

# Classifying Hindustani Indian Ragas with Convolutional Neural Networks

Pitzer College



Rishov S. Chatterjee

06 May 2019



## Senior Thesis Readers

1. Dr. Yan Li, Professor of Information Systems and Technology at Claremont Graduate University
2. Dr. David Bachman, Professor of Mathematics at Pitzer College

I would like to exhibit words of gratitude to Dr. Yan Li for teaching me about data mining, machine learning, and database technologies to develop a thorough understanding required to do a thesis of this magnitude. I would also like to thank Dr. Michael Spezio at Scripps College for deepening my understanding of machine learning through its application with neural signals and sharing his wisdom about audio signal processing and words of advice about conducting end-to-end machine learning for any project. Also, many thanks to my advisor, Dr. Linus Yamane at Pitzer College for believing in my academic efforts through his constant support and communication with me. Finally, I want to thank my father, Dr. Samir Chatterjee at Claremont Graduate University for supporting me through every trial and tribulation during my undergraduate career.

# Introduction

I have been exposed to Hindustani classical music ever since I was small. I was raised in an Indian household to immigrant parents and my mom is a vocalist and an exponent of Indian classical music. Indian classical music is categorized into two distinct forms: Hindustani and Carnatic, which are practiced in North and Southern India. Unlike western classical music, Indian classical music is very old form and typically doesn't have clear structures but largely depends on the performers or instrument players own elaboration of a melody. Indian classical music is defined by two basic elements – it must follow a Raga (classical mode), and a specific rhythm, the Taal [1]. Most compositions follow a Raga and I have noticed that even experts sometimes have difficulty of telling which Raga a particular song or composition is based on. This is particularly challenging for novices or beginners. Being a data science major, I quickly became attracted to this problem of “Raga detection”. My intuition said that machine learning algorithms and techniques could help classify a composition into a main Raga on which it is based. Thus begins my journey to explore and hence this senior thesis.

I will mainly focus on North Indian form which is referred to as the Hin-

dustani classical music. Compositions in Hindustani classical music also are based on a drone, i.e., a continual pitch that sounds throughout the concert, which is tonic [2]. This drone acts as a point of reference as the performer is expected to come back to this home base after a flight of improvisation. The variations and complexity in Hindustani music stems from its use of notes that comprise a Raga. There are seven main musical notes (also called swaras) – Sa, Re, Ga, Ma, Pa, Dha and Ni – along with five intermediate notes (flats and sharps) referred to as “vikrit swaras”. The seven notes are referred to as Shuddha and belongs to the saptak (a scale). The flat notes are called “komal” and the sharp notes are called “teevra”. A raga consists of at least five notes, and each raga provides the musician with a musical framework within which to improvise [3, 4 5]. The specific notes within a raga can be reordered and improvised by the musician. Ragas range from small ragas like Bahar and Shahana that are not much more than songs to big ragas like Malkauns, Darbari and Yaman, which have great scope for improvisation and for which performances can last over an hour. Each raga traditionally has an emotional significance and symbolic associations such as with season, time and mood [6]. The raga is considered a means in Indian musical tradition to evoke certain feelings in an audience. Hundreds of raga are recognized in the classical tradition, of which about 30 are common [7].

The swaras in a raga can be played in three octaves, the first or lower octave starting from 130 Hz, then middle octave starting at 260 Hz; and upper octave from 520 Hz. The artists are allowed to improvise over the definitions

of raga to create their own renditions. If you listen to two performance of the same raga, they may sound strikingly different to novice ears, though they still retain the rules and defining qualities of ragas.

The rest of the thesis is organized as follows. In Chapter 2, we take a closer look at ragas to understand certain nuances and patterns they exhibit. In Chapter 3, we discuss Librosa, a python package for audio and music signal processing. In Chapter 4, we cover background and related work done on identifying Indian ragas using machine learning and other methods. In Chapter 5, we present a deep learning methodology for raga classification using Convolutional Neural Networks (CNN). Chapter 6 presents the details of the dataset and image data generation. In Chapter 7, I present the data preprocessing steps for the CNN algorithm to be used for raga detection. In Chapter 8 I present the results and analysis of this project. Finally, I conclude in Chapter 9 with a summary of findings and future work.

# Indian Classical Ragas

Raga can be identified by various parameters. The particular choice of notes, Ascending and Descending sequences (known as arohana and avarohana pattern), nature of inflexion on different notes (gamaka/meend), characteristic phrases (pakad) all can be helpful to classify a raga. These are further described below:

## 1. Choice of Notes

A rāga has a given set of notes (swaras), on a scale, ordered in melodies with musical motifs. The Indian tradition suggests a certain sequencing of how the musician moves from note to note for each rāga, in order for the performance to create a rasa (mood, atmosphere, essence, inner feeling) that is unique to each rāga. Theoretically, thousands of rāga are possible given 5 or more notes, but in practical use, the classical tradition has refined and typically relies on several hundred. For most artists, their basic perfected repertoire has some forty to fifty rāgas [8-10]. Each raga has a different set of swaras that constitutes it. There must be the notes of the rag. They are the allowed swar. This concept is

similar to the Western solfege. There must also be a modal structure. This is called that in North Indian music and mela in Carnatic music. There is also the jati. Jati is the number of notes used in the rag. Rāga in Indian classic music is intimately related to tala or guidance about "division of time", with each unit called a matra (beat, and duration between beats) [11]. A rāga is not a tune, because the same rāga can yield an infinite number of tunes [12]. A rāga is not a scale, because many rāgas can be based on the same scale. Each raga tends to have a "Vadi" swara, a king swara on which maximum focus is given in a performance [1]. It is also known as the most frequently occurring swara in a particular raga. It is followed by Samvadi (next in importance), then Anuvadi. The swaras that are not allowed in a particular raga are known as Vivadi swaras (enemy notes).

## 2. Arohana/Avarohana

There must also be the ascending and descending sequence of notes. This is called arohana /avarohana. Arohana and avarohana are the descriptions of how the raga moves. The arohana, also called aroh or arohi, is the pattern in which a raga ascends the scale. The avarohana, also called avaroh or avarohi, describes the way that the raga descends the scale. Both the arohana and avarohana may use certain characteristic twists and turns.

## 3. Pakad



The pakad or swarup, is a defining phrase or a characteristic pattern for a raga. This is often a particular way in which a raga moves; for instance the “Pa M’a Ga Ma Ga” is a tell-tale sign for Raga Bihag, or “Ni Re Ga M’a” is a telltale sign for Yaman. Often the pakad is a natural consequence of the notes of arohana / avarohana (ascending and descending structures). However, sometimes the pakad is unique and not implied by the notes of the arohana / avarohana. It is customary to enfold the pakad into the arohana / avarohana to make the ascending and descending structures more descriptive.

#### 4. Gamakas

Gamakas are better known as ornamentations used in Hindustani music system. These are inflexions and rapid oscillatory movements taken across swaras.

We now take one common raga as a running example and explain how the notes behave with respect to the above definitions and terms. Yaman emerged from the parent musical scale of Kalyan. Considered to be one of the most fundamental ragas in Hindustani tradition, it is thus often one of the first ragas taught to students. Yaman is a heptatonic (Sampurna) Indian classical raga of Kalyan Thaat. Yaman’s Jati is a Sampurna raga.

Arohana: Sa Re Ga Ma (Kori Ma/tivra Ma i.e. Ma#) Pa Dha Ni Sa’

Avarohana: Sa’ Ni Dha Pa Ma ((Kori Ma/tivra Ma i.e. Ma#)) Ga Re

Sa

The ascending Aaroha scale and the descending style of the avroha includes all seven notes in the octave (When it is Shadav, the Aroha goes like N,RGmDNS' , where the fifth note is omitted; Pa but the Avaroha is the same complete octave). All the scale notes (called swaras) in the raga are Shuddha, the exception being Teevra Madhyam or prati madhyamam.

### **Vadi and Samavadi**

Vadi is G (ga) and Samvadi is N (ni).

### **Pakad or Chalan**

Kalyan has no specific phrases or particular features, many musicians avoid Sa and Pa in ascend or treat them very weakly. You will often hear N0 R G M+ D N S' in ascent and S' N D M+ G R S in descent). Sa is avoided in beginning the ascend such as N0 R G M+ P D N S'. To summarize the rules that make a raga:

A raga has at least 5 notes, including the Shadja. More than 5 is definitely ok. We can then add a further complexity, by choosing different swara in the ascent (Aaroha) and the descent (Avaroha). So the number of combinations can then be 5-5, 5-6,5-7,6-5,6-6,6-7,7-5,7-6 and 7-7. Five is Odhav, six is Shadhav and 7 is Sampoorana. So, an odhav-sampoorna raga will have 5 swar in the aaroha and 7 in the avaroha.

# **Librosa: Processing Musical Information in Python**

## Background and Related Work

# Methodology

## Initial Dataset and Image Data

# Data Preparation and Processing

## Results and Analysis



## Future Steps

# Bibliography

# Appendix