Tone Bending

Bending of pitch, timbre and loudness, that's what we're going to do this time, not just with a pitch bender, but with those handy aids as integrators and differentiators.

Subtle, nuanced pitch bends are extremely important for the expressive character of sounds. You can hear it especially in the wind and string instruments, but also in electric guitars, where the strings are often pulled resulting in pitch bends. Except for some of those electric guitars that also have a special vibrato lever, you will only encounter such a specific pitch bender on synths and keyboards.

Subtle bends on string and wind instruments you get, for example, with the slipping of the place where your string presses the key, or with breath pressure and embouchure. I have often tried to realize these minimal expressive bends with my pitch bend wheel. Difficult because of the click position in the middle of the pitch bender. You first have to overcome pressure and then you shoot too far, but maybe I do not practice enough either.

A musical instrument as a carrier modulator
Further reflecting on all those beautiful subtle bends that you can hear in the sound of many acoustic instruments, I had to think again of the beautifully illuminating view of Stan Tempelaars in the book Elektronische muziek. Globally, Tempelaars distinguishes two types of different modulation: **global modulation** and **fine structure modulation**.

The first are the **notes** you play, the **global modulation**. The second involves all those other (minute) modulations that take place and that you (usually) do not find in the score. This is the so-called **fine structure modulation**.

The source of this is twofold. On the one hand it originates from the instrument itself, that is the characteristic uniqueness of the clarinet, trumpet or violin system. You can hardly do anything about that as a player. This is called the **internal fine structure modulation**.

On the other hand, you also have input on sound forming as a **player**. Everything you can add to shape a sound as a player is known as **external fine structure modulation**.

PID controller
So letting the thoughts run free I had to think of the so-called PID controllers. These are really the control wizards in the (electronic) process control. The abbreviation PID stands consecutively: proportional, integrating and differentiating. Hey, that sounds familiar. Yes, proportional is the original control variable, which can be weakened or amplified, hence

proportional. This same original control is also available in parallel via an integrator and differentiator.
That gave me the idea to see a random sequence of (midi) note numbers as global modulation, no matter where it comes from: whether you play those notes on the keyboard yourself or whether they come from a sequencer.

Is it possible to derive three separate control signals from the note sequence for the three psychoacoustic characteristics, pitch, timbre and loudness? Hell yes.
Load PID Control. You now see that our 'musical' PID controller consists of successively the note input followed by Level Converter with which the input can possibly be inverted. Then the signal goes to both a differentiator (FltHP) and an integrator (Glide).

I installed a rectifier module (Rectifier) behind the output of the differentiator. This can be switched on or off as desired. If this rectifier is switched off, it gives a pulse to the output with each new note, positive or negative. This depends on whether you play a higher or lower note than the previous one. Going up results in a positive output. Down gives a negative result. If you repeat a note, the output will remain zero.

With activated rectifier you can choose whether you get only the positive, the negative, or all positive and negative pulses at the output. Here again: when repeating the same note, the output result is zero. Because the time constant of the high pass filter that functions as differentiator can not be low enough, an amplifier (LevAmp) is placed at the back with which the output signal can be increased.

Finally, the outputs of the integrator and differentiator are added together in a mixer (Mix).

PTL-Control
The sound generation in PTL-Control (Pitch, Timbre, Loudness) consists of only one oscillator (OscShA) and a level modulator (LevMod). The pitch control input of this nanosynth is controlled by such a PID control circuit with original (midi) note sequence, whether or not provided with portamento (glide, integrator) and or differentiator.

The oscillator also has a control input for the waveform. This control input is also equipped with its own PID controller, which then dynamically controls the timbre.
Another such PID system is also available for amplitude control in the LevMod, resulting in dynamic loudness gradations. Copy the patch and tweak it to your heart's content, listen to how you get varied catchy sounds from just a 'strait' series of notes.

NiceNoises
A very different way to achieve bending in the big three: pitch, timbre and loudness is inspired by acoustic systems. These are, by definition, linked

systems, ie the system elements interact with each other. In the virtual world we can mimic these systems through feedback.

NiceNoises consists of two identical ocillators (OscShA1 and OscShA2). These are mixed in a mixer module. The output of this mixer goes to the input of an amplitude de-modulator_(Envelope Follower). Simply stated, the incoming signal is rectified and then guided through an integrator. The output of this integrator is applied as feedback control to the two waveform control inputs of the oscillators.

In addition, the output signal from the integrator goes to the input of a differentiator, in which the speed of the signal variation is converted into a related value. Suppose that both oscillators are not tuned exactly the same, then there are beatings, which also manifest themselves in amplitude fluctuations.

The magnitude of these fluctuations is converted in the envelope follower into a proportional control value for the waveform control. The speed at which the integrator output signal varies is converted to a feedback control value on both the FMLin input of the oscillators.

In this way we have realized a linked system that, depending on the relevant settings, can produce a wide range of sounds, noises and complex audio. What is so striking and nice about such a linked system is that it almost always produces a 'natural' sound output in one way or another.

Although the patch is not that complicated in terms of the number of modules, its operation is. So take the time for experimenting. Start tweaking with just a single parameter. Just listen to the differences you can achieve by simply changing the time constant of the envelope follower (Attack and Release) and the differentiator (FltHP). You can produce the most weird and yet 'natural' sounding noises.

Sounds that resemble what you hear from the circuit bending scene. And that is not so surprising. The circuit bending musicians often use simple electronic instruments, all of which are based on only feed forward coupling.

By deliberately intervening in these feed forward-only systems by, for example, short-circuiting battery voltage and already experimenting random circuit points, or providing resistors and/or capacitors, these instruments are transformed into a coupled system. Well, and there you can enjoy some bends.
Bends in the three sound qualities, bends that are strongly related to each other in a certain way (through system construction). In short, there is a lot of modality in the sounding output.

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PID controller
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