Non-linear Controller Mapping for Gestural Control of Gamaka

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Abstract

Novel proximity based controllers such as ultrasound and electromagnetic controllers allow for the use of exaggerated and theatrical gesture in live synthesiser performance. However, when larger gestures are used to control traditional Indian pitch-bend ornaments, such as gamakas, linear pitch to distance relationships become unwieldily and unplayable. Linear pitch-bend relationships also do not resemble the non-linear force-pitch relationships of wire string systems which creates a bias in the interpretation of intricate pitch-bend and microtonal ornamentation on synthesiser. This demonstration presents research into the development of non-linear maps for gestural controllers, suitable for the performance of Karnatic music gamakas. The maps are developed for ancillary and novel controllers that require input ranging from small hand gestures to larger arm gestural control.

1 Introduction

This demonstration presents controller mapping techniques developed for the *LightHarp's* ancillary proximity based controller, (Favilla, 1994a). This ancillary controller was designed to perform expressive and virtuosic pitch-bend suitable for Indian music and other types of synthesis control. The *LightHarp* was designed as a live ensemble performance instrument. Its design features make performance gesture highly visible and exaggerated to the audience. It is hoped that this connection of sound and gesture will allow the audience to recognise ensemble parts, technical proficiency and ensemble interaction within abstract timbre based synthesiser music. This sympathy for a much stronger link between sound and gesture was also sought to engage practitioners of synthesiser and computer music at an ensemble performance level.

Research related to this project has so far produced; a Light-string MIDI interface, 3 *LightHarp* MIDI controller instruments, (Favilla, 1994a), transcription data in the form of audio files and fundamental pitch analyses, new virtuosic performance techniques for synthesiser and *LightHarp*, (Favilla 1994b), and new notation for the composition of synthesiser ensemble music. Current research is investigating ensemble rehearsal of new notation and the composition of timbre sets or ragas as foundations for new ensemble repertoire.

2 Background and Aims

Although proximity based controllers are visually theatrical and capable of fine control, they also remain difficult to master. This is because they offer the performer limited controller feedback which is also often poor quality. This lack of feedback impedes the development of skilled performance, (Pressing, 1990).

Proximity controllers however, can be most effective if their data is mapped or in a sense automated. This investigation chose to focus specifically on the application of the LightHarp's controller to the skilled performance of Karnatic music *Gamaka*.

3 Gamaka

Gamaka is a comprehensive term in Karnatic music and it refers to all bends, shakes, stresses, accents, slides and graces that accompany *ragas*. In fact. *Gamaka* is defined as; ".. any manipulation of a note that results in a musical effect" (Sambamurthy, 1982). However, vina players usually term the finger plucking techniques of the right hand, *mittu*, while *gamaka* is considered appropriate to left hand, or fret board, technique (Subramanian, 1986). This would suggest that *gamakas* are pitch and not timbre orientated but this is also untrue. Vocal *gamakas* such as *Humpita* and *Namita* are specifically related to dynamics, whereas *mudrita* means to sing with a closed mouth, or humming (Sambamurthy, 1982). Also another family of effects known as *vettu*, or cuts, are also classified as *gamaka* (Kumar, Stackhouse, 1987).

There are three main contemporary systems of *gamaka*; the "Panchadasa" *gamakas*, the ten vina *gamakas* and Subramma Dikshitar's fifteen gamakas, (Favilla 1994b). However, most practising professional Indian musicians are unaware of these systems and have learnt *gamaka* purely aurally. Secondly, the interpretation of *gamakas* differs from school to school and teacher to teacher. There are also gamakas specific to particular instruments. This creates quite a problem for the researcher.

Because the tradition lacks a practised, unified theory of gamaka, it seemed appropriate to narrow the study to include only violin and vina performance. The violin offers the performer multiple dimensions of control each of which demonstrates good degrees of freedom, (Pressing, 1990).

Amongst the musicians I have met from the Karnatic tradition, there seems to be a common knowlegde of the gamakas The vina gamakas were also of interest to me because they can be split into three main groups specific to vina fingerboard techniques, (Viswanathan, 1977). These groups include:

Jaru/Ullasita (Slides)

Irakka - jaru - descending slide

Etra - jaru - ascending slide

Gamaka (Deflections)

Nokku - stress from above on successive (non repeated) tones.

Odukkal - stress from below on successive (non repeated) tones.

Kampita - oscillation

Orikai - momentary flick, at the end of the main tone, to a higher tone.

Janta (Fingered Stresses)

Ravai - turn from above

Sphurita - stress from below on repeated tones.

Pratyahata - stress from above on repeated tones.

Khandippu - sharp dynamic accent.

It is easy to forget from these brief descriptions by Viswanathan that all of these ornaments involve pitch-bend. It is also unclear from these descriptions that gamakas such as sphurita and pratyahata can sound much like a wide vibrato or oscillation. They remain separate from kampita due to their oscillatory speed. Kampita means "trembling", and is performed much faster than these other gamakas.

Recordings of traditional repertoire, improvisations and raga swara examples were analysed. Volume was examined together with the fundamental pitch. An algorithm used for speech analysis provided the most accurate data which provided accurate transcriptions for study.

4 The Proximity Controller

The electromagnetic proximity controller, EMPC, works on the principle of induction. Two coils of copper wire wrapped around ferrous iron rods are moved in close spatial proximity to each other. A short coil carries a current and acts as a transmitter. Another larger coil acts as receiver and is used as a wand by the musician's left hand. The resultant emf can be defined by the following formulae whereby d is distance, Φ_2 is the magnetic flux through the receiver circuit and i_1 is the instantaneous current in the primary transmitter coil circuit:

$$e_2 = -\frac{d\Phi_2}{dt} \propto -\frac{di_1}{dt}$$

This emf in turn affects a voltage interfaced to the LightHarp motherboard through the first input of an eight-channel ADC. Control data is scanned by a 15KHz subprocessor providing an accurate, source of proximity based MIDI data. Although the scanning resolution is only 7-bit, the scanning rate of 15KHz for the subprocessor yields an extremely smooth and responsive flow of data for pitch-bend control. This contrasts greatly to scanning rates of ultrasound controllers which usually have scans spaced to avoid flase readings due to reverberation. These spacings can be anywhere between 2 to 15 milliseconds yielding scanning rates of only 6.7 to 50 Hz.

The EMP controller can be easily configured in reverse, so that the transmitter coil is held by the musician. By doing so, three receiver coils could be used allowing for 3D spatial control, a common technique for ultrasound controllers. In addition the rotation of the wand and position forward, behind, above and below the main playing path or line can also be used to affect control. Rotation of the wand, swaps the poles of the electromagnetic field providing a large range of MIDI data: refer to figure 1.

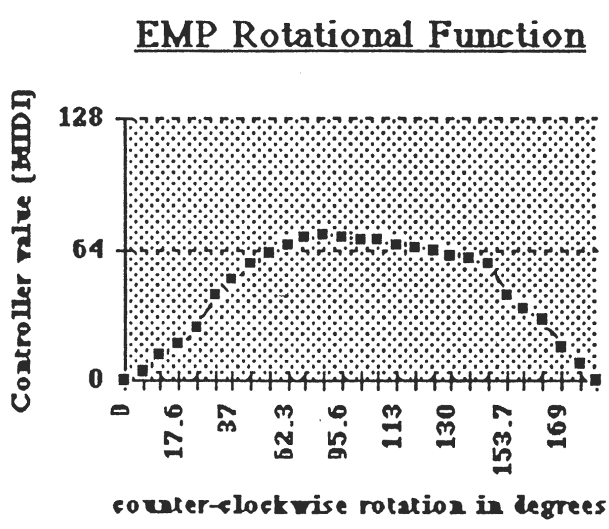

figure 1.

The relationship between distance and MIDI data is variable and can be attenuated through control of a threshold and sensitivity pot on the LightHarp motherboard. The following chart, (refer to figure 2), demonstrates how the controller works when both transmitter and receiver coil are held parallel to each other. The threshold and sensitivity are set to an optimum for playing gamaka.

EMP Distance function

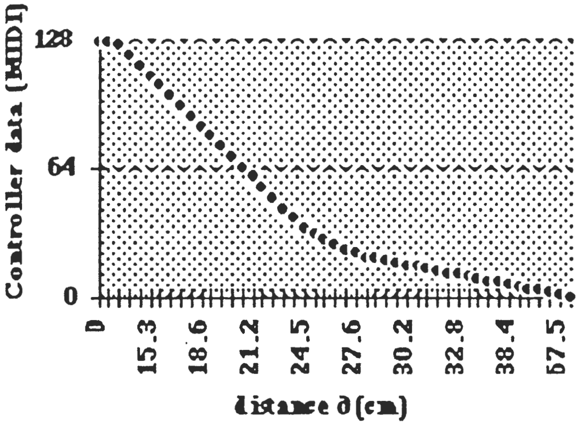

figure 2.

As we can see from this chart, the EMP controller demonstrates a two-stage linear relationship between MIDI data and distance. The region from MIDI data values 64 to 127 forms a good solid line making it simple to remap in MAX table objects or via a EPROM lookup table on the LightHarp board.

5 Controller Mapping

All controller maps were designed to be used with a monophonic continuous sustaining sound with a pitch-bend range of 5 semitones. MIDI volume was controlled using a breath controller.

+- Pitch-Bend Lookup Table

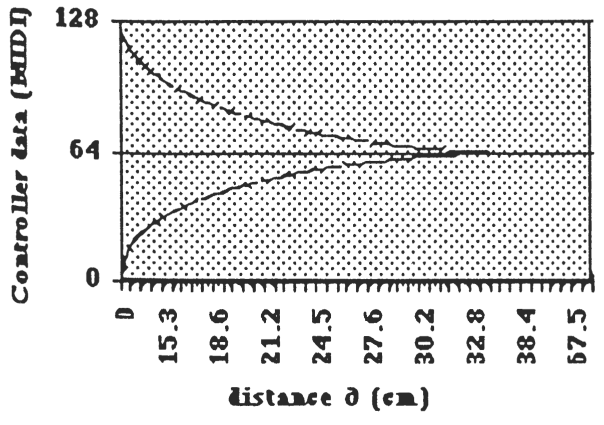

figure 3.

The first controller map was devised to allow the same direction of movement to control both positive and negative pitch-bend. This made use of the polarity of the magnetic field. If the wand was flipped top to bottom, the poles of the electromagnetic field were reversed. A sloping curve had to be used to map the linear data of the wand to create a playable mid point value of 64 (see figure 3). This map had only limited success in performing gamakas because the distance required to effect shakes and repeated stresses became too large to be playable.

Many of these bends and shakes have pitch ranges of up to a perfect fourth and oscillatory speeds of up to 6-7 Hz. These gestures were found to be best mapped to steep curves, (figure 4). These curves would require more distance to be covered in order to affect pitch-bend towards the top of the range. This produced an effect similar in sound to vina gamakas which slope off as the tension in the string increases.

Steep Curve Lookup Table

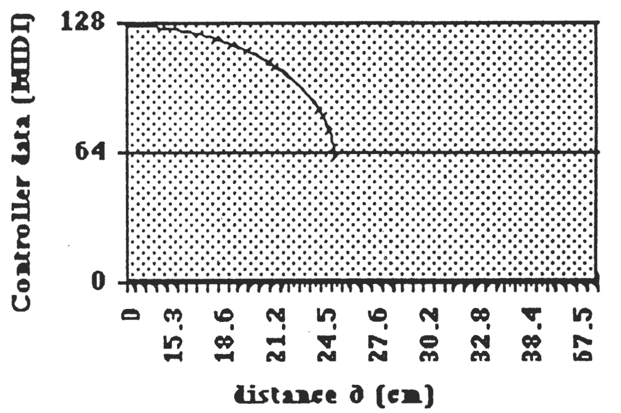

figure 4.

This type of map gave the most playable results for gamaka. The forearm could be used to position the wand while the hand could pivot from the wrist providing pitch glissandi of up to a third with ease. However this type of curve makes it difficult to move freely to specific sruttis (notes) within ragas. This type of table can only work in either a positive or negative direction because it proved impossible to find the pitch-bend midpoint value of 64.

Table objects in MAX proved useful in the creation of steps within curved maps (see figure 5). These steps provided zones where a specific microtonal pitch could be found and successfully played. These tables could not be used with glides or portamentos but could provide excellent results with performing speed phrases. Separate tables had to be used to cover the range of Sa (1) to Ma(#4) and from Pa (5) to top Sa(8), to cover all of the ragas srutttis. This type of table can only work if it is used specifically on one pitch (swara).

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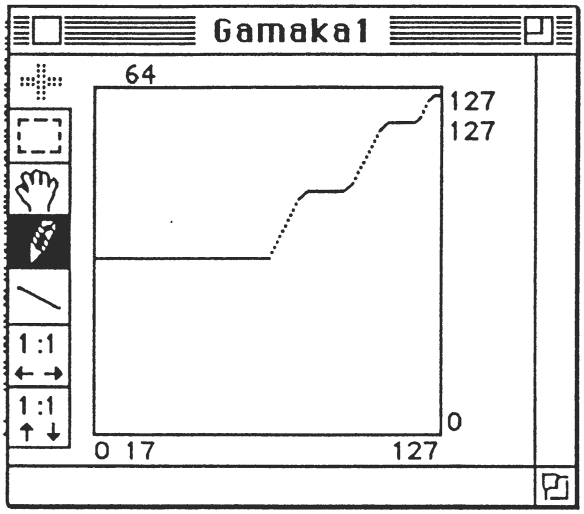

figure 5.

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