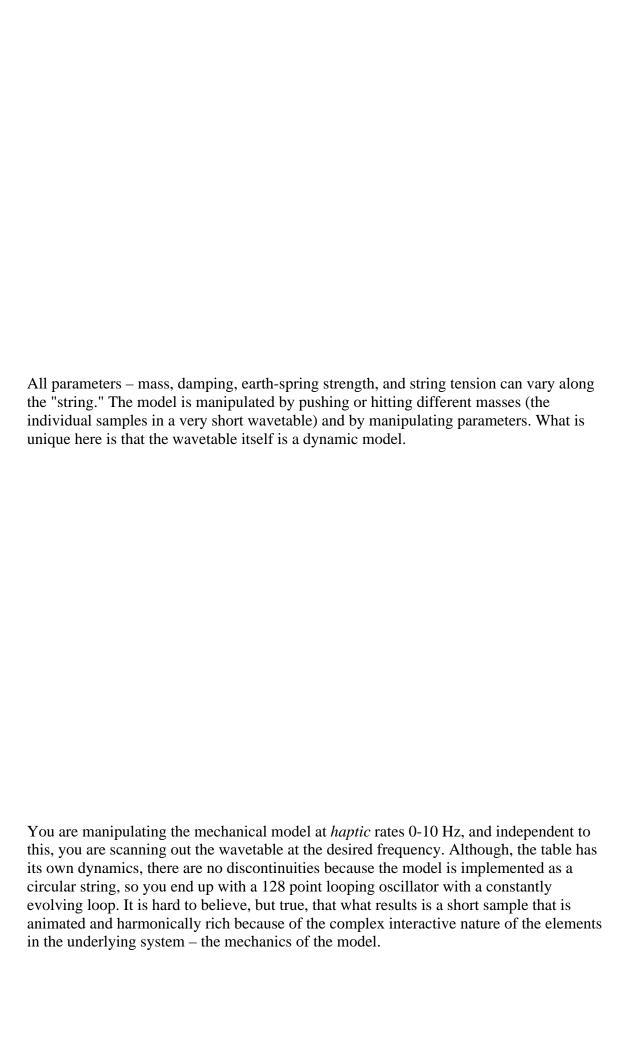# Scanned Synthesis
A Csound TOOTorial by Richard Boulanger

Scanned Synthesis represents a powerful and efficient technique for animating wavetables and controlling them in real-time. Developed by Bill Verplank, Rob Shaw, and Max Mathews between 1998 and 1999 at Interval Research, Inc. it is based on the psychoacoustics of how we hear and appreciate timbres and on our motor control (*haptic*)

All parameters – mass, damping, earth-spring strength, and string tension can vary along the "string." The model is manipulated by pushing or hitting different masses (the individual samples in a very short wavetable) and by manipulating parameters. What is unique here is that the wavetable itself is a dynamic model.

You are manipulating the mechanical model at *haptic* rates 0-10 Hz, and independent to this, you are scanning out the wavetable at the desired frequency. Although, the table has its own dynamics, there are no discontinuities because the model is implemented as a circular string, so you end up with a 128 point looping oscillator with a constantly evolving loop. It is hard to believe, but true, that what results is a short sample that is animated and harmonically rich because of the complex interactive nature of the elements in the underlying system – the mechanics of the model.

String:

Circle:

Torus:

All Connect: (note all squares should be blackened in this figure meaning that all points connect to all other points in the table.)

To produce the matrices, the file format is straightforward. For example, for 4 masses we

Whenever tt4er tasses are connected tnev tne point tney define is 1, so for aunidirconional string we would h

Similarly for the other shapes, just find the connections and fill them out. This gets saved
in an ASCII file, column by column. So the 4 mass string would be saved as:

```
0.
1.
0.
0.
0.
0.
1.
0.
0.
0.
0.
1.
0.
0.
0.
0.
```

```
<CsoundSynthesizer>
<CsOptions>
</CsOptions>
```

<CsInstruments>

```
<CsInstruments>

<CsScore>
; Initial condition
f1 0 129 7 0 64 1 64 0
; Masses
f2 0 128 -7 1 128 1
; Spring matrices
f33 0 16384 -23 "cylinder-1
; Centering force
f44 0 129 -7 2 54 0 54 2
; Damping
```

Finally, because Smaragdis has separated the opcode that scans the waveform from the

```
<CsoundSynthesizer>
<CsOptions>
; Csound -n -P1000 -m0 -A -iadc -MIDI -s -b128 -B128 -V50 -F32
```

<CsInstruments>

```
i1  cpsmidi
a1  foscil  1000, i1, 1, .5, .01, 3
    cut     a1
    endin
```

; Vibrating structure with audio injection
instr 2
a0   in

Conclusion & Acknowledgements

Charting and discovering these new worlds of scanned synthesis is up to you. And for the time being, the only place to do this exploring is Csound. On behalf of the Csound