Rubik’s Cube, Music’s Cube

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ABSTRACT
2017 marks the 40th anniversary of the Rubik’s Cube (under its original name the Magic Cube). This paper-demonstration describes explorations of the cube as a performance controller for music. The pattern of colors on a face of the cube is detected via USB video camera and supplemented by EMG data from the performer to model the performer’s interaction with the cube. This system was trialed in a variety of audio scenarios and deployed in the composition “Rubik’s Study No. 1”, a work based on solving the cube with audible connections to 1980’s pop culture. The cube was found to be an engaging musical controller, with further potential to be explored.

Author Keywords
Tangible User Interfaces, Rubik’s Cube, Myo Armband

ACM Classification

1. INTRODUCTION
The Rubik’s Cube (Figure 1) is a popular 3D puzzle invented in the 1970s by Erno Rubik [9]. The standard cube has a 3 x 3 grid of squares on each face, while all faces can rotate freely. When solved, each face displays a single color, usually white/yellow, blue/green and red/orange on opposite faces. Despite ~43 x 10¹⁸ permutations, any state can be solved in <21 moves [9]. Typically solving uses more moves, but “speed cubers” can still do so in a few seconds [12].

Our enquiry into cube-as-controller derived from the fact that the cube is a highly tactile object inviting user interaction, it has a large number of states, it can embody user skill in its manipulation, while basic moves are simple to learn, and, not least, it is fun to play with.

Figure 1. The Rubik’s Cube puzzle

2. RELATED WORK
2.1 Tangible User Interfaces
The manipulation of physical objects to control digital information is described as a tangible user interface, a well-known music example being the Reactable [3], where the manipulation of fiducial marker cubes and discs (and finger touch) on a circular back-projected surface allows the user(s) to assemble, configure and control a real-time software modular synthesizer. Its open source tracking, reacTIVision, has been used by others in music [11] and non-music [2] examples, while related Rotor software allows an iPad to be used with tangible “rotor controllers”. Similarly, but in general computing, Microsoft’s PixelSense tables supported object recognition and tracking on the screen, ideas at least partly carried forward to their Surface Studio’s interactive “dial”.

2.2 Computer Vision and Rubik’s Cube
A number of published student projects can capture the current state of a cube to use with solving algorithms, e.g. [1, 5, 7].

Robot solvers can achieve sub-second results [4], but fix the cube’s position relative to the camera(s), so their reading code is likely not ideal for human performers.

2.3 Rubik’s Cube and Music
Hakan Libdo [6] used up to 16 pre-prepared 4 x 4 cubes as a sequencer grid (time, pitch axes), colors indicating instrument parts. It is similar to Candy Synth by the same artist, and other tangible sequencers. Whilst a fun application, it is not altogether clear how using the cube is advantageous. We were keen to explore the cube more as an instrumental controller, although this is clearly just one musical possibility.

3. CUBE EXPLORATION
3.1 System
Karpathy’s tracking code [5] was modified to transmit face colors via OSC to Max/MSP and then mapped to the six cube colors using Euclidean distance (in HSL color space) relative to the calibrated mean for each face. This is then mapped to audio parameters.

We determined that tracking performer-cube interaction would be important. We decided upon performer sensing, since we wished to use an unmodified cube and didn’t want to limit cube movement to within camera shot. A Leap Motion optical hand-tracker was confused by the cube and so a Myo Armband [8] was tried, collecting motion and EMG (electromyograph) data from the forearm. The Myo moved little when “cubing”, but EMG data was a good predictor for cube activity, as values varied with finger pressure. A Max external was developed to access EMG data.

Figure 2. Cube Instrument
successful completion of the puzzle leading to a clear sense of tonal arrival and, therefore, closure for both the performer and audience. A clear sense of trajectory is created through the transformation of the materials.

The overall duration and changes in musical material (e.g. pitch, granulation, sonority) are connected closely to how the performer solves the cube and their particular ‘cubing’ abilities. For example, the duration of a Rubik’s cube champion would be rather short but would create some exciting granulation textures in the process. Similarly, a more measured or hesitant approach would result in the exploration of a wider range of different pitch sonorities. Both are equally valid performances.

Another important issue in developing the work was to playfully but purposefully rejoice in nostalgia for the 1980s. The Rubik’s cube is a treasure passed down from the 80s as are the FM synthesiser and Casio VL-Tone drums used.

5. CONCLUSIONS

The Rubik’s cube is an interesting object to explore as a music controller. While naturally lending itself to ideas of order and randomness, the seemingly endless reconfigurations in a small, easily manipulated cube offer both stochastic and predefined control options while providing interesting gestural elements for performer and audience. In further work we plan to develop additional audio control mappings, less invasive activity capture and to explore temporal synchronization between cube and system response.

6. REFERENCES


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