

Preface

Attitude measurement is key and vital for spacecraft. It guarantees accurate orbit entrance and orbit transfer, high-quality performance of spacecraft, reliable space-to-ground communication, high-resolution earth observation, and successful completion of many other missions to be conducted in space. Star sensor is the core component in the autonomous high-quality attitude measurement of in-orbit spacecraft based on the observation of stars. By taking advantage of a star's astronomical information, the star sensor method has the characteristics of good autonomy, high precision, and high reliability and can be widely applicable in space flight (celestial navigation).

Generally speaking, star sensor works in two modes, namely, Initial Attitude Establishment and Tracking. The star sensor enters into the Initial Attitude Establishment Mode when it starts working or when attitude gets lost in space due to unforeseen problems. In this mode, full-sky star identification is needed because there is no available attitude information. Once initial attitude is established, the star sensor enters into Tracking Mode. Full-sky autonomous star identification is key in star sensor technological development, which has encountered many difficulties and therefore it is a focus for research.

Star identification is interdisciplinary and related to astronomy, image processing, pattern recognition, signal and data processing, computer science, and many other fields of study. This book summarizes the research conducted by the author's team for more than ten years in this specific field. There are seven chapters, covering basics in star identification, star cataloging and star image preprocessing, principles and processes of algorithms, and hardware implementation and performance testing. Chapter 1 is a general introduction, covering basics in celestial navigation, with a discussion on star sensor method and star identification, and reviews algorithms used in star identification and the development trends in this field. Chapter 2 deals with the preliminary work in star identification, covering star cataloging, selection of guide stars, processing of a double star, star image simulation, star spot centroiding, and calibration of centroiding error. Chapter 3 is a brief introduction to star identification using triangle algorithms, with a special emphasis

on two modified examples, namely angular distance matching and the P vector. Chapter 4 focuses on star identification using star patterns, including star identification utilizing radial and cyclic star patterns, by using the log-polar transformation method, also without calibration parameters. Chapter 5 discusses basic principles of star identification using neural networks. Two methods are presented—star identification based on neural networks carried out by using features of star vector matrix and by also using mixed features. Chapter 6 introduces rapid star tracking using star matching between adjacent frames, covering star tracking modes of the star sensor method, different algorithms in star tracking, with simulation results presented and analyzed. Chapter 7, taking RISC CPU as an example, deals with hardware implementation, as well as hardware-in-the-loop simulation testing and field experimentation of star identification.

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This book is based on many years of research on star identification by the author and his team. The author wants to express his gratitude to the following people in his team—Xinguo Wei, Jie Jiang, Qiaoyun Fan, Xuetao Hao, Jian Yang, Juan Shen, Xiao Li, and many others, who have contributed to much of the work introduced in this book. The author is also indebted to the National Defense Industry Press for including this monograph in its book series on spacecraft and guided missiles.

Citations in the book are given due credit. References are listed so that interested readers know where to look for further information.

Star identification involves a wide range of topics and is related to many research fields. The author does not venture to cover all in this single book and knows clearly the limitations that may exist. Any mistakes, therefore, remain the sole responsibility of the author.

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