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Entropy-based Complexity Measures for Dynamic Decision Processes

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Abstract. Complex dynamic systems are wide spread in many industrial sectors such as manufacturing systems, queuing systems and supply chain systems. How to measure the complexity of dynamic decision processes in a complex system is an important issue but yet remains to be solved. In this paper, we apply Shannon's entropy as well as other entropic indices to measure the complexity of dynamic decision processes, and extend the measures for complexity, uncertainty and unpredictability in a Markov chain to measure Markov decision processes. We develop a methodology of information-theoretic complexity measures for fully and partially observable Markov decision processes under random and deterministic policies.

Keywords. Entropy Measure, Complexity, Markov Chain, Markov Decision Processes.
AMS (MOS) subject classification: 68Q19,68Q25

1 Introduction

Many dynamic systems are complex and difficult to measure and control such as large scale manufacturing systems, queuing systems and supply chain systems. It is therefore not surprising that the investigation of complex dynamic systems is of growing importance and interest to both research community and industry. One of the focuses of the existing research is on how to describe complex dynamic behavior and chaotic behavior of a system, which are related to the growing sophistication of the system rather than randomness. Because of the multiplicity of complexity, it is difficult to define complexity in such a way that could be universally acceptable [3,7,14,18], and it remains an unresolved problem to quantify complexity. Measuring complexity is in fact to use different ways to measure the difficulties of a complex system, such as the difficulty of constructing an object, the difficulty of describing a system, the difficulty of performing a task, and so on [18]. For example, one way is to define algorithmic complexity or computational complexity, which measures the difficulty of a task. Algorithmic complexity is the minimal difficulty of storing a program to reproduce any particular pattern/number/index, and computational complexity can be seen as an asymptotic difficulty (in terms