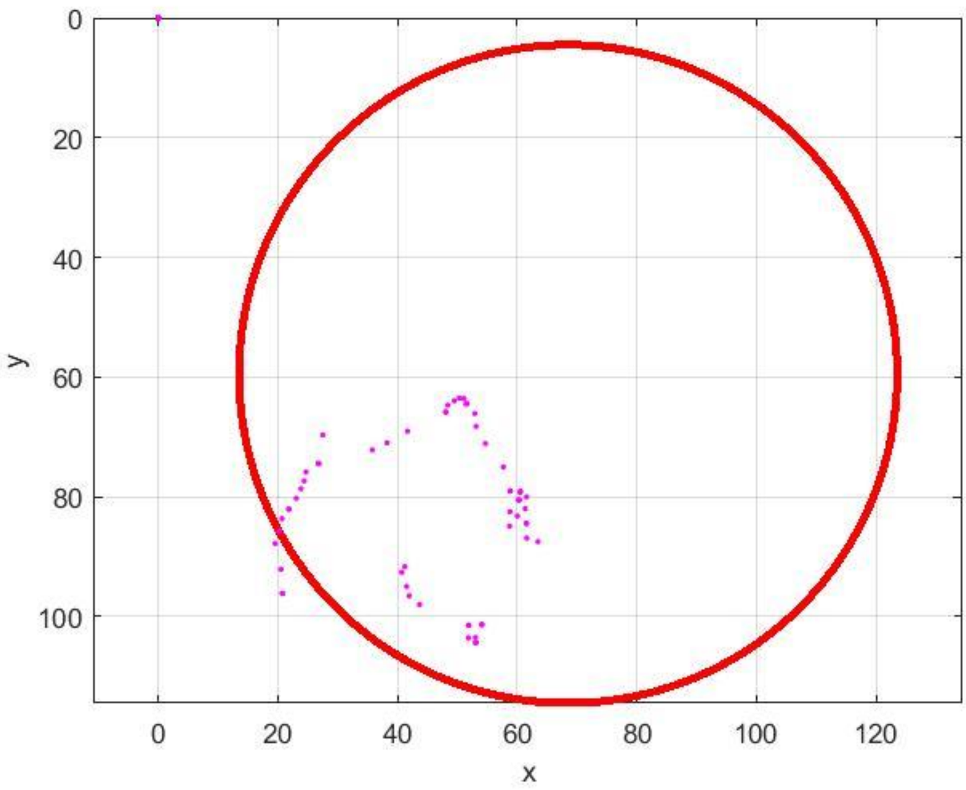
Morphological analysis is carried out over binary image so as to detect the corresponding shape (chase aircraft) using a structuring element. The basic morphological operation includes image erosion and image dilation. Erosion was used to find a match of the structuring element with the aircraft and remove the unwanted pixel and dilation was used to smoothen the edges of the detected pixels. Best match between aircraft as shown below and diamond shaped structuring element was observed using diamond of radius 3.

Figure 11 shows disk shaped structure after image erosion and dilation

Best match of structuring element with the aircraft was successfully counted using a counter and plotted to locate the centroid of the aircraft. To carry out the simulation MATLAB was used.

NUMERICAL RESULT

From the results, it was concluded that this project traced the location of aircraft within the inner circle corresponding to individual frames with an accuracy of greater than 98%. The plot shown below is results of one of the test points where the handling quality of the aircraft is assessed at 84.05%. The red circle in the plot below represents the circle of attack present on the HUD of the chase aircraft. The pink dots represent the position of the enemy aircraft with reference to the targeting circle. It can be observed that some dots are plotted outside the circle which represents that the aircraft was not able to target the enemy aircraft for these frames.



CONCLUSION

Hence, in this paper we were able to successfully assess the handling quality of LCA-Tejas. The tool in itself may not justify the effort required to carry out this analysis as lot of other resources along with telemetry were used to satisfy the requirement. The edge detection technique however proved to be an icing on the cake to arrive at a final quantitative result which very nearly represents the handling quality of LCA.

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