The LDR Controller

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Abstract

The LDR controller allows performers to play virtual sensing beams. These beams are traced from light sources, such as lamps and lasers, to light-dependant-resistors (LDRs), which act as optical switches. The controller was developed as an inexpensive alternative to using video camera, sonar or infrared control interfaces. The current model of the controller allows for the interface of up to 32 switches but another 96 can be added. The processor is mounted in a rack-mount unit while sensors are mounted onto lengths of coaxial cable which are simply plugged directly into the front panel of the rack unit. A voltage divider circuit is coupled to each of he LDR sensor input which allows for the sensitivity of each sensor to be attenuated individually. LDRs of differing sensitivity are cheap and readily available to performers to customize their own performance instruments and installations. Sensitive LDRs can be used to trace beams of up to fifty meters in length from stage lights and well in excess of one hundred meters from lasers.

Introduction

The LDR controller was developed as part of a larger research project into the development of a new live performance based ensemble music for synthesizers. Concurrent areas of research have included: a historical survey of synthesizers and synthesizer control interfaces, studies of pitch ornamentation and microstructure in Asian music stringed instrument traditions, a study into the aesthetic symbolism, iconography and design of the South Indian vina and the development of virtuosic live performance technique for the synthesizer. Initially, the LDR controller was designed as a versatile MIDI interfacing device with which ideas for prototype, virtual-stringed, synthesizer control interface instruments could be implemented and tested. Later it became the interface mechanism and foundation for an entire ensemble of synthesizer controller instruments, the light-instrument-technology-ensemble or LITE ensemble. Instruments of this ensemble include two LightHarps, a LaserLyre and the original LDR controller which is either configured as an extra LightHarp or as a dance controller.

Existing commercial controllers such as keyboards, guitar and wind controllers are foremost designed for the performance of 'pop' music. In addition, keyboards are designed for the performance of polyphonic or chord based musics in equal temperament. Because of this most keyboards, with the exception of piano accordions, are designed to lie horizontally and directly in front of the performer to facilitate the use of both hands. Often, technique and finger movements are hidden from the audience's view. Also when performing monophonic modal musics many keys are redundant and in addition, the equally distanced keys show no conceptual relationship to the performer playing microtonal tuning systems. Similarly, physical gestures playing ancillary controllers, such as pitch-bend wheels, foot controllers and sliders are small and often missed by the audience or hidden from their view during performance. The aesthetic design of commercial controllers reflects a generic high-tech commercialised Western culture, which contradicts the cultural aesthetic of Asian musics. Asian modal music string-instrument techniques, such as arpeggiated glissandos and the strumming of sympathetic strings of Indian instruments, are difficult, uncomfortable and generally ill suited to perform on keyboards. Many of these techniques are better suited to harps, zithers and dulcimers. The need for an instrument that required a playing technique that was highly visible to the audience precipitated the design of an inexpensive, versatile and easily configurable substitute MIDI keyboard controller; the LDR (light-dependant-resistor) controller.

The LDR Controller

The LDR controller is a trigger-pitch type controller. Spot-lights and lasers trace virtual sensing beams to light-dependant-resistors, (LDRs) or photocells. When performers hands, body parts or mallets cross these beams a corresponding MIDI note message is sent out to either an effector mechanism such as a synthesizer or sampler, or via a computer first for processing.

The prototype LDR controller interface was built using a pre-existing circuit board designed by Melbourne based microcomputer designer Robbin Whittle, for upgrade of analogue synthesizers to MIDI based devices. The controller interface consists of a three unit high rack mount box with thirty-two quarter inch jack input sockets mounted onto the front panel. For each of these inputs there is a corresponding resistor pot which is used to attenuate the sensitivity of each sensor. There is also a super bright LED indicating MIDI OUT activity. On the rear panel of the box there is a MIDI OUT connection and an input for a nine volt power supply. The entire cost for the design and construction of the prototype model was about US$ 600.00 which covered the wage of the technician at a high hourly rate.

LDRs were connected to lengths of coaxial cable which then plugged straight into the front panel of the interface. The coaxial cable and the LDRs were encased inside lengths of clear plastic, one centimeter diameter polytube. The polytube was fastened onto the coaxial cable with plastic heat-shrink thus protecting the sensors. Using the clear plastic polytube also had an extra advantage. This was that lengths of this tubing could slide into 1.2 centimeter black plastic polytube lengths which in turn, functioned as effective extensions in masking ambient light. Lengths of this black tubing could also be mounted onto frames, stands and sculptures in order to save time in setting up for live performances or installations. The black polytube can be found in garden sprinkler-system kits while the clear plastic polytube is often used for fish-tank attachments; both are extremely cheap and readily available. Once the LDRs are connected to the interface a light source must be directed onto them and the black polytube mask corrected to block ambient light.

Each LDR channel input is expecting a normally open switch contact or a normally high resistance. The input is pulled towards +5 volts by a resistor pot with a total resistance of between 470 ohms and 5K ohms. This input voltage is fed to a schmitt trigger HCMOS device with typical voltage thresholds of 2.7 volts (positive going) and 1.8 volts negative going. When an object or a hand passes through these virtual beams a drop in voltage activates a schmitt trigger HCMOS device and a corresponding signal is sent to the system processor. The CPU is a Z180 type processor, CPU 61480 Hitachi Z180 chip, and this is integrated with two serial ports, a DMA and timers. Software and code is programmed with EPROM chips. When the signal is received from the schmitt-trigger a corresponding NOTE ON message is sent to the MIDI OUT. Similarly when the light source re-illuminates the LDR, the schmitt trigger is reset and a corresponding NOTE OFF message is sent to the MIDI OUT. The timer circuit uses a 10 KHz crystal which provides the interface with a scanning resolution of a thousand per second.

The inclusion of the variable resistor pot was essential because of significant time delays, up to seven seconds, in the time needed for the LDRs to react to changes in light. The cadmium-sulphide material of the light-dependant-resistors needs time to 'heat up' and 'cool-down' resulting in a hysterisis; or a slowness to react or stickiness. Hysterisis can be overcome by using less sensitive LDRs, that is LDRs with wider gap between electrodes and shorter total length of this gap. These LDRs react to dramatic changes of illumination much faster. When attenuated by the resistor pot only a fractional change in voltage is required to trigger the schmitt-trigger which results in only fractional timing delays.

These timing delays were measured using a propeller driven circular strobe plate. This allowed a single sensor to be accurately strobed by discrete pulses of light. The strobe played in effect a single string, comparable to one key on a keyboard. This was then recorded on a Macintosh Computer using a MIDI sequencer program PRO4. The sequencer was run at the fastest possible clock speed while the data was recorded. The strobe template had eight gaps cut into it with eight masking sections equal in length. Then the propeller was driven up to the maximum speed before notes were lost or misread and the data was examined on the sequencer.

The strobe propeller assembly could clearly play 216 notes per second at maximum speed. When the propeller's speed was increased past this, notes would be lost or dropped out of the stream. When the MIDI transcript of the data was analysed it was expected to show equal durations between notes and silences however this was not the case. The note durations were clearly shorter, 1-2 msec, than the gaps, 3-4 msec. This means that the combined timing delays of both note-onset and note-offset for a single note was found to be 1-3 milliseconds. Whether these delays are caused by hysterisis is uncertain. These delays are small enough to be caused by the limit of resolution of the controller's scanning rate or delays incurred with MIDI.

Onset delays were also measured for chords of up to 12 simultaneous attacks and random delays were found in the vicinity of 10-40 msec. Delays of this kind a still suitable for performance of music and are generally only noticeable when controlling sounds with precise percussive attacks (Moore, 1987. (Small & Campbell, 1962). These delays can be attributed to the serial nature of MIDI (Pressing, 1987 & 1991), and also to the scanning rate of the controller. These delays are also comparable to commercial keyboard controllers such as the Yamaha DX7, measured random delays in chord note onsets of 30-40 msec, (Pressing, 1987). I also ran experiments on a Roland D70 and found delays of up to 50 msecs. The LDR Controller Interface mechanism is certainly effective enough to suit most musical instrument interface demands with exception that it can only provide a NOTE ON/OFF message with a set velocity value. Once the prototype LDR controller interface was designed tested and constructed, the design of instrument frames and shapes began.

Instruments: The LightHarp and LaserLyre

The LightHarp and the LaserLyre the first instruments built using the LDR controller. The idea behind each of the instruments was to design a keyboard type controller that would demonstrate a strong link between performance gesture and synthesizer sound. The LaserLyre was intended as more of a novel design allowing a performer to play the intersections of laser beams for novel approaches of polyphony. The use of dry-ice sublimated CO_2 or inscense smoke to reveal the actual beams during performance, provides the performer with added visual feedback. The instruments are also supported by a number of other ancillary MIDI controllers; breath controllers, large ornate continuous controller dials, pedals and a magnetic proximity controller, that would allow the LightHarps and LaserLyre to be specialised for both monophonic and polyphonic performance setups.

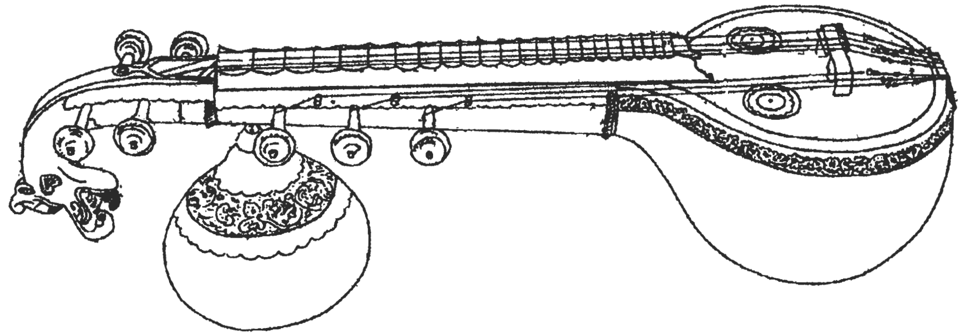
LDR sensors were mounted in a curved wooden frames and traced virtual strings to either a single lightweight halogen spot-lamps mounted on extension arms or groups of lasers, mounted in the frame of the LaserLyre. The frame of the LightHarps were designed to stand vertically in front of the performer, seated cross legged or on a stool, whose hands come around in front of the sensors. Sensors mounted higher up triggered correspondingly higher MIDI note numbers or notes. This design allows the player to either play strings freely in space between the light and the frame or while resting one or two hands on the leading smooth fingerboard edge of the frame, providing the player with important tactile feedback as to the exact position of fingers and hand. The vertical aspect of the frame demonstrates a strong theatrical sense of register and pitch while the spot-lamp also serves to illuminate and highlight the performer.

The instrument frames were constructed at the Monsalvaat violin studio under the supervision of instrument maker David Brown. Much experimentation was done in order to get the proper shape and proportions of the frames. Prototype frames were cut from glued sheets of chip-board which was then drilled for the sensor mounts. The instruments proper consisted of necks shaped from branches of Australian native trees that were connected to fibreglass moulded gourds. The fingerboard edge on the necks were smoothed, polished, drilled and then painted matt-black in order to absorb any ambient light. ORP12 light dependant resistors were used for the LightHarps and LaserLyre since they have a small surface area, roughly 12 mm^2, which is relative to the cross-sectional area of the virtual string. By keeping the area small, the string is responsive to fine fingertip gestures as well as larger hand gestures. Each instrument had its own modified LDR controller board contained inside the gourd. The modifications included the addition of an eight channel analogue to digital convertor, to support eight analogue ancillary controllers; a breath controller, a magnetic proximity wand for pitchbend, four assignable ornate dials and two continuous pedal inputs. Also an extra panel board was constructed to cut down on the soldering of attenuation pot connections. This board sat directly behind the front panel.

The aesthetic design of the LightHarp was modeled from the South Indian vina. The decoration and structure of the vina represents strong symbolic, iconographic and cultural design (Subramanian, 1986). Symbolically the vina parallels the anatomy of the human body which relates it to the Indian science of yoga. The curved dragon headed end of the vina and frets are symbolic of the human spinal column while the gourd is representative of the human abdomen. The gourds of the vina and the dearhorn nippled tuning knobs represent female breasts. Yogic philosophy considers the human body to have six main nerve centers starting from the lowest point of the spinal column extending up o the head.

These nerve centers are representative by the six frets for the root and fifth which span the range of three octaves. The three side strings are representative of three principles of Brahman, while the four main playing strings of the vina are representative of the four aspects of man or the concept of "Atman": dharma (duty), artha (material gain), kama (love) and moksha (liberation), (Subramanian, 1986).

These aesthetic attributes were mirrored in the design of the LightHarps: The inclusion of the dragons head or yali. The range of two and one half octaves in register, corresponding to the six roots and fifths, or the yogic nerve centers. The representation of the four principles of Atman and feminine principles with the inclusion of four breast shaped continuous controller knobs, and the use of an abdomen shaped gourd. The decoration of the LightHarps is also symbolic of the project: The yali representative of the import of Asian music influences, the gourd and its microcomputer as the technological foundation of the ensemble, the halogen light as source of life and the neck as the bridge connecting all of these symbolic elements together.



The South Indian Vina

Conclusion

The LDR controller has proven so far to be a successfully versatile and musical controller. It is limited in the fact that it is purely a switching device. It cannot provide velocities, channel pressure or polyphonic pressure. However, the technique is highly visible to the audience which makes it possible for the audience to discern individual parts within ensemble pieces consisting of scales or collections of complex sound objects and note-attachments. When combined in LightHarp form, the LDR controller proves to be very expressive and adapts very well to the performance of Indian music and other Asian monophonic musics. The use of the magnetic proximity bar to effect pitch-bend is very visual and theatrical while the instrument also accommodates harp-like glissandi and runs. MAX has been used to compose intricate performance set-ups and configurations for the LightHarp in performance. Amongst the more successful of these include synthesizer key set-ups of Japanese Gagaku percussion, orchestras of bird, animal and insect sounds, and a monophonic Indian sarangi-like sound (breath control assigned to volume) which is alternated with a plucked sympathetic string sound (breath control assigned to the velocity).

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