

Group-target Tracking

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ISBN 978-981-10-1886-2 ISBN 978-981-10-1888-6 (eBook)
DOI 10.1007/978-981-10-1888-6

Jointly published with National Defense Industry Press

Library of Congress Control Number: 2016947186

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Preface

As an important issue in military and civil researches, target tracking has got brilliant achievements not only in theory but also in practice. Meanwhile, we are expecting a continuous development in it. In terms of theory and technology, target tracking is classified into two categories—(a) Single-target tracking and multi-target tracking by single sensor based on Kalman filtering theory. (b) Single-target tracking and multi-target tracking by multi-sensor based on information fusion. In particular to the latter, the tracking to multi-target in high density is becoming a highlight and a challenge.

In some sense, multi-target tracking is actually an issue related to processing of multi-measurement data. For target tracking systems, however, multi-target naturally generates multi-measurement data, which are not necessarily resulted from multi-targets. For instance, an extended single target generates multi-measurement data. Meanwhile, high-resolution radar, multi-sensor, and multi-path effect could also be the resources. Such multi-measurement data are sometimes mixed with true and false information, which are even hard to select. For example, as false targets, interference, and other factors lead to mixture of true and false multi-measurement data, it is hard to distinguish the multi-measurement data produced by extended targets. The situation would be more complicated when there come the so-called indirect measurement data produced by multi-targets in high density with multi-path effect. Moreover, in the current target tracking system, target tracking and situation perception are separated at the physical layer. That is, the state estimation of every target is given first, and then a special information processing platform perceives the situation of multi-targets. Is it possible to find a new approach which integrates single-target and multi-target tracking while estimating the situation by connecting the physical layer, data layer, and perception layer without considering the quantity and density of targets?

Apparently, we cannot find such an approach unless we change our way of thinking. For this purpose, the book puts forward the concept of group-target tracking.

Group-target tracking is a multi-target centroid tracking method based on modern target tracking theories and formation tracking approach. It unifies group-target data association and situation association, as well as integrates group-target maneuver judgment, situation assessment, and combination/separation detection. Group-target tracking breaks through the restrictions on the quantity and density of targets as well as the restriction that requires one-to-one correspondence between real measurement data and relevant targets. It overcomes such problems as obscure data association for multi-target tracking in high density, inability to choose real measurement data from multi-returns of single target, and loss of useful information for target tracking during processing of indirect measurement data as false measurement data. As a result, it enables connection between the physical layer, data layer, and perception layer. Group-target tracking is a complete system capable of determining how a group-target is formed, how a group-target track initiates, how to make group-target association and track maintenance, and how to detect when new targets join in and old ones leave the group. It is also capable of providing prior information for capture of targets separated from the group and enabling group-target track termination. In fact, from a bionic perspective, group-target tracking is also a reverse situation perception process based on animals' vision process—first the whole picture, then each part, and finally each individual target.

Centered on group-target tracking, with consideration of perception issues such as situation association, situation fusion, and intention judgment, the book elaborates essential issues including formation of group-targets, track initiation, data association, combination/separation detection, and group-target track termination. The originality and novelty of the book lies in multiple aspects: (1) It proposes the group-target tracking concept featured by the unification of single-target tracking and multi-target tracking, the unification of multi-target tracking in sparsity and multi-target tracking in high density, and the unification of target tracking and situation perception; (2) it establishes the group-target tracking architecture; (3) it proposes the method to realize group splitting detection and group-target track initiation simultaneously; (4) it proposes for the first time the nearest neighboring—all-neighboring single group-target association algorithm; (5) it proposes for the first time the multi-group-target association algorithm under double multi-multicorrespondence; (6) and it proposes for the first time the method to realize group-target combination/separation detection, situation synthesis, and intention judgment simultaneously. To highlight the themes with limited words, the book does not discuss in detail the so-called fundamental theory on target tracking and instead, only provides some relevant basic knowledge. The readers are referred to other references when more information is needed.

My research on group-target tracking is a long process. Based on my actual work experience, I came up with an idea, asked experts for advice and guidance, and then tried many methods to work on it before the final complete algorithm system is shaped. During this period, I drew inspirations from the works of Hongren Zhou, an expert in information technology and executive chairman of Advisory Committee for State Informatization, received helpful guidance from academician De Ben,

researcher Qingyu Cai and professor Yingning Peng, and benefited from the valuable suggestions of Ms. Hongya Liu. I would also like to express my heartfelt thanks to Mr. Jun Lu and Jianliang Zhu for their efforts to check on relevant issues.

However, target tracking theories and technologies change with each passing day. While I have referred to massive materials and used a lot of research achievements for reference, it is impossible to avoid defects and mistakes in the book due to insufficient knowledge reserve and incapability. Therefore, I'm looking forward to the generous opinions and advice of experts and scholars that are focused on target tracking.

The book is translated from Chinese by Ge Geng and Fan Yang.

Thanks to National Defense Sci-tech Publishing Fund for its support.

Thanks to Mr. Zhili Xiao for his help and guidance to the publishing of the book.

Thanks to all experts and scholars that have contributed to the book directly and indirectly.

Thanks to my family for their constant support over the years.

Beijing, China
June 2015

Wendong Geng

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Abstract

It is always an attractive subject to realize the unification of single-target tracking (STT) and multi-target tracking (MTT), the unification of sparse multi-target tracking and high-density multi-target tracking, and the unification of target tracking and situation perception. With this in mind, the authors come up with the idea of group-target tracking.

This book elaborates the general situation of target tracking technologies at both home and abroad, as well as the research results of the authors in this field. It covers seven chapters, with main contents including general development of target tracking and typical tracking systems; background for group-targets, formation process of group-target tracking theory, group-target concept and connotation, group-target tracking principles, and their application prospects; basic concepts of target tracking, Kalman filtering, target motion model, target tracking algorithms, and other basic knowledge; group splitting detection for the formation of group-targets and group-target track initiation algorithms; single-/multi-group-target association algorithm based on integrated data association and situation association; and group-target combination/separation detection algorithm enabled simultaneously by maneuver detection and situation perception, as well as simulation design and verification of group-target tracking algorithms, among others.

This book can be used as a reference by technical personnel engaged in such areas as radar data processing, MSDF, electronic countermeasure, situation perception, and command information system, as well as textbook for undergraduate and graduate students studying relevant majors.