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SIMULTANEOUS OPTIMIZATION OF CLASSIFICATION DECISIONS FOLLOWED BY A MASTERY DECISION

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Introduction

Decision problems in educational and psychological testing can be classified in many ways. An elegant typology of test-based decisions has been given in van der Linden (1985, 1990). Each type of decision making in this typology can be viewed as a specific configuration of three basic elements, namely a test, a treatment, and a criterion. In general, the following four elementary types of decisions can be distinguished: selection, mastery, placement, and classification. The four elementary decisions can also be considered in combination with each other. One combination, for instance, is test-based decision making in Individualized Study Systems (ISSs) (Vos, 1990, 1992; Vos & van der Linden, 198,). The purpose of this paper is to explore the simultaneous optimization of combinations of elementary decisions. To illustrate the approach, a classification (in case of two treatments) and a mastery decision are combined into a decision network and it is shown how so-called weak and strong optimal cutting points can be derived, i.e., decisions which explicitly take and do not take prior achievement on the classification test into account. Two main advantages can be identified of the simultaneous approach comparing to optimizing these decisions separately. First, decisions to be made later in the decision network can already be taken into account. Secondly, more realistic utility structures can be handled effectively by the simultaneous approach.

Methods and techniques

An appropriate framework for dealing with decision problems such as above is Bayesian theory (e.g., Lindgren, 1978). There are two fundamental elements in a Bayesian procedure: probabilities and utilities. In this paper, an additive utility structure is adopted in which the form associated with each separate decision is assumed to be a threshold function. The optimal procedure as prescribed by Bayesian decision theory is to look for a decision rule that maximizes expected utility. To derive the optimal monotone rules, methods of numerical optimization have been used.

Data sources and results

To illustrate the optimal decision procedures presented in this paper, a case with empirical data is given coming from a well-known problem in the Netherlands: the assignment of students to appropriate continuation schools at the end of the elementary school (i.e., at grade 8). In general, the transition process from the elementary to the secondary school is based on the teacher's recommendation, parents' preference, and an achievement test administered in February or March at grade 8. The Dutch National Institute of Educational Measurement (CITO) prepares annually an achievement test, which is used by most elementary schools for this purpose. In addition, on the basis of the grade-point average, it is decided whether or not a pupil finishes the first year of secondary school succesfully. This means that the problem can be characterized as a combined classification-mastery decision problem. It turned out that with the simultaneous approach students were sooner assigned to higher types of secondary education than with the separate approach. In particular for a low weight for the utility associated with the separate classification decision, pupils were assigned much sooner to higher types of education. On the other hand, the optimal mastery rules did not yield large differences. Furthermore, the overall expected utility both for the simultaneous and separate approach was computed to investigate whether there was a gain in overall expected utility for the simultaneous approach compared to the separate approach. It turned out, however, that the separate overall expected utility was larger than the simultaneous overall expected utility. This unexpected result could be explained by the fact that the so-called monotonicity conditions were not satisfied. Finally, it could be shown that the overall expected utility for the weak monotone solution was slightly larger than for the strong monotone solution. This result was in accordance with a Lemma shown in the paper.

Conclusion and discussion

Although the simultaneous approach did not yield a larger overall expected utility than the separate approach, due to the fact that a local maximum instead of an absolute maximum was found, the simultaneous model still seems to be a promising new approach to derive optimal rules for combinations of elementary decisions. More research is needed in other optimization methods than Newton-Raphsons's iterative procedures, which was used in this paper. For instance, a first-order method such as steepest descent or quasi-Newton techniques may be applied. A final remark is appropriate. The models presented in this paper have a larger scope than selecting optimal continuation schools. For instance, the qclassification-mastery decision problem may be important in classification-mastery decision problem may be important in classification of students in ISSs with tracks at different levels followed by a mastery test at the end of the tracks. Another example may be found in the area of psychotherapy in which patients have to be assigned to the most promising therapy followed by an end-of-therapy test.

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