# GAMAKA SYNTHESIS FOR KALPITHA SWARAS IN CARNATIC MUSIC

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## Introduction

Carnatic Music is a system of music commonly associated with southern part of India. The main emphasis of the system is vocal music, known as the 'Gayaki' style [1]. A notable trait of the genre is the use of microtonal variations, where musical notes (Swaras) of phrases are almost always performed with ornamentation called 'gamakas'. A raga is a melodic framework akin to a melodic mode, in Indian classical music [2]. Unlike western music where the modes/scales are only defined by the notes and the key, in Carnatic music, the gamakas are integral parts of asserting a raga.

Synthesising/Generating gamakas given plain notes has various applications like music education, Robotic musicianship, AI driven music performances, virtual instruments (VSTs) and so on.

We propose a novel data driven approach to generate gamakas for tempo based swaras in Carnatic music. Our application is to use GamakaNet to generate gamakas given plain midi notes that will then be used in Hathaani [3] - A Robotic violinist for Carnatic Music.

## Dataset

The first step to achieve this is to have the right dataset. We recorded Carnatic Varnams (Songs with a specific structure) from 5 artists. It includes 3 violinists, a veena artist and a keyboard player. Each of them tracked 2 different varnams in 3 different tempos (80, 120, 160 BPM). This was annotated at the note level to form the dataset. As far as we know, there is no such Carnatic dataset available for this task.

## Architecture and Training

We designed an autoencoder architecture with a masked latent space representation (shown in fig 1) to model different Gamakas that are tied to different notes and ragas.

By masking latent vectors, we were able to isolate key features that distinguish the Gamakas of each raga while retaining and sharing common features using the skip connections and shared weights of the encoder and decoder between between different ragas. There are N masked latent vectors corresponding to N Ragas in the dataset. Only the vector that corresponds to the raga is unmasked during training and inference.

After pretraining the model on just the pitch contours on saraga dataset and out dataset, We trained GamakaNet for 2000 epochs, optimizing using Stochastic Gradient Descent (SGD) with a starting learning rate of 0.001 and a momentum of 0.99 with midi pitch contour as input and the pitch contour tracked from performance as target. We used the Mean Absolute and Squared Error (MASE) as the loss function which is MSE + MAE.

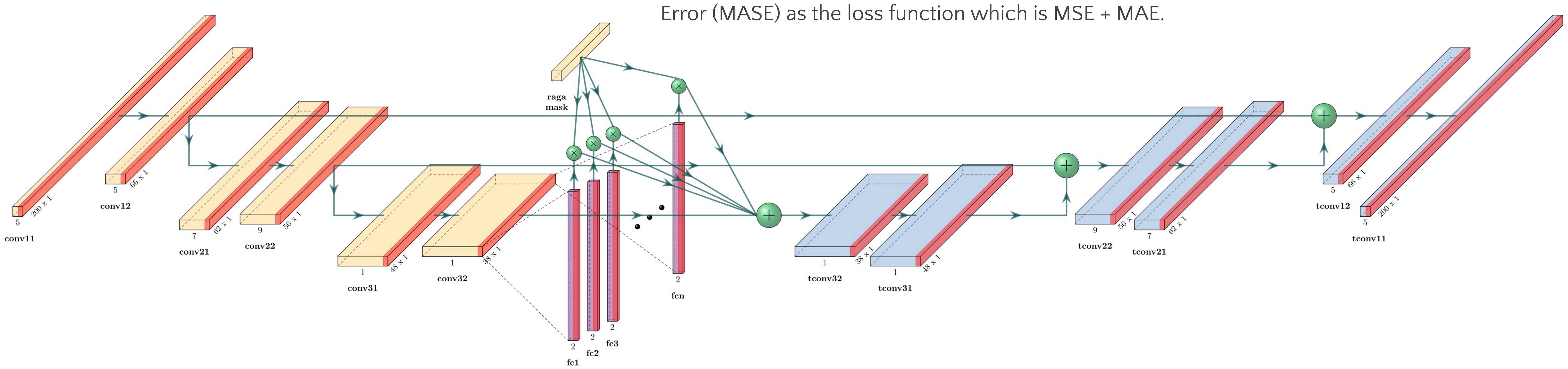


*Figure 1. GamakaNet Architecture*

## Related Works

There are very few attempts at synthesizing gamakas for Indian music especially Carnatic Music. Ashtamoorthy, Anand, et al. [4] concentrated on rule based gamaka generation with flute synthesis which again suffered the fact that the gamakas need to be manually provided. The Gaayaka [5] software could synthesize automatic gamakas with a custom musical representation. However, the work is not open source and is not scalable since each raga requires a separate definition file. MellisAi [6] employs a data-driven approach, which features an LSTM-based architecture to model music generation while using mathematical models to generate the Gamakas.

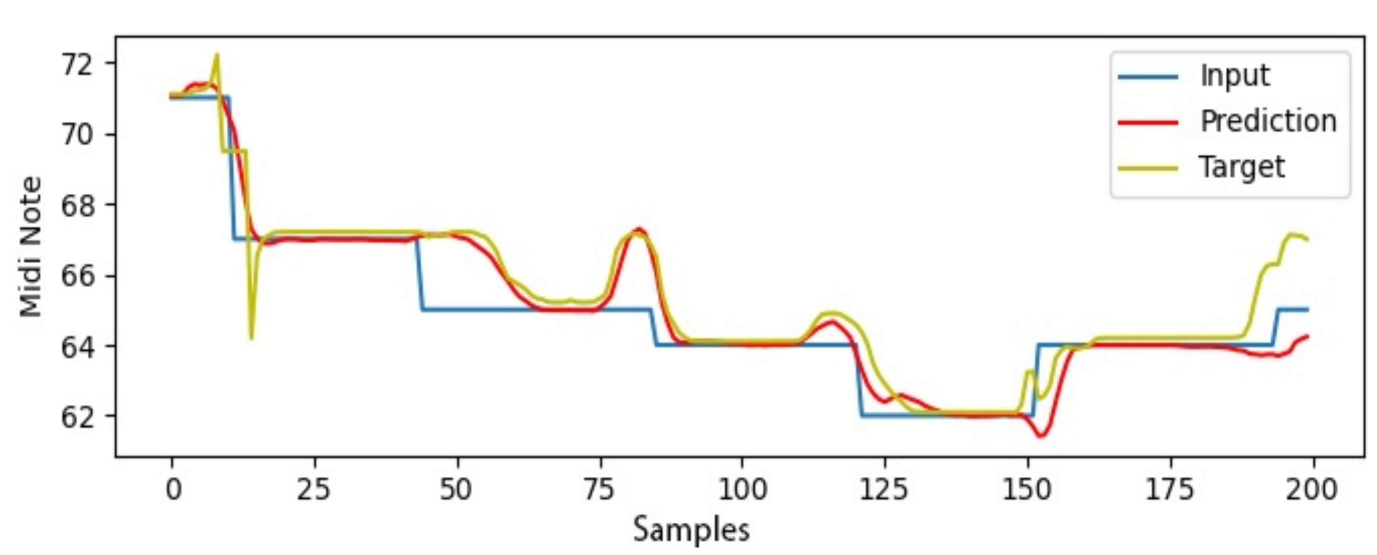


*Figure 2. Pitch contour of phrase in raga Abhogi*

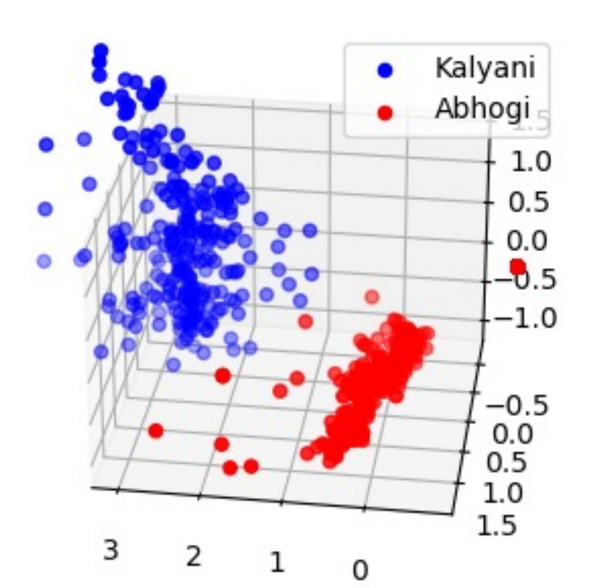


*Figure 3. Latent space of Raga Abhogi and Kalyani*

## Results and Discussion

Figure 2 shows an excerpt of phrase in Abhogi. The generated pitch contour closely matches the target.

Figure 3 shows the latent space of GamakaNet. We used Principal Component Analysis (PCA) to project the latent vector into 3d space. The latent vectors learn distinguishable information for the two ragas.
Blue points being spread out could be because Kalyani is a melakartha raga [4] with a lot more gamaka variations while Abhogi is a pentatonic raga.

Figure 4 shows the generated pitch contours in 3 tempos. The values are shifted and re-sampled for readability. We notice the complexity of gamakas getting lower as the tempo increases which is similar to how a musician would handle gamakas at different tempos.

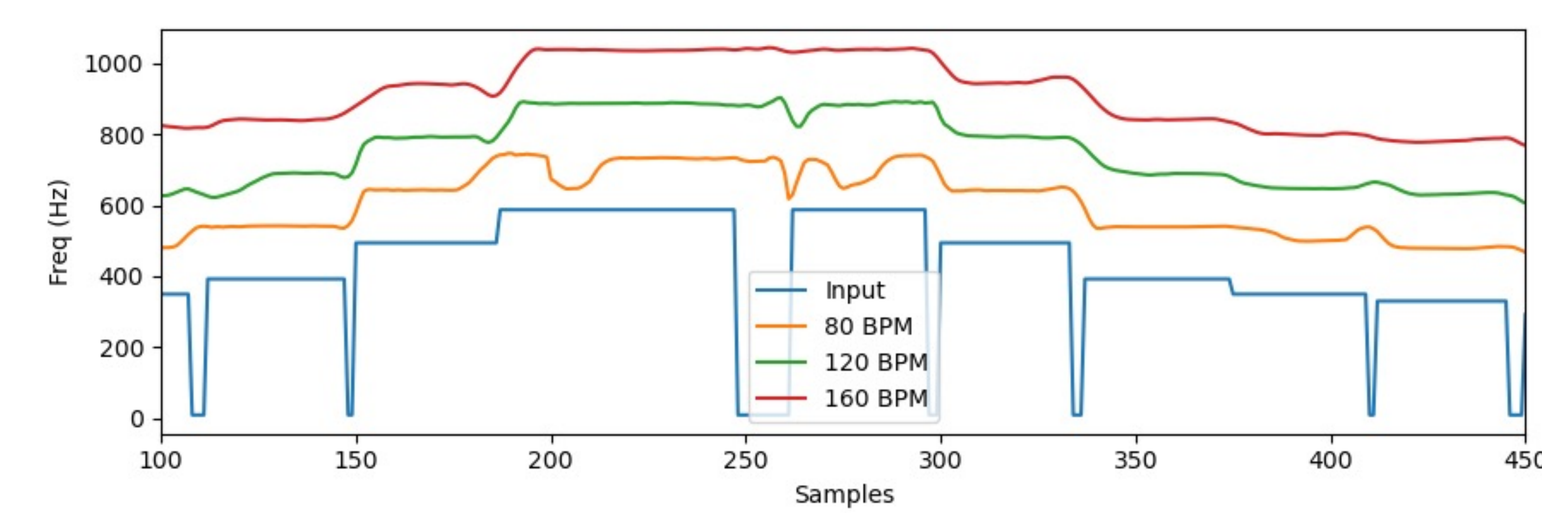


*Figure 4. Pitch contour generated in 3 different tempos*

## Future Work

In this work, we explored a data-driven approach to gamaka synthesis for kalpitha swaras in Carnatic music. The system receives MIDI scores and synthesizes pitch contour for the given notes with gamaka information embedded in it.

We plan to conduct listening test with performance scoring on a held-out test set along with the Turing test. We will invite 10 experienced Carnatic musicians to listen to the audio samples synthesized from the synth detailed in paper. We included the Tanpura in all the samples for completeness and pitch reference. We will use a Likert scale for the scoring. The baseline for our tests will be the Gaayaka software [5].

## References

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4. Ashtamoorthy, Anand, et al. "Frequency contour modeling to synthesize natural flute renditions for carnatic music." SPCOM 2018. IEEE, 2018.
5. https://carnatic2000.tripod.com/autogamakam.htm
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