RESEARCH ARTICLE OPEN ACCESS

Gesture Based Musical Metronome Implementation Strategy

Mr. Mahesha Padyana [1], Dr. Bindu A Thomas [2]
Department of Electronics and Communication
Vidya Vikas Institute of Eng and Technology
Mysore – 570010
Karnataka - India

ABSTRACT
Percussion instruments do a great role in maintaining rhythm of the music. Thaala is a repeating rhythmic pattern of beats or sounds synchronized with the music. Thaala can be played by hand or using percussion instruments. Most of the Indian classical music is bound by thaala. Keeping thaala without going out of sync is an uphill task for the musician while rendering complex structures of the music. This paper presents the software implementation details of a musical metronome comprising various features such as dynamic tempo detection and change in thaala of the music, displaying thaala gestures on screen and synchronizing the thaala with the music in real time mode. This musical metronome will help to free the musician from keeping track of the thaala so that musician can give more attention to the complex music rendering.

Keywords:- Thaala Meter, musical metronome, tempo value measurement, dynamic tempo detection, metronome synchronization, thaala gesture

I. INTRODUCTION

Thaala is very important part of any music [1][2]. Thaala is indicated by a series of rhythmic beats using hand gestures or stick or percussion instruments. One of such repeating pattern of thaala is called as an aavartha or cycle. Thaala pattern in one aavartha is a combination of some basic parts or group of parts such as anudhrutha (gesture shows outer side of palm), finger beats (Reckon by fingers), visarjitha (gesture shows inner side of palm) and viraama (pause). Total number of all parts together in one aavartha is known as total thaalaakshara or thaalaakshara count. The time between any two thaalaakshara (considering equal duration thaalaakshara) is known as thaalaakshara kaala[2]. Total thaalaakshara kaala per minute decides the tempo of the music and expressed in terms of TPM. The thaalaakshara can be further divided into smaller pulses called thaala modulation or thaala nade. This is basically done to avoid mistakes in reckoning of thaala when thaalaakshara kaala is large and each thaalaakshara could be represented by multiple beats.

Most of the music is strictly bound by thaala. If thaala goes out of sync with the music, the quality of the music will be lost. So it is very important to ensure that the thaala is repeating regularly with same thaalaakshara kaala. Technically speaking, thaala has a strong mathematical base. So thaala is also a science in addition to the art. In most of the Indian music, one or more participants keep the thaala running by hand gestures or using certain percussion instruments or sticks.

There are several musical metronomes or rhythm generators available in the market to keep the thaala running. One problem with existing musical metronomes is that they do not provide real time synchronization. If thaala goes out of sync, it cannot be synchronized with the mainstream music that is in progress. Also the thaalaakshara kaala of the music cannot be changed dynamically during runtime by playing thaala. Thaalaakshara kaala can only be varied by using speed change buttons or knobs thereby, synchronizing the tempo with ongoing music is difficult. Also audible sounds cannot be configured for each part of the thaala, and finally thaala gesture display is not available.

This paper presents the detailed implementation for the musical metronome. Various features such as dynamic thaalaakshara kaala detection anytime synchronization of thaala using the synchronizer, changing thaala dynamically during runtime, changing nade dynamically, display hand gestures etc. are implemented for classical type thaalas and custom thaalas.

II. HIGH LEVEL ARCHITECTURE

A. System Oveview

As outlined in Figure 1. Musical Metronome mainly consists of a thaala engine module running on the processing unit that will control the overall thaala execution. Thaala script files contain the list of thaalas that are configured. Thaala editor is used to add, modify, configure and delete the thaala information.

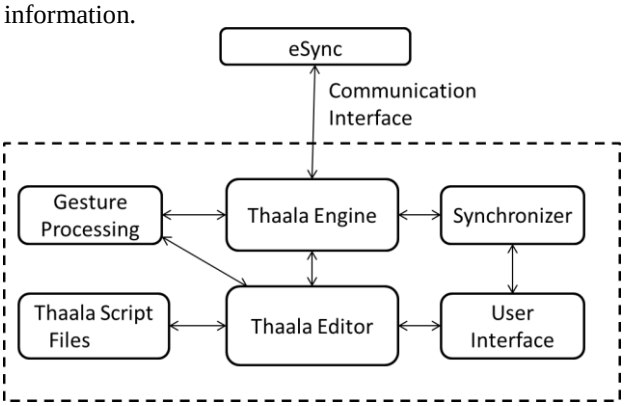

Figure 1 High Level Architecture

User will be able to start/stop the selected thaala using the user interface. User can synchronize the thaala using the synchronizer. Once thaala is started, selected thaala will keep on running until stopped or changed. While thaala is running, its nade can be changed dynamically by using the user interface. In addition to this, thaalaakshara kaala can be doubled or halved using simple button clicks in the user interface.

Thaala synchronizer is one of the core modules of this application and used for synchronizing the thaala. It senses the starting point of the thaala and also the thaalaakshara kaala (tempo) which decides the overall tempo of the music. Musician will be able to change the tempo of the thaala dynamically during course of rendering music by changing the thaalaakshara kaala. In addition to this, musician can restart the thaala from any point thereby synchronizing the thaala to any point. The synchronizer could be internal or external.

The application is developed using JavaFX. Java MIDI library is used for synthesizing percussion instrument sounds for each thaalaakshara kaala. JavaFx is the software platform used for developing the GUI of the application. It was designed with Model-View-Controller (MVC) through the use of FXML and Java. Controller of MVC defines the behavior of the application based on user interaction. All the event handling techniques are implemented in the controller section. MIDI requires a channel number, a note number (depending on the instrument) and a volume to play the sound. The ninth channel of the MIDI library is used in this application for percussion instruments and instrument or volume parameter can be changed depending on the user preference.

B. Basic Thaala Structure

The basic thaala structure gives the skeletal pattern which is to be played. It will have a specific number of thaalaakshara. Each thaalaakshara has specific properties like instrument played, volume level etc. based on user settings. Depending on the user selection thaala structure can be static and dynamic. Custom thaala will have a static structure which is created when user generate the custom thaala. In case of classical thaala, the structure is created dynamically based on user selection. The main components which describe the structure of classical thaala are classical thaala type and laghu type. Thaalaakshara in classical or custom thaala will have following main properties

- Instrument selected to play
- Volume of the beat sound
- Mute thaalaakshara by representing it as a viraama

User is allowed to modify the properties assigned to each thaalaakshara.

Thaala nade and thaalaakshara kaala will decide how the thaala pattern is to be played. Initially there is a configurable default TPM and can be dynamically modified based on the changes in tempo by synchronizer. When the tempo is very low, thaala nade may also be applied to generate thaala pulses which will reduce the gap between thaalaakshara. Based on the value of thaala nade each thaalaakshara is repeated as many number of times as the thaala nade. In some cases, repetition may be less than the nade value by muting some positions.

C. Graphical User Interface

The user is provided with a graphical user interface (GUI) to interact with the software. This is the front end of the application which provides a visual display screen of thaala player with an easy access menu bar for other settings. Thaala player is the main screen, which handles the playing of different thaalas. The thaala player screen displays a default thaala automatically selected by the application and is ready to play at the beginning. Thaala start or stop buttons are also provided. The user can even change various thaala parameters or even change the thaala itself dynamically. While playing the thaala it can also display the corresponding hand gesture animation. The menu bar is having links to custom thaala management and user settings. Custom thaala management opens a GUI screen to create and manage custom thaalas. User can change the default selections and settings of the overall application by changing user preferences in user settings. User settings are saved in the user configured script file. The overview of the GUI is given in Figure 2.

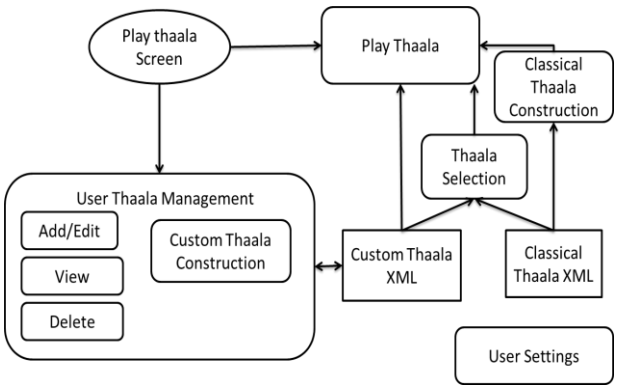

Figure 2 GUI Overview

1) Thaala Selection GUI

The GUI window contains combo boxes for selecting the thaala parameters. Initially each one is provided with some default values which are available in the user configured script file. GUI also provides buttons for play, stop, modify the thaala structure etc. If the thaala parameters are modified during runtime, changes will be applied from next aavartha of the thaala onwards. GUI also contains radio buttons for easy access of frequently used thaala nade. Each combo boxes and buttons are provided with event listeners to handle the events occurred.

2) Thaala Player GUI

The GUI has combo boxes to select the thaala parameters, radio buttons for easy accessing of thaala nade, buttons for playing and stopping the thaala and modifying the thaala. Thaala name in thaala parameters can be for a classical thaala type or a custom thaala. If classical thaala type is selected then a default laghu type will be automatically selected. The user is allowed to make changes in the selected laghu type. If a custom thaala is selected then the corresponding thaala settings shall be read from the custom thaala script file and laghu type selection is disabled. Once the thaala is selected, its thaala pattern is generated and application is ready to play the thaala. User can access the play button to start playing the thaala. User is able to stop, restart or restart and adjust the thaalaakshara kaala while playing. The user can also change the laghu type, thaala nade audio instruments associated with thaalaakshara, volume component associated with thaalaakshara or even the thaala itself dynamically.

3) Custom Thaala Management GUI

The module, custom thaala management is for managing the user defined or custom thaalas. Users are allowed to create and manage their own thaalas. While creating a custom thaala, user must specify the thaalaakshara count of the custom thaala. The GUI screen will display various thaala properties to define the structure of thaala. User can select required properties to define the custom thaala. GUI also displays options for instrument selection for each thaalaakshara. The user can also select the gesture associated with each thaalaakshara with the help of GUI. User Settings GUI

The software provides options to the user for customizing the application. All these user settings are updated though GUI. Some of these configurable parameters are given below:

- Sync Thaala enable/ disable.
- Default thaala with default parameters to be loaded when application is launched.
- Save last selected thaala properties as default values.
- Thaalaakshara kaala detection Timeout value.
- Hand gesture animation enable/disable.

III. MUSICAL METRONOME IMPLEMENTATION

The overall flow of the application is indicated in Figure 3.

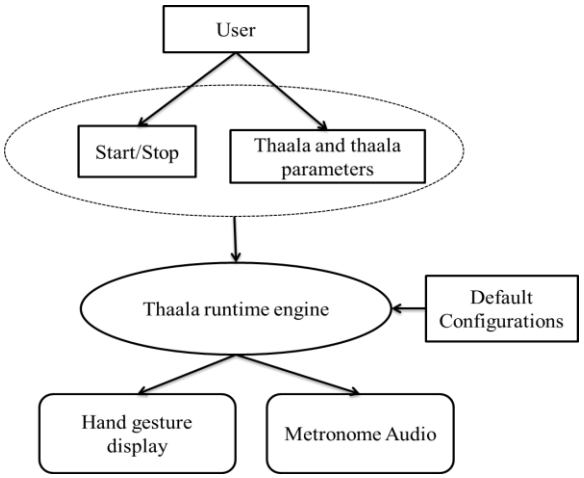

Figure 3 Software overview

The application comprises a thaala runtime engine which controls the overall flow. Thaala engine gets the thaala information from the user interface. Thaala runtime engine will process the thaala and play the applicable sounds associated with thaala parts and also display the applicable gestures on the screen. The architecture of thaala runtime engine is shown in Figure 4.

The user interactions are handled by the event listeners and event handlers. Event listener will always be alert and detect every action of the user. Event listeners inside the application are implemented in such a way that whenever any change occur in user selection or thaala parameters, the necessary action will be taken and produce the corresponding output.

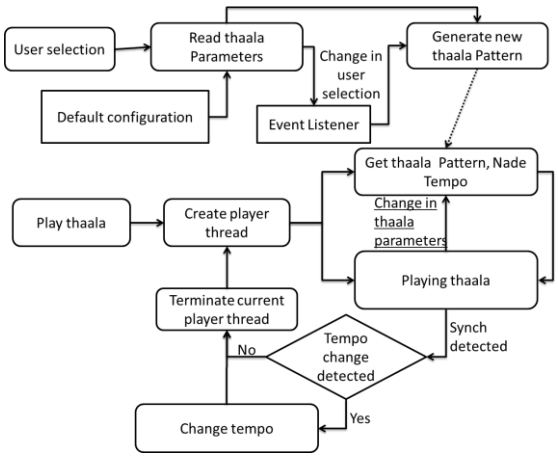

Figure 4 Thaala Runtime Engine

A. Thaala Selection

Based on the default thaala and parameters selected in the GUI, system will prepare a basic thaala structure and will be ready to play the default thaala.

Each combo boxes in thaala selection GUI is tied up with an event listener which will be invoked when there is any

change in the selection. When an event occurs, the application will extract the corresponding data of current thaala parameters. Basic thaala structure will be affected only if the thaala or laghu type selections have changes. The listeners of thaala and laghu type combo boxes will handle modification in the basic thaala structure. The listener of thaala combo box will also distinguish the selection between a custom thaala and a classical thaala type. When a classical thaala type is identified, the selected laghu type value is also read. Thaala nade and thaalaakshara kaala will affect the repetition and duration of each beat in the thaala pattern. So the listener of thaala nade and thaalaakshara kaala combo boxes will be handling the duration and repetition count of thaalaakshara. Based on thaala nade, the thaala pattern is modified in such a way that it will add inner pulses, which is the repetition of each thaalaakshara.

B. Dynamic construction of Classical thaala

Classical thaala section will be dealing with the Sulaadi saptha thaalas. A default classical thaala script file is associated with the application which contains all the information of thaala parameters required for the dynamic generation of the classical thaala. The classical thaala type and laghu type together contribute for the dynamic construction of the classical thaala. When the user changes the classical thaala type or laghu type, the corresponding changes will be applied. Classical thaala type is the composition of three anga such as dhrutha, anudhrutha and laghu. At least one laghu will be present in every classical thaala type, which will change depending on laghu type. Basic thaala structure of the thaala is generated by replacing dhrutha in the classical thaala type with one anudhrutha followed by one visarjitha. Laghu type will define the number of parts in laghu and it is easy to determine the number of finger beats in laghu. The number of finger beats will always be one less than laghu type. Laghu in basic thaala structure is replaced by one anudhrutha followed by that many finger beats.

In MIDI library, a number is associated for each percussion instrument. In the application, the ultimate thaala pattern to be played is a series of instrument numbers and its corresponding volume. Default percussion instrument corresponding to each thaalaakshara is assigned at the beginning and user is allowed to make changes in the settings.

C. Custom thaala Management

Based on the user input for the thaalaakshara count of the custom thaala, a default basic thaala structure is generated with specified number of thaalaakshara, all having the same default properties. The default basic thaala structure is displayed on custom thaala management GUI and the user is allowed to make changes in the properties of thaalaakshara. Each thaalaakshara in the basic thaala structure is assigned with the corresponding percussion instrument number in the thaala pattern. Each thaalaakshara/percussion instrument is associated with a volume while playing. Viraama will not have any instruments associated and hence there will not be any volume component. Once every setting is updated, user can save the custom thaala and its properties in custom thaala script file with a unique thaala name.

When user selects a custom thaala for playing, system will read all its required information from the custom thaala script file and recreate the thaala pattern which is to be played.

User is allowed to modify the properties of existing custom thaala. When user makes changes in the instrument settings or any other properties, the corresponding changes are applied in the thaala pattern as well as in the custom thaala script file. User is also allowed to remove the custom thaala from the custom thaala script file.

D. Play Thaala

Based on the user selection or default setting, system will generate the thaala pattern and get ready to start. The play button and a stop button in GUI can be accessed to start and stop playing thaala respectively. Play and stop button can also be accessed by shortcut keys. When user presses the play button, the system will collect all the thaala information which is required to start playing the thaala. Thaala player is handled by a thread called player thread, which will play the thaala continuously until it is interrupted. It will also check for any changes to the thaala parameters and implement the corresponding changes from subsequent aavartha.

Thaala pattern can be played using MIDI library functions. The ninth channel in MIDI is used for playing thaala since it is dealing with percussion instruments. Thaala pattern represents the series of instrument numbers and their corresponding volume. These values are used by the MIDI function to produce the sound in particular volume. The player thread will sleep for thaalaakshara duration before moving to next thaalaakshara. This will create an effect of rhythmic beats and each beat have an equal duration. When the player thread reaches the end of one aavartha, it will restart from the beginning. But incase if any thaala parameter has changed in between the execution, after one aavartha it will start playing the new thaala.

E. Synchronization of thaala

Synchronization of thaala is done by the user by using the thaala synchronizer. Thaala synchronizer will perform synching the thaala as well as dynamic thaalaakshara kaala changing. Once a thaala is started to play, it will continuously repeat the aavartha one after another. The same play button is used by the synchronizer for synchronizing and dynamic thaalaakshara kaala changing. Synchronization is achieved when the thaala is currently playing continuously. When user presses the synchronize key, a key press event is detected by the synchronizer. The event handler of synchronizer will check whether it was for synchronizing the thaala or for dynamic tempo change. First key press is considered for the synchronizing and second for tempo change. There is a predefined timeouts for tempo change, which is the maximum time allowed between a sync detection and tempo change detection. The key press is considered as for synchronizing if the timeout is expired. When synchronizer detects sync,

thaala is restarted so that the starting of thaala will synchronize with key press. Synchronization of thaala is implemented by interrupting the execution of current player thread and, creating and start executing a new thread immediately. The new player thread will play the current thaala from the beginning with the same features it had before.

F. Dynamic thaalaakshara kaala change

The thaala will start playing with the selected thaalaakshara kaala which is calculated based on the default value. The user can change the thaalaakshara kala to sync it with the ongoing music. Dynamic change of tempo is achieved by pressing the synchronizer key twice. The user can configure the timeout for the second key in user configuration settings. Also the second key detection will have configurable minimum time before which second key will not be accepted to avoid accidental key press. The time gap between the two key presses measured is the new thaalaakshara kaala. Even thaala nade can also be considered and in such case time between two key presses decides the nade duration.

G. Thaala Gestures Processing

In Indian classical music, the musician will use some hand gestures or stick or percussion instrument to represent the thaala of the music while playing. When hand gesture is used, for each part in thaala, there is a particular gesture indication. JavaFX animation is used for implementing the gesture processing. Multiple images are combined based on the thaala structure and displayed on the screen one after another based on the thaalaakshara duration. The following are the default gestures in classical thaala.

- Anudhrutha (one clap using palm or beat using stick or other means)
- Finger Beat (Reckoning using fingers)
- Visarjitha (waving or beating on reverse side of the palm)
- Viraama (Break or pause, continue the previous gesture)

When the thaala player starts to play the thaala, the corresponding hand gesture is also displayed on the screen synchronizing with the thaalaakshara. Gesture image for Aadi thaala (Chathurashra laghu type thriputa thaala comprising laghu dhrutha dhrutha parts) is given in the Figure 5.

Figure 5 Gesture display for Aadi thaala

IV. RESULTS

Mainly there are two ways to show the output, one is through gestures and the other is through audio output.

In case of gestures, thaala gesture was displayed on the screen in real time mode and the result was satisfactory.

Sound clips associated with each part of the thaala are produced on the speaker when thaala is executed. This was verified for various types of thaala and the result was satisfactory.

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