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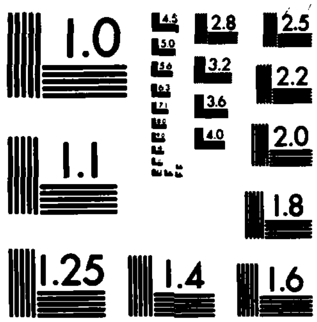

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ON AUTOMATIC GENERATION OF DESCRIPTIVE AND NORMATIVE THEORIES

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This paper discusses a large-scale programming system, the Quasi-Optimizer (QO), that has four major objectives: (1) to observe and measure adversaries' behavior in a competitive environment, to infer their strategies and to construct a computer model, a descriptive theory, of each; (2) to identify strategy components, evaluate their effectiveness and to select the most satisfactory ones from a set of computed descriptive theories; (3) to combine these components in a quasi-optimum strategy that represents a normative theory in the statistical sense; and (4) to provide information as to in which (CONTINUED)

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ITEM #20, CONTINUED: regions a given strategy is most proficient, to a meta-strategy. It will then shift the domain of confrontations between the strategy and its adversaries to the regions specified and, thereby, increase the effective quality of the strategy.

SUMMARY

The paper discusses a large-scale programming system, the Quasi-Optimizer (QO), that has four major objectives:

(i) To observe and measure adversaries' behavior in a competitive environment, to infer their strategies and to construct a computer model, a descriptive theory, of each;

(ii) To identify strategy components, evaluate their effectiveness and to select the most satisfactory ones from a set of computed descriptive theories;

(iii) To combine these components in a quasi-optimum strategy that represents a normative theory in the statistical sense;

(iv) To provide information as to in which regions a given strategy is most proficient, to a meta-strategy. It will then shift the domain of confrontations between the strategy and its adversaries to the regions specified and, thereby, increase the effective quality of the strategy.

The first of six fairly independent modules of the QO system, QO-1, constructs a descriptive theory of static strategies given as black-box programs impenetrable by QO-1. It also identifies which of all possible decision variables are relevant for the strategy being modelled. The program can use either an exhaustive search pattern or a binary chopping technique in the space of decision variables while carrying out a sequence of controlled experiments on the strategy. As an inductive discovery feature, it can also correlate certain stochastic consequences of the strategy with subranges of values of each decision variable. The strategy response surface is assumed by QO-1 to be weakly monotonic.

The second module, QO-2, freezes the learning components of an evolving strategy, invokes QO-1, and makes a snapshot, a computer model of the strategy at successive stages of development. It then computes the asymptotic form of the sequence of snapshots, which will then be taken as a contributory strategy for the normative strategy to be computed.

The third module, QO-3, minimizes the total number of experiments performed in constructing the descriptive theory of a strategy. It no longer assumes that the strategy response surface is monotonic and also deals with multi-dimensional responses. QO-3 starts with a balanced incomplete block design for experiments and computes dynamically the specifications for each subsequent experiment. In other words, the levels of the decision variables in any single experiment and the length of the sequence of experiments depend on the responses obtained in previous experiments.

The fourth module, QO-4, performs the credit assignment. It identifies the components of a strategy and assigns to each a

quality measure of 'outcomes'. An outcome need not be only the immediate result of a sequence of actions prescribed by the strategy but can also involve long-range consequences of planned actions. An important extension of this subproject enables a meta-strategy to channel the domain of confrontation to such regions in which a given strategy is most proficient.

The fifth module, QO-5, constructs a 'Super Strategy' by combining the best strategy components of all input strategies, the descriptive theories, applicable for every region in the total domain.

Finally, the sixth module, QO-6, generates a Quasi-Optimum strategy from the Super Strategy by eliminating inconsistencies and redundancies from the latter. We refer to the result as quasi-optimum rather than a normative theory for four reasons. First, the resulting strategy is optimum only against the original set of strategies considered. Another set may well employ controllers and indicators for decision-making that are superior to any in the "training" set. Second, the strategy is normative only in the statistical sense. Fluctuations in the adversary strategy, whether accidental or deliberate, impair the performance of the QO strategy. Third, the adversary strategy may change over time and some aspects of its dynamic behavior may necessitate a change in the QO strategy. Finally, the generation of both the descriptive theories (models) and of the normative theory (the QO theory) is based on approximate and fallible measurements.