Pertanika J. Sci. & Technol. 31 (4): 1695 - 1716 (2023)

PERTANIKA JOURNALS

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Hybridised Intelligent Dynamic Model of 3-Satisfiability Fuzzy Logic Hopfield Neural Network

Farah Liyana Azizan[1,2], Saratha Sathasivam[1]* and Majid Khan Majahar Ali[1]

[1]School of Mathematical Sciences, Universiti Sains Malaysia, Penang, 11800, USM, Malaysia
[2]Centre for Pre-University Studies, Universiti Malaysia Sarawak, 94300 UNIMAS, Kota Samarahan, Sarawak, Malaysia

ABSTRACT

This study presents a new way of increasing 3SAT logic programming's efficiency in the Hopfield network. A new model of merging fuzzy logic with 3SAT in the Hopfield network is presented called HNN-3SATFuzzy. The hybridised dynamic model can avoid locally minimal solutions and lessen the computing burden by utilising fuzzification and defuzzification techniques in fuzzy logic. In addressing the 3SAT issue, the proposed hybrid approach can select neuron states between zero and one. Aside from that, unsatisfied neuron clauses will be changed using the alpha-cut method as a defuzzifier step until the correct neuron state is determined. The defuzzification process is a mapping stage that converts a fuzzy value into a crisp output. The corrected neuron state using alpha-cut in the defuzzification stage is either sharpening up to one or sharpening down to zero. A simulated data collection was utilised to evaluate the hybrid techniques' performance. In the training phase, the network for HNN-3SATFuzzy was weighed using RMSE, SSE, MAE and MAPE metrics. The energy analysis also considers the ratio of global minima and processing period to assess its robustness. The findings are significant because this model considerably impacts Hopfield networks' capacity to handle 3SAT problems with less complexity and speed. The new information and ideas will aid in developing innovative ways to gather knowledge for future research in logic programming. Furthermore, the breakthrough in dynamic learning is considered a significant step forward in neuro-symbolic integration.

Keywords: 3SAT, alpha-cut, defuzzification, fuzzification, fuzzy logic, Hopfield network

ARTICLE INFO

Article history:
Received: 16 June 2022
Accepted: 13 September 2022
Published: 24 May 2023

DOI: https://doi.org/10.47836/pjst.31.4.06

E-mail addresses:
afliyana@unimas.my (Farah Liyana Azizan)
saratha@usm.my (Saratha Sathasivam)
majidkhanmajaharali@usm.my (Majid Khan Majahar Ali)
* Corresponding author

ISSN: 0128-7680
e-ISSN: 2231-8526

INTRODUCTION

Artificial Intelligence (AI) is the impetus for today's technological advancement. Thus, it leads to the advanced development of machine learning techniques to solve those problems. Artificial Neural Networks (ANNs) can be categorised as a sub-domain of AI widely used to improve decision-making in various disciplines. An ANN comprises interconnected neurons with discrete input and output layers inspired by the biological neuron model. The system is an aligned computing system created by simulating the human's instinctive thinking while investigating the biological brain's network in terms of biological neurons (Garcez & Zaverucha, 1999). The Hopfield Network (HNN) is a single-level recursive neural network (RNN) in which every single neuron output is linked to every other neuron response (Hopfield & Tank, 1985). HNN uses a particular symbolic learning model to efficiently coordinate the propagation of the input and output neurons in solving problems. The capacity of the HNN to resolve to the closest minimal solution determines the neuron state's dynamic behaviour. Abdullah (1992) proposes a method for logic programming on the HNN.

After defining the connection strengths, or mostly called the synaptic weight with logic programming, that is, by comparing cost and energy functions, the network performed a logical inconsistency reduction in programming. Abdullah (1993) introduces the learning phase in the HNN directly. The logic paradigm of Abdullah has become the most prominent and has lately been employed (Mansor & Sathasivam, 2021; Sathasivam et al., 2020). A mathematical framework can describe various scientific and technological challenges in daily life. However, one must first create methods for resolving some mathematical issues to do so. Many crucial problems, such as categorising or finding an ordered list, can be solved with realistic solutions. Nevertheless, a mathematical problem is the Satisfiability Problem (SAT). Unravelling these difficulties is possible with the aid of a computer. The Satisfiability Problem, or SAT, is one of the most well-known issues. It is described as an approach for achieving the best task utilising Boolean quantities to verify that the 3SAT formula is met. A large number of NP issues can be simplified via SAT.

In earlier research, the HNN model and 3SAT logic programming were combined to characterise the innovation as a singular data mining method. This model has been tested with a real-life dataset to assess its efficiency of the model. The method assesses various data sets related to cardiovascular disorders (Mansor et al., 2018). More logic mining strategies, including 3SAT in HNN, have been presented using real-life datasets such as the Bach Choral Harmony and German Credit (Zamri et al., 2020). However, the existing work's 3SAT problem in the Hopfield network only considers zero and one neuron values. Hence, to resolve this problem, this model is further improved by incorporating fuzzy logic techniques to create a hybridised intelligent dynamic model