

# Training neural networks with a procedure guided by BNF grammars

Ioannis G. Tsoulos<sup>1,\*</sup>, Vasileios Charilogis<sup>2</sup>

<sup>1</sup> Department of Informatics and Telecommunications, University of Ioannina, Greece; itsoulos@uoi.gr

<sup>2</sup> Department of Informatics and Telecommunications, University of Ioannina, Greece; v.charilog@uoi.gr

\* Correspondence: itsoulos@uoi.gr

**Abstract:** Artificial neural networks are parametric machine learning models that have been applied successfully to an extended series of classification and regression problems found in the recent literature. For the effective identification of the parameters of the artificial neural networks, a series of optimization techniques have been proposed in the relevant literature, which, although they present good results in many cases, either the optimization method used is not efficient and the training error of the network is trapped in sub-optimal values, or the neural network exhibits the phenomenon of over-training which means that it has poor results when applied to data that was not present during the training. This paper proposes an innovative technique for constructing the weights of artificial neural networks based on appropriate BNF grammars, used in the evolutionary process of Grammatical Evolution. The new procedure locates an interval of values for the parameters of the artificial neural network, and the optimization method effectively locates the network parameters within this interval. The new technique was applied to a wide range of data classification and adaptation problems covering a number of scientific areas and the experimental results were more than promising.

**Keywords:** Neural networks; Genetic algorithms; Grammatical Evolution; Evolutionary algorithms

**Citation:** Tsoulos, I.G.; Charilogis, V.

Training neural networks with a procedure guided by BNF grammars.

*Journal Not Specified* **2024**, *1*, 0.

<https://doi.org/>

Received:

Revised:

Accepted:

Published:

**Copyright:** © 2024 by the authors.

Submitted to *Journal Not Specified* for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

|  |                      |
|--|----------------------|
| 1. Introduction  | 16                   |
| 2. Materials and Methods   | 17                   |
| 3. Results   | 18                   |
| 4. Conclusions   | 19                   |
| <b>Author Contributions:</b> I.G.T. and V.C. conceived the idea and methodology. I.G.T. performed the experiments, employing several datasets, and provided the comparative experiments. V.C. performed the statistical analysis. All authors prepared the manuscript.   | 20<br>21<br>22       |
| <b>Funding:</b> This research received no external funding.  | 23                   |
| <b>Institutional Review Board Statement:</b> Not applicable.   | 24                   |
| <b>Informed Consent Statement:</b> Not applicable.   | 25                   |
| <b>Data Availability Statement:</b> Not applicable.  | 26                   |
| <b>Acknowledgments:</b> This research has been financed by the European Union : Next Generation EU through the Program Greece 2.0 National Recovery and Resilience Plan , under the call RESEARCH – CREATE – INNOVATE, project name “iCREW: Intelligent small craft simulator for advanced crew training using Virtual Reality techniques” (project code:TAEDK-06195). | 27<br>28<br>29<br>30 |
| <b>Conflicts of Interest:</b> The authors declare no conflicts of interest.  | 31                   |

|  |                |
|--|----------------|
| <b>References</b>  | 32             |
| 1. Autho   | 33             |
| <b>Disclaimer/Publisher’s Note:</b> The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content. | 34<br>35<br>36 |