

UNIVERSITI TEKNOLOGI MARA

**NEUTRALISATION STATE DRIVEN
SINGLE-AGENT SEARCH
STRATEGY FOR SOLVING
CONSTRAINT SATISFACTION
PROBLEM**

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ABSTRACT

In the past seven decades, Constraint Satisfaction (CS) has been extensively studied and remarkably evolved to where the scientific community perceives it as the centre of the intelligent behaviour. Therefore, most of the recent research in the field is devoted to improving the problem solvers that utilize search strategies and techniques. Since Constraint Satisfaction Problem (CSP) is an NP-complete problem, brute-force search algorithms such as Backtracking algorithm (BT) are required as the guarantee to find a solution, when there is one. Moreover, since the establishment of the field, AI pioneers and specialists have setup instructions and guidelines on how to solve this type of problems back in the seventies of the last century and have not been changed or improved. For example, the framework of solving CSP imposes a complete permutation of assignments to all remaining variables in order to derive a valid model. The author argues in this study that the problem can be neutralised and it is not necessary to perform brute-force searching all the time if a search strategy could have guided the process to the level where the values of the remaining variables can be determined implicitly, creating what the author calls *Solo-Path* of assignments in the problem search tree. The deficiency of the commonly adopted heuristic strategy of Minimum Remaining Values (MRV) clearly appears whenever two or more frontiers get evaluated with the same heuristic value in a phenomenon called by the author Fog of Search (*FoS*). In such an event, selecting the most promising state is usually taken based on nothing but an arbitrary random selection to break a tie. Since the quality of states selection relies on a coherent evaluation to the available information of the revealed part of the problem search-space; this study aims to introduce a novel strategy called *Contribution Number* (*CtN*) that helps in accelerating the neutralisation process. In order to achieve that, basic definitions and lemmas of the novel approach will be provided to construct the concept from scratch. Thereafter, an extensive study conducted on graph topologies will be introduced to help in understanding the type of features a constraint network needs to neutralise the problem efficiently. Thenceforward, the established foundations will be used to create network structures of the testing models for all three methodologies of the research. The behaviour of the proposed strategy has been examined using the well-known Australia map case study and the result concludes that the technique was able to prune out 41% of the total size of the search-tree as it was able to identify 17,706 neutralisation nodes, only six of which were considered the most optimal solutions to the problem that lead to the longest solo-path. The research, then, presents an exhaustive proof for evaluating 8,550 distinct constraint networks that fall into 10 different levels of complexity, and the results show that *CtN* was consistently able to outperform *MRV*. Last but foremost, the proposed strategy was evaluated on a popular and well-studied CSP instance of Sudoku puzzle as the author have conducted an extensive experiment on a large set of Sudoku puzzles that includes 10,000 puzzles and falls into five different difficulty categories. The results show that *CtN* is 30%~50% faster in neutralising the puzzles than *MRV* and remarkably avoids *FoS*.

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