Precise Control on Compound Curves

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ABSTRACT
This paper presents the 'Bean', a novel controller employing a multi-touch sensate surface in a compound curve shape. The design goals, construction, and mapping system are discussed, along with a retrospective from a previous, similar design.

Keywords
Musical controller, sensate surface, mapping system

1. INTRODUCTION
The Bean is a development of ideas tested in the 'Ski' over several years [2]. As with the previous design, the main goal is to create a musical instrument with a broad sonic scope, one that can play in many styles and easily collaborate with traditional or modern instruments. Using conductive rubber materials and an AtmelAVR microcontroller [4], a multi-touch sensing pad is built on an arbitrary shape with three distinct peaks intended to delineate octaves of the instrument's range. Notes are mapped so that musically useful intervals fall under the fingers naturally. The map combines some elements from stringed instruments, the piano keyboard, and the kalimba, making it more intuitive for the experienced musician. I will discuss experience gained on the Ski and how it was applied this new experiment. While the Ski made headway towards a viable instrument, technical improvements were needed for further development of a precise playing technique. The Bean takes a fresh approach on the instrument's shape, and is the next step towards the kind of accuracy that will enable virtuosic performance characteristics in a new controller.

2. FORM FACTOR

2.1 Choice of Shape
The Tactex [3] pads used in the Ski are only flexible in one axis, limiting the choice of shapes for the playing surface. In looking for ways to include more positional cues in the shape, the idea of portions of a sphere for each octave kept coming to mind. In an early drawing, it began to look like a giant pea-pod and so the bean shape was conceived. While it is visually novel and memorable, the ends of the pod are useful for holding it under the chin or between knees. It is hoped that a roughly spherical section for each octave will help in locating notes on the surface. Another new shape element is a convex surface on the back of the instrument making it easier to grasp without stretching. Compared to the Ski, the new instrument is much shorter so that it will be easier to transport. It can have a leg added to rest on the floor, a neck strap, or can simply be held by the musician as described above.

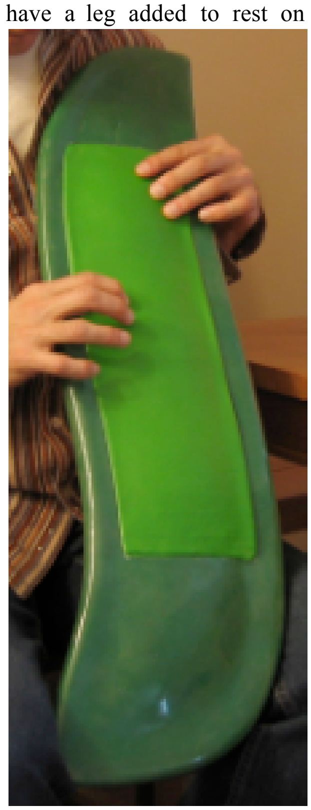

Figure 1. The Bean

2.2 Construction
A fiberglass over foam construction method was chosen for the Bean. It is similar to the way surfboards are made and has the advantages of low cost and ease of carving. After shaping, the body was painted and laminated with two layers of fiberglass cloth and epoxy. Once complete, the active sensing area was cut out, foam core removed, structure and electronics added inside, and the sensor laminate applied to the outside. The finished product is strong and light, and changes or repairs are fairly simple to make.

2.3 Sensing Pad Details
After seeing conductive rubber used in the HyperPuja during NIME03 [5], I experimented with using it in a position-sensing pad. Zoflex® conductive rubber [6] is available in sheets, either conductive full-time or under pressure (like a switch or force-sensitive resistor). Here a pressure-switching sheet is sandwiched between rows and columns of conductive material. At the bottom layer, aluminum tape is used for the column strips. On top are rows of full-time conductive rubber glued to the back of a leather playing surface. Contacts are made where the strips wrap around the edge of the pad.

Using the Atmel microcontroller, a voltage is applied to each row in sequence. If there are pressure points on that row, the voltage will pass through the switching layer to the column strips underneath. The columns are read in groups to make four 8-bit words for each row, which are sent to the computer via a serial connection and used to build a matrix representing activity on the pad. Centroid detection is carried out by a Max/MSP/Jitter object written by Randy Jones [1].

One difficulty with the Ski was the wide separation between fingers needed to register discrete centroids. In the new pad, separate centroids appear even when adjacent fingers are nearly touching each other, making it easier to form chords. This is achieved by spacing the sensitive points about 4mm apart as opposed to 12mm on the Ski.

3. MAPPING STRATEGY

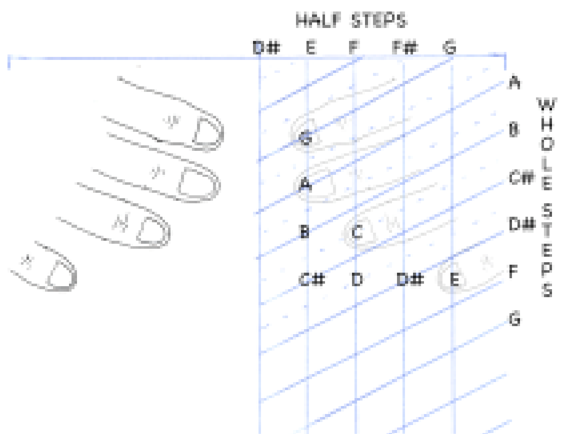

Figure 2: Tuning Map

3.1 An Evolving Favorite

Since the tuning used on the Ski worked well and could stand more exploration, the same basic tuning is used on the new instrument. In it, four notes of a pentatonic scale are mapped to fall under four fingers resting in a natural, relaxed position (home position). These are the 5th, 6th, root, and 3rd, in that order [Figure 2.]. The map is a mirror image on each side (like a harp or kalimba). Pitch is lower at the top and higher at the bottom, similar to a stringed instrument but equally spaced like a keyboard with one octave per 'pea'. Moving a fingertip's width toward the center of the pad will lower the pitch by a half-step, and toward the outer edge, up a half-step.

3.2 Sound and Playability

The sound of these instruments comes from a software synthesizer and so could be anything at all. Since the main effort is to develop a technique, I have chosen to use simple sounds which make tuning and articulation easy to hear and adjust: a straightforward synth bass, a melody voice built from a flute patch, and a basic analog synth with resonant filter, etc. Like any instrument, it lends itself more to certain kinds of musical figures than others. For instance, wider intervals are much easier to manage then closer ones, and scales currently work best with a two-handed technique that is tricky and a bit awkward. In its non-quantized pitch mode ('fretless') it is very expressive and can make lyrical melodic lines and strong bass parts. Improvements made on the sensing pad will afford broadening the technique. For instance, the ability to play single-handed chords in the Bean has opened up a whole new area to explore.

4. LOOKING FORWARD

4.1 Technical Challenges

Certainly, increasing the density of sensors has improved accuracy of the pad and opened up new avenues for technique development, but it also vastly increases computational overhead needed to support the device. For this reason, speed will continue to be a big issue. Sending sensor data using digital audio signals instead of standard serial ports is one way to help things. Handling more signal processing at the microcontroller level instead of at the host computer will help improve efficiency. Also, more experimentation is needed with different materials and construction methods for the pad.

4.2 Final Thoughts

A major step forward with the Bean is that it was relatively inexpensive to make in terms of the cost of materials. This device was hand-made and therefore time-consuming and difficult when real precision was needed. Future versions will use printed circuits on flexible materials to solve this problem and make it simple to build more instruments cheaply. Getting a few beans into the hands of more people, especially musicians and children, will provide valuable feedback to help speed development.

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6. REFERENCES

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