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Advanced Problem-Solving Techniques and Heuristic Search Algorithms in AI

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Abstract

The chapter delves into advanced problem-solving techniques and heuristic search algorithms in AI, focusing on the intricacies of balancing exploration and exploitation in algorithmic design. The text explores the integration of diverse problem-solving strategies, including hybrid approaches that combine heuristic and exact methods, to address the complexities of high-dimensional problem domains. Key topics include the decomposition and abstraction of complex problems, the evaluation of algorithmic performance, and the emerging trends in AI-driven applications. The chapter also examines the ethical considerations and the role of AI in enhancing decision support systems, autonomous systems, and environmental sustainability. This comprehensive analysis provides a critical understanding of the current advancements and future directions in AI-based problem-solving, offering valuable insights for researchers and practitioners alike.

Keywords: Advanced Problem-Solving, Heuristic Search Algorithms, Exploration-Exploitation Balance, Hybrid Approaches, AI Applications, Algorithmic Performance Evaluation.

Introduction

AI has become a game-changing technology that has a big impact on how complicated issues are tackled and resolved [1]. Heuristic search algorithms and problem-solving strategies are two of the many facets of artificial intelligence that stand out for their vital role in empowering robots to take on tasks that were previously thought to be unsolvable [2,3]. These methods form the computational basis for exploring large solution spaces and locating ideal or nearly ideal solutions, making them essential to the development and use of intelligent systems [4]. The fact that these techniques are used in so many different fields from environmental management and transportation to healthcare and finance underlines how important are [5]. The need for increasingly sophisticated and effective problem-solving techniques grows with problem complexity, spurring ongoing innovation in this area [6-9].

The difficulty of regulating the trade-off between exploration and exploitation lies at the heart of AI problem-solving [10,11]. While exploitation concentrates on improving upon existing solutions to get better results, exploration entails looking through a wide variety of options to find new solutions [12]. This balance was important because too much exploration can result in early convergence to unsatisfactory solutions, while too much exploitation can lead to inefficiency and the waste of computing resources on less promising portions of the solution space [13]. To handle this trade-off, contemporary heuristic algorithms have been created, including particle swarm optimization, simulated annealing, and genetic algorithms [14]. Each of these algorithms uses a

different set of techniques to successfully explore the solution terrain [15]. Intelligent algorithms that are capable of dynamically balancing exploration and exploitation are a characteristic of sophisticated problem-solving strategies [16-18].

One of the significant advancements in AI problem-solving was the development of hybrid approaches that combine the strengths of different algorithms to enhance performance [19]. These hybrid methods leverage the complementary advantages of various problem-solving strategies, such as the precision of exact algorithms and the flexibility of heuristics. By integrating diverse approaches, hybrid algorithms can tackle complex, high-dimensional problems that are beyond the reach of traditional methods [20]. For instance, combining genetic algorithms with local search techniques can enhance both the global search capability and the fine-tuning of solutions. Similarly, the integration of machine learning with optimization algorithms allows for adaptive and intelligent problem-solving, where the algorithm learns and improves its performance over time. These hybrid approaches represent a significant step forward in the quest to solve increasingly complex problems in AI.