Design of Different Controllers for an Electro-Optical Target Acquisition and Pointing System

ABSTRACT

of the Ph.D. Thesis

Submitted to

Jamia Millia Islamia

for the award of the Degree of Doctor of Philosophy

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ABSTRACT

Fire control and surveillance in the Defence environment have traditionally relied on operator for acquisition, detection and tracking of the targets. Significant performance improvements can be realized with the introduction of an automatic target acquisition, tracking and pointing system. Recently military community has developed a considerable interest in vehicle and area protection weapon systems for the Defence against line-of-sight and top attack threats. These threats are of short duration, difficult to detect due to low signatures and may approach at any angle of attack. Thus to meet the challenge of defending against a multitude of different type of threats a fire control and surveillance system must have the capabilities to detect, acquire, track, range estimation and devise a mechanism on to the target within required timeline.

The target acquisition requires the enhancement of contrast of real time image and also measurement of the same with respect to target and background. This needs pre-processing and also estimation of the change in contrast. The object in the image can be identified by its features such as corners, edges and many other types. The feature detection is a crucial step in development of tracking systems. It is desirable to select the good features and track them in next frame. The present work uses KLT algorithm for feature tracking. This approach identifies image region, which contains salient features to track determines displacements of features between two frames. This is a simple yet robust method and offers lower computational time and lesser ambiguity in matching the feature with its predecessors.

These tracking algorithms are of no avail when there is an occlusion of target image. In such scenario prediction algorithms can be applied for predicting the future location of the target. There are many prediction algorithms available for predicting future locations of the

moving targets in case of partial / full occlusion. The accuracy rate of these algorithms is also different. The thesis proposes a solution for estimating motion from a sequence of images using three algorithms, viz., Batch, Recursive and Bootstrap methods. Firstly the sequence of frame of images from the video is made using the appropriate tools. Then KLT is applied on it for tracking the features. The output is given to motion algorithms as the input. Using spherical projection, a simple equation that relates the image motion with the object motion is derived. This equation is reformulated into a dynamical state space model, for which Kalman and Extended Kalman filters are applied to yield the noiseless result.

The performance of an electro-optical tracking and pointing system mounted on a mobile platform decreases exponentially with an increase in the disturbances on line of sight (LOS). The problem is sought to be reduced by stabilising the LOS. The stabilization requirement may vary from hundred micro-radians to few micro-radians for achieving jitter free image. In the present work a detailed mathematical model of the system based on the gimal electro-mechanical parameters obtained from mechanical design and servo-mechanical parameters has been generated. A detailed design of a conventional controller for a LOS stabilization loop is presented in the work. This forms the basis for the development of advanced and intelligent controller for LOS stabilization. Classical control design usually ignores the higher order dynamics and plants are linearized around an operating point.

The Modern control techniques, with the advent of powerful computing facilities are easy to design. The design carried out in time domain (state-space methods) requires an observer for implementation thus increasing the computational load. The ageing of components and system to system variations deteriorate the performance of the overall system.

The controllers based on soft-computing techniques present a good methodology to overcome the above-stated difficulties. The intelligent controllers based on fuzzy, ANN and PSO techniques are developed. The fuzzy logic controller's performance is better than conventional controller. The fuzzy-neural controller designed from the knowledge of input-output data, exploiting fuzzy curves approach for determination of rules and significant input and provides good performance. A Choquet fuzzy integral controller with non-additive fuzzy model and lesser computational burden is developed. This controller gives encouraging results for both dynamic response and disturbance rejection. The thesis explores an evolutionary technique to train fuzzy controller. A PSO-trained fuzzy controller is developed and implemented on the plant under study. The work carried out in the thesis gives a detailed account of performance comparison of all the mentioned LOS stabilization controllers.