Abstract

Several currently planned space missions consist of a set of micro-satellites flying in a formation. This enables a much higher functionality of the mission compared to missions consisting of only a single large satellite. On the other hand, this introduces several new problems, especially in the handling of the formation. Besides their geometric structure, the formation of micro-satellites also has a communication network among the micro-satellites which is the basis for the cooperative behavior of the micro-satellites in order to accomplish the overall aim of the mission.

The first part of the research has resulted in the development of a new control law for the controlled formation flight of micro-satellites in the halo-orbit proximity. In this process, we also address the issue of stability of the formation based on the Laplacian eigenvalues, modified stability radius, and hence, evaluate their performance. The central problem addressed by this thesis is the problem of constructing an efficient non-linear control law while considering the topology of the communication network of the micro-satellites. The topology of this communication network can be a bottleneck in the operation of the formation because the transmission of information and the efficient coordination of the formation relies on this topology. This is particularly the case for a large number of micro-satellites in the network. We consider the modified and a new developed structured stability radius for the formation of micro-satellites to analyze their behavior in response to some destabilizing factors which are the case in the most realistic scenarios where the micro-satellites are deployed. Finally, we achieve the non-linear control law which includes the "formation keeping control" and "leader follower control" to achieve the efficient controlled formation flight in a periodic orbit which is a result of solving the Hill's equation.

In the second part, we derive a multi-level multi-metric clusterization technique to solve the problem of accommodating larger number of micro-satellites in the formation while maintaining the required small distances for optical interferometry. We consider the sensor network of the micro-satellites which result due to the inter-micro-satellite sensing and also the sensing of the outer-space data by the space telescopes. We derive a hierarchical multi-metric algorithm for the clusterization of the micro-satellites in the formation. We achieve the desired goal of hexagon of hexagons and further on if required by our clusterization algorithm and compare it with the traditional greedy algorithms to show it efficiency.