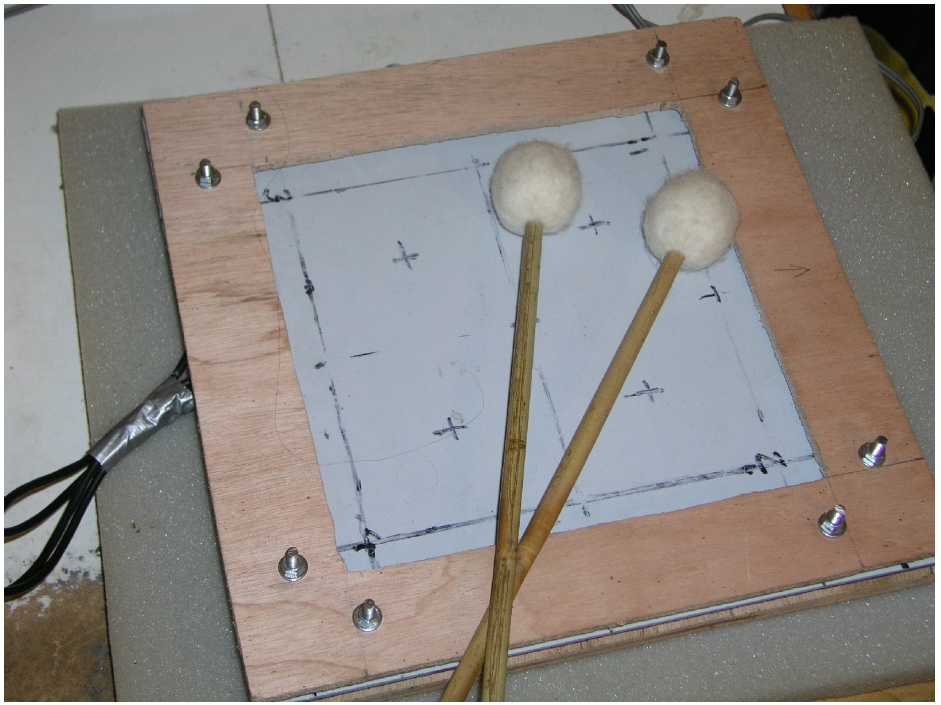
The synpad – a position sensing midi drum interface



I will be talking today about my attempts to build a cheap, playable, midi drum interface with position sensing capability.

Overview

- Motivations – why build this?
- Research – previous designs.
- Physical design.
- Electronics.
- Driver software – firmware and position mapper.
- Synth software – using supercollider.
- Results.
- Similar work.
- Future directions.
- Conclusion.

Motivations

Why build something like this?

- I find drum machines limiting and awkward.
- I wanted something more immediate and responsive.
- Drum triggers are good but you can't change the tone.
- Wanted something more like a real drum.

Research

- Tried a couple of other designs.
- Voltage gradients in a conductive rubber sheet.
- Time of flight of pressure waves.
- Just sensing transferred pressure worked ok.

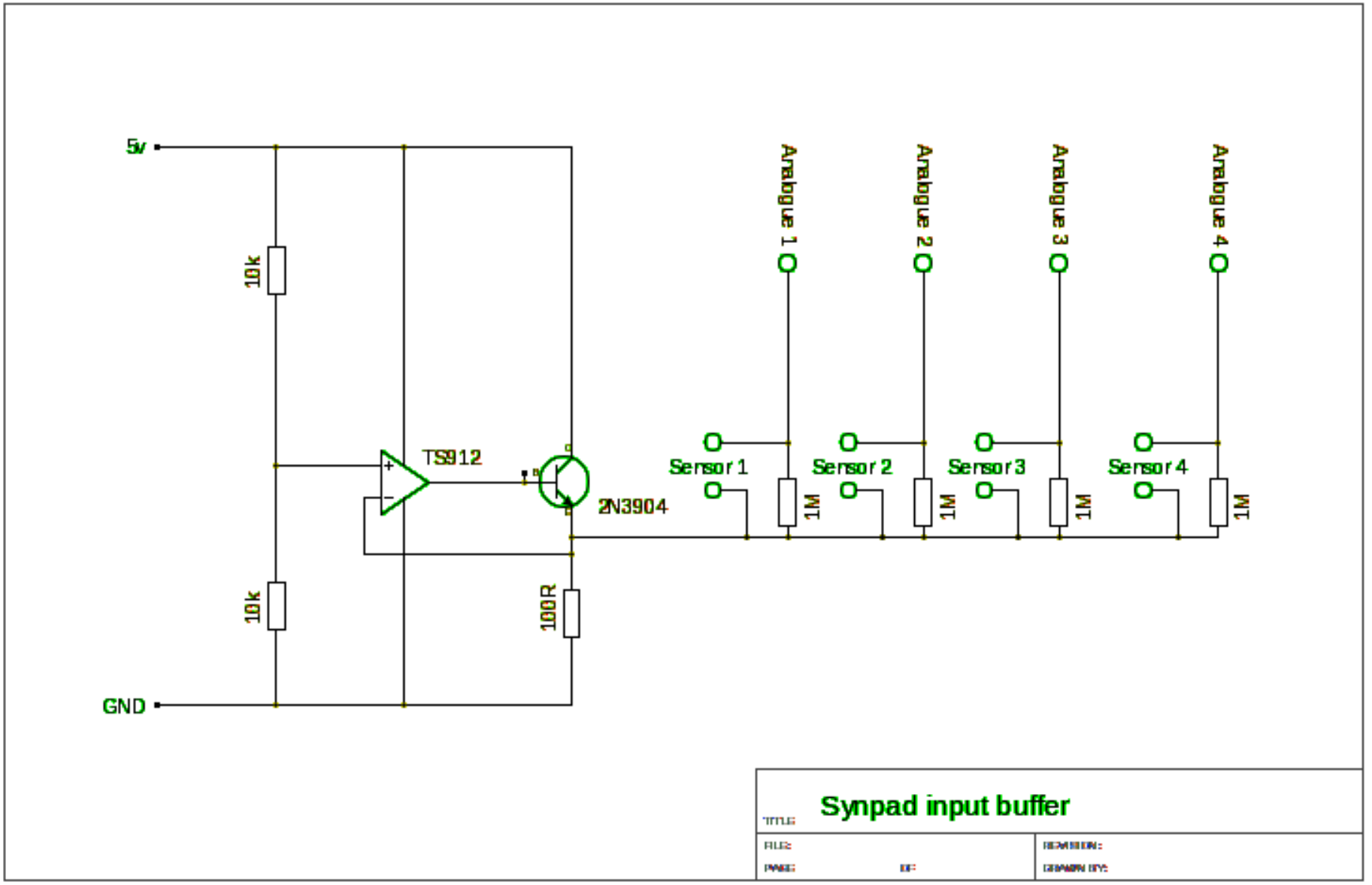
Physical design

- Playing surface is an aluminium sheet.
- The sheet moves freely in a wooden frame.
- Piezo sensors under each corner detect differences in transferred strike pressure.
- The signals are brought out to an arduino board.

Electronics

- Quite simple electronics.
- Provides a false ground level.
- Prevents voltage drift on the piezos.

Circuit diagram



Driver software - firmware

- Firmware turns analogue signals into 4 velocities.
- ADC sample rate: 76 kHz across 4 lines.
- Trigger level for detection.
- Absolute values summed for 16 samples = 0.84 ms
- Summed values are written to USB at 230400 baud (0.34 ms)
- 1300 sample / 68ms release period.

Position mapping software

- Python program maps sensor readings into x, y and velocity coordinates.
- Pad calibrated by striking at known positions.
- Least squares curve fit for position and velocity.
- X,Y and V are converted to midi note and controller values.

The position mapping equation.

```
# s[n] = reading for sensor n
# x = x or y return value.
# k[n] | f[n] = adjustable coefficients.
f1=s1
f2=s2*k2
f3=s3*k3
f4=s4*k4
x=(l1*f1+l2*f2+l3*f3+l4*f4)/
(f1+f2+f3+f4)
return x
```

Synth software

- The pad is just an interface.
- Existing synths not suitable.
- I wrote my own in SuperCollider.
- Could have used CSound or PureData.
- Could also use a graphical modular synth like Ingen.
- Learning to write synthdefs.
- 'Synth Secrets' series from 'Sound on sound'.

```
SynthDef.new("MidiDrum", { |vel=100, x=64, y=64,out=0|
    // resonant snare sound
    var sndbuf= Buffer.readChannel(s,
"/home/andy/Desktop/music/supercollider/samples/84001__s
andyrb__KBSD_C42_VELOCITY9.wav", channels:0);
       var rq=10**((16-y) / 41);
    var env,amp;
    var noteMin=30;//54;
    var noteMax=128;//66;
    var note=(x*(noteMax-noteMin)/127)+noteMin;
  //note=(note/12).floor*12;
    vel=vel+((127-note)/40)+((127-y)/50);
       amp=((vel-96)/3).dbamp;
    env=EnvGen.kr(Env.triangle(1,4),1,doneAction:2);

Out.ar(out,amp*env*Pan2.ar(RLPF.ar(PlayBuf.ar(1,sndbuf),
note.floor.midicps, rq  ), 0) );
    } ).store;
```

```
SynthDef.new("MidiDrum", { |vel=100, x=64, y=64,out=0|
    // synth drum with pink noise, comb delay line and low
pass filter.
  var rq=10**((y-40) / 41);
    var env,amp;
    var noteMin=55; // 200Hz
    var noteMax=128;//66;
    var note=(x*(noteMax-noteMin)/127)+noteMin;
  var baseFreq=100;
  amp=16*((vel-96)/3).dbamp;
    env=EnvGen.kr(Env.perc(0.01,0.5,1),1,doneAction:2);

Out.ar(out,amp*env*Pan2.ar(LPF.ar(CombC.ar(PinkNoise.ar(
0.1),1,1/baseFreq,rq),note.midicps), 0) );
    } ).store;
```

```
SynthDef.new("MidiDrum", { |vel=100, x=64, y=64, out=0|
   // bass drum patch with variable square wave / saw wave ratio.
   var baseFreq=50, baseDelayMin=0.1, baseDelayMax=3, baseAmp=1,
attack=0.01;
   var baseFreqMod=1, harmLPFreqMin=baseFreq,
harmLPFreqMax=baseFreq*10;
   var fmBaseFreq=500, fmModSig=250, fmAmp=0.5, fmDelay;
   var amp,ampEnv, baseFreqEnv, harmSig, harmLPFreq, baseDelay, sawRatio,
oscSig;
   baseDelay=0.5; //((y/128)*(baseDelayMax-baseDelayMin))+baseDelayMin;
   fmDelay=baseDelay/5;
   amp=((vel-32)/3).dbamp;
   harmLPFreq=((x/128)*(harmLPFreqMax-harmLPFreqMin))+harmLPFreqMin;

ampEnv=amp*EnvGen.kr(Env.perc(attack,baseDelay,baseAmp),1,doneAction:2)
;
   baseFreqEnv=EnvGen.kr(Env.perc(attack,baseDelay,baseFreqMod,'sine'));
   sawRatio=(y/128);
   oscSig=sawRatio*LFTri.ar(baseFreq+baseFreqEnv)+(1-
sawRatio)*Saw.ar(baseFreq+baseFreqEnv);
   harmSig=LPF.ar(oscSig,harmLPFreq);
   Out.ar(out,Pan2.ar(ampEnv*harmSig,0));
   } ).store;
```

```
SynthDef.new("MidiDrum", { |vel=100, x=64, y=64, out=0|
   // snare drum from synth secrets (based on roland 909).
   // different version with fixed noise delay and low pass filter.
   var part1Freq=180, part1Amp=0.1, part2Freq=330, part2Amp=0.05,
minDistortPow=0, maxDistortPow=3, partDelay=0.7;
   var attack=0.01, noiseLPFreq=10000, noiseHPFreq=2000, noiseAmp1=0.005,
noiseAmp2Ratio=2;
   var noiseDelay=0.4;
   var partSig, partEnv, amp, noiseEnv, noiseSig1, noiseSig2, noiseSig,
outSig,lpFreq;
   var distort;
   distort=10**(((x/128)*(maxDistortPow-minDistortPow))+minDistortPow);
   amp=((vel/4)-28).dbamp;
   partEnv=amp*EnvGen.kr(Env.perc(attack,partDelay,1),1,doneAction:2);
   partSig=part1Amp*atan(SinOsc.ar(part1Freq, 0, distort))
+part2Amp*atan(SinOsc.ar(part2Freq,0,distort));
   noiseSig1=noiseAmp1*LPF.ar(WhiteNoise.ar(1),noiseLPFreq);
   noiseSig2=(amp**0)*HPF.ar(noiseSig1*noiseAmp2Ratio,noiseHPFreq);
   noiseSig=(noiseSig1+noiseSig2);
   noiseEnv=amp*EnvGen.kr(Env.perc(attack,noiseDelay,1),1,doneAction:0);
   lpFreq=((y*3/5)+51).midicps;
   outSig=RLPF.ar(partSig*partEnv+noiseSig*noiseEnv,lpFreq,0.5);
   Out.ar(out,Pan2.ar(outSig,0));
   } ).store;
```

```
SynthDef.new("MidiDrum", { |vel=100, x=64, y=64,out=0|
    // interfering oscillators.
    var env,amp;
    var noteMin=54;
    var noteMax=66;
    var note=(x*(noteMax-noteMin)/128)+noteMin;
    var noteMiny=66;
    var noteMaxy=78;
    var notey=(y*(noteMaxy-noteMiny)/128)+noteMiny;
    amp=((vel-96)/3).dbamp;
    env=EnvGen.kr(Env.perc(0.1,0.5,1),1,doneAction:2);

Out.ar(out,amp*env*Pan2.ar(SinOsc.ar(note.midicps)*SinOsc
.ar(notey.midicps), 0) );
    } ).store;
```

Results

- Physically easy to construct.
- Low cost (approx 50-60 pounds)
- Playability is not bad.
- The accuracy of position mapping is about 15-20%.
- Velocity mapping is ok in practice. Lower cutoff.
- Latency of the firmware is about 1.1ms.
- Have written some playable synths.

Similar Work

- Various people have produced similar instruments.
- Korg Kaoss pad and Kaoscillator.
- Mandala drum from Synaesthesia Corp.
- Randall Jones's MSc thesis.

Future Directions

- Physical design could be improved.
- Might try a different design.
- A graphical interface would be good.
- Morphing presets.
- Synth design.

Conclusions

- The basic concept is sound.
- However this particular design has some weaknesses.
- Not much interest from people building their own.
- I enjoyed making it.
- I intend to develop the idea further.
- Learning to play it.

Acknowledgements

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Thanks also to the Supercollider developers.

For more information and updates see:

http://highfellow.org/synpad