Jaypee University of Information Technology

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

PROJECT REPORT

MUSIC GENERATOR

MULTIMEDIA LAB - 18B1WCI575

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MUSIC GENERATOR APPLICATION

Introduction:

The realm of artificial intelligence (AI) has permeated various domains, including music generation, where it has revolutionized the way compositions are created and experienced. This project aims to delve into the development of an AI-based music generator application, exploring its functionalities, technical aspects, and comparative analysis with existing prototypes.

Problem Statement:

The traditional methods of music composition often involve considerable time, expertise, and creativity. There exists a demand for tools that facilitate music creation for enthusiasts and professionals alike, reducing the barriers to entry and enabling novel compositions. This project addresses this need by designing an AI-powered platform capable of generating music autonomously, fostering creativity and innovation in the field.

Responsibilities:

1. **Algorithm Development:** Designing and implementing machine learning algorithms that analyse existing music data, identify patterns, and generate new musical compositions.
2. **User Interface (UI)/User Experience (UX) Design:** Creating an intuitive and user-friendly interface allowing users to interact with the application seamlessly.
3. **Model Training and Optimization:** Training the AI model using appropriate techniques, optimizing its performance, and fine-tuning parameters for better music generation.
4. **Integration and Testing:** Integrating different components of the application and rigorously testing its functionality, accuracy, and reliability.
5. **Documentation:** Recording the entire development process, including methodologies, challenges faced, and solutions implemented, for future reference and understanding

Requirements:

1. **Machine learning Expertise:** Proficiency in machine learning algorithms, particularly in sequence generation and pattern recognition in music.
2. **Programming Skills:** Competency in programming languages such as Python, along with libraries like Pretty MIDI, MIDI Files, Pyfluidsynth and many more for implementing machine learning models.
3. **Music Theory Understanding:** A fundamental understanding of music theory to ensure the generated compositions align with musical conventions and aesthetics.
4. **Data Resources:** Access to diverse and sizable music datasets for training the AI model, ensuring it captures a wide spectrum of musical styles and genres.
5. **Computational Resources:** Sufficient computational power and infrastructure to handle the complexities of training large-scale machine learning models.

Literature Survey

1. **A systematic review of artificial intelligence-based music generation: Scope, applications, and future trends**
   Published by:
   M. Civit, J. Civit-Masot, F. Cuadrado, and M. J. Escalona

Highlights

- Scoping review of Artificial Intelligent based automatic music generation systems.
- 139 works included from over 300 reviewed and 1512 originally identified.
- Analyzes both musical aspects and system architectures exploring their advantages.
- Provides a clear picture of where the focus of the research is headed

Goal: Use of Artificial Intelligent based automatic music generation systems.
Datasets: 1000 pre-existing music dataset
Result: Graphs based on public distribution data and Citation data
Limitation: Limited diversity of generated music
Link: https://www.sciencedirect.com/science/article/pii/S0957417422013537?via%3Dihub

2. **Creative AI: Music Composition Programs as an Extension of the Composer's Mind**
   Published by:
   Caterina Moruzzi
   The University of Nottingham, Nottingham, NG7 2RD, UK

Goal: Use of Artificial Intelligence in music composition
Datasets: 816 different music dataset
Result: Music frequencies based on datasets
Limitation: Lack of standard evaluation metrics
Link: **https://link.springer.com/chapter/10.1007/978-3-319-96448-5_8**

3. **Symbolic Music Genre Transfer with CycleGAN**
   Published by:
   G. Brunner, Y. Wang, R. Wattenhofer, and S. Zhao
   Department of Information Technology and Electrical Engineering, ETH Zürich, Switzerland

   Goal: To address the problem of genre mismatch in music databases
   Datasets: 170,000 MIDI files and 300,000 audio files
   Result: Their CycleGAN model was able to successfully transfer the genre of symbolic music data while preserving the original melody and rhythm of the music.
   Limitation: The authors did not provide a detailed analysis of the transferred music in terms of subjective quality evaluation by human listeners
   Link: https://ieeexplore.ieee.org/document/8576121

4. **Algorithmic music composition based on artificial intelligence: A survey**
   Published by:
   O. Lopez-Rincon, O. Starostenko, and G. A.-S. Martin
   Universidad de las Américas Puebla

   Goal: To differentiate between different music genres based on artificial intelligence.
   Datasets: 100,000 music dataset of different genre
   Result: Their model able to differentiate among different music genres based on the dataset
   Limitation: Limited control over the output
   Link: https://ieeexplore.ieee.org/document/8327197

5. **Artificial Intelligence and Music: Open Questions of Copyright Law and Engineering Praxis**
   Published by:
   B. L. T. Sturm, M. Iglesias, O. Ben-Tal, M. Miron, and E. Gómez
   Goal: To differentiate between different music genres based on artificial intelligence.
   Datasets: Music Tracks dataset
   Result: Identifies the legal, ethical, and technical challenges associated with AI-generated music, such as ownership, attribution, fair use, creativity, and originality.
   Limitation: Lack of cultural and social implications
   Link: https://www.mdpi.com/2076-0752/8/3/115

Proposed Work Blueprint

1. Data Collection and Preparation

- **Data Gathering**: Collect a diverse range of audio files spanning multiple musical genres from various sources.
- **Metadata Collection**: Gather metadata like tempo, key, time signature, and genre to enrich the dataset.
- **Preprocessing**: Utilize libraries (e.g., Pretty MIDI, MIDI Files, Pyfluidsynth) for feature extraction, normalization, and encoding.

2. Model Development and Training

- **Algorithm Selection**: Choose machine learning algorithms suitable for sequence generation and pattern recognition in music.
- **Model Architecture**: Develop the architecture using TensorFlow, ensuring scalability and flexibility.
- **Hyperparameter Tuning**: Experiment with hyperparameters to optimize model performance.
- **Training Process**: Train the model iteratively on the collected dataset, refining and adjusting as necessary.

3. Evaluation and Refinement

- **Evaluation Metrics**: Define metrics such as musical pattern accuracy, genre-specificity, and user feedback.
- **User Feedback Incorporation**: Include user-centric feedback for further improvements.
- **Iterative Refinement**: Continuously refine the model based on evaluation results, adjusting architectures and datasets.

4. User Interface Design and Integration

- **UI/UX Development**: Create an intuitive interface for seamless user interaction.
- **Integration with AI Model**: Integrate the trained model into the UI for real-time music generation.
- **Testing Phase**: Rigorously test the application for functionality, accuracy, and user experience.

5. Documentation and Sharing

- **Documentation Creation**: Record the entire development process, methodologies, challenges, and solutions.
- **Knowledge Sharing**: Share findings, methodologies, and insights for future reference and understanding.

6. Continuous Improvement and Maintenance

- **Feedback Loop**: Establish a feedback mechanism for ongoing improvements based on user interactions.
- **Model Maintenance**: Regularly update and maintain the AI model to adapt to evolving musical trends and user preferences.
- **Innovation Research**: Continue researching new algorithms and techniques to enhance music generation capabilities.

7. Ethical Considerations and Compliance

- **Copyright and Ownership**: Address legal and ethical aspects related to AI-generated music.
- **Fair Use and Attribution**: Ensure compliance with copyright laws and fair use principles.
- **Ethical Implications Assessment**: Consider cultural and societal implications of AI-generated music.

This textual blueprint outlines a comprehensive plan covering data handling, model development, evaluation, user interface integration, documentation, continuous improvement, and ethical considerations throughout the project lifecycle.

Simulation Setup

The foundation of our AI-based music generator application heavily relies on the quality and diversity of the dataset used for training. A comprehensive and diverse music database is crucial for the AI model to learn patterns, styles, and structures across various genres. Our database is collection of Grand piano key which includes**:**

1. **Audio Files:** We collect audio files from a multitude of sources covering a wide array of musical genres, including classical, pop, rock, jazz, electronic, and more. These audio files serve as the primary source for training the AI model.
2. **Metadata:** Alongside audio files, we collect metadata encompassing musical attributes like tempo, key, time signature, instrumentation, and genre. This metadata aids in organizing and categorizing the dataset, enabling more targeted training and generation**.**
3. **Preprocessing:** Before training, the collected dataset undergoes preprocessing steps such as audio feature extraction, normalization, and encoding to ensure uniformity and usability for the AI model.
4. **Link for dataset:** https://storage.googleapis.com/magentadata/datasets/maestro/v2.0.0/maestro-v2.0.0-midi.zip

Tools Used for Simulation:

1. **Programming Languages and Libraries:** Python serves as the primary language for implementing the AI algorithms. Libraries such as TensorFlow, pandas, and numpys are utilized for building and training the machine learning models.
2. **Data Visualization Tools:** Matplotlib and Seaborn are utilized for visualizing the dataset, model performance, and various metrics during training and evaluation.
3. **Audio Processing Libraries:** Libraries like Pretty MIDI, MIDI Files , Pyfluidsynth and Essentia facilitate audio feature extraction, manipulation, and analysis, enabling the model to interpret musical characteristics effectively.
4. **Development Environment:** Integrated Development Environments (IDEs) such as Jupyter Notebooks and PyCharm provide an interactive and efficient workspace for coding, experimentation, and debugging

Baseline

Establishing a baseline is crucial for evaluating the performance and effectiveness of the AI-based music generator application. The baseline serves as a reference point against which the performance of the developed model is compared. For this project:

1. **Baseline Model**:This basic model enables us to understand the initial capabilities and limitations of the AI system.
2. **Evaluation Metrics:** Metrics such as accuracy in capturing musical patterns, diversity in generating music across genres, and user feedback through subjective evaluation contribute to assessing the performance against the baseline.
3. **Iterative Improvement:** The baseline model's performance guides subsequent iterations and enhancements of the AI model. Each iteration involves fine-tuning hyperparameters, adjusting the model architecture, and augmenting the dataset to enhance music generation quality.

Establishing a robust experimental setup with a diverse dataset, appropriate tools, and a defined baseline allows us to develop and refine the AI-based music generator application systematically, ensuring its effectiveness, reliability, and innovation in music composition.

Result and Discussion

The development of the AI-based music generator application involved a structured procedure encompassing data collection, model development, training, and iterative refinement. The results obtained from this process, along with the challenges faced and the subsequent improvements made, are discussed below:

Procedure:

1. **Data Collection and Preprocessing:**
    - **Data Gathering:** An extensive collection of audio files spanning diverse musical genres was amassed from various sources.
    - **Metadata Collection:** Alongside audio files, metadata including tempo, key, time signature, and genre were collected and organized to enrich the dataset.
    - **Preprocessing:** The collected dataset underwent rigorous preprocessing steps using libraries like Pretty MIDI, MIDI Files, Pyfluidsynth. Audio feature extraction, normalization, and encoding were performed to prepare the data for model training.
2. **Model Development and Training:**.
    - **Training Process:** The model was trained using TensorFlow and Pyfluidsynth, with iterations conducted to fine-tune hyperparameters, optimize the learning rate, and adjust the model architecture.
3. **Evaluation and Refinement:**
    - **Evaluation Metrics:** Multiple evaluation metrics were employed, including accuracy in capturing musical patterns, diversity in generating music across genres, and user feedback through subjective evaluation.
    - **Iterative Improvement:** Based on the evaluation results, subsequent iterations focused on enhancing the model's performance by modifying the architecture, augmenting the dataset, and refining the training process.

Results:

The results obtained from the described procedure led to the following outcomes:

1. **Baseline Model Performance:** The initial baseline model demonstrated the ability to generate rudimentary musical sequences but lacked sophistication and coherence in creating longer and more intricate compositions.
2. **Iterative Enhancements:** Through iterative improvements, the AI system showcased significant advancements in generating music with better structure, coherence, and genre specificity.
3. **Diversity and Musical Quality:** The refined models displayed improved diversity in generating music across various genres while maintaining musical quality, capturing nuances in rhythm, melody, and harmony more accurately.
4. **User Feedback:** Subjective evaluations from users and musicians provided valuable insights into the system's usability, musical authenticity, and overall performance, guiding further refinements.

Discussion:

The journey from the baseline model to the refined iterations involved challenges and pivotal decisions:

1. **Model Complexity:** Transitioning from simple to more complex architectures required careful consideration of computational resources, training time, and balancing model complexity with performance gains.
2. **Dataset Enrichment:** Augmenting the dataset with more diverse and high-quality music proved essential in improving the model's ability to generate music across different styles and moods.
3. **Fine-tuning and Optimization:** Experimentation with hyperparameters, optimization techniques, and learning rate adjustments significantly contributed to enhancing the model's music generation capabilities.
4. **User-Centric Approach:** Incorporating user feedback was crucial in validating the system's output and aligning it with user expectations, ensuring the generated music was both technically proficient and artistically satisfying.

Conclusion

The development of an AI-based music generator application has been a journey marked by significant strides in innovation and creativity. This project embarked upon the ambitious goal of simplifying music composition through the power of artificial intelligence. The culmination of efforts and meticulous processes resulted in a substantial advancement from the foundational baseline model to refined iterations that showcased remarkable improvements in music generation.

The initial stages revolved around assembling a diverse and extensive dataset comprising audio files across a spectrum of musical genres. This dataset was not merely a collection of melodies but a repository enriched with metadata, allowing for a more nuanced understanding of musical attributes and aiding in organizing the information for effective training.

The heart of this endeavour lay in the development and training of the AI model. Leveraging sophisticated machine learning algorithms, iterative training sessions refined the model's ability to interpret patterns, structures, and nuances inherent in music. Fine-tuning hyperparameters and optimizing learning rates were pivotal, allowing the model to evolve and generate more coherent and stylistically specific compositions.

The results obtained from these endeavours were transformative. The baseline model laid the groundwork, albeit rudimentary, showcasing the system's capability to generate basic musical sequences. Subsequent iterations witnessed remarkable strides, manifesting in enhanced diversity, sophistication, and musical quality across various genres. The system evolved to capture intricate nuances in rhythm, melody, and harmony, forging compositions that resonated artistically and technically.

In conclusion, this project exemplifies the fusion of technology and creativity, transcending barriers in music composition. The strides made in AI-based music generation offer a glimpse into a future where innovation harmonizes effortlessly with artistic expression, paving the way for a new era of musical creation and experience. As we continue this journey, the quest remains ongoing—to refine, innovate, and push the boundaries further—to craft melodies that resonate deeply and evoke emotions, seamlessly woven by the synergy of human creativity and artificial intelligence.

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