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A primer on the application of neural networks to covering array generation

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ABSTRACT
In the past, combinatorial structures have been used only to tune parameters of neural networks. In this work, we employ neural networks in the form of Boltzmann machines and Hopfield networks for the construction of a specific class of combinatorial designs, namely covering arrays (CAs). In past works, these neural networks were successfully used to solve set cover instances. For the construction of CAs, we consider the corresponding set cover instances and use neural networks to solve such instances. We adapt existing algorithms for solving general set cover instances, which are based on Boltzmann machines and Hopfield networks and apply them for CA construction. Furthermore, for the algorithm based on Boltzmann machines, we consider newly designed versions, where we deploy structural changes of the underlying Boltzmann machine, adding a feedback loop. Additionally, one variant of this algorithm employs learning techniques based on neural networks to adjust the various connections encountered in the graph representing the considered set cover instances. Culminating in a comprehensive experimental evaluation, our work presents the first study of applications of neural networks in the field of covering array generation and related discrete structures and may act as a guideline for future investigations.

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1. Introduction

Since their first introduction in the 1940s, e.g. by McCulloch and Pitts, artificial neural networks (ANNs) have been studied in several phases by many researchers. They have been successfully applied in various fields of computer science, solving problems of prediction, classification and pattern recognition, while being less successful when applied to optimization problems, as stated in [32]. The author of [40] argues towards the capabilities of ANNs, as they can be used to tackle many different types of combinatorial optimization problems, as many of these approaches result in competitive solutions compared to alternative solution techniques in terms of solution quality. Further, for many years researchers were forced to simulate the behaviour of neural networks on digital computers while awaiting the development of specific hardware advances. According to [40], such simulations can only evaluate the potential of neural networks in terms of generating near-optimal solutions to combinatorial optimization problems and thus result in large CPU times that

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