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Problems and algorithms for covering arrays via set covers

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A B S T R A C T

In this paper, we explore some connections between covering arrays (CAs) and set covers (SCs) that already existed in the literature, and in some cases we provide new mappings between these structures. In particular, the devised mappings make feasible an interpretation of weighted budgeted CAs (WBCAs) as weighted budgeted SCs. These connections in turn make it possible to reformulate known greedy heuristics for computing mixed-level CAs and evolve new algorithms for WBCA generation. This also enables importing an upper bound on the size or a lower bound on the covered weight of the generated arrays. We further carry out a comparison of a CA generation strategy that has an analogue in the SC world with one developed specifically for CAs.

Moreover, we experiment with several problem instances for CA and WBCA generation, and compare CA solvers versus SC solvers, both in quality of their output size and covered weights, as well as computation time. Our experiments underpin the hypothesis that CA solvers provide solutions of comparable quality to the ones returned by the considered SC solvers, although the latter solvers generally provide solutions of better quality. Nevertheless, CA solvers provide solutions to the respective problem instances much faster.

1. Introduction

Covering arrays (CAs) are discrete structures appearing in design theory. Most frequently, they are introduced as arrays having specific coverage properties regarding the appearance of tuples. In this regard, they can be considered a generalization of orthogonal arrays. These covering properties make CAs very interesting for both theoretical and practical use. In recent years, CAs have attracted significant research attention due to their applications in automated software testing [23,24,32].

See [25] for a survey on CA generation methods and [11] for a survey on combination testing strategies. Despite the extensive efforts of numerous researchers, finding an optimal CA (i.e. a CA with minimal number of rows) for a given configuration remains a challenging problem. Few results exist regarding the covering array number, the smallest number of rows for which a certain CA exists. More precisely, this number is completely determined only in the case of binary CAs of strength two [22] and for alphabet sizes that are a prime power, where the number of columns is restricted with respect

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