Computer Aided Music Generation Using Genetic Algorithm and Its Potential Applications

[1]J Vasudha, [2]S Iniya, [3]G Iyshwarya, [4]G. Jeyakumar

[4] Assistant Professor

[1,2,3,4]Department of Computer Science and Engineering, Amrita School of Engineering, Coimbatore, India

[1]vasudhajagan@gmail.com, [2]iysh16@gmail.com, [3]iniyasubbaraman@yahoo.com, [4]g_jeyakumar@cb.amrita.edu

***Abstract*- Music speaks what cannot be expressed, soothes the mind and gives it rest, heals the heart and makes is whole. Not everyone is gifted with a good voice but almost everyone has good ears when it comes to pleasant music. This music ranges from strictly organized compositions, through improvisational music to aleatoric forms which makes it tough to automate music generation. In this paper we try to bring in the idea of automated Carnatic music generation using genetic algorithm and its applications. Firstly a variety of compositions on specific ragas can be generated which can be improvised to deliver a good quality musical concert. This concept of automated music generation can also be applied to build an 'online musical instrument tutorials' by which users get to learn any instrument level by level. The work can also be modified to produce music of same fitness as any pre existing composition by giving the latter's notes as input. The application of computerized composition can be used in Music Therapy which is the use of a selected music to obtain the same expected changes and hormonal alterations in the body, played uninterrupted for a while, to obtain the desired positive effect. The above mentioned field of music generation can be used by the medical practitioners by selecting a raga for playing after giving the patient details and disease as input. The application is developed using Java. A Java API, called JFugue is used to support music programming.**

***Keywords*—Carnatic music, Genetic algorithm, Music composition, Music Therapy, Musical instrument tutorials, Carnatic concert**

I. INTRODUCTION

Music can be defined as an art form that arranges sounds in a fashion that follows certain natural principles and provides that special inner feeling of happiness and contentment. Carnatic Music which is a classical Music of Southern India has its origin which dates back to 4th century A.D. Research works conducted on carnatic music have shown that carnatic music can be used for healing numerous medical ailments. But carnatic music has always been composer dependent and subjected to stringent rules thereby making it difficult for the therapist to apply in treatment. So there arises a need for a system which can generate music on its own in variety as long as and in the way the user wants it. On probing further it can be found that genetic algorithm can very well be used in automatic generation on user specific music.

A. Carnatic Music-Definition

Indian Carnatic Music [3] has two components namely raga and tala as its cornerstones. A raga is basically the melody (scale) and the tala is the rhythm (beat).The seven basic notes (or the Saptha swaras) that comprise a raga are Sa, Ri, Ga, Ma, Pa, Da and Ni. Whereas the swaras Sa and Pa are always fixed,the swaras Ri, Ga, Da and Ni have three variants and the swara has two variants. The Carnatic Music ragas are structured into a mathematical table based on a scientific calculation of their swaras (Fig 1). The 72 ragas identified are known as the Melakarta ragas (Parant ragas) from which are obtained other ragas known as the Janya ragas. Neural research proves that the 72 ragas have the power to control 72 nerves in the human body.

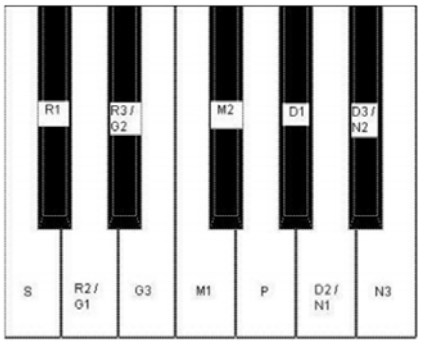


Figure 1. Mathematical table of Swaras

II. IMPLEMENTATION

A. System Overview

The application consists of a central database that contains the list of ragas. On entering the raga to be played, the corresponding notes (aarohana and avarohana) are retrieved from the database. From the initial random population chosen, cross over and mutation are performed which is tested for fitness. Those which satisfy the fitness criteria are played. The whole system architecture is as in Fig 2.

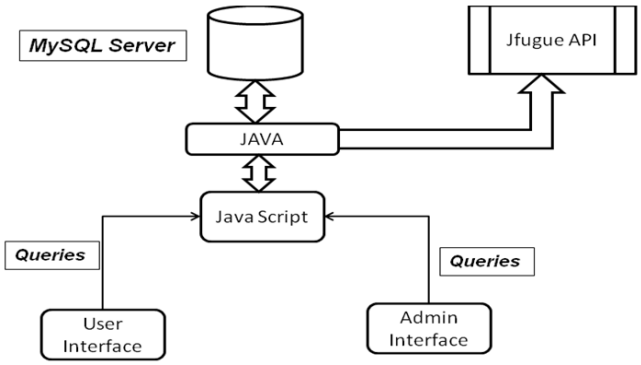


Figure 2. System Architecture Diagram

1. Initialization and Selection

Initially, a set of substrings of the raga's swaras is generated randomly that constitutes the initial population. Only those strings that satisfy the tala (rhythm) are retained and all others are discarded.

2. Reproduction

The next step is to generate next generation population of solutions from those selected through genetic operators: crossover (also called recombination), and/or mutation. For each new solution to be produced, a pair of "parent" solutions is selected for breeding from the pool selected previously. By producing a "child" solution using the above methods of crossover and mutation, a new solution is created which typically shares many of the characteristics of its *"parents"*. New parents are selected for each new child, and the process continues until a new population of solutions of appropriate size is generated. These processes ultimately result in the next generation population of chromosomes that is different from the initial generation. This process of reproduction is repeated until each child reaches the cut off fitness value, set previously depending on the type of output required. This process leads to fitter children for quality musical output.

3. Production of Musical Length of Desired Length

The resultant offspring strings are randomly combined to produce larger musical fragments which are later evaluated for fitness based on criteria like tempo, rhythm, harmony, melody, pitch, duration. Crossing over and mutation [4] are performed on these larger fragments for the production of fitter fragments. Once the cut off fitness value is reached, this process is stopped and the music is played. The flow of actions is as shown in Fig 3.

Let us consider a raga called punnaagavarali. The swara set for this raga is:

C C# D# F G G# A#

Let us consider the population which is generated in random to be

a) Initial Population

C D F F G A# C# C#

D A# G A# C C C# F

F G C C# A# G F C

A# C C C# F F C G

Let us take two random cross-over points and perform cross-over on two pairs of population generated. Let us take the cross-over point to be four. Performing cross-over on the first two, the resulting population obtained is shown below.

b) Cross-over

C D F F C C C# F

D A# G A# G A# C# C#

c) Mutation

Generally mutations can be of different types as shown in the Fig 4.

Mutation is performed on the population obtained after cross-over. Let us consider the notes to be replaced in the

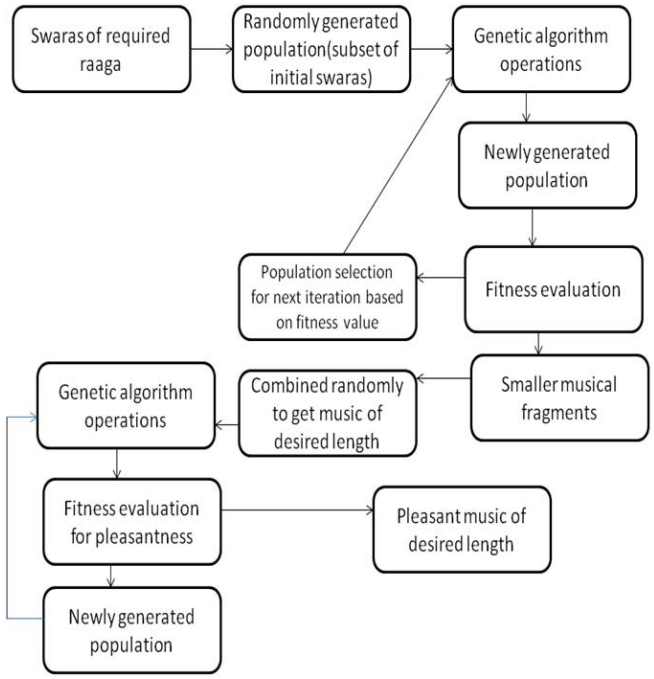


Figure 3. System Flow Diagram

first two populations to be C# and D respectively. The population obtained after mutation is

C D F F C C E F
C A# G A# G A# C# C#

At this stage first level plain music is generated which consists of notes with equal duration. Let us alter the notes obtained by considering different durations. Appending half notes (h) and whole notes (w) randomly to the population generated with quarter notes (q) we get,

Cq Dq Fh Fq Cw Cq Eq Fq

Cw A#q Gh A#q Gq A#q C#q C#q

Let us consider Aadi Tala which consists of 8 equal duration beats. The basic duration note considered is the quarter note. By adjusting the notes duration according to the tala, we get

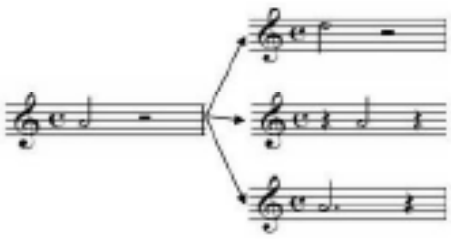
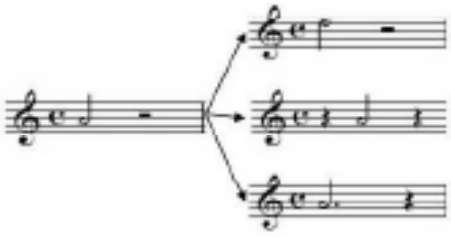
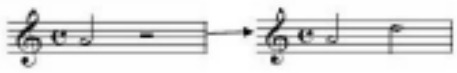
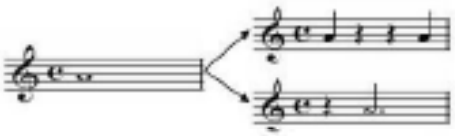
Name	Description	Illustration
Irradiate	Randomly changes a feature of a BasePair. This can result in an alteration of one of three things: its pitch, its start time or change its end time. This is the most basic of the mutations and has the highest randomness.	
Nudge	Works exactly the same as Irradiate, but only changes each feature incrementally, by the smallest amount possible. Hence, the pitch is changed by one semitone, or, the start or end time are changed by one time slice, i.e. the smallest amount that will not be rounded off.	
Lengthen	Adds another BasePair to a Gene. This serves as the primary asexual way of increasing the size of the transcription, i.e. adding more notes.	
Split	Inserts silence to a BasePair. The silence can span the entire note, thus removing it, or it could appear at the ends, thus shortening the note, or it could appear in the middle, splitting the note into two.	
Reclassify	Moves a section of one Gene to another, possibly new, Gene. This allows multiple instruments to be introduced and for information to be shared between different Genes within the same individual.	
Assimilate	Takes a section of a Gene from one individual and copies it to another genome. This is the only sexual mutation, since it takes material from two different individuals. Along with lengthen, assimilate increases the size of the gene.	

Figure 4. Different Types of Mutations

Cq Dq Cw Cq Eq

Cw A#q Gq A#q C#q

Advantages of using Genetic Algorithm:

1. Large search space- Experiments all possible subsets of the swaras thereby becoming a variety musical generation technique.

2. The resultant population of an iteration is further put into operations of the genetic algorithm based on their fitness value and the hence the newly evolved population is better than the previously evolved population thereby producing very pleasant music.

III. APPLICATIONS

A. Online Musical Instrument Tutorials

Let us zero in on piano tutorials for further discussion. The online application can train the learner on note identification, playing patterns generated by the system and rhythmic perfection. Toughness of the music generated increases after the learner passes every stage. Appropriate feedback after every stage is given for the learner to make corrections. Based on the learner's grasping ability the system sets the toughness for the further levels. For easy understanding, the user is provided with an interface resembling a piano which highlights the key that has to be played. This kind of tutorials can be made available for any instrument as the random notes generation and toughness criteria are set by genetic algorithm.

B. Musical Concert

Any carnatic music concert will have instruments to provide melodic, rhymic and harmonic support. Mridangam provides the basic rhythmic support and violin gives the melodic support. The system proposed takes the raga, tala, leading rhythmic and melodic instruments and supporting instruments for harmony, as input. Aalapana, tillana, neraval and other elements are played to present a concert-like effect. By generating compositions of different tempos or speeds, contrasts can be brought about.

C. Carnatic Music and Music Therapy

Music Therapy [5, 6] is a newly developed branch of Para medicine in which music or sound pulses that generate different kinds of music are being employed in curing ailments like mesothelioma, asthma, depression, and even Asbestos Cancer, peritoneal mesothelioma etc. According to an ancient Indian text, Swara Shastra, the seventy-two melakarta ragas (parent ragas) control seventy-two important nerves in the body. It is believed that a person who sings/performs a raga bound to the raga specifications (lakshanas) and with purity in pitch (swara shuddi) will have complete control on the corresponding nerve. To quote a few, for those who suffer from hypertension, ragas such as Ahirbhairav and Todi are prescribed. To control anger and bring down violence within oneself, Carnatic ragas like Punnagavarali, Sahana come handy. A list of ragas used in music therapy is given in Table I.

TABLE I. RAGAS USED IN MUTSIC THERAPY

Raga	Treatment
Todi	Provides relief from cold and headache
Shivaranjani	Memory problems
Bhairavi	Provides relief from Sinus, cold, phlegm, toothache.
Chandrakauns	Treatment of heart ailments and diabetes.
DarbariKanara	Eases tension and provides relaxation.

Context level diagram for the music therapy application is depicted in Fig 5.

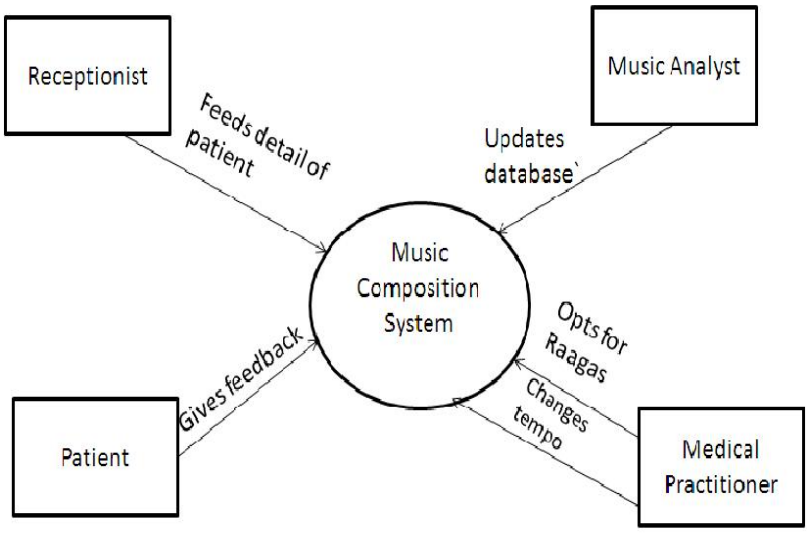


Figure 5. System Context Diagram-Music Therapy

IV. FURTHER WORK

This work can further be extended by giving an already existing composition as input, evaluating the fitness of the composition, producing and playing an equally fit music. This can remove the need for professional music composers but is equally challenging to make a perfect fitness evaluation of the existing composition and to incorporate the same standard in the music to be generated.

V. CONCLUSION

Thus on refining and modifying the music generated by the genetic algorithm according to the requirements and specifications, music for varied applications can be generated. The salient feature of this prototype is that the music once generated will not be repeated anytime in future which guarentees variety and scope for evolution when a feedback loop is inserted into the system. Moreover, the application can help creating new varieties of concerts altogether by changing the order of events, instruments, raga, tala etc., which may gain the attraction of audience. The application also has the potential to create new ragamaalikas (mixture of ragas in a single song) and compostions which can challenge the composers. Thus using genetic algorithm, music of good quality and variety and which has unexplored but rich potential in the above mentioned applications can be produced using this application.

VI. REFERENCES

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