Circular Optical Object Locator

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Abstract
The Circular Optical Object Locator is a collaborative and cooperative music-making device. It uses an inexpensive digital video camera to observe a rotating platter. Opaque objects placed on the platter are detected by the camera during rotation. The locations of the objects passing under the camera are used to generate music.

Keywords
Input devices, music controllers, collaborative, real-time score manipulation.

INTRODUCTION
The Circular Optical Object Locator (COOL) was built for Music 250A/B[4], a course at Stanford University about musical controllers taught by Bill Verplank and Max Matthews. The COOL was originally inspired by old-style player pianos that can automatically play a musical piece encoded as a pattern of holes punched in a long reel of paper.

The COOL exhibits two behaviors which are unique to modular instruments like the player piano. The first is that of mapping spatial coordinates to tonal and rhythmic relationships. This spatial mapping allows the physical score to be read automatically by the machine. The second is the removal of virtuosity as a requirement for creating meaningful sound. These two aspects intentionally constrain the compositional and physical possibilities of the instrument in order to make the COOL easy to use.

The COOL is unique because it allows direct access to and real-time manipulation of the score. This allows users to freely modify a composition's structure within a range of predefined pitches.

Additionally using the COOL can be collaborative. It allows several participants to create and modify a piece simultaneously.

CONSTRUCTION OF THE COOL
The physical construction of the COOL consisted of three main parts: Cutting the platter, building the rotation mechanism and camera scaffolding, and building the other control elements.

The platter is a disc of clear acrylic, mounted on a spindle recovered from a large computer hard disk. The spindle is bolted onto a welded steel hexagonal box that acts as the structural hub of the device. Long incandescent light bulbs are mounted on the box, and extend outward in six directions. Light from the bulbs shines up through acrylic plates of varying colors. Support arms made

Figure 1. Participants moving tokens and experimenting with the COOL.

made from cut ABS pipe surround the light bulbs, and have nylon wheels mounted at the end. The wheels support the platter and allow its rotation even while under the downward force of a person leaning. The scaffolding overhangs the rotating disc, allowing a PC camera to be affixed in a downward-pointing orientation. The trigger pieces are small (about 2cm diameter) pieces of any opaque material that can be arranged on the platter in real-time by a performer or group of performers. A bank of dimmers allows the user to fade the individual lights up and down, and photo-resistors gauge the amount of light being emitted from each bulb. A panel of buttons allows the user to change modes.

SENSING AND INTERPRETATION
The COOL uses the Microsoft Vision SDK API[3] in order to grab images from the PC camera. Custom routines extract the relevant information from each frame. The brightness of the lights is sensed by photoresistors connected to a basic stamp, and the mode buttons are connected to the stamp as well. All music-output is managed in an interpretation stage taking place on a Macintosh running Max/MSP[1]. Communication between the Vision SDK and the interpretation stage is via UDP network packets sent across a direct ethernet cable. The data is formatted according to the OpenSound Control Protocol[5]. Communication between the basic stamp and the interpretation stage is via MIDI signals.

Sensing Stage

The pixels representing six equally spaced radii of the platter are monitored by the camera in each frame. Any changes from the last frame are transmitted to the interpretation stage. For example, a change would be that a particular pixel is dark, where that pixel was light in the previous frame. To judge the brightness of a pixel, we convert its red, green, and blue values to HSV (hue, saturation and value) space[2], and we test whether the "V" component of the pixel exceeds a threshold. A single UDP packet for each changed pixel is transmitted to the interpretation stage, where the mode constraints are applied before generating output. A single photoresistor mounted inside each light housing measures the intensity of the light being emitted by the bulb. The photoresistors are connected to an A/D converter, which is in turn connected to a basic stamp. The buttons are connected directly to the basic stamp.

Interpretation Stage

Data in the form of UDP packets is received from the sensing stage by an "otudp" external object[5] in our Max/MSP patch. In Max, the data from each scanned line is used to generate MIDI note signals with a different timbre. The intensity of the lights, controlled by the faders, is interpreted in Max as the volume control for each sound. Max also responds to the buttons by changing the modes or scales the COOL plays in: once in a particular mode, the software filters the data, choosing notes from a given scale. To these basic interpretation routines, we have added features that make the musical results more predicable: a patch to prevent the rapid repetition of the same note if a pixel is half lit or flickering, and another that re-maps the entire pixel range into the mode range, so that small triggers will always play a note, and will never fall in-between notes from the current mode.

USING THE COOL

To manipulate the COOL, users hand-rotate the platter, place "triggers" on the platter's surface, fade the lights up and down with dimmers, and change the mode by pressing the buttons. Playing the COOL is an iterative process. This is partially due to the fact that the platter lacks a visible reference-grid. Such a grid could delineate tonal and rhythmic regions but could also produce unwanted sound artifacts. This lack of visual reference information means that placing triggers onto the table's surface and hand spinning the table results in sounds that are not entirely predictable. Typically, users will begin by randomly scattering triggers onto the table. They will then listen to the sound which results from spinning or rocking the table back and forth, and adjust individual pieces to create desired patterns. They can also sculpt a composition by changing its mode at interesting times, or by fading the lights up and down quickly, which triggers many notes at once.
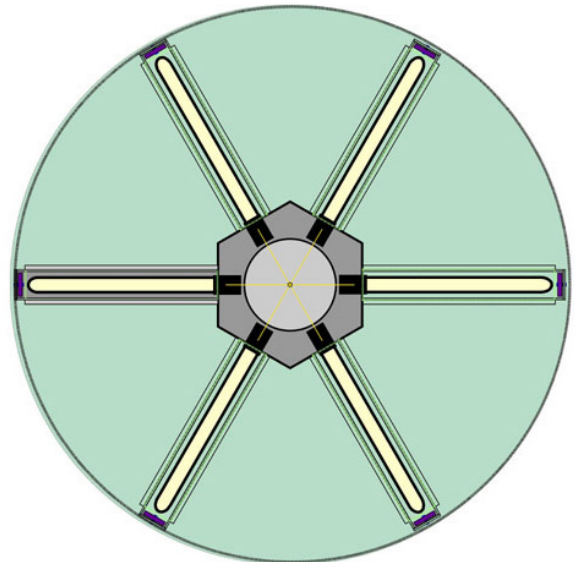
Figure 2. The camera's-eye view of the COOL. Each of the 6 radii is monitored by the software.

CONCLUSION AND FUTURE DIRECTIONS

The COOL is a unique music-making device. Although it does not require any degree of virtuosity from a performer, it can support quite sophisticated manipulation. It allows for the exploration of timbre and repeating motifs, and facilitates collaboration between several participants. Our goal is to make the COOL available to the public as an interactive installation, to provide a new and exciting musical experience. With some structural reinforcement, the COOL will be ready to meet the world.

ACKNOWLEDGMENTS

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