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Book Reviews

Guidance and control 2000 edited by Robert D. Culp and Eileen M. Dukes, Advances in Astronautical Sciences, Vol. 104, published for the American Astronautical Society by Univelt, Inc., P.O. Box 28130, San Diego, California 92128, 2000, xiv + 724, $130.

This volume is a compilation of papers presented at the 23rd Annual American Astronautical Society Guidance and Control Conference, held at Breckenridge, Colorado, in February 2000. This is an annual event where astronautical scientists and engineers from all over the world gather to present and listen to papers on guidance and control as they apply to astronautical sciences. The papers in this volume are categorized under various sections depending on the session titles.

The first group is under the heading 'Advances in guidance and control' and has seven papers. The paper by Goodzeit *et al.* discusses a fault-tolerant attitude control system for a geosynchronous communications satellite, based on a redundancy management system that detects and corrects attitude control system components. In the next paper, Kasdin discusses the development of a two-step optimal filter for nonlinear recursive estimation and shows its effectiveness in reducing the estimation error in comparison with different forms of extended Kalman filters. The paper by Cuzen *et al.* describes a system for automated rendezvous and capture for spacecraft in Earth orbit, developed by NASA, and presents the official system test results. The next two papers address issues related to enhancement of the lost-in-space capability through more effective attitude-determination strategies. The paper by Ju *et al.* addresses the attitude-determination problem in the absence of any prior attitude information using a star pattern recognition algorithm. Chapel *et al.* too address the problem of attitude determination for the Mars Climate Orbiter using a star tracker camera and a stellar compass software operating on a pattern-matching principle developed specifically for this purpose. The paper by Hubert addresses the issues involved in the dynamics of mechanical reconfigurations of the Genesis spacecraft. The last paper in this section is by Schneeberger *et al.* and addresses the design of fire control systems for high-energy laser applications in terms of precision-pointing requirements.

The next set of papers appears under the heading 'Formation flying and constellations' and addresses challenging issues concerned with spacecraft flying in close and precise formations. The first paper is by Lawton *et al.* and considers the problem of rotating a group of spacecraft about a fixed axis while maintaining relative spacecraft alignment. The paper by Alfriend *et al.* addresses the effect of gravitational perturbations, nonlinearity, and circular orbit assumption on formation-flying strategies. The next paper by Yan *et al.* considers the problem of relative position control for multiple spacecraft formation flying using a Lyapunov-based adaptive control technique. The paper by Stevens *et al.* describes the development of formation-flying control strategies for the Gravity Recovery and Climate Experiment (GRACE) mission, designed to produce a new model of the Earth's gravity field. The next paper by Quinn *et al.* proposes a novel concept based on tethered formation flying to be used for an experiment conducted to answer fundamental questions about evolution of

the universe. Busse *et al.* discuss the differential GPS-based navigation system for formation flying. Mesbahi and Hadaegh discuss logic-based switching for formation flying for optical interferometer applications.

The next set of papers is on the topic 'Guidance and control issues for the International Space Station'. The first paper by Lee describes the assembly stages of the guidance, navigation, and control system for the International Space Station (ISS), while the paper by Bedrossian discusses the control challenges that arise in the assembly process. Abdel-Motagaly *et al.* report studies on the attitude control system design for the crew return vehicle for the ISS. Green, in his paper, addresses the design of thermal radiator pointing system for the ISS to ensure maximum heat-rejection efficiency. The paper by Chamitoff *et al.* presents a design for command maneuver optimization for higher fuel efficiency.

The topic 'Guidance and control storyboard displays' has papers on adapting a spaceborne geolocation system for airborne experiments by Hope *et al.*, development of a new Sun sensor called Nanosol by Glaberson, and development of a star tracker for the naval satellite NEMO by Marsei *et al.* The next four papers are based on developmental work carried out at the Honeywell Space Systems and describe a novel design for reaction wheel assembly component of satellites by Marshall *et al.*, design of a redundant launch vehicle guidance unit having enhanced fault-tolerant architecture by Wright, development of a radiation-resistant processor by Campbell *et al.*, and design of a redundant architecture for a laser gyro-attitude reference system intended for use in long-life satellite missions by Moulton *et al.* The next paper by Bialke is on turbo-charged torque wheels to meet higher torque demand by using a momentum storage technique. Goodwin *et al.* describe the preliminary design efforts involved in developing an interferometric fibre optic gyroscope. Overbeek gives a blow-by-blow account of how the Solar and Heliospheric Observatory (SOHO) lost contact with the earth station and was almost lost in space, and how it was finally recovered by expert monitoring of the orientation of its solar panels. Rullman *et al.* describe the design of a GEO earth sensor and Unwin and Oldfield the design of a spaceborne GPS receiver. The next paper by Dalton *et al.* describes an experimental sounding rocket designed by students at the University of Colorado. The last paper in this set by Wiegand *et al.* is on inflight performance of a magnetic torquer assembly flown on the German satellite ABRIXAS.

The section on 'GNC technology for micro/nano spacecraft' has several papers on this interesting and currently emerging area of space research involving miniature satellites. The first paper by Chavez and Schmidt is on the operational issues involving formation flying of two hypothetical nanosatellites. Gambino describes MEMS rate sensors that are crucial components in nanosatellites. The paper by Underhill *et al.* describes a nanosatellite designed and built by students at the Arizona State University. Benton and Itchkawich's paper describes the attitude control system design for the Mightysat I satellite. The paper by Connelly *et al.* covers certain aspects of design of sensors for guidance, navigation and control using MEMS technology for use in micro and nanosatellites. Landes and Bottcher-Arff present the design of digital reaction wheel assemblies for use in small spacecraft. Anthony and Patel present the design of an attitude control system for an interplanetary spacecraft.

The final section contains a mix of papers under the title 'Recent experiences in guidance and control'. Wertz *et al.*'s paper is on autonomous orbit control of the UoSAT-12 satellite,

while Spath and Eckart discuss the critical problem of fuel optimization for aerobraking during the Mars mission. Attitude control system initialization for the QuikSCAT satellite is the topic covered by Hegel and Mitchell and the performance of the pointing control system of the Chandra X-ray observatory was discussed by Quast *et al.* Robertson *et al.* describe the fascinating step-by-step procedure that was designed and used to recover the TOMS-EP satellite that had gone into a safe mode and stopped functioning. The last paper by Barker and Lange details the operational experiences with the Globestar satellites.

The proceedings of this series is remarkable in that most of the papers in it give a first-hand account of real engineering problem faced by space scientists and engineers. To a researcher they provide an invaluable source of case studies and practical problems of real concern that will eventually form the basis of testing and proving the efficacy of many theories for guidance and control of spacecraft. One of the most interesting aspects of this particular volume is that the papers describe serious student projects undertaken in university laboratories for implementation in actual missions.

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History of rocketry and astronautics edited by Herve Moulin and Donald C. Elder, AAS/Univelt, P. O. Box 28310, San Diego, California 92198, USA, 2003, pp. 358, $85.

The 30th IAA History Symposium was held at Beijing, China, as part of the 47th International Astronautical Congress. The proceedings of the symposium is now available in print. It contains 20 papers from eleven countries and covers a very broad spectrum of subjects and various time periods. Following recent tradition, the papers do not appear in symposium order, but arranged, for the reader's convenience, by topic into three sections consisting of 'Pioneering work,' 'Unmanned applications,' and 'Manned projects' having 4, 11, and 5 papers, respectively.

The history of any scientific or technical subject is interesting since among other things it leads to humility while admiring the contributions of the pioneers generally under trying conditions of technical, physical, and human behavior which has not changed since time immemorial. It also provides a hope that one can also contribute in a small way when so many have succeeded. Also history shows the way many problems have been overcome. The present collection of papers contains typical examples of the above features. This review has followed a style that hopefully excites the people to read the original proceedings.

The first paper by Frank H. Winter describes the fantasy phase of astronautics involving carnivals and other highly popular shows up to about 1915 all over US and Canada like the 'Trip to the moon' based on simple, mechanical and electric scenic productions. The second paper by Karlheinz Rohrwild deals with another pioneer Hermann Oberth, one of the trio of rocketry. After unhappy experiences with the German 'Society for Space Travel', Oberth moved to Romania where the king offered him facilities to continue his experiments. He

claims to have launched his rocket in 1935. The verification of these claims came through a letter in 1995 from Mr Togan of Medias, who had met a 76-year-old woman named Mrs Elene Ciurescu who had seen Oberth launch his rocket and the students of Stephen Ludwig Roth school. A letter sent to Romania with many questions revealed unknown facts such as the launch of rocket by Oberth in 1935, which was witnessed by about 70 people including the commander and students of the flying school, at its airfield, on a beautiful day with clear skies, and fuelled to reach a height of 7 km. The third paper by Gazenko deals with Tsiolkovsky, the father of astronautics. In spite of severe scarlatina complicated by hypoacusis when about 10 years old this self-taught pioneer studied and thought of most problems of the present-day space flight. These include experiments on insects and chicken to determine their tolerance to acceleration, selection and training of space crews, the working environment, regeneration of cabin air, arranging food and water supplies, and utilizing human waste in a spacecraft. He also indicated that the problem of microgravity can be handled by creating 'artificial gravity' by spacecraft rotation. The only problem left out was radiation, which was unknown at that time! The fourth paper by Sokolsky *et al.* on pioneers provides the background for the initiation of the study of the history of rocketry and astronautics in the International Academy of Astronautics to provide scholarly studies on various aspects of developments in different countries from the earliest times. It also describes all the previous publications.

The fifth paper by Jacques Villain narrates the successful cooperative development of ARIANE by the Europeans. Both USSR and USA launched their first satellite in 1957 and 1958, respectively. Success came much later to France (in 1965) and to Britain (in 1970) though these inherited the rocket knowhow in 1945. However, only failures occurred in the field of launchers to place geostationary satellites. The tough conditions posed by the USA for launches and even prohibiting commercial uses of satellites forced Europe to develop the ARIANE launcher independently. After some initial failures it eventually achieved success as a reliable and regular commercial venture and reached a market share of more than 50% in 1985. The success was achieved in spite of different languages, changing governments and work cultures among the participating countries. The author however notes that the end of communism, and the expected entry of Chinese Long March, Japanese H2A, and the Indian GSLV posed problems to ARIANE. Thus space has moved from exploits to an industrial activity in its own right. The sixth paper by Julius H. Braun considers the first flight of the US Army's Redstone missile in the early 1950s, which was similar to the German V-2 rocket. It was a failure but as is usual each one of the specialist groups blamed the other. But at the insistence of Dr Von Braun everybody in the pre-launch activities had to recount what they had done. It turned out that a guidance technician using a screwdriver put a tightening screw on every screw he could reach and unfortunately one was a previously adjusted trim potentiometer in the roll control system. This caused roll instability and subsequent tumbling of the missile. The author recalls Gavin on the development of Apollo Lunar Module. "There are no random failures. All failures have a cause that can be found and fixed. In 10 years, we tabulated 14,242 failures or anomalies of which only 22 defied satisfactory understanding." Protective management showing patience and support helped Redstone program to become one of the most reliable ever produced. The seventh paper by John Becklake reveals the enthusiasm of the Allies after the Second World War to develop

a supersonic fighter or at least faster than sound. Most supersonic tunnels were in Germany but none working in the critical transonic region. Thus the necessity to obtain the aerodynamic data by scaled aircraft models dropped from an aircraft was pursued by Britain. After many unsuccessful trials during 1947 and 1948 to ignite the rocket motor to propel the model to supersonic speeds the Transonic Model Aircraft project was cancelled following one successful flight. In the meantime, Chuck Yeager of the USA had attained a speed of Mach 1.06 on his rocket-propelled Bell X-1 aircraft in October 1947. The eighth paper by Chen Shilu *et al*. is on the progress of the space activities in China through the developments of a series of Long March launchers to place satellites from LEO to GEO. China has also launched multiple satellites of other countries as well. The ninth paper by Yasunori Matogawa describes the solid rockets of the Japanese in Second World War whose development dates back to 1930s. The enormous shortage of ordinary guns led to providing rocket guns which are easier to produce and carry. The rocket bomb and its launcher called, respectively, as 'Funshin-dan' and 'Funshin-lo' were a set of official weapons possessing a range of charge and range capacity. During the last stages of the War a surface-to-air missile as well as a rocket-propelled piloted glider with a bomb in the nose were also available. The tenth paper by Shatalov describes how the military rocket base facility in USSR with the secret name 'Angara' became in 1966 the world's most intensely working 'Plesetsk' cosmodrome. In the middle of its construction in 1959, Nikita Khrushchev introduced a resolution to stop building the facility, though was resisted by one Barmin from a military point of view. But for this, the world would not have had a cosmodrome accounting for half the space launches of the world. In 1966, when Cosmos 112 was launched the military facility became a cosmodrome. The eleventh paper by Huang Jianding and Ye Dingyou covers the systematically developed solid rocket motors in China all the way in size and capacity from those used in sounding rockets to help launch geostationary satellites. They also claim a record of no failures with high reliability. The twelfth paper by Philippe Jung dwells on the interesting feature, namely, France, employing the Germans for propulsion work, launching hundreds of French rockets of all types in the 1950s, of all places on the beach of Cannes close to the film festival palace! These consisted of anti-aircraft training vehicles, rockets, fastest airbreathing ramjets which provided many world altitude and speed records. All these 1100 rockets and missiles were developed by a team peaking at a mere 400 in 1958! The thirteenth paper by Theo Pirard reviews the heritage of Peenemunde in Egypt, Zaire, and Libya. The development and termination of rocket programs with space ambitions in these countries with engineers who were involved in V-2 rocket has been mainly due to bad technical design of being too heavy and no good guidance systems as well as the political pressures on Germany to stop supporting these activities. The fourteenth paper by Herve Moulin is a short description of the French D1 satellite program. The experiments helped to study the Van Allen radiation belts, and compare Doppler, laser echo, and photographic methods for geodesic information as well as the position of a satellite with one meter precision. The fifteenth paper by Boris V. Rauschenbach reviews the stability of a rocket flight. Some had earlier located the rocket engine in front to pull the vehicle, which however led to many more difficult aerodynamic flow problems. Robert Goddard had tested a gyro-stabilized rocket in 1935. Finally, it was Von Braun who turned the basically unstable rocket into a stable system following curvilinear trajectory with a control system and paved the way for space rocketry.

The sixteenth paper by Oleg A Sokolov discusses the unrealized Soviet manned lunar program. The initial Soviet project 'Soyuz' was to assemble it in LEO followed by circumlunar orbit with one to three men. However, with the Apollo achievements becoming clear, a direct space flight to Moon was favored, but a large number of failures halted the project. Later, the 'Soyuz' docking project was pursed and success was achieved without any relation to the lunar program. The seventeenth paper by Shirley Thomas reviews the Apollo capsule tragedy on the ground during simulated experiments. It brings out the surprising 'blind spot' in the design all the way from the Mercury and Gemini days, namely, pressurizing the capsule to 16.7 psia to avoid buckling with pure oxygen on ground when an accidental fire would set of an inferno. Further, the escape hatch needed 90 seconds to open! The same pure oxygen would not burn a candle in space due to lack of convection without gravity. The cabin pressure in space was to be 5 psia equivalent to flying at just under 30,000 feet altitude. The Soviets used a mixture equivalent to pure air in their orbiting spacecraft and thus a procedure was evolved for the docking of their spacecraft with the US spacecraft. Though NASA had specified the test procedure much bitterness followed between them and the North American contractor. However, the latter was vindicated by their winning the next important job for the Space Shuttle. The eighteenth paper by Valentina Ponomereva and Debra D. Facktor describes how the first team by five women cosmonauts was recruited and trained. The final selection between Tereshkova and Ponomereva both of whom had supporters higher up was decided by Premier Khrushchev who chose the former based on her looks and was a 'working class representative' fitting his ideas of the socialistic state. It was not the lack of funding or 'male chauvinism' that led to skepticism about human flights involving women but that is of Tereshkova not being able to manage her flight properly. Another cosmonaut flying a different vehicle while communicating with her felt she was crying. She used up almost all fuel for experiments and for emergency and her flight was cut short and everybody was happy when she landed safely. It took nearly 20 years before another Soviet woman had a space flight. The nineteenth paper of Christian Lardier describes that from 1957 to 1991 the conquest of space in USSR was a complete secret. The name of Korolev revealed only at his death in 1966 marked the beginning of active research to identify Russian designers in the space program. Fragmentary information based on memoirs, membership of academic bodies, state decorations helped to locate some. So much so when the idea of awarding the Nobel Prize to the creator of Sputnik-1 arose, Khruschev refused to reveal the identity of Korolev who had received many national honors but did not get the due international recognition. The last paper, the twentieth, recounts the work of Prof. Cotton of Australia who did pioneering work during the 1940s in developing anti-g suits for fighter pilots and disseminated the information all over the world which ultimately helped in the design of the spacesuit.

This book is strongly recommended for engineering professionals and students and in particular for those in aerospace engineering. Some lessons to learn from these papers are; (i) the need to follow an independent policy, (ii) it is never too late to start, and (iii) failures and accidents are part of the eventual achievement. In our own country with all the noteworthy progress and achievements in aeronautics and aerospace, archiving the historical development is ignored. It is strongly urged that historical material be written by people closely associated with these activities. If this is not done soon it would make the life of

later historians difficult or even miserable. Archiving is a must so that proper recognition is given to persons involved in such difficult pursuits which cannot be quantified through normal scientific publications.

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Readings in the machine translation edited by Sergei Nirenberg, Harold Somers, and Yorik Wilks, The MIT Press, 55, Hayward Street, Cambridge, MA 02142, USA, 2003, pp. 413, $55.

As a researcher and teacher of machine-translation(MT), I enjoyed going through the collection of articles in the book and I congratulate the editors for having done a great job and for rendering great service to the MT community. MT has come along way with lots of interesting ups and downs in the last five decades. The journey has not been smooth. MT research has both contributed to as well as gained from the research in knowledge representation, artificial intelligence and computational linguistics. This book is a collection of articles which may be considered as early landmarks or stepping stones both in terms of success and failures/limitations.

This book is not meant for beginners, nor for MT developers or MT users. This requires an a-priori knowledge of what the problem of MT is and what are the open issues. Some knowledge of history of MT will help sailing through the articles. To quote the editors: What this book is NOT: 'This is not an introductory book on MT… Nor it is a review of the history of MT. .. not attempted to provide an extensive bibliography.' What this book IS: '… much-cited articles, especially older papers, which are *difficult to find.*'

Thus this volume of collection of articles is primarily meant for well-initiated researchers, teachers and students of MT. The entire collection is divided into three parts: i) Historical, ii) Theoretical and methodical issues, and iii) System design. The historical section spans through the classical articles of Warren Weaver, the (in)famous ALPC report and more. The section on theoretical and methodological issues cover the classical articles on sub-language and controlled input, aspects concerning machine-aided translation, meaning and knowledge representation, approaches to multilingual MT, relationship of analysis and generation, and the role of heuristics. Finally, in the section on system design, the editors have picked up early works on knowledge-based, statistical and example-based approaches, and computational issues. Obviously, Section 3 overlaps with the other two sections. This section is probably the most difficult one in terms of selections and detail. The reader may get a little disappointed here. MT system design is a difficult problem in itself and involves a period of time over which it may get revised. So the reader should only expect to get an overall idea about the system design. The articles span from the early works on survey to speech translation.

In general, the editors have selected articles based on their historical significance and also how obscure it is for the readers. The choice has obviously been influenced by the individual *taste* of the editors. No description of individual systems has been provided.

The readers are advised to first read the 'Introduction' provided at the beginning of all the three sections of the book. This gives a fairly good idea about the nature of the article if one is not already aware of.

It is interesting to note that the book is a collection of articles which the editors have considered to be *classical* written only in English. There is no attempt even to cite ancient works on Indian linguistics that have greatly influenced some of the early works.

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102 Combinatorial problems (From the Training of the USA IMO Team) by Titu Andreescu and Zuming Feng, Birkhauser Verlag AG, CH-4010 Basel, Switzerland, 2003, pp. 217, sFr. 38.

This book is aimed to broaden a student's background in mathematics so that he can successfully participate in competitions related to mathematics. The problems gradually build the combinatorial and other topics. The various applied problems selected demand an excellent exposure to problem-solving abilities. Though the book is designed towards strength building for competitions, it is also useful for researchers to sharpen their background in the area of combinatorics.

The book consists of two types of problems; the first set of 51 introductory problems and the next set of 51 advanced problems. Solutions to these problems have been provided. In a few cases, mutiple solutions too have been presented. An interesting feature of the book is that problems have been selected from diverse topics such as combinatorial arguments and identities, generating functions, graph theory, recursive relations, sums and products, probability number theory, polynomials, theory of equations, complex numbers in geometry, combinatorial and advanced geometry, algorithmic proofs, classical inequalities and functional equations. The book is bound to stimulate the interest of the reader in a variety of mathematical areas relevant to combinatorics. Whereever possible, sample applications have been considered to demonstrate the utility of these challenging problems in the context of real-life examples. It also contains a set of 39 useful references.

On the whole, this is a very useful book for anyone interested in the application of the principles of combinatorial theory.

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Control and modeling of complex systems edited by Koichi Hashimoto, Yasuaki Oishi, Yutaka Yamamoto, Birkhauser Verlag AG, Klösterberg 23, CH-4010, Basel, Switzerland, 2003, pp. 368, chF. 144.

This book is a festschrift in honour of Prof. Hidenori Kimura on his 60th birthday. The editors' preface outlines the major contributions of Prof. Kimura to the areas of systems and control over the years, followed by lists of awards and honours and his publication list. This is followed by 20 articles in areas related to his research interests, divided into five sections. These are briefly summarized below.

The first deals with signal processing and has four articles. The article by Byrnes and Lindquist considers the classical moment problem with a nonclassical complexity constraint and reduces it to a convex optimization problem. The article by T. Georgiou is in a similar vein and considers the problem of obtaining Toeplitz approximations of an empirical non-Toeplitz sample covariance matrix of a time series using Von Neumann relative entropy as a distance measure. The next two papers are on digital signal processing, dealing, respectively, with filter design based on ideas from sampled data control theory (Yamamoto and Nagahara) and design of time-domain FIR filters in continuous and discrete time (Kwon and Han).

The second set of articles deals with the issue of system identification. Of these, the first article by Milanese and Taragna takes a set membership approach to model set identification in H^{∞} framework. The other two articles, respectively, by Vidyasagar and Karandikar, and Oishi, take the 'statistical learning theory' approach to system identification, the high point of which is precise finite time bounds.

The third collection is devoted to robust control. The first article by Anderson and Bombois analyses the effect of adaptive weight change in robust controller design. The second article, by Chen and Hara, studies joint minimization of tracking and regulation error along with controller input energy. The third, which could have gone into the preceding section, is an analysis of model complexity in controller design by Tsumura. The fourth article, by Sugie, proposes a scheme for reference signal shaping under input and state constraints. The final article by Hara and Iwasaki summarizes their work on finite frequency characterization of easily controllable plants under control effort constraint.

The fourth section deals with an area of great recent interest and activity: hybrid, chaotic and nonlinear systems. The five articles under this grouping deal with stabilization of switched linear systems (Guo), well-posedness of a class of affine systems (Imura), robust stabilization of chaos via delayed feedback (Yamamoto and Ushio), deadbeat control of high-order chained systems with applications to underactuated manipulators (Mita and Nam) and control of nonholonomic systems with bad controllability structure (Sampei, Date and Nakaura).

The final section with three articles is devoted to applications. These are respectively, control of vehicles (Tomizuka), active noise control (Adachi) and high-speed robot control (Hashimoto, Namiki and Ishikawa).

This is an interesting and useful (though not indispensable) collection of articles that gives a whiff of where things are headed in certain areas of control engineering. While cov-

ering a rather broad spectrum, it still retains some focus, thanks to all articles being related to the research interests of Prof. Kimura. It's a worthy tribute to him.

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