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# التوثيق الالكتروني والميكروفيلم

HOSSAM MAGHRABY

# جامعة عين شمس

## التوثيق الإلكتروني والميكروفيلم

## قسم

**نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها**

**علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات**



## يجب أن

**تحفظ هذه الأقراص المدمجة بعيدا عن الغبار**

HOSSAM MAGHRABY

COMPUTER SCIENCE DEPARTMENT
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# Computational Intelligence Techniques in Music Composition

A thesis submitted to the Department of Computer Science,
Faculty of Computer and Information Sciences,
Ain Shams University, Cairo, Egypt.

In partial fulfillment of the requirements for the degree of Doctor of Philosophy, Ph.D. in Computer Science

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*Nermin Siphocly*

*May 2021*

# Abstract

Engaging computers in composing musical pieces is a challenging and trending field of research. The musical tasks that can be performed or aided by computers' computational powers, are numerous. This thesis is concerned with computational intelligence techniques in music composition. Its main objective is to introduce various intelligent techniques for performing miscellaneous music composition tasks. To achieve this objective, the thesis first provides a thorough survey on the most famous artificial intelligence algorithms used in computer music composition discussing their applications, strengths, and weaknesses. The thesis then proposes multiple applications adopting some of the studied artificial intelligence and machine learning algorithms; including rule-based, case-based reasoning, artificial neural networks, and the relatively new: "generative adversarial networks".

The contributions of this thesis include: First, providing a comprehensive survey on the field of computer music generation highlighting the most famous adopted algorithms, their most recent applications, their weaknesses, and strengths. Second, proposing an intelligent algorithm for major/minor melody conversion, comparing between rule-based and case-based reasoning in performing the task. This application also introduces a smart method for musical scale detection.

Third, developing an intelligent secondary melody generator with two techniques: artificial neural networks and case-based reasoning. Fourth, comparing between both techniques in performing the task of secondary melody generation. The comparison results show that case-based reasoning secondary melody generator outperformed the artificial neural networks generator by a success percentage of 50%.

Fifth, presenting a novel approach for accompaniment generation using pix2pix generative adversarial networks which is considered from the state-of-the-art in the machine learning area. Sixth, presenting a novel musical data representation which enhanced the pix2pix network training and the overall results. Specifically, this work suggests using color encodings to represent music notes inside images. Experimental results show that the proposed music representation achieved better results on pix2pix GANs over the traditional representations, reaching a loss function value of 0.001.

Seventh, studying the effectiveness of the proposed color encoded data representation showing that it outperformed the previously known representations. Eighth, proposing a post-processing technique on the generated images for enhancing the quality of the generated music, based on erosion. Ninth, to introducing two music evaluation metrics to automate the assessment of the generated music based on harmony and dissimilarity. Experimental results show that the proposed post-processing technique enhanced the musical harmony and the dissimilarity of the generated music by 51.26% and 81.98% respectively. Finally, listing multiple promising ideas for future work and research related to the field of computer music generation.

# Table of Contents

# List of Tables

*Number* *Page*

# List of Figures

# List of Abbreviations

| | |
|---|---|
| AI | Artificial Intelligence |
| AIS | Artificial Immune System |
| AN | Artificial Neuron |
| ANN | Artificial Neural Network |
| BM | Basis function Model |
| BN | Bayesian Network |
| CBR | Case-Based Reasoning |
| CNN | Convolutional Neural Network |
| CRBM | Conditional Restricted Boltzmann Machine |
| CRBM | Convolutional Restricted Boltzmann Machine |
| DFA | Deterministic Finite state Automaton |
| DNN | Deep Neural Network |
| FO | Factor Oracle |
| GA | Genetic Algorithm |
| GAN | Generative Adversarial Network |
| HMM | Hidden Markov Model |
| IE | Inference Engine |
| KB | Knowledge Base |
| LSTM | Long Short-Term Memory |
| NFA | Non-deterministic Finite state Automaton |
| PTGG | Probabilistic Temporal Graph Grammar |
| RNN | Recurrent Neural Network |
| TIS | Tonal Interval Space |
| WCL | Weighted Centroid Localization |
| WM | Working Memory |