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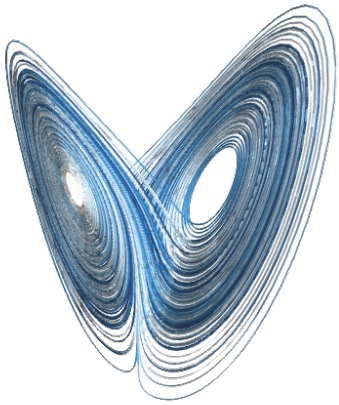

Modeling Dynamic Systems using Machine Learning Techniques

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Thesis to obtain the Master of Science Degree in

Electrical and Computer Engineering

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Abstract

This research aimed to model dynamic systems using machine learning techniques and investigate their applicability in capturing the complex behavior of real-world organisms, processes, and systems. To simulate the dynamic responses of these systems to various stimuli, electric circuits were employed as proxies. These circuits provided an avenue to comprehend the underlying behavior, predict future reactions, and bridge the gap between the intricacies of real-world phenomena and computational modeling.

White-box models, which enable accurate predictions and offer insights into the internal phenomena driving system responses, were initially explored. However, as systems grew increasingly complex or demanded excessive detail, these models became impractical. Consequently, black-box models, which prioritize accurate prediction over internal understanding, emerged as a more suitable alternative. Machine learning techniques excelled in constructing black-box models by observing input-output data and inferring the system's behavior.

This work built upon a PhD thesis from the 1990s that investigated neural network applications for device and subcircuit modeling in circuit simulation. Various neural network architectures, including standard neural networks, dynamic neural networks, recurrent neural networks, and continuous-time recurrent neural networks, were employed. These models were tested on different circuits known for their dynamic behavior, aiming to exploit the practicality of using such models to capture the nonlinear behavior exhibited by real-world organisms, processes, and systems.

Throughout the thesis, a comparative analysis of the different neural network models was conducted, highlighting their respective strengths and weaknesses. Insights gained from this comparison enabled the extraction of valuable conclusions regarding the performance and suitability of each model in capturing the dynamic behavior of the studied systems.

Overall, this research contributes to the understanding of modeling dynamic systems through machine learning techniques. By leveraging electric circuits as proxies and drawing upon the advancements made since the earlier thesis, this work demonstrates the potential of black-box modeling approaches in accurately mimicking the complex behavior of real-world organisms, processes, and systems, opening doors for diverse applications in scientific and engineering fields.

Keywords: Dynamic Systems, Machine Learning, Circuit Modeling, Neural Networks Architectures, Sequence-to-sequence prediction, Input-to-output modeling, Black-box modeling