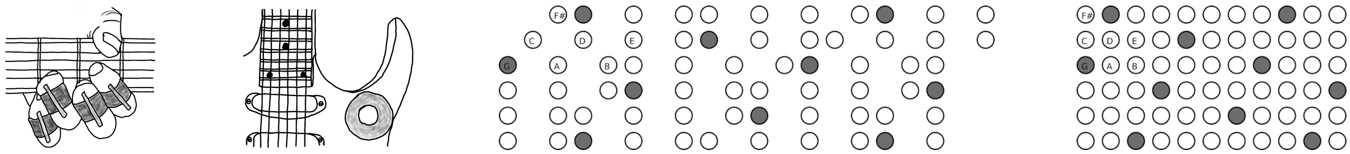
Guitar-Leading Band

M. Cicconet, Visgraf/IMPA
L. Velho, Visgraf/IMPA
P. Carvalho, Visgraf/IMPA
G. Cabral, D'Accord Music Software



(1) (2) (3) (4)

Phalange rods (1), guitar fiducial (2), bad (3) and good (4) arrangement of notes.

1 Motivation

Interfacing with the guitar using the audio signal is one of the oldest problems in Computer Music, and advances in the area were astonishing. In our days it is possible to simulate a huge range of amplifiers, apply many filter effects and evaluate the pitch of a plucked string robustly, to mention a few useful applications.

However, there are problems very hard to solve using audio, like recognizing the chord being played when the musician is not down- or up-stroking all strings at once, but picking them one at a time.

In this work we explore the visual interface of the guitar, a subject that only in recent years has received the proper attention. Three aspects are treated. The first has just been mentioned: the problem of chord recognition when not all notes of the chord are played. The second relates to the implementation of an automatic composition algorithm inspired on the bi-dimensional nature of the representation of the diatonic scale in the guitar fretboard. Finally, the knowledge about the current chord, or simply the rough position of the hand in the guitar fretboard, allows controlling some parameters of the automatic composition algorithm, what becomes specially interesting in live performance.

2 Chord Recognition and Hand Location

A Supervised Machine Learning algorithm is used to learn the patterns of the rough positions of the fingertips (in guitar-fretboard coordinates) corresponding to the chords we want to recognize. To determine the approximate position of the fingertips in the scene, retro-reflexive rods are attached to the back of the finger middle phalanges, by means of elastic ribbons (Figure 1). To locate the guitar, four circular retro-reflexive fiducials are attached to it (Figure 2). Then, using infrared light and camera, fiducials and rods can be isolated, and a projective transformation is used to estimate the north-most extreme of the rods in guitar fretboard coordinates. The center of mass of the finger points represents the rough position of the hand in the same coordinate system.

3 Automatic Composition

Let us say we want to compose a melody using the diatonic scale, in the key of G. Figure 3 shows almost all the notes of such a scale between the first and the 19th fret of the guitar. Such a representation is not algorithmically friendly, due to the absence of a clear pattern. Fortunately we can rearrange the notes of the scale as shown in Figure 4. This way, it becomes easy to write routines to build a sequence of notes, i.e., a melodic line. We can, for example, implement two independent markovian processes, one for the rows and the the other for the columns of the matrix of points.

This kind of interface is more adequate for simulating guitar improvisation, since the availability of a musical note near the current region of improvisation is also important, besides the note itself. The availability of a note changes depending on the dimension of the instrument interface, so a bi-dimensional method fits better in the case of the guitar.

The sequence of rhythmic patterns may also be controlled by a markovian process. Every time a new beat is about to begin, the system decides if one whole, two halfs, three thirds of four quarter notes should be played along it. Or even if no note should be played at all. Only then the melodic line is built. This time the information of the chord currently being played is relevant, because melody and harmony must combine. As an example, the algorithm may check if the first note of the sequence sampled for the next beat is the same (regardless the octave) of the current chord's root note.

4 Guitar-Led Piece

It should be clear by now how the above mentioned bi-dimensional automatic composition algorithm and visual chord-recognition/hand-detection methods can be combined. Some parameters of the former are controlled by the information provided by the latter.

As a proof of concept we have composed a music piece in which those methods are explored. It is organized in cycles, bars and beats: four beats per bar and four bars per cycle. We have used four musical instruments: guitar, string ensemble, drums and piano, of which just the former is a real instrument. Most of the time the string ensemble follows exactly the chord that is being captured by the computer vision system, but in some cycles it can also perform a chord sequence memorized in previous cycles. After the drum loop is triggered by a keyboard command, the pre-programmed loops will run for a certain number of cycles, up to the end of the piece. Every time a new beat is about to begin, the Markov-process based sequences are sampled and resampled until the melody conditions are satisfied or the maximum number of trials is reached. Eventually the system turns the "Air Guitar" module on, so the location of the hand controls the region to where the sequence of notes has to converge. Although the improvisation is guitar-based, other sounds can be used. We chose the piano.

Results are very encouraging. We see many areas that could benefit from the proper exploitation of the visual aspect of the guitar interface, like teaching, music games and live performance, to cite a few. As future work we plan to eliminate the need of using finger rods and to improve the restrictions of the guitar improvisation method, observing the human-hand joint system.

More about this project can be found at:
www.impa.br/∼cicconet/thesis/guitar_leading_band.

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