Stochastic Dynamic Programming Based Approaches to Sensor Resource Management

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Abstract — *This paper describes a stochastic dynamic programming based approach to solve Sensor Resource Management (SRM) problems such as occur in tracking multiple targets with electronically scanned, multi-mode radar. Specifically, it formulates the SRM problem as a stochastic scheduling problem and develops approximate solutions based on the Gittins index rule. Novel results include a hybrid state stochastic model for the information dynamics of tracked targets, an exact index rule solution of the SRM problem for a simplified tracking model, and use of approximate dynamic programming to extend the index rule solution to more realistic models.*

Keywords: Sensor resource management, dynamic programming, Gittins index, multi-armed bandit.

1 Introduction

Modern sensor suites contain sensors that are agile, allowing fast redirection (e.g., electronic scanning) and fast switching between modes (e.g., radar modes such as SAR and MTI), giving a large number of control options. However, allocation of sensor resources is also subject to a variety of constraints: there may be many things to look at (complex environments with multiple targets), limited time to sense targets because of deadlines on the usefulness of information (urgent requests) or exposure to threat environments, sensors may have a limited field of view, and so on. Developing sensor control algorithms that satisfy such constraints and maximize the value of information obtained is the goal of Sensor Resource Management (SRM) research.

Stochastic dynamic programming [1] provides a principled, systematic approach to formulating and solving SRM problems [8]. However, its application requires paying the price of developing mathematical models for the problem formulation and then finding efficient algorithmic solutions. In this paper we describe new results in developing efficient solutions based on stochastic dynamic programming to solve SRM problems such as occur in tracking multiple targets with electronically scanned, multi-mode radar.

Specifically, we formulate the SRM problem as a stochastic scheduling (or multi-armed bandit) problem and develop approximate solutions based on the Gittins index rule [2]. Although there has been much research on index rules [7], [6], [3], [9], [5], there appear to be no applications to SRM except for the recent work by Krishnamurthy and Evans [4]. The reason for this is that the SRM problem, formulated as stochastic scheduling, doesn't usually satisfy the conditions necessary for the existence of an index rule solution. Thus, one is forced to develop approximations (e.g., the "restless bandit" work of [9], [5]). In this paper we show how to relax one of the "usual" conditions and to develop index rule-based SRM algorithms for kinematic tracking.

The new contributions of this paper include:

1. Stochastic scheduling formulation of SRM and a corresponding extension of the index rule solution to more general reward functions, more suitable for SRM problems.

2. Hybrid state stochastic model of information dynamics for tracking problems, which facilitates efficient solutions of stochastic dynamic programs and alleviates the "curse of dimensionality."

3. Exact index rule solution for a simple tracking model. This solution provides a basis for efficient approximations of more realistic tracking models.

4. Lookahead approximation of the stochastic dynamic program solution based on an index rule solution, applicable to more realistic tracking models.

Section 2 formulates the SRM problem as a stochastic scheduling problem and shows how to extend the index rule solution to more general types of reward functions. This section also discusses generalizations of the formulation to controlling sensors with variable dwell times and

Stochastic Scheduling And Dynamic Programming

Christodoulos A. Floudas,Panos M. Pardalos

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Stochastic Scheduling and Dynamic Programming Ger M. Koole,1995   *Stochastic Scheduling and Dynamic Programming* Gerhardus Martinus Koole,1992   Deterministic and Stochastic Scheduling M.A. Dempster,2012-12-06 This volume contains the proceedings of an Advanced Study and Re search Institute on Theoretical Approaches to Scheduling Problems The Institute was held in Durham England from July 6 to July 17 1981 It was attended by 91 participants from fifteen different countries The format of the Institute was somewhat unusual The first eight of the ten available days were devoted to an Advanced Study Insti tute with lectures on the state of the art with respect to deter ministic and stochastic scheduling models and on the interface between these two approaches The last two days were occupied by an Advanced Research Institute where recent results and promising directions for future research especially in the interface area were discussed Altogether 37 lectures were delivered by 24 lecturers They have all contributed to these proceedings the first part of which deals with the Advanced Study Institute and the second part of which covers the Advanced Research Institute Each part is preceded by an introduction written by the editors While confessing to a natural bias as organizers we believe that the Institute has been a rewarding and enjoyable event for everyone concerned We are very grateful to all those who have contributed to its realization   Stochastic Scheduling of Closed Queueing Network Production Systems Shirish Ekbote,1999   *Encyclopedia of Optimization* Christodoulos A. Floudas,Panos M. Pardalos,2008-09-04 The goal of the Encyclopedia of Optimization is to introduce the reader to a complete set of topics that show the spectrum of research the richness of ideas and the breadth of applications that has come from this field The second edition builds on the success of the former edition with more than 150 completely new entries designed to ensure that the reference addresses recent areas where optimization theories and techniques have advanced Particularly heavy attention resulted in health science and transportation with entries such as Algorithms for Genomics Optimization and Radiotherapy Treatment Design and Crew Scheduling   Multi-Agent Systems and Applications IV Michal Pechoucek,Paolo Petta,Laszlo Zsolt Varga,2005-09-06 The aim of the CEEMAS conference series is to provide a biennial forum for the presentation of multi agent research and development results With its p ticular geographicalorientation towards Central and Eastern Europe CEEMAS has become an internationally recognised event with participants from all over the world After the successful CEEMAS conferences in St Petersburg 1999 Cracow 2001 and Prague 2003 the 2005 CEEMAS conference takes place in Budapest The programme committee of the conference series consists of est lished researchers from the region and renowned international colleagues sh ing the prominent rank of CEEMAS among the leading events in multi agent systems In the very competitive eld of agent oriented conferences and workshops nowadays suchasAAMAS WI IAT EUMAS CIA MATES thespecialpro le of CEEMAS is that it is trying to bridge the gap between applied research achievements and theoretical research activities Our ambition is to provide a forum for presenting theoretical research with an evident application potential implemented application

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