AN ANALYSIS OF THE BEHAVIOR OF A CLASS OF GENETIC ADAPTIVE SYSTEMS

by
Kenneth Alan De Jong

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Doctoral Committee:

Professor John H. Holland, Chairman
Associate Professor Larry K. Flanigan
Associate Professor Richard A. Volz
Associate Professor Bernard P. Zeigler

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ABSTRACT

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Chairman: John H. Holland

This thesis is concerned with the design and analysis of adaptive systems, particularly in the area of adaptive computer software. To that end a formalism for the study of adaptive systems is introduced and, within this framework, a means of evaluating the performance of adaptive systems is defined. The central feature of the evaluation process is robustness: the ability of an adaptive system to rapidly respond to its environment over a broad range of situations. To provide a concrete measure of robustness, a family E of environmental response surfaces was carefully chosen to include a wide variety of surfaces, including multimodal and discontinuous ones. The performance of an adaptive system is evaluated over E by computer simulation by monitoring two distinct performance curves: on-line and off-line performance. With on-line performance every response of the adaptive system is evaluated, reflecting situations in which an adaptive system is used to dynamically improve the performance of a system. With off-line performance only responses which improve performance are evaluated, reflecting situations

in which testing can be done independently of the system being controlled.

Within this evaluation framework, a class of genetic adaptive systems is introduced for analysis and evaluation. These artificial genetic systems, called reproductive plans, generate adaptive responses by simulating the information processing achieved in natural systems by means of the mechanisms of heredity and evolution. This is accomplished internally by maintaining a population of individuals whose "genetic" material specifies a particular point on the response surface. New individuals (responses) are produced by simulating population development via mating rules, production of offspring, mixing of genetic material, and so on.

Even the most elementary genetic adaptive plan is shown to produce performance on E which is superior to pure random search of the response surfaces. However, these elementary genetic plans were shown to be easily affected by stochastic side-effects resulting from internal random processes. By suitable adjustments in parameters and modifications to the basic genetic plan, a considerable improvement in the performance was achieved on E.

As a final point of comparison, the performance of two standard function optimization techniques was evaluated on E. Their performance is shown to be superior on the continuous quadratic-like functions for which they were designed. However, the genetic plans are shown to be superior on the discontinuous and multimodal surfaces, suggesting that genetic plans hold a valid position between specialized local adaptive techniques and pure random search.