ADAPTIVE APPROACHES TO STOCHASTIC PROGRAMMING

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Economists have found a need to model agents who behave in ways that are not consistent with the traditional notions of rational behavior under uncertainty but that are oriented in some looser manner toward achieving "good" outcomes. Adaptation over time in a myopic manner, rather than forward-looking optimization, has been proposed as one such model of behavior that displays bounded rationality. This paper investigates the relationship between adaptation as a model of behavior and as an algorithmic approach that has been used in computing solutions to optimization problems. It describes a specific adaptive model of behavior in discrete choice problems, one that is closely related to adaptive algorithms for optimization, and shows that this model can be fruitfully applied in studying several economic issues.

Keywords: Adaptive behavior, bounded rationality.

1. Introduction

It is clear that economic agents do not always behave in ways consistent with the traditional model of rational behavior under uncertainty, as described by von Neumann and Morgenstern [29], Savage [26], and others. Even if they are not precisely rational, however, it seems reasonable to believe that agents act so as to try to attain "good" outcomes with high probability, rather than behaving arbitrarily or even perversely. Motivated by this belief, economists have proposed that behavior under uncertainty be modeled in ways that allow for limited rationality. Adaptation has been proposed as a feature in many such models, that is, that agents do not pick their behavior by precisely solving an optimization problem ab initio, but rather, they experiment with various actions over time and try to learn which of them is the best. No particular model of adaptation has yet come to be widely accepted as an accurate description of actual economic behavior, indeed, the most important area for research at the current time is in generating many such models and testing their predictions against experimental or empirical data. Fortunately, a variety of adaptive decision procedures have already been developed by mathematicians who were interested in prescribing efficient approaches to solving stochastic programming problems. The purpose of
this paper is to suggest that the literature on stochastic programming is a fertile source from which to extract algorithms that can describe actual economic behavior, and also that mathematicians who develop or study stochastic programming algorithms may want to investigate their applicability as descriptive models as well as prescriptive ones. In order to approach this objective, the paper presents an adaptive algorithm for discrete choice problems that is indeed a modified version of one that has been prescribed in the mathematical optimization literature and that is shown here to have substantial potential for describing actual economic behavior.

Both theoretical reasoning and empirical observation lead us to believe that actual economic behavior will not always display perfect rationality, and the ways in which actual behavior and perfectly rational behavior differ will determine what features a model of limited rationality should have. The theoretical argument in favor of bounded rationality holds that the mathematical problems facing a perfectly rational agent making even the simplest economic decisions are so complex that in general, neither a human brain nor a computer can possibly solve them. The source of this complexity lies in a feature of any economic situation except the most trivial – there are interactions among several separate decision-makers. Rational behavior requires an agent to keep in mind a list of all the possible stochastic or uncertain events that can affect him and to be able to model the interactions of these events with his own actions in determining his well being. In any situation in which there is strategic interaction among many agents, however, the uncertain events that an agent must model include the actions of the other agents and the beliefs that guide them, including their beliefs about his beliefs, then his beliefs about their beliefs about his beliefs, and so forth (see Aumann [1] for a description of this process of reasoning about the beliefs of others in the context of games). It can be shown that acting in accordance with such a probabilistic model would in general require agents to have an infinite memory capacity (although Aumann limits his analysis to agents with finite memory by assumption). An important consideration influencing models of bounded rationality is that they be implementable with finite memory, and so they must allow agents to fail to consider at least some aspects of the uncertainty they face.

There have been many observations of actual behavior that is not consistent with the standard definition of rationality, particularly in controlled experiments, where the "rationality" of behavior can be unambiguously determined. Such behavior can even be found in laboratory subjects solving very simple single-agent decision problems, without the complexities generated by strategic interaction among many agents. An extensive catalog of such behavior can be found in Kahneman and Tversky [12]. A particularly interesting recent example is reported in Keller [16], whose experimental subjects made different decisions in a simple discrete choice problem depending on whether the information they were given about the probabilities of the different possible outcomes was presented in a