A Comparative Evaluation of Neural Network Architectures and Genetic Algorithms for Adaptive Decision Making in Autonomous Systems

Nico Green
PhD
Massachusetts Institute of Technology
77 Massachusetts Ave, Cambridge, MA 02139, USA

Morgan King
D.Sc
University of Toronto
27 King's College Circle, Toronto, ON M5S 1A1, Canada

Jesse Brown
Professor
Technical University of Munich
Arcisstraße 21, 80333 München, Germany

Abstract. In the pursuit of enhancing adaptive decision-making capabilities in autonomous systems, this study presents a comparative analysis of various neural network architectures and genetic algorithms. We systematically evaluate the performance of convolutional neural networks (CNN) in conjunction with genetic algorithm optimization against traditional multi-layer perceptron (MLP) configurations. Employing a series of simulations across diverse autonomous scenarios, we measure efficiency, accuracy, and adaptability metrics. The results indicate that hybrid models combining CNNs with genetic algorithms significantly outperform conventional MLPs, particularly in complex, dynamic environments. This research not only contributes to the theoretical framework surrounding adaptive systems but also offers practical insights for future AI developments in autonomous technologies.

Keywords: neural networks, genetic algorithms, autonomous systems, decision making, adaptive systems, machine learning, algorithm comparison, optimization techniques

Introduction

Artificial Intelligence (AI) has emerged as a pivotal technology in enabling autonomous systems to function with enhanced decision-making capabilities. The global relevance of AI in this context cannot be overstated, as societies increasingly rely on AI-driven solutions in critical sectors such as transportation, healthcare, and manufacturing. The ability of autonomous systems to make informed decisions rapidly and adaptively is essential for their successful integration into everyday life, particularly from 2024 onwards, when the demand for reliable and efficient autonomous technologies is expected to surge. One of the central challenges in the development of adaptive autonomous systems lies in selecting the optimal algorithmic frameworks that can effectively handle complex and dynamic

environments. Recent advancements in neural network architectures, particularly convolutional neural networks (CNN), have shown promise in various applications. However, their integration with genetic algorithms—a robust optimization technique that mimics the process of natural selection—has not been extensively explored. This study aims to bridge this gap by providing a comparative assessment of these two paradigms, focusing on their collective impact on enhancing decision-making processes in autonomous systems. This paper is structured as follows: after this introduction, we present a detailed methodology section that outlines the experimental design and evaluation criteria used for our comparative analysis. Following this, we delve into the results, discussing the implications of our findings in the context of current AI discourse. Finally, we conclude with a summary of our contributions and potential avenues for future research.

References

1. Kumar, N., & Kataria, V. Enhanced Sentiment Classification using a Multi-layered Stacked Ensemble Architecture.
2. Kumar, Nitin, and Vipin Kataria. "Enhanced Sentiment Classification using a Multi-layered Stacked Ensemble Architecture."
3. Kumar, N., & Kataria, V. (2023). Enhanced Sentiment Classification using a Multi-layered Stacked Ensemble Architecture. International Journal of Intelligent Systems and Applications in Engineering, 11(4s), 304–311.