SurTarang

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***Abstract*—Sur Tarang is an interactive device that acts as a one-stop solution for all the needs of the lead performer.**

***Index Terms*—Interactive Music, Hindustani Classical Music, Gesture Recognition, Brain Body Music, Machine Learning.**

I. CONCEPT

In Indian classical music concert setting, a performer has a various instruments as accompaniments at their disposal. The *tanpura*, the *swar mandal*, the *harmonium*, the *violin* as the primary melodic instruments and the *tabla*, the *mridangam* as the primary percussive instruments.

With Sur Tarang, we aim to build a device that acts as a one-stop solution for the needs of the lead performer as well as an accompanying artist. Using biosensors, the lead artist can control several parameters of the accompanying instruments without the need to touch or manipulate physical interfaces. This is all done by translating body and mind signals as well as gestures into the sounds of the accompanying instruments, so it can be viewed also as a biofeedback tool to make the performer aware of their internal states during performance. Sur Tarang also incorporates gesture recognition and generative modules. This makes Sur Tarang a one-stop, highly collaborative, cross modal interface providing just the right balance between control and improvisation prominent in Indian Classical music.

Sur Tarang is developed with a focus on the Indian classical musician synthesizing and rendering a variety of timbres highly prominent in this style . However, as a biofeedback tool, it can be used by anyone interested in gaining awareness of their mental states when engaging in different musical sections of different musical styles.

II. CONTEXT

The use of Brain computer interfaces has been increasing rapidly due to the availability of affordable BCI devices and software that only requires quick setup time in getting the BCI to work as per the use case [1]. Since the early 60s, physiological signals have been used as input for artistic interactive systems. The seminal work “Music for Solo Performer” from Alvin Lucier [2], is generally taken as the first musical work to use brain waves as a controller interface for generating sound [3].

raag (or *raga* in Hindustani Classical music is a melodic framework associated with certain characteristic phrases called *pakad/chalan* and time of day at which it is believed to convey maximum emotional impact. Recent research have demonstrated the therapeutic impact of various ragas [4], [5]. For demonstrating the capabilities of Sur Tarang, we have chosen Raag Bhairav which is a morning *raag* historically believed to induce meditative and peaceful states in the performer as well as the listener.

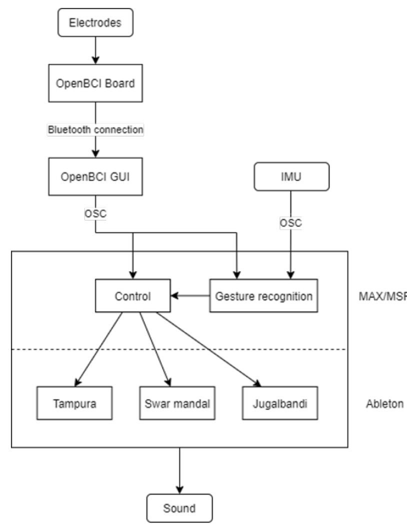

Fig. 1: Design of the system

III. IMPLEMENTATION

Experiment Design

Sur Tarang is composed of three modules which are as follows-

- input module taking input from bio signals and gesture tracking,
- processing module appropriately scaling, manipulating, and mapping the input signals, and
- sound engine mapping the signals to interesting and relevant timbral layers.

The input module is composed of bio-signals and gesture tracking. The bio-signals are acquired through EEG composed of the OpenBCI physical interface (it can either be the Ganglion board or the Cyton board) and the OpenBCI GUI. The purpose of the GUI is to track the quality of the acquired bio signals and transmit them to the processing module by converting the data into OSC messages.

The gesture tracking is designed to enable the performer to control discrete features of the sound. Gestures can be tracked directly from the OpenBCI signal or from an IMU to detect

Fig. 2: The tanpura

Fig. 3: The *swar mandal*

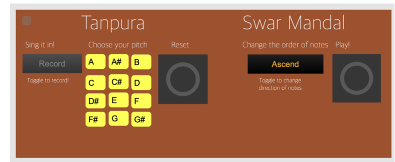

Fig. 4: MIRA Interface to control the *tanpura* and *swar mandal*

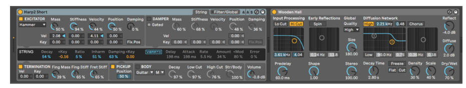

Fig. 5: Ableton Sound synthesis of the *swar mandal*

hand gestures. One of its main role is to trigger specific sounds linked to a specific gesture.

The sound module is composed of a series of patches developed on Max/MSP and sound synthesis in Ableton. The Max/MSP patches convert the events detected by the bio-sensing module into sounds or manipulate generated sounds based on specific data sent by the bio-sensing module.

The experimental setup consists of the following - 1. OpenBCI Ganglion/Cyton board along with dongle, battery back to power it on. 2. Electrodes and conduction gel 3. WiFi connection to link OpenBCI to Max/MSP 4. Preferably 2 laptops (one receiving the input streams and another controlling the sound) 5. Phone with working OSC message sending capacity

Sound Engine

We have chosen two highly representative melodic instruments of Hindustani Classical music – the *tanpura* (fig 2) and the *swar mandal* (fig 3). The *tanpura* is the drone for the rendition of the raga and the *swar mandal* is typically tuned to the individual raga being sung and strummed by hand. It is played almost exclusively by the lead vocalist.

Synthesis of the melodic components.

1. The *tanpura* instrument is synthesized using the Analog instrument consisting of two oscillators operating at different frequencies coupled with a sub-oscillator. The oscillators are synthesized such that they bring about the sympathetic vibrations of the *tanpura* string. There is also a layer of chorus audio effect applied over this instrument. Together they create a timbrally dense and rich *tanpura* sound that the singer can render the raga over. 2. The *swar mandal* instrument is synthesized by modifying the components such as the attack, damping, pick up position of the pluck and adding audio effects such as reverb to a traditional harp sound.

Percussive component

For this performance we decided to use a pre-existing tabla track as a percussive accompaniment for the bandish and jugalbandi section.

The MIRA Interface

At the start of the performance, the performer is presented with a user interface on a MIRA frame. This interface can be obtained on any medium as per the preference of the singer. They begin by choosing their pitch or singing on a pitch. This pitch gets mapped to the *tanpura* sound in Ableton. There is also an option to restart the pitch selection by simply clicking on the Reset button on the MIRA interface.

This interface also contains the control for the *swar mandal* which contains the control for the order of the notes of the raga (ascending or descending) and a trigger button called Play.

Mappings

Brain waves, pre-processed by OpenBCI, are sent to MaxMSP and Ableton Live to control various aspects of both the *tanpura* and the *swar mandal*.

Band powers levels extracted from the incoming EEG signal have been mapped to several parameters of the audio engine for synthesizing the *tanpura* sound.

A combination of the gamma and theta wave levels from the EEG signal is also being used to recognize eyes blinks as a gesture. In this implementation, a single eye blink triggers the *swar mandal* as an incidental accompaniment sound. An additional mapping in the *swar mandal* is the modulation of its timbre particularly the by alpha timbre of the *swar mandal* is also modulated by features extracted from the EEG signal.

Owing to the improvisatory and spontaneous streak of Hindustani Classical music, we also decided to include a generative component to this system. A performer (performer 2) other than the main performer (performer 1) interactively participates in the ongoing performance through their hand gestures. The hand gestures get mapped to a Markov improviser which is trained on midi files containing melodies in the specific Hindustani raga. The Markov improviser is trained by routing the note values, note velocities, note onsets and note durations to different Markov models. In the musical performance, we have included this aspect in the jugalbandi (call and response) section. It takes an input from a linear accelerometer (x, y and z components). The classifier is trained with 4 gestures:

- Arm rotation right‘
- Arm rotation left
- Arm lifted in front of the body
- No movement

During the performance when the singer (performer 1) sings 2 bars of a taan (an improvisatory phrase), the gesture recognition is triggered where the accompanying musician (performer 2) performs any of the trained gestures. The classifier classifies the gesture into one of the above four classes, and this opens a midi bus to the specified midi instrument on Ableton Live. After the first two bars, the Markov improviser is triggered which improvises based on the training data. The training data consist of phrases from the Bhairav raag that are played on a midi keyboard. We have ensured that the markov improviser generates notes similar to what an accompanist in a classical music setting would play, thus giving the singer new musical ideas. The generated midi notes are then routed to the bus that had been previously opened during the classification stage. This way, the accompanying artist can control the type of sound that the Markov model improvises on by their gestures. This cycle repeats 4 times and then a trigger is switched to stop the process.

Sur Tarang is designed as generic biofeedback system for Indian Classical Music. For validation, an artistic piece, namesake, is designed for its specific use.To demonstrate each part of the system, the piece will be composed by four sections: prelude, alaap, bandish and jugalbandi. The prelude section is meant to acclimate the audience with the piece. The performer will be in silence and only the *tanpura* will be sounding. Nonetheless, the *tanpura* timbre will be modulated by the brain state of the performer (based on EEG power bands), so what the audience will be hearing will not be only a *tanpura*, but a sonification of the brain state of the performer into a *tanpura* sound. On alaap section, which is usually associated with the non-metric and slow section of a classical Hindustani performance, the performer will start singing in an improvised way. During this stage, along with the *tanpura* modulate by the EEG power bands, gesture recognition for eye blinking will the activated and shall control the trigger of the *swar mandal*. The timbre of the *swar mandal* will also be modulated by EEG power bands. For the bandish section, which traditionally is metric and more fast paced than the alaap section, a tabla is added to the performance. Due to the distinct features of this section, in comparison to the alaap section, the audience shall notice some changes on the sounding of the accompaniment instruments. The jugalbandi section is intended to show the gesture recognition and generative portion of the system. In a traditional performance, jugalbandi is the "call and response" section where two musicians establish a melodic dialog. For this performance, a second performer will be controlling an IMU sensor linked to the gesture recognition system. By performing some specific, pre-trained, gestures, this second performer will trigger the generative system with different generative parameters, creating unique melodies for each gesture. The first performer shall improvise based on these generated melodies, establishing so the dialog.

IV. Strengths and Weaknesses

For the development of Sur Tarang, a deep understanding of the acquisition and treatment of body signals, mainly EEG, had to be obtained. The scenario of a live musical performance is mostly different from the usual ambient where EEG hardware is commonly used. Dealing with wired connection, head movements and artifacts emerged from singing and gesticulation was some of the main challenges faced during this development. A meaningful mapping between brainwaves and/or brainwave features to sounds is also a subject of great discussion. The results obtained on Sur Tarang were considered satisfactory, but this is still considered an open issue. For future versions, other physiological signals (like ECG or EDA) are intended to be aggregated to the system, providing more expressive possibilities and even a complete affective biofeedback capability.

V. Improvements and Future Work

Mapping brain waves into sound in a meaning way is still an open problem. Many artists and researchers have been investing a long effort in this direction. Dr. Leslie on her work "Vessels" decided to tackle this problem from an different perspective, instead of trying direct mappings, Leslie decided to use cross-synthesis between her own brain waves and the ambient sound she uses for the performance [6]. Recent approaches also have been trying to use physiological datasets for training machine learning algorithms to recognize mental and emotional states in order to use this recognition as inputs for interactive sonification systems [7].

For future works, we intent to explore new possibilities for the sonification of physiological signals, based on these recent approaches, mainly the cross-synthesis approach presented by Dr. Leslie. Besides the sonification, we also intend to incorporate other physiological signals as electrocardiogram (ECG) and electrodermal activity (EDA) signals, as these are usually good signals for emotion recognition, an information of great value for artistic expression to be use on interactive system.

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