Book Review

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Advances in the Astronautical Sciences, edited by David B. Spencer et al. Published for the American Astronautical Society by Univelt, Inc., P.O. Box 28130, San Diego, California 92198, 2002, pp. 2592, $450.

The volume encompasses several topics of interest to Astrodynamics community covering not only orbit determination, navigation and trajectory optimization but also providing details of attitude stability, dynamics, control and determination for past, current and planned LEO, GEO and interplanetary missions and tethered satellite systems. Theoretical developments from several researchers worldwide and the practical experience of operators of spacecraft missions, viz. JPL and NASA to university students have been reported in this volume. Of late, the concept of formation flying/constellations of spacecraft has emerged as a new tool in space applications. This demands new methods and strategies in understanding the spacecraft dynamics, estimating the trajectory, maneuvering and controlling the cluster together. Several articles have been reported covering this topic. There are some new topics reported which are fundamental in nature (for example, application of dynamical systems theory in obtaining libration orbits) and others that are numerical in development (for example, Gauss-Jackson and ENCKE numerical integration procedures) which require further investigation for application in real missions. A topic by topic review of this volume may be cumbersome; however, in the following, some salient features reported in certain areas/topics are touched upon.

Atmospheric drag is a predominant error source in the force models of precision orbit determination (POD) of LEO satellites. By launching a CHAllenging Minisatellite Payload (CHAMP) with a Spatial Triaxial Accelerometer for Research (STAR), the effect of nongravitational forces (read aerodynamic force) on a LEO satellite is measured. The accuracy is determined by comparing the measured to the predicted accelerations. There are three very good articles on this topic. In another effort to improve the density models, a neutral density model NRLMSISE-00 is generated. Also, this model includes the effect of extreme ultraviolet (EUV) radiation as a source of density variation. A complete section is devoted to neutral density, elaborating various efforts in this direction. Some specific theoretical developments such as (i) a new Guass-Jackson predictor corrector numerical integration for orbit propagation and (ii) a coupled orbit/attitude trajectory generation by ENCKE-type numerical integration have been included in a section devoted to orbital mechanics. Further, the efforts current on the thinking of Astrodynamics standards and standard space mechanics tools have also been brought out in two well-written articles.

GEO Collocation is another interesting section where details of GEO satellite collocation strategies are presented. The methods are classified into: (i) Sun-pointing e-i method and (ii) halo formation method. The more popular method at this point is the former though when the number of collocated satellites is greater than 3 (collocation of 5-7 GEO satellites possible) the minimum relative distance is undesirably small. Occultation also occurs. Further, this method is computationally intensive as numerical search is necessary. The material in this section can be used as a good reference for this activity.

Several articles dealing with attitude control, attitude dynamics, guidance and navigation appear in as many as four sections. The topics of interest in attitude are estimation of inertia parameters and misalignment of sensors, gyro calibration methods and designing various attitude filters. Linear and nonlinear control strategies to tackle rigid and flexible modes of satellites and manipulators are reported in the control and attitude dynamics sections. In guidance, navigation and control section, two topics, namely, (i) potential function guidance scheme and (ii) navigation using landmark identification are of interest. The article on autonomous orbit and attitude control for PROBA demonstrates the space autonomy for Earth-observation minisatellites.

Another topic that had wide coverage in this volume is exploration of the solar system. The articles mainly deal with the exploration of earth and lunar missions, Mars, Venus, Mercury and asteroid EROS (NEAR Shoemaker) missions. In two sections, the utility and design of libration orbits around L1 (Solar Heliospheric Observatory-SOHO)/L2 (Next Generation Space Telescope- NGST) libration point of Sun-Earth system using dynamical systems theory are explored. Approaches and algorithms to autonomous aerobraking at Mars are covered in a section. In yet another section, details of new Mars s atmospheric model, OD uncertainties due to Mars gravity models and Mars approach navigation using optical data are discussed. A mission to map and land at EROS, a nearby asteroid, by NEAR Shoemaker satellite has proved many a technologies. Some of them are: a two-year orbit of DV and Earth Gravity Assist (DVEGA), near real-time determination of physical properties of EROS such as mass, gravity field, inertia tensor, spin rate and rotation pole orientation, a controlled descent to EROS with 1.5-1.8 m/s impact velocity and optical navigation using altimeter crossover for an irregular body. This experience seems to be a very valuable one.

Formation flying is a revolutionary tool and is extremely powerful for space-based explorations. Associated challenges such as (i) trajectory estimation for clusters, (ii) constellations for a zonal coverage and constellations to minimize revisit time, (iii) station keeping of clusters and (iv) usage of tether in controlling spacecraft formations are highlighted in four sections. There are valuable papers on collision avoidance tracking and detecting facility of the Naval Space Surveillance System named FENCE which catalogs debris. The insight provided by FENCE about the Earth atmospheric variability effect due to solar storms has been found to be informative. In yet another section, the intricacies of orbit and attitude determination of Tethered Satellite Systems (TSS) are studied. The section on Earth and lunar missions brings about new technologies such as tugboats for resupply of materials to International Space Station (ISS) and service vehicles for on-orbit station-keeping and repositioning for GEO satellites.

Overall, the volume reports the latest happenings in this field in three parts. It is heartening to note that university participation in building nano-satellites such as ION-F-Hokiesat has created greater awareness among undergraduate and graduate students about the challenges of spacecraft technology. It is imperative that those who work in space industry as well as every university library should have a copy of this volume for reference.

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Book Review

Probabilistic models of the brain: Perception and neural function

edited by Rajesh P. N. Rao, Bruno A. Olshausen and Michael S. Lewicki. A Bradford Book, The MIT Press, Cambridge, MA 02142, 2002, pp. 324, $50.

The book contains a systematic presentation of some of the current probabilistic approaches to understanding perception and brain function. The 16 chapters of the book are drawn from presentations made at a Workshop on Statistical Theories of Cortical Function held as part of the Neural Information Processing Systems Conference in December 1998 as well as invited contributions from other researchers in this field. The topics covered are primarily in the areas of probabilistic and information theoretic models of perception, theories of neural coding and spike timing, and the development of receptive field properties from natural signals. The sixteen chapters demonstrate how ideas from probability and statistics can be used to interpret a variety of phenomena, ranging from psychophysics to neurophysiology.

The chapters in the book are organised into two categories. The first approach emphasises computational algorithms rather than the details of the underlying neural machinery. Part I of the book on Perceptron has eight chapters to construct the probabilistic theories of the brain. The approach adopted in these chapters has been followed in psychology, cognitive science, and artificial intelligence. The second approach formulates the theories of brain function and is manifested in Part II of the book entitled Neural function, containing eight more chapters.

The book will be of great interest to researchers in computational and cognitive neuroscience, psychology, statistics, information theory, artificial intelligence, and machine learning. An exposure to elementary probability and statistics, together with some knowledge of basic neurology and vision, should be adequate for an understanding of the book.

Research in the area of developing probabilistic models to explain behavioral and neural response properties exhibited by the brain is still in an evolving stage. Such models are general, rich enough to provide a global framework for vision, from low-level sensory coding to higherlevel object recognition and detection. A very interesting feature of the book is a collection of several open questions such as, how does the brain represent probabilities, how does the brain deal with noise, should neurons be deterministic or stochastic elements, etc.

On the whole, this is an excellent collection of papers dealing with computational models of brain.

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Book Review

Ten lectures on random media

by Erwin Bolthausen, Alain-Sol Sznitman, Birkhauser Verlag AG, P. O. Box 133, CH-4010 Basel, Switzerland, 2002, pp.128, sFr.42.

In a variety of probabilistic models, a typical feature is some diffusion-type mechanism taking place in an inhomogeneous medium. The traditional point of view of probability theory has been to regard the motion of the diffusing particle to be random. Though such an approach has been very fruitful, it has limitations. In situations where certain materials have defects or inhomogeneities, it is more realistic to assume that the medium is random in addition to the motion; such situations arise in diverse fields like condensed matter physics, physical chemistry, oceanography.

Randomness in the medium results in unexpected effects, particularly concerning asymptotic behaviour; what often in the beginning was deemed to be a simple toy-model ended up as a major mathematical challenge . A striking example is the one-dimensional random walk in random environment with site randomness. In this case, p(x,w), x e are i.i.d. random variables (as functions of w) taking values in [0,1]; the parameter w indicates randomness in the medium. For any given realization w of the environment, {Xn} is a Markov chain with probability p(x,w) of jumping to the right neighbor x + 1 and with probability 1 - p(x, w) of jumping to the left neighbour x - 1, given it is located at x at present. The law of large numbers in this case, even with an ergodicity assumption on environment, is quite different from what happens for asymmetric nearest neighbour simple random walk; a curious reader is invited to look at Lecture 1 of the book under review. Of course, about two decades of research in this field has resulted in a few paradigms and some general methods.

The book under review in fact consists of two minibooks, which grew out of the DMV lectures on Random Media given by the authors at the Mathematical Research Institute in Oberwolfach in November 1999; both the authors are well-known probabilists. The first five lectures, by Sznitman, concern random motions in random media; only discrete models are considered. The next five lectures, by Bolthausen, are on mean-field spin glasses.

The lectures by Sznitman advertise two general ideas, viz. the point of view of the environment viewed from the particle , and the preponderant role of pockets of atypically low principal eigenvalues . The ideas are elucidated using three models: random walk in random environment with site randomness, with bond randomness, and random traps. An ergodicity assumption is imposed on the environment; in the first two lectures, law of large numbers and central limit theorem for random walks in random environment are discussed. Some ideas from homogenization problems for diffusions influence the development. Long time survival for random traps are studied in Lecture 3; focus is on annealed quantities. Multidimensional random walks in random environment are considered in Lectures 4 and 5. Since questions concerning recurrence and transience are not well understood, a transience-like condition (called condition T) is imposed, and a functional central limit theorem is proved; some large deviation estimates are also analysed for certain exit distributions and the connection with small eigenvalues pointed out.

The lectures by Bolthausen highlight the mathematical challenges associated with the celebrated Sherrington-Kirkpatrick model of spin glasses. Existence of free energy for the model at high temperature with zero or nonzero magnetic field is established in Lectures 6 and 7. As a mathematically rigorous proof of existence of free energy at low temperature is still eluding, the last three lectures present some attempts to understand the low temperature regime. Lecture 8 deals with the random energy model; in this model the gaussain random variables occurring in the Hamiltonian of SK model are taken to be independent, and free energy is shown to exist even for low temperatures. Lectures 9 and 10 discuss a generalized random energy model and a related Markovian clustering process.

The lecture notes maintain an informal style, and the authors make no claim to completeness or even an overview. However, as the contents concern fields which are fast growing the book should be of interest to probabilists and mathematical physicists. Graduate students in probability theory are especially urged to take a careful look at the book and related literature.

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