

# Registration of background images using correlation for a land-based IRST system

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## Abstract

Image registration is useful for the moving target detection and tracking in the Infra-Red Search and Trackers. We present a new image registration method based on the maximum likelihood principle. With our approach to the image registration, displacements between frames are calculated using the correlation, and then, the new image is rectified to the reference image by compensating the displacement through two steps of coarse and fine rectifications.

## 1 Introduction

The image/signal processing unit of the IRST (Infra-Red Search and Tracker) detects and tracks targets through intensive computation. The detection and tracking of independently moving objects from a moving platform can be greatly simplified by removing all the motion from the camera output, so that the scene background looks stationary. The moving target detection with stationary background can be performed using the frame difference method. With this method, stationary background clutters are removed by subtracting two consecutive frames. For the land-based IRST mounted on a vehicle such as a tank, background images are distorted by the platform motion. To make background images stationary, each input image has to be registered to the reference image. Most previous approaches to the image registration require a control point set [1, 2, 3, 4]. The extraction of control points in the background image of the land-based IRST, however, cannot be performed automatically because of the variety and unpredictability of background images.

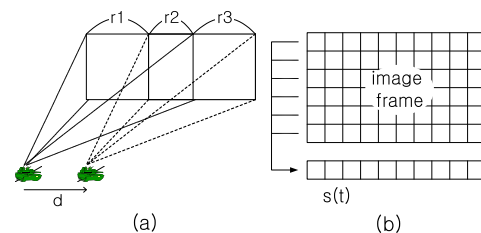
We present an ML-based correlation method to register image frames. Using the correlation method, we can obtain displacements between consecutive frames and compensate these displacements.

The remainder of this paper is organized as follows: section 2 discusses the proposed algorithm, and section 3

gives our simulation results. Conclusions are given in section 4.

## 2 Proposed algorithm

Remotely sensed IR images contain distortions between frames. Among them, the translation distortion caused by the motion of the platform during the time required for each mirror sweep is the major distortion for the moving platform. The perspective effect resulted from the change of the platform position also gives additional distortion. Figure 1(a) shows the cause of the transla-



**Figure 1:** (a) Translation distortion between two image frames (b) Signal model

tion distortion when the platform has a lateral motion. The size of the overlapping region between two consecutive frames is determined by vehicle's speed.

We use the present frame as the search image and the previous frame as the reference image. Although platform on which IR sensor is mounted moves on rough terrain, a vertical movement of sensor is compensated minutely with gyros in a usual IRST system, such that we have only to compensate the horizontal translation. This means that we have no need to calculate the vertical displacements. Therefore, we define each row of the image frame as a received signal  $r(t)$  as shown in figure 1(b):

$$r(t) = s(t - \theta(t)) + n(t)$$

where  $s(t)$  is the reference signal,  $\theta(t)$  is the displacement and  $n(t)$  is the Gaussian noise. Here,  $t$  represents the position of a pixel (or the column number). The displacement of a same point between two frames is different for each pixel because of the difference in range. Hence, the displacement,  $\theta$ , is a function of  $t$ . Now the problem is to determine the displacement  $\theta(t)$ . The distortion between images is rectified by compensating these displacements.

To find  $\theta(t)$ , an ML-based method is used. The resulting ML estimation of  $\theta(t)$  is equivalent to find  $\tilde{\theta}(t)$  that maximizes

$$\lambda(\tilde{\theta}) = \int r(t)s(t - \tilde{\theta}(t))dt$$

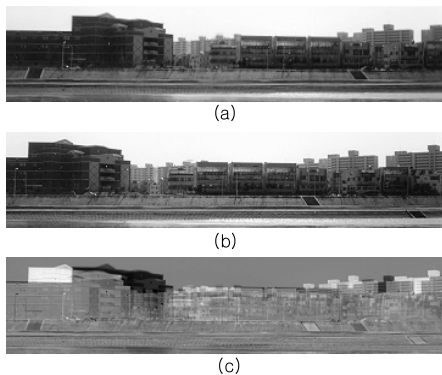
which is the correlation function after all.

We first find the displacement,  $\theta$  of each row with this criterion. By compensating this displacement, we can obtain the coarse rectification of the input image. A fine rectification should follow to correct the displacement of pixel in a row and this process can be made by the area correlation method. Once a displacement is found for a pixel, we can compute the correlation with this  $\tilde{\theta}(t)$  for neighborhood pixels and compare with a certain threshold value. Until this correlation exceeds the threshold, we continue this process for the next pixel in a row. Otherwise, a new displacement  $\tilde{\theta}(t)$  should be found. It reduces the computational load of computing the correlation for every pixel.

With this scheme, we can rectify the search image to the reference image. Notice that we can register only the overlapping region of the two frames.

### 3 Simulation results

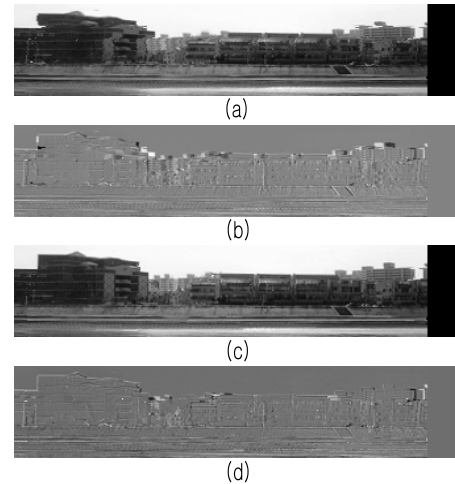
The simulation studies are made using image sequences in that the distance difference of the platform between two consecutive frames is about 5 m. Figure 2(a) and



**Figure 2:** Two consecutive images : (a) search image (b) reference image (c) difference image

2(b) show two consecutive images when the vehicle has

lateral motion and figure 2.(c) shows the difference of two images. The images shown in figures 3(a)-3(d) il-



**Figure 3:** (a),(b) after coarse rectification (c),(d) after fine rectification

lustrate an example of the application of the proposed algorithm. Figure 3(a) shows the rectified image after the coarse rectification. The difference image after the coarse rectification is given in figure 3(b). Figure 3(c) and 3(d) show the rectified image, and the difference image after the fine rectification, respectively.

### 4 Conclusions

We have presented a new registration method based on the maximum likelihood criterion. Experimental results of the algorithm are given. The image registration may be followed by the moving-target detection step based on a frame difference technique.

### References

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