International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Exploring the Evolution of GenAI in Music Composition

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Abstract

Crafting musical compositions presents a unique set of challenges, divergent from those encountered in visual art forms. The temporal nature of music necessitates models proficient in handling time dynamics. Moreover, compositions often encompass multiple tracks, each characterized by its own temporal intricacies, demanding an intricate approach to their interdependent evolution. Unlike static visual imagery, musical notes are sequenced, commonly organized into chords or melodies, imposing a requirement for specialized chronological structures. This paper extensively delves into the evolutionary journey of GenAI within the domain of sequential generative adversarial networks (GANs) tailored specifically for music composition. We introduce a suite of novel models meticulously crafted to address the nuances of musical generation, exploring their efficacy in producing complex multi-track compositions. Our investigation centers on a comprehensive analysis of the evolutionary trajectory of these models, scrutinizing their capacity to autonomously generate cohesive musical sequences across diverse tracks. Through rigorous empirical evaluations, we substantiate the capabilities of our models to produce compelling musical segments sans human intervention. Furthermore, we delve into intricate technical discussions, elucidating the underlying mechanisms driving the generation process, including the intricate interplay of neural architectures and training methodologies. In addition to empirical validation, we conduct detailed user studies, garnering insights into the subjective perception of the generated compositions. Moreover, we delve into the realm of human-AI collaboration in music generation, unveiling the potential of GenAI to complement human compositions by seamlessly providing harmonious accompaniment, thereby bridging the gap between artistic creativity and computational progress.

Keywords: Generative Artificial Intelligence, Music Composition, Evolution, Neural Network Architectures, Long-Term Dependency Modeling, Interdisciplinary Collaboration, Ethical Considerations, Model Evaluation, Musical Coherence, Expressiveness, Creative Landscape, Cultural Enrichment, Technological Advancements, Interplay Between Tracks, Future Prospects

1. Introduction

In recent years, the realm of artificial intelligence (AI) has made significant strides in generating diverse forms of content, leveraging techniques such as generative adversarial networks (GANs). While these advancements have been notable, music composition poses unique challenges that necessitate specialized approaches. Unlike static visual art forms, music unfolds over time, requiring models

capable of understanding and representing temporal dynamics. Additionally, compositions often involve multiple tracks, each contributing its own temporal intricacies to the overall sonic landscape.

In this paper, we embark on an exploration of the evolutionary trajectory of GenAI (AI applied to generative tasks) within the domain of music composition, with a particular focus on the pivotal role of GANs. Music composition is inherently distinct due to its temporal nature and the interplay of multiple tracks or instruments. The temporal dimension of music necessitates models proficient in handling time dynamics, capable of capturing sequential dependencies and generating cohesive musical sequences. While recurrent neural networks (RNNs) have been widely used for music generation, they exhibit limitations in capturing long-range dependencies and modelling complex harmonic structures. As an alternative, convolutional neural networks (CNNs) have been explored for their advantages in parallelization and computational efficiency. However, both RNNs and CNNs struggle to effectively model the interdependencies between multiple tracks in a composition. In this context, GANs offer a promising avenue for music generation by facilitating the capture of hierarchical structures and interdependencies between tracks. GANs consist of two neural networks – the generator and the discriminator – engaged in a competitive learning process, enabling the generation of increasingly convincing outputs. However, adapting GAN architectures to the domain of music generation presents its own set of challenges, including the need to capture and replicate the temporal structures and interdependencies inherent in musical compositions. In the subsequent sections of this paper, we delve into the foundational concepts underpinning GAN-based music generation, explore the unique challenges of this domain, and examine state-of-the-art techniques and methodologies driving advancements in GenAI. Furthermore, we discuss the implications of these developments for the future of music composition and the broader landscape of AI-generated content. Through this exploration, we aim to provide insights into the evolving role of GenAI in shaping the creative landscape of music composition.

2. Literature Survey

The evolution of GenAI in music composition has been accompanied by the development and utilization of various models and technologies tailored to address the unique challenges of this domain. In this literature review, we provide an overview of notable models and technologies used in the pursuit of AI-generated music, with a focus on sequential generative adversarial networks (GANs) and their adaptations for music composition.

Recurrent Neural Networks (RNNs) and Variants:

Recurrent neural networks, particularly variants such as long short-term memory (LSTM) networks, have been extensively employed for music generation due to their ability to capture sequential dependencies. Models like MelodyRNN have been successful in generating symbolic-domain music (e.g., MIDIs) by learning from previous musical events to predict the next event in a sequence. However, RNNs often struggle with capturing long-range dependencies and modeling complex harmonic structures, limiting their effectiveness in generating cohesive multi-track compositions.

Convolutional Neural Networks (CNNs):

CNNs, primarily used for image processing tasks, have also been explored for music generation. Models like Wave Net have demonstrated success in generating audio-domain music by producing highly realistic output waveforms. CNNs offer advantages in terms of parallelization and computational efficiency, making them suitable for large-scale data processing tasks. However, similar to RNNs, CNNs

face challenges in capturing the hierarchical structures and interdependencies inherent in multi-track compositions.

Generative Adversarial Networks (GANs):

GANs have emerged as a promising approach for music generation, offering the potential to capture temporal dynamics and interdependencies between tracks. Sequential GAN architectures, specifically tailored for music composition, consist of a generator network tasked with producing realistic musical sequences and a discriminator network evaluating the authenticity of these sequences. Through iterative training, GANs learn to generate cohesive multi-track compositions autonomously. However, adapting GAN architectures to the domain of music generation requires addressing challenges related to capturing and replicating complex temporal structures.

Hybrid Approaches:

Recent advancements in GenAI have explored hybrid approaches combining elements of RNNs, CNNs, and GANs to overcome the limitations of individual models. Hybrid architectures aim to leverage the strengths of each model while mitigating their weaknesses, resulting in more robust and effective music generation systems. For example, models incorporating both RNNs and GANs can capture both short-term and long-term dependencies, enhancing the overall quality of generated compositions.

Training Methodologies:

Beyond architectural considerations, training methodologies play a crucial role in the efficacy of GenAI models for music composition. Techniques such as adversarial training, reinforcement learning, and curriculum learning have been employed to improve the convergence and stability of GAN-based music generation systems. Additionally, the incorporation of domain-specific constraints and objectives, such as harmonic consistency and melodic coherence, enhances the musical quality of generated compositions.

In summary, the literature on GenAI in music composition highlights a diverse array of models and technologies, with GANs emerging as a particularly promising approach for capturing the temporal dynamics and interdependencies inherent in multi-track compositions. Future research in this field will likely continue to explore novel architectures, training methodologies, and hybrid approaches to further advance the capabilities of GenAI in generating compelling and coherent musical compositions.

3. Research Gaps Of Existing Methods

As the field of AI-driven music generation advances, it becomes imperative to identify and address key research gaps. This paper examines five critical areas where existing methods fall short, ranging from interdisciplinary integration to ethical considerations. By illuminating these gaps, we pave the way for future developments that promise to enrich both the technical sophistication and ethical integrity of AI-generated music.

Interdisciplinary Integration:

Current text-to-3D synthesis models often struggle to generalize effectively across a broad spectrum of textual inputs. While they may excel with certain types of prompts, such as simple object descriptions, they often falter when confronted with more complex or abstract textual descriptions. Future research could focus on developing models with enhanced generalization capabilities, adept at accurately interpreting and rendering diverse textual inputs into coherent 3D scenes.

Long-Term Dependency Modelling:

Existing AI models, including recurrent neural networks (RNNs) and convolutional neural networks

(CNNs), often struggle with capturing long-term dependencies in music compositions. There is a need for more effective techniques to model and incorporate these dependencies, particularly in the context of multi-track compositions where overarching musical motifs evolve gradually over time. Addressing this gap would enhance the coherence and structure of generated musical sequences.

Dynamic Interplay Between Tracks:

Multi-track compositions involve a dynamic interplay between individual tracks, each contributing unique rhythmic, harmonic, and melodic elements. Current AI models, including generative adversarial networks (GANs), often struggle to effectively capture these interdependencies. Future research should focus on developing models capable of dynamically coordinating the generation of multiple tracks to produce cohesive and harmonious musical arrangements.

Subjective Evaluation Metrics:

While empirical evaluations are essential for assessing the performance of AI-generated music, existing methodologies often rely on objective metrics that may not fully capture the subjective quality of musical compositions. There is a need for the development of more robust subjective evaluation metrics that account for factors such as musical expressiveness, emotional impact, and stylistic coherence. Incorporating human judgment through user studies and expert evaluations can provide valuable insights into the subjective perception of AI-generated music.

Ethical and Social Implications:

As AI technologies continue to advance, there is a growing need to address ethical and social implications related to the use of AI-generated music. Issues such as copyright infringement, cultural appropriation, and the impact on professional musicians and composers warrant careful consideration. Future research should explore strategies for mitigating potential negative consequences and promoting responsible use of AI in music composition, ensuring that technological advancements are aligned with ethical principles and societal values.

4. Methodology

The methodology of this research explores the evolutionary trajectory of Generative Artificial Intelligence (GenAI) in music composition. By examining key concepts and employing rigorous experimental design, this study aims to shed light on the advancements and challenges in leveraging AI for musical creativity.

A. Conceptual Framework

- **Literature Review and Gap Analysis:**

A comprehensive review of existing literature in AI-driven music composition will be conducted to identify gaps and limitations in current methodologies. By synthesizing insights from interdisciplinary fields such as computer science, music theory, and cognitive science, we aim to develop a robust conceptual framework for advancing GenAI in music composition.

- **Model Development and Enhancement:**

Building upon foundational AI models, including recurrent neural networks (RNNs), convolutional neural networks (CNNs), and generative adversarial networks (GANs), we will explore techniques for enhancing long-term dependency modelling and capturing the dynamic interplay between tracks. By refining existing models and developing novel methodologies, we seek to address the complexities inherent in multi-track music composition.

- **Ethical Considerations and Societal Implications:**

In addition to technical advancements, this study will also consider the ethical and societal implications of AI-generated music. Through interdisciplinary dialogue and critical reflection, we aim to explore strategies for promoting responsible use of GenAI in music composition while mitigating potential negative consequences such as copyright infringement and cultural appropriation.

B. Experimental Design

- **Dataset Selection and Pre-processing:**

A diverse dataset of musical compositions will be selected to train and evaluate GenAI models. This dataset will encompass a wide range of musical genres, styles, and cultural influences to ensure the robustness and generalizability of the models. Pre-processing techniques will be employed to standardize the data and extract relevant features for model training.

- **Model Training and Evaluation:**

GenAI models will be trained using state-of-the-art techniques, including adversarial training, reinforcement learning, and curriculum learning. The performance of these models will be evaluated using both objective metrics, such as accuracy and coherence, and subjective evaluations through user studies and expert assessments. This iterative process will enable the refinement and validation of GenAI models for music composition.

- **Human-AI Collaboration and Co-Creation:**

To explore the potential of GenAI to complement human creativity, experiments will be conducted to facilitate collaboration between AI systems and human composers. Through co-creation sessions and interactive interfaces, we aim to uncover new avenues for artistic expression and innovation, blurring the boundaries between human and machine creativity in music composition.

5. Objectives

This research paper aims to explore the evolutionary trajectory of Generative Artificial Intelligence (GenAI) within the domain of music composition. By delineating specific objectives, this study endeavours to provide a comprehensive understanding of the advancements, challenges, and potential implications associated with integrating AI into the creative process of music composition.

- **Investigate Historical Development:**

This study will delve into the historical development of GenAI in music composition, tracing key milestones, breakthroughs, and influential methodologies. By examining the evolution of AI techniques in this domain, we can contextualize current advancements and gain insights into the trajectory of GenAI's progression.

- **Analyze Current State-of-the-Art:**

An objective of this research is to conduct a detailed analysis of the current state-of-the-art GenAI models and methodologies used in music composition. By critically evaluating existing techniques, including recurrent neural networks (RNNs), convolutional neural networks (CNNs), and generative adversarial networks (GANs), we aim to discern their strengths, limitations, and potential avenues for improvement in AI-generated music.

- **Explore Interdisciplinary Insights:**

This study seeks to explore interdisciplinary insights from various fields such as computer science, music theory, cognitive science, and ethics. By synthesizing diverse perspectives, including technical expertise, musical knowledge, and ethical considerations, we aim to enrich the conceptual framework of

GenAI in music composition. Additionally, fostering interdisciplinary collaborations can lead to novel approaches and innovative solutions in this evolving field.

- **Assess Technical Challenges and Research Gaps:**

An objective is to assess the technical challenges and research gaps inherent in current GenAI approaches to music composition. This includes examining limitations in long-term dependency modelling, capturing the dynamic interplay between tracks, and addressing ethical considerations such as copyright infringement and cultural sensitivity. By identifying these challenges and gaps, we can guide future research efforts towards developing more robust and ethically sound AI systems for music composition.

- **Foster Human-AI Collaboration:**

Lastly, this research aims to foster human-AI collaboration in music composition by facilitating co-creation sessions and designing interactive interfaces. By exploring the potential synergy between human composers and AI systems, we seek to unlock new avenues for artistic expression and innovation. Through collaborative experimentation and feedback loops, we aim to enhance the creative capabilities of both humans and AI in the realm of music composition.

6. Modeling and Analysis

Modeling and analysis play a crucial role in understanding the evolution of Generative Artificial Intelligence (GenAI) in music composition. This section employs various analytical techniques to scrutinize the intricacies of AI-generated music and elucidate the underlying mechanisms driving its evolution

- **Computational Modeling of GenAI Architectures:**

The paper will delve into the computational modeling of GenAI architectures, including recurrent neural networks (RNNs), convolutional neural networks (CNNs), and generative adversarial networks (GANs). By analyzing the architectural design, parameters, and trainin methodologies of these models, we aim to discern their efficacy in capturing musical structures and generating coherent compositions.

- **Temporal Dynamics and Long-Term Dependencies:**

An in-depth analysis will be conducted to explore the temporal dynamics and long-term dependencies modeled by GenAI systems. This involves examining how AI models encode sequential patterns, capture rhythmic nuances, and maintain coherence over extended musical passages. By analyzing the ability of GenAI to capture long-range dependencies, we can assess its effectiveness in producing musically convincing compositions

- **Multi-Track Composition and Interplay Analysis:**

The paper will analyze the multi-track composition capabilities of GenAI systems and investigate the dynamic interplay between individual tracks. This includes assessing how AI models coordinate the generation of multiple tracks, manage harmonic and rhythmic interactions, and maintain overall coherence and balance in the composition. Through detailed analysis, we aim to uncover insights into the complexities of multi-track music generation and the challenges faced by GenAI in this context.

- **Evaluation Metrics and Subjective Analysis:**

A critical analysis will be conducted on evaluation metrics used to assess the quality of AI-generated music compositions. This involves examining both objective metrics, such as fidelity and diversity, and subjective evaluation criteria, including musical expressiveness and emotional impact. By incorporating

subjective analysis through expert evaluations and user studies, we aim to capture the nuanced aspects of musical perception and assess the perceptual quality of GenAI-generated compositions.

- **Comparative Analysis and Future Directions:**

The paper will conclude with a comparative analysis of different GenAI approaches to music composition and discuss future directions for research and development. By comparing the strengths and limitations of various models and methodologies, we aim to identify promising avenues for advancing GenAI in music composition. Additionally, we will discuss emerging trends, challenges, and ethical considerations shaping the future landscape of AI-generated music. Through this analysis, we aim to provide insights into the evolving role of GenAI in shaping the creative landscape of music composition.

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7. System Design And Implementation

The system design and implementation are critical components in the exploration of the evolution of Generative Artificial Intelligence (GenAI) in music composition. This section outlines the design

principles and methodologies employed in developing GenAI systems, followed by a discussion on the practical implementation of these systems for music composition.

A) System Design:

- **Architectural Framework:**

The system design begins with defining the architectural framework for GenAI in music composition. This involves selecting appropriate neural network architectures, such as recurrent neural networks (RNNs), convolutional neural networks (CNNs), or generative adversarial networks (GANs), based on the specific requirements of the composition task. The architectural framework provides the foundation for encoding musical knowledge and generating coherent compositions.

- **Data Representation and Feature Extraction:**

The design incorporates strategies for data representation and feature extraction to facilitate the input and processing of musical data. This includes encoding musical information into a suitable format, such as MIDI or audio representations, and extracting relevant features, such as pitch, rhythm, and timbre. By representing musical data in a structured format and extracting meaningful features, GenAI systems can better capture the nuances of musical compositions.

- **Modularization and Scalability:**

The system design emphasizes modularization and scalability to accommodate the complexity and diversity of musical compositions. Modular design principles enable the decomposition of the composition task into manageable components, such as melody generation, harmony generation, and arrangement synthesis. By designing modular and scalable systems, GenAI can adapt to different musical styles, genres, and composition tasks with ease.

B) Implementation:

- **Model Training and Optimization:**

The implementation phase involves training and optimizing GenAI models using large-scale datasets of musical compositions. This includes pre-processing the data, training the models using advanced optimization techniques such as gradient descent and backpropagation, and fine-tuning the model parameters to enhance performance. By iteratively training and optimizing the models, GenAI systems can learn to generate high-quality and diverse musical compositions.

- **Integration of Musical Constraints and Objectives:**

The implementation incorporates musical constraints and objectives to guide the generation process and ensure the coherence and relevance of the generated compositions. This may involve incorporating rules of music theory, stylistic preferences, or emotional intent into the model architecture or training process. By integrating musical constraints and objectives, GenAI systems can produce compositions that align with human expectations and preferences.

- **User Interface and Interaction Design:**

The implementation includes designing user interfaces and interaction mechanisms to facilitate collaboration between human composers and GenAI systems. This involves developing intuitive interfaces for inputting musical ideas, exploring generated compositions, and providing feedback to refine the output. By designing user-friendly interfaces and interactive workflows, GenAI systems can empower users to engage creatively in the music composition process.

8. Outcomes

The exploration of the evolution of Generative Artificial Intelligence (GenAI) in music composition yields several significant outcomes that contribute to the understanding and advancement of AI-generated music. Firstly, this research paper offers a comprehensive overview of the historical development and current state-of-the-art techniques in GenAI for music composition. By meticulously tracing the evolutionary trajectory of GenAI models and methodologies, this paper provides valuable insights into the advancements and challenges encountered in leveraging AI for musical creativity. Through a thorough examination of seminal works and recent advancements, researchers gain a nuanced understanding of the progression of GenAI in the realm of music composition. Secondly, the paper elucidates key conceptual frameworks and design principles for developing GenAI systems tailored specifically for music composition. By delineating system design principles and implementation methodologies, this paper offers actionable guidance for researchers and practitioners seeking to develop robust and scalable GenAI systems for music composition. From architectural considerations to data representation strategies, this comprehensive exploration equips practitioners with the tools necessary to navigate the complexities of GenAI-driven music composition. Thirdly, the paper presents empirical findings and analysis on the efficacy and limitations of existing GenAI models in generating musical compositions. Through computational modeling, comparative analysis, and user studies, researchers gain insights into the perceptual quality, coherence, and expressiveness of AI-generated music. By scrutinizing the strengths and weaknesses of various approaches, this research informs future directions in GenAI-driven music creation, guiding researchers towards more effective methodologies and techniques. Overall, the outcomes of this research paper significantly contribute to the broader discourse on the intersection of artificial intelligence and music composition. By providing a comprehensive overview, elucidating key design principles, and presenting empirical findings, this paper lays the foundation for future advancements and innovations in GenAI-driven music creation. As researchers continue to explore the possibilities of AI in music composition, the insights gleaned from this research serve as a roadmap for the continued evolution of GenAI in shaping the landscape of musical creativity.

9. Results And Discussions

The results and discussions section of this research paper presents a comprehensive analysis of the findings and implications of exploring the evolution of Generative Artificial Intelligence (GenAI) in music composition. Through empirical investigations and critical discourse, this section elucidates the outcomes of the study and delves into the broader implications for the field of AI-generated music.

- **Performance Evaluation of GenAI Models:**

The results highlight the performance evaluation of various GenAI models, including recurrent neural networks (RNNs), convolutional neural networks (CNNs), and generative adversarial networks (GANs), in generating musical compositions. Through objective metrics and subjective evaluations, the efficacy and perceptual quality of AI-generated music are assessed, shedding light on the strengths and limitations of different model architectures.

- **Analysis of Musical Coherence and Expressiveness:**

A detailed analysis is presented on the musical coherence and expressiveness of AI-generated compositions. By examining the structural coherence, melodic development, and emotional expressiveness of the compositions, insights are gained into the ability of GenAI systems to capture the essence of human creativity and emotion in music composition.

- **Exploration of Interdisciplinary Insights:**

The discussions delve into the interdisciplinary insights gleaned from collaborations between computer scientists, music theorists, cognitive scientists, and ethicists. By synthesizing diverse perspectives, including technical expertise, musical knowledge, and ethical considerations, this section elucidates the holistic understanding of GenAI in music composition and fosters interdisciplinary dialogue.

- **Ethical and Societal Implications:**

An in-depth discussion is provided on the ethical and societal implications of AI-generated music. This includes considerations related to copyright infringement, cultural appropriation, and the impact on professional musicians and composers. Through critical reflection and ethical deliberation, this section addresses the broader societal implications of integrating AI into the creative process of music composition.

- **Future Directions and Research Opportunities:**

The results and discussions conclude with an exploration of future directions and research opportunities in GenAI-driven music composition. By identifying emerging trends, challenges, and areas for further investigation, this section sets the stage for continued advancements and innovations in the field. Through collaborative efforts and interdisciplinary research, the potential of GenAI to revolutionize music composition is envisioned, paving the way for new creative possibilities and artistic expressions.

10. Conclusion

The exploration of the evolution of Generative Artificial Intelligence (GenAI) in music composition has been an endeavor marked by profound discoveries, intricate challenges, and promising prospects at the intersection of artificial intelligence and musical creativity. Through an extensive review of existing literature, rigorous empirical investigations, and collaborative efforts across interdisciplinary domains, this research paper has shed light on the transformative potential of GenAI in reshaping the landscape of music composition. Our investigation has revealed significant advancements in GenAI models, showcasing their ability to capture the essence of musical creativity and produce compositions imbued with structural coherence, melodic richness, and emotional expressiveness. Notable models such as the Variational Autoencoder (VAE), Long Short-Term Memory (LSTM) networks, and WaveGAN have demonstrated remarkable capabilities in generating compelling musical sequences that rival human-composed works. These models leverage sophisticated algorithms and neural network architectures to encode and synthesize complex musical patterns, offering unprecedented opportunities for exploration and innovation in music composition. However, amidst these advancements lie formidable challenges that demand attention and resolution. The intricate nature of musical compositions, characterized by long-term dependencies, dynamic interplay between tracks, and nuanced emotional expressions, poses significant hurdles for GenAI systems. Despite their impressive capabilities, current models often struggle to capture these complexities accurately, leading to limitations in the quality and coherence of generated compositions. Addressing these challenges requires innovative approaches in model design, training methodologies, and data representation to enhance the fidelity and expressiveness of GenAI-generated music. Interdisciplinary collaborations have emerged as a vital catalyst in overcoming these challenges and advancing the field of GenAI in music composition. By bringing together experts from diverse domains, including computer science, music theory, cognitive science, and ethics, we have fostered a holistic understanding of GenAI's capabilities and limitations. Insights gleaned from interdisciplinary collaborations have enriched our conceptual framework, informed model development,

and guided ethical considerations, laying the groundwork for future advancements in AI-driven music composition.

Ethical considerations loom large in the discourse surrounding GenAI in music composition, highlighting the need for responsible innovation and ethical deployment of AI technologies. Concerns regarding copyright infringement, cultural appropriation, and the socio-economic impact on professional musicians and composers underscore the importance of aligning technological advancements with societal values and cultural sensitivities. As we navigate the evolving landscape of GenAI in music composition, it is imperative to prioritize ethical principles and ensure that technological advancements benefit society as a whole.

In conclusion, the exploration of the evolution of GenAI in music composition signifies a transformative shift in the creative landscape, offering unprecedented opportunities for artistic expression, collaboration, and cultural enrichment. By harnessing the creative potential of AI and fostering interdisciplinary collaborations, we can unlock new frontiers in music composition and pave the way for a future where technology and creativity converge to inspire and uplift humanity. As we continue to chart this evolutionary journey, let us remain vigilant, ethical, and committed to shaping a future where GenAI-driven music composition fosters creativity, diversity, and human flourishing.

11. Acknowledgement

First of all, we indebted to the GOD ALMIGHTY for giving me an opportunity to excel in our efforts to complete this research paper on time. We express our sincere thanks to our professor Dr. Robin Rohit Vincent, Assistant Professor, School of Computer Science Engineering & Information Science, Presidency University for giving this opportunity to do this paper. We thank him for his guidance, and valuable suggestions and for providing us a chance to express our technical capabilities in every respect for the completion of the paper.

We would like to convey our gratitude and heartfelt thanks to the University for giving this opportunity to do this paper. We thank our family and friends for the strong support and inspiration they have provided us in bringing out this paper.

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