

Symbolic music generation using Mamba architecture

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Abstract—Over the past few years, a lot of effort has been put into making Transformers more and more efficient. However, they still suffer from quadratic memory and inference time complexity. Recently they have been experiencing increasing competition from state space models (SSMs), that avoid some of transformer’s drawbacks. In this paper we test one of state of the art SSM models called Mamba in symbolic music generation. To achieve this we conducted several experiments on MAESTRO MIDI dataset. Our results show that TODO

Index Terms—deep learning, transformer, music, symbolic music generation, neural network, generative, unsupervised learning, state space model, ssm, mamba

1. Introduction

Symbolic music generation has been an area of active research over the past decades. In the beginning it was dominated by classical methods like Hidden Markov Models. During the advent of deep learning in the last decade, neural networks managed to become a go to method for this task. During those years a lot of architectures, including Long Short-term Memory networks (LSTMs) [9], Variational Autoencoders (VAEs) [11] and Generative Adversarial Networks (GANs) [3] were used to successfully generate music in symbolic formats. However, after popularisation of Transformers [13] and Diffusion Models [8] in the field of deep learning, they seem to be gaining more and more dominance in the area of symbolic music generation. In the case of transformers, which are the go to architecture in the area of natural language processing, a lot of effort has been put into small iterative improvements, to make the more efficient. However, they still suffer from quadratic GPU memory, as well as inference time complexity. To mitigate those problems State Space Models (SSMs) [6] were developed. Recently they have been experiencing gaining popularity and even beating transformers on some of their most signature tasks in the field of nature language processing, while being significantly smaller [4]. They seem to be especially suited for long time dependencies. Musical data, which often contains such long dependencies seem to be suited to further test the performance of SSMs. Therefore

we decided to use current state of the art SSM model called Mamba [4] to generate music in symbolic format.

2. Data

We decided to use MIDI [14] music representation. It is by far the most popular format in the field of symbolic music and allows us to freely use the largest symbolic music datasets available. Because of model’s size a lot of data is required to reduce the chance of overfitting. The dataset we chose is MAESTRO (MIDI and Audio Edited for Synchronous TRacks and Organization) [7] [12]. It contains over 200 hours of virtuosic piano performances. The data comes from ten years of International Piano-e-Competition. It is one of the most popular datasets, which allows us to easily compare our results to other models. The data was downloaded using Muspy [1] library, which allows for convenient handling of symbolic musical data. The tokenization was conducted using miditok [2] library. It contains methods for tokenising MIDI data into most of the most popular formats. We decided to opt for REMI [10] format with learned Byte-Pair Encodings.

3. Architecture

Mamba utilises a novel approach called selective state space models (SSMs), which enhance traditional state space models by allowing parameters to be functions of the input. This design enables the model to selectively propagate or forget information along the sequence length, dependent on the current input token. Mamba integrates this selective SSM approach into a simplified end-to-end architecture, foregoing traditional components like attention or MLP blocks found in architectures like Transformers.

The main difference between Selective SSM and traditional SSM is the input-dependence, which mimics what the attention mechanism in Transformers does—essentially assessing whether a specific token is important or not. However, this feature sacrifices the ability of traditional SSMs to precompute all learnable matrices (Δ , A , B , C) and their configurations based on sequence length in a single inference pass. To address this, we introduce a mechanism

TABLE 1. MODEL COMPARISON [4]

Architecture	Complexity	Memory	Performance
Transformer	$O(N^2)$	$O(N^2)$	great
RNN	$O(N)$	$O(N)$	poor
SSM	$O(N)$	$O(N)$	poor
Selective SSM (Mamba)	$O(N)$	$O(N)$	great.

of Parallel Associative Scan (similar to Prefix Sum) that requires storing precomputed calculations, leading to higher memory usage but still maintaining linear computation.

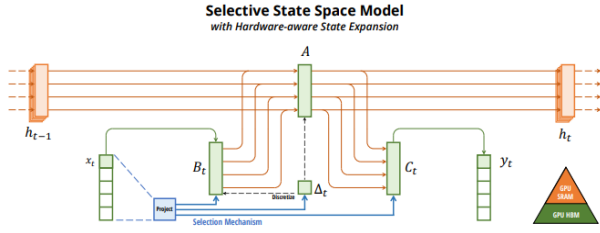


Figure 1. Selective SSM [4]

To enhance efficiency further, the authors proposed using a hardware-aware algorithm that leverages two main types of GPU memory: SRAM, which is fast but has limited capacity (ideal for matrix calculations), and HBM, which is slower but has a larger capacity. The main bottleneck of this approach is managing the data transfer between these memory types.

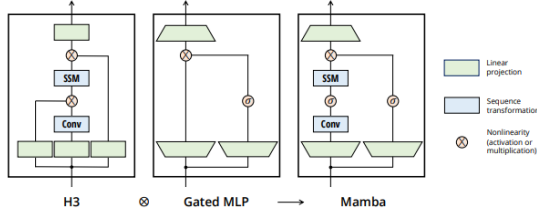
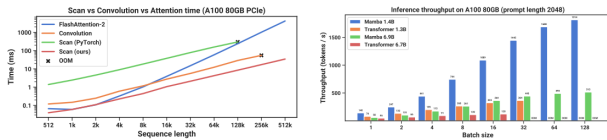


Figure 2. Mamba block [4]

Selective SSM is a crucial component of the Mamba block, but the system also includes linear layers that increase dimensionality, nonlinear layers, and gating connections. Whole architecture is built from many Mamba block which are computed layer by layer.



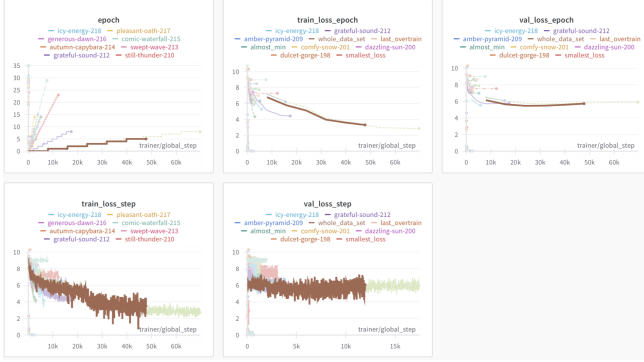


Figure 5. Training and validation losses in various experiments

6. Conclusions

Although mamba managed to generate novel samples, they weren't of high quality. This may be due our models being unable to handle the complexities of virtuosic music. The model might be more suited for simpler datasets that do not contain such intricate musical scores.

6.1. Future work

While Mamba offers better performance than transformers, it comes at the cost of output quality. A promising direction for future research is to experiment with hybrid architectures that combine the strengths of both models. Examples of such architectures include **MambaFormer** [mambafomer] and **Jamba** [jamba]. It is also worth trying different datasets, to see how mamba handles them.

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