

PREFACE

This book is devoted to modern sensors and their applications in control systems relevant to aerospace vehicles.

Two centuries ago, a person who wished to move faster than walking or running would mount a good horse and enjoy riding using all his or her sensory perceptions. Since that time, many kinds of vehicles have been created for satisfying the desire for fast and elaborate transportation. In the air, and more recently in space, considerable increases in the speed-ranges of various forms of transport have taken place, but have demanded the creation of a huge variety of sensing elements for detecting the state and behavior of the relevant vehicles.

A horse-rider does not need to supervise the function of a horse's legs, and to turn, it is enough to give a clear command via the harness. However, all aerospace vehicles demand the monitoring of many parameters and it is only recently that control systems have become sufficiently "intelligent" to relieve the pilot of constantly monitoring the behavior of those parameters and interpreting their aggregate meaning. Thus, a modern aerospace vehicle may be compared to a good horse, which itself knows how to operate each leg so as to orient its body in the direction desired by its rider.

Another example is afforded by birds, which may be considered excellent examples of "intelligent" flight control. They too can be compared with modern aircraft, which some believe are actually winning the competition with nature, and which demand near-perfect sensors and control algorithms for the realization of such phenomenal performance.

The automatic control of aerospace systems with huge numbers of operating parameters is one of the highest technological achievements of modern civilization, and does indeed compete functionally with those inherent in natural life-forms, including human beings. However, the operating principles of the various necessary sensors and automatic systems are often essentially different from those utilized in nature and form the knowledge base of leading designers and firms in the field of aerospace instrumentation. It should also be noted that the majority of aerospace sensors differ considerably from those designed for applications in automobile, ship, railway, and other forms of transportation, or those used in industrial, chemical, medicinal, and other areas. The topic of aerospace sensors therefore merits special treatment, and it is hoped that this book will to some extent fulfill this requirement.

The intent of the volume is to present the fundamentals of design, construction and application of numerous aerospace sensors, a concept born in the International Federation of Automatic Control (IFAC), especially in its Aerospace Technical Committee. An international team of twelve authors represents four countries from Eastern and Western Europe and North America, and all of whom have considerable experience in aerospace sensor and systems design.

The nine chapters in this volume cover the majority of sensors for aircraft and missiles, and many for spacecraft, satellite, and space probes. Principles of operation, design, and achievable performance for different sensors are presented along with particulars of their construction. The introductory Chapter 1 briefly reviews the characteristics of atmospheric and space environments, this knowledge being essential for understanding the operation of aerospace sensors. Material on aerospace vehicle classification, specific design criteria, and the requirements of onboard systems and sensors is presented.

Chapter 2 is devoted to modern achievements in the development of the oldest group of aircraft sensors—membranous aneroid and other atmospherically-based instruments. Flight altitude and components of speed, attack, and slip angle measurements are also considered.

Chapters 3 and 4 introduce radio-altimeters and other autonomous radio sensors for motional parameters such as ground speed and crab angle. Airborne weather sensors and collision avoidance devices are also reviewed.

Chapters 5 and 6 cover accelerometers and gyroscopes of various kinds which are broadly used as basic sensors in the construction of gimballed and strapdown inertial navigation systems (INS) and for direct applications in aerospace vehicles.

Chapter 6 was written by six co-authors and became the largest in the book. It recognizes the particularly important role of INS and separate gyroscopic sensors for aerospace vehicular navigation and motion control.

Chapter 7 presents the different aspects of magnetic, gyro-magnetic, and electronic compass design and their application to flight.

In Chapter 8, engine parameter information collection systems are considered. Fuel quantity and consumption sensors, pressure pick-ups, tachometers, vibration control, and temperature sensors are all described.

Finally, Chapter 9 is devoted to principles and examples of sensor integration. The most important facets of sensor system choice, integrated measuring system optimization, and the simulation of sensor integration by appropriate algorithms are described. The examples of sensor integration considered include the noninvariant and robust integrated metering of speed, radio-inertial measurements, airborne gravimetry, and orbital verticality.

The book is written for practicing engineers, designers, and researchers in the area of control systems for various aerospace vehicles including aircraft, UAVs, missiles, spacecraft, satellites, and space probes. It may also be used as a study guide for both undergraduate and graduate students and for postgraduates in aerospace engineering, aeronautics, astronautics, and various related areas. Moreover, it will be found useful by other people wishing to satisfy their general interest in the modern aerospace technologies that are so important in shaping our twenty-first century life-styles.

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