

Dr. Shai Arogeti, Ben-Gurion University

Unique Configurations of Drones – Model Development and Control

In this talk, we will present two unique Configurations of drones, developed at our lab. The talk will begin with the basic control principles of drones. Then we will focus on the following two configurations.

1. String of Drones for Load Carrying When a point-load is carried by a group of drones, it generally involves counteracting forces that deteriorate energy efficiency. To prevent this, we propose an innovative carrying configuration that is based on a string of drones. Each drone is connected to the drone below by a cable, and the lowest drone is connected with the load. The string is controlled such that the point load follows a desired trajectory.
2. Tethered Drones for Precise Maneuvering Tethered drones are physically connected with a ground system. In the current case, the drone is connected by a tether to a ground active mechanism. Under the assumption that the tether is kept taut, a full autonomous flight can be designed, where the tether functions as the drone's position sensor. The main challenge here is to design an optimal control law to the aerial-ground unified system that takes physical constraints into account.

Dr. Hector Rotstein, Rafael and Dept. of EE, Technion.

Vision-Based Terrain Aided Navigation

joint work with Ehud Rivin and Amir Geva

Terrain Navigation was invented in the late 1950's motivated by the need to limit the growth of inertial navigation errors as required by the cruise missiles flight control of that time. The first method developed was called Tercom (TERrain COntour Matching) and was based on correlating a Digital Terrain/Elevation Map (DTM/DEM) with a collection of on-line height-over-the-terrain or "clearance" measurements obtained using a radar altimeter. Research in Tercom and its Kalman-filtering tracking variation SITAN was more or less abandoned on the early 1980's due to the advent of the Global Positioning System and the intrinsic difficulties of a method requiring the existence of a reliable terrain data base which was hard to keep updated when most required.

More than a decade ago, the dangers of absolute reliance on GPS prompted a terrain navigation comeback, with research concentrating on improved estimation schemes that remove some of the drawbacks of the classical solutions. Alternatively, vision-based navigation was proposed as an altogether different method for dealing with inertial divergence. As such, several structure-from-motion algorithms were developed with mixed success, given that the resulting navigation errors still grow with time. In order to eliminate this growth an external source of information is required prompting a renewed interest in digital terrain maps. Emphasis, though, has changed: not cruise missiles but pervasive flying platforms like quadcopters provided with low quality inertial measurement units, and image acquisition systems instead of electromagnetic altimeters. This gave rise to vision-based terrain aided navigation, which combined two or more image frames and a digital terrain map as a replacement of GPS.

The purpose of this presentation is to provide an overview of vision-based terrain navigation including the Correspondence and DTM constraint that extends standard Epipolar Geometry, and modifications to the Bundle Adjustment algorithm that incorporate altitude over the terrain conditions in a natural manner. Some recently developed conditions for the uniqueness of the solution will be discussed that applies to both the two and multiple-view approaches showing how the ambiguity intrinsic to image-based methods is eliminated under normal conditions when using terrain constraints. The presentation will revise some central developments and also showed results obtained when using the algorithms in practice.

Prof. Arie Levant, Depart. Of Applied Mathematics, Tel-Aviv University
Homogeneity Approach to Mathematical Black-Box Control

The most basic, and still one of the most challenging control problems is the output regulation of a black box with a single (numeric) control input and a single (numeric) output. The mathematical model of the process is not available, and only some basic assumptions are postulated.

The presented strategy is based on the theory of homogeneous sliding modes. The control can be done as smooth as needed. It is produced in real time basing on a number of the real-time-calculated time derivatives of the output. The same control is demonstrated to be efficient in keeping a car to a given route and regulating the blood glucose level of a living rat.

The presented strategy requires practical high-order differentiation.

A finite-time-exact arbitrary-order real-time differentiator is demonstrated that requires only two parameters: the differentiation order n and a fixed upper bound for the absolute value of the $(n+1)$ th-order input derivative. In the absence of noises it produces n exact input derivatives. The differentiator is robust to small noises, noises of small average values, delays and digital errors.

The proposed universal control algorithms are ready to use, do not require much calculations, and can be easily applied without understanding the underlying mathematical theory.

Prof. Yoram Halevi, Dean of Faculty of Mechanical Engineering, Technion
On the role of infinite dimension transfer in modeling and control of flexible structures

Flexible structures are described by partial differential equations which is neither common nor convenient starting point for control design. Seemingly that can be circumvented by finite dimension approximation such as Finite Element Method (FEM) or truncated modal model. However there are two major disadvantages to that. First, very large orders are required for reasonable accuracy, and secondly all physical insight is lost. In this work a different approach is taken and the system is represented by accurate, infinite dimension, transfer functions from actuation to measurement. These transfer functions are used to derive the absolute vibration suppression (AVS) which is a dedicated control method for flexible structures. In case of the one dimensional wave equation, the transfer function consists of pure time delays and low order rational terms and the AVS controller is rational. In all other cases, the transfer functions and consequently the controller are fractional order in both the delays and the "rational parts". The paper considers physical aspects of the model and the control scheme including stability, performance and implementation.

Prof. Eli Gershon, Faculty of Engineering, HIT
Advanced topics in the control and estimation of state-multiplicative noisy systems

The field of state-multiplicative stochastic noisy systems has matured over the last three decades where in the last decade the control and estimation of such systems has been focused on delayed systems. In the latter systems, the delay may be fixed or time-varying and it may resides in the systems states and the input channel. In the time-varying case the delay is characterized by upper bounds on both its size and its rate of change. In this talk, recent advances in the said field will be presented starting from improved solutions for the problems of robust control and filtering for uncertain stochastic state-multiplicative systems and continued to their delayed counterparts. Both continuous and discrete-time systems will be considered where the various solutions are achieved using simple Linear Matrix Inequalities (LMIs). Some practical engineering oriented examples taken from various fields (including aviation and process control) will be presented