Real-time Control of Synthesis Parameters for LightHarp MIDI Controller

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Abstract

The LightHarp MIDI controller is a versatile instrument that allows a varied combination of simultaneous continuous control modes. These control modes can be assigned to work either independently, ie with multiple degrees of freedom or be set to contribute to a single or group of synthesis parameters. This demonstration/paper discusses the configuration and application of combinations of control modes for LightHarps and investigates strategies for effective real-time performance-based synthesis control. This research presents documented findings from three contrasting musical case studies of LightHarp performance repertoire. The repertoire examples include: a reflexive continuum real-time synthesis based piece; performance of traditional Karnatic music; and performance of 72-note equally-tempered microtonal music. Key issues include parameter interfacing and patching through MAX; tactile, visual and haptic-surface sensory feedback within the performance system; control data modification through data interpolation and averaging; and the development of skilled performance techniques with ancillary controllers. [Ancillary MIDI controllers for the LightHarp include 4 curvaceous dials, 2 continuous pedals, breath-controller and a proximity based wand.]

1. Introduction:

Research into real-time synthesis control has taken several interesting directions during the past three years. The ergonomic evaluation of human-music control continues through the research work of; [Bongers, 1994], [Vertegaal, Eaglestone & Clarke 1994], [Vertegaal & Ungvary, 1995], [Vertegaal, Ungvary & Kieslinger, 1996], [Winkler, 1995] and [Polfreman & Sapsford-Francis, 1995] has brought into focus the primary importance of quality tactile feedback in expert controller performance. The Ergonomic approach has driven the design of instruments such as the "aXiØ Controller", [Cariou, 1994&95], and continues to offer new solutions away from the modelling of existing acoustic instrument interfaces. The appropriation of physical gesture to novel hardware has continued with the further development and redevelopment of proximity based ultrasound, infra-red, video-camera and other optical sensing controllers. Notable work in this area includes [Katayose, Kanamouri & Inokuchi, 1996], [Mott & Sosnin, 1996] and [Camurri, 1995] to mention a few. Large scale dance gesture and public interaction are the key musical and artistic areas for this work. Implementation of heightened sensory feedback has had some emergence since the modular-feedback keyboard, [Cadoz, Lisowski & Florens, 1990], through discussion of haptic feedback in the use of accurate sound-localisation [Chu, 1996], display of performance nuance [Chafe & O'Modhrain, 1996] and the use of visual feedback systems such as Padmaster [Lopez-Lezcano, 1996].

It is important to note how little any of this work has developed within the framework of a specific musical vocabulary or repertoire. Novel instrument design and construction work of two-dimensional keyboards for microtonality; such as the "Rolky", [Johnstone, 1985], and "Continuum", (Haken, Abdullah & Smart, 1992) suffered from a lack of repertoire testing unlike simpler two-dimensional keyboards such as the "Clavette", [Fortuin, 1995]. Also there is little work published to date dealing with the manipulation of data from gestural sensors and their relationships to target synthesis parameters within specific musical vocabularies in real-time. The aim of this paper is to address this through the evaluation of several contrasting LightHarp case studies of recent performances and repertoire.

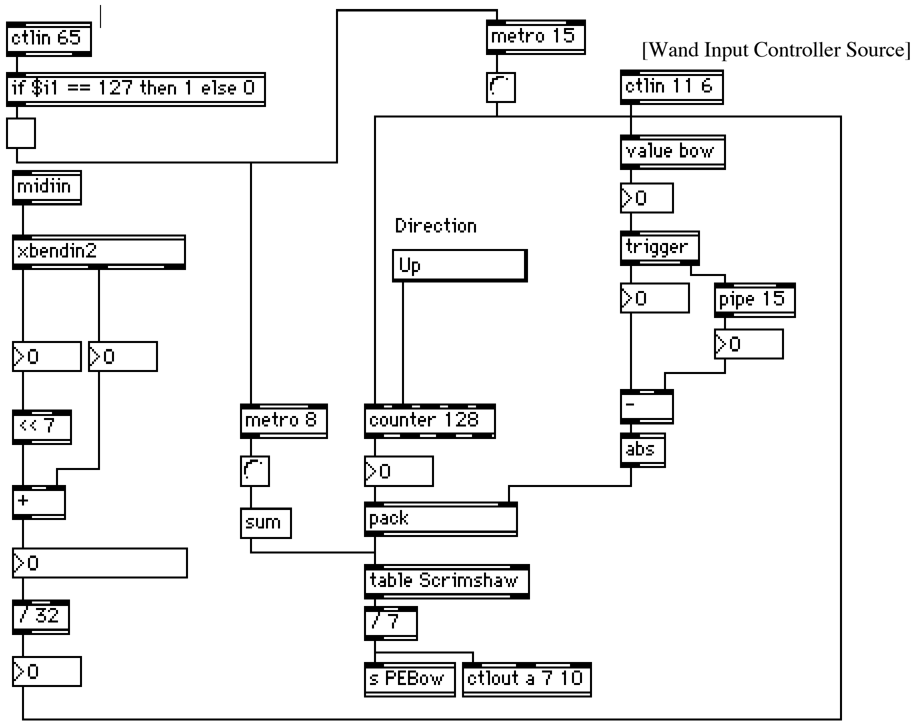
2. The LightHarp and Ancillary Controllers

The LightHarp MIDI controller is modelled from the traditional South Indian Vina and was designed as the first instrument to use the Light-sensor or LDR Controller mechanism, [Favilla, 1994a, 1994b & 1996]. The current models of LightHarp, used for the case studies, have 32 sensors/virtual strings mounted in the neck of solid fibreglass bodies. Each of these sensors have attenuable threshold trimpots mounted on the rear panel of the Harps' gourds which are used to mute strings and also minimalise onset delays. The hardware transmutes sensor signals into MIDI note messages with a fixed velocity of 64. Velocity can be controlled with a plug-in ancillary breath controller which also outputs MIDI volume. Other ancillary controllers include; 4 curvaceous dial controllers [continuous controllers 21, 22, 23, 24 on LightHarp specific MIDI channel], 2 continuous foot controllers [continuous controllers 25, 26], a Roland two dimensional pitchbend/modulation controller and a electromagnetic proximity based wand controller.

The electromagnetic proximity wand works on the principle of electromagnetic induction. Two coils of copper wire wrapped around ferrous iron rods are used in spatial proximity to each other. A short coil has been made to carry a current through it and acts as a transmitter. The receiver coil has been made larger and swung freely 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.

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

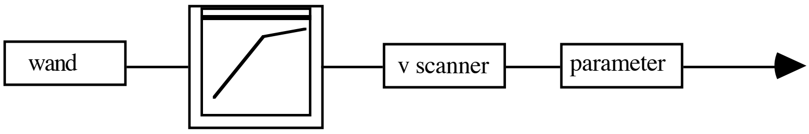
This emf in turn affects a voltage interfaced to the LightHarp motherboard through the first input of an eight-channel ADC. Control data is scanned by a 15KHz sub-processor providing an accurate, source of proximity based MIDI data. Currently the scanning resolution is only 7-bit but will be modified in the future to 9-bit. The scanning rate of 15KHz for the sub-processor yields an excellent smooth and responsive flow of data for control.



[9-bit Controller Source] [fig.1 Velocity Scanner]

This contrasts greatly to scanning rates of ultrasound controllers which usually have scans spaced to avoid reverberations of ultrasound pulses in transducers. Reflections of ultrasound pulses are a furthur problem if the ultrasound transducers are not omni-directional [Mott & Sosnin, 1996]. These spacings can be anywhere between 2 to 15 milliseconds yielding scanning rates of only 6.7 to 50 Hz. In addition the EMP wand can be easily configured in reverse, so that the transmitter coil is held by the musician. By doing so, more than one receiver coil can be added allowing for three dimensional spatial control. The change of data or approximate speed of the wand is generated using the following MAX patch [figure 1] which first captures data from the wand and then interpolates/averages it using the summing of an 128 set table object called “Scrimshaw”.

Another table object can be inserted before the value object to obtain a perfect linear relationship between controller value and distance between transmitter and receiver coils, [figure 2]. The smoothness and responsiveness of this interpolation patch can be adjusted in several ways. The input scanning rate and output rate can be run much faster, the size of the table object can be adjusted along with the divider object's argument. Results with this patch in performance have allowed bowing, slewing and pumping wand gestures which have been mapped to LFO speed, MIDI volume, filter cutoff f_c, and other parameters. The patch is activated by a thumb switch mounted on the wand, which can be also set to disengage its proximity mode of control.



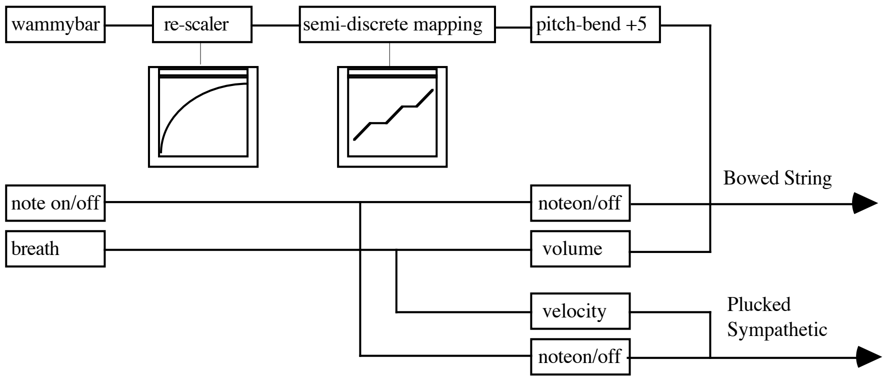
[fig.2]

3. Case Studies

3.1 Karnatic Music *Gamaka*

The first case study involved the adaptation of instrument and pitch specific raga ornamentation for synthesiser. The theory of *gamaka*s and their execution in terms of synthesiser technique has already been documented [Favilla 1994b & 1996]. Essential issues affecting the implementation of control modes is the necessity for the sound to be immediately interrupted or stopped/dampened. Fluid control of pitchbend to at least a major third above the source pitch is also necessary. The stresses, jerks, swells, oscillations and slides comprising the art of *gamaka* can all be performed, once practised, with simple but very responsive modes of continuous control.

Software tools for the LightHarp have been added to include re-scaling and semi-discrete srutti pitchbend tables. Re-scaling tables are necessary to redefine the slope of electromagnetic control. Best results were obtained when a pitchbend range of +4 semitones was scaled to a actual wand movement distance of approx 10cm with a further 5cm generating a movement in pitch of only an extra semitone. The semi-discrete tables allow for thew proximity wand to plateu at specified sruttis [specifically tuned microtonal intervals]. This results in a look-up table that has continuous zones and zones that are static or discrete. This modification was made so that speed phrases could be performed, by the proximity wand controller, on the root [sa] and the fifth [pa] sensor positions. The tuning of sruttis was achieved through scale-tuning synthesis programming on a JV1080 synthesiser module. Two basic sounds are mixed; a bowed sustaining sarangi like sound is played together with a softer plucked-string sound, [figure 3]



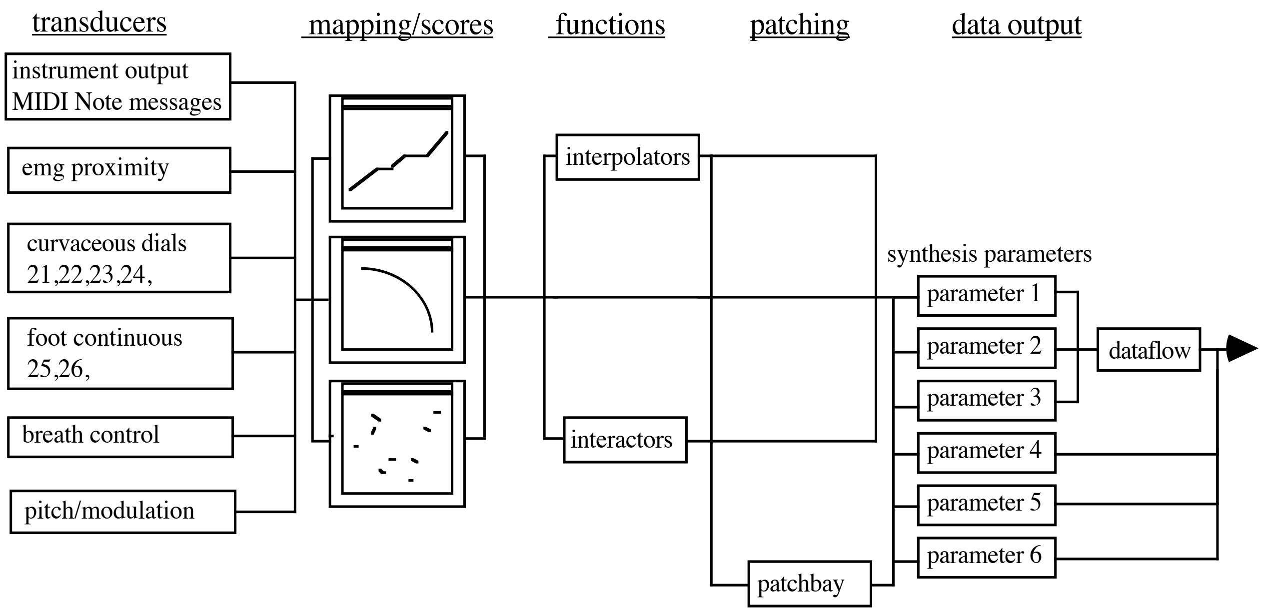
[fig.3 LightHarp Control Modes for Gamaka]

3.2 Reflexive Continuum

The aim of the reflexive continuum case study was to take advantage of as many simultaneous modes of control available to the LightHarp. The aim was to also redirect the performer/improviser's actions and gestures towards the exploration of sound through synthesis control. The resulting set of control modes were applied to a varying number of sound-objects and multi-timbrel set-ups. Musical repertoire and synthesis vocabularies included were; a study of portamenti and glissandi techniques, signal processing control of an eclectic orchestra of gongs and chanting sounds; synthesis and spatial processing control of an orchestra of LFO based insect and bird-call sounds; and finally, synthesis control of single sound-objects providing radical transformations.

Every mode of control available to the LightHarp was used although it is impossible to actually play more than six independent modes at any particular time [noteon/off, breath control, 2x foot control, bamboo extended Roland Pitchbend/modulation bar]. Specific synthesis parameters were assigned to specific MIDI controllers were possible on the JV1080 synthesiser module otherwise the parameters were accessed using system exclusive data sets. MIDI log jams were avoided using MAX speedlim objects which would pulse the sysex messages at timed intervals between 20 and 35 milliseconds.

Visual feedback aids were displayed on a monitor in front of the performer during performances. A separate computer interpreted THRU MIDI data from the Powerbook and displayed it through a MAX patch. The MAX patch display included a JV1080 program name/No. , 0-127 data displays for all controllers, a real-time piano roll and set of multiSlider MAX object displays which also worked in real-time. The window also showed the performer the transducer and target parameter either side of number boxes or multiSlider objects. [figure 4] shows the control modes and the controller mapping sequence:



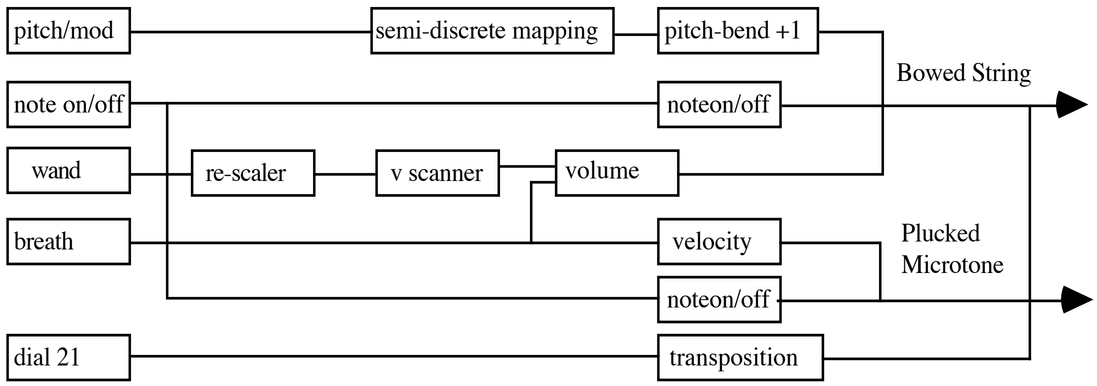
[fig.4 LightHarp Control for Relexive Continuum]

Mapping functions re-scaled, automated or reversed the output of transducers. Mapping functions were also used to specifically score the output of a transducer. All were programmed using tables or buffer type objects in MAX. Interpolation functions included variations of the bowing/pump patch shown earlier. Interaction functions included a series of independent generative MAX algorithms which the transducers affected either through control of their metronomes or dimensions of their data outputs. The patch-bay program consisted of a computer window grid of possible intersection points between input sources [either from mappings, functions or the transducers themselves] and parameter destinations. Screen-shots of the patch-bay were stored in memory preset objects allowing for easy switching between set-ups.

3.3 72-note Equal Temperament

A third case study was carried out exploring the potential of the LightHarp to perform microtonal tuning systems. Having no obvious tonal arrangement of keys for pitch control makes the LightHarp an ideal instrument for microtonal tuning systems. Glissandi are also very natural gestures to perform on the LightHarp and can be found in a large amount of microtonal music repertoire. During this study the LightHarp controlled two synthesis sound objects; a long sustaining sample of an Erhu together with a plucked string sound. Both the wand and breath control were used to control volume. The wand was used to control volume for the performance of chords.

The necks of the LightHarps were marked for 72-note equal temperament. Once again visual feedback in the form of MultiSlider objects were used to keep track of fine pitch bend control. Also small speakers were fixed into the neck of the harp to provide a haptic tactile response. This was done in order to aid the timing of first and second order beatings of dissonances. The bamboo extended pitch and modulation controller was also used for this study. Automation remapping tables were used to split the +1 semitone pitchbend range into smaller intervals and these were controlled by modulation control while smooth pitchbend control was controlled using the sideways pitchbend control of the pitch/mod wammybar. An overview is provided in [figure 5].



[fig.5 LightHarp Control Modes for Microtonality]

4. Evaluations and Future Directions

Criteria for the evaluation of computer music controllers and control-mode synthesis parameter mapping have been derived from two disciplines; ergonomics; [Vertagaal, Ungvary & Kieslinger, 1996] and cybernetics [Pressing, 1990]. From the cybernetic viewpoint Pressing formulated 10 fundamental principles with which one could evaluate how well a controller and control mode performed a specific task. For [Vertagaal, Ungvary & Kieslinger, 1996], the important criteria for determining the suitability of a transducer for a particular musical function are parameters such as; movement type sensed (position, movement, force); resolution of data (continuous or discrete); agent of control (hand, fingers lungs); and the type of feedback (tactile, kineaesthetic or visual). [Vertagaal, Ungvary & Kieslinger, 1996] have refined these criteria and included other criteria from [Shackel, 1990]. According to Shackel, the usability of systems can be measured using four criteria: learnability, ease of use, flexibility and Attitude [defined as the positive or negative attitude of the user against the system].

[Vertagaal, Ungvary & Kieslinger, 1996] also place the importance of visual feedback during earlier learning phases of an instrument playing activity. Expert performance relies on tactile and aural forms of feedback rather than by visual means. Tactile and haptic feedback is certainly an area that has to be addressed with respect to the case studies. Two years of carefully developing precise wand technique for the performance of Karnatic music *gamakas* still does not compare with results obtained with a simple bamboo extension on a pitch-bend wheel. Tighter springs that provide a back-pressure to push against achieve even finer expressive control after some rehearsal. The proximity wand is still a very useful and most theatrical controller. However, bowing and pumping are emerging now as its most useful modes of control.

More sophisticated haptic feedback systems should emerge now that piezoelectric material is becoming available in flat sheets and strips. It should be possible to mould surfaces of instruments with vibrating pressure-sensitive surfaces. This is an area for future research and development for other instruments including the modifications of LightHarps.

This demonstration/paper has overviewed research into real-time synthesis control and LightHarp performance. This study has evaluated through performance, a number contrasting strategies for the configuration and application of control modes. The difference between strategies outlines the importance the musical language plays in the nature and practice of control. The project has developed a set of valuable software tools for the LightHarp and significant music repertoire and performance techniques.

5. Acknowledgments

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[Stuart Favilla with Dragon and Elephant LightHarps. photograph by Ray Joyce]

photograph by Ray Joyce, 1996.