Nonlinear Sequencer 2.0

Cross sequencers

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ABSTRACT

The Nonlinear Sequencer (NLS) is a set of generative rhythm objects that explore ways of breaking away from the linear nature of the sequencer's time function, one that has characterized it from its inception. NLS is an idiosyncratic CAC (computer assisted composition) practice: it focuses on generating not only pattern data but also values that are part of the *process* of pattern generation. The end goal is to be able to map the generative parameters to musical ones to obtain organic results. This approach has produced interesting results consistent with the premises of this research. NLS has been incorporated in the Package Manager of the widely used music programming software Max8 by Cycling74. This paper deals with a new iteration of NLS which adds a new set of objects, *Cross Sequencers*, and expands the accessibility of NLS to VCV Rack users.

1 NLS: CURRENT IMPLEMENTATION

NLS exists as a Max package and as a VCV Rack plugin. It comprises two main processes and a set of ancillary tools. The core processes are:

1. Fluctuating phasor (Max)
2. Cross Sequencer (Max and VCV Rack)

A detailed discussion of the first process is found in my "Nonlinear Sequencer" paper [1]. The present paper deals with the second set of objects, which have been recently added to the package.

The Max8 version of the package includes all existing NLS objects. The VCV Rack plugin includes all Cross Sequencers and ancillary objects related to them. The latter can be downloaded from GitHub.[1]

2 CROSS SEQUENCERS

A Cross Sequencer (XSeq) detects the intersections between two or three LFOs of variable frequency, shape, amplitude, phase and pulse width. The LFO rates are relative to the overall process' frequency.

2.1 XSeq2

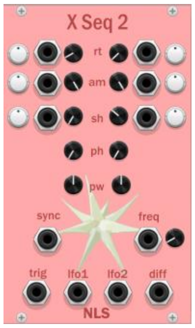

Figure 1: XSeq2 implementation in VCV Rack

XSeq2 generates triggers at the intersection of two LFOs of variable shape, amplitude, rate, phase and duty cycle (rectangular shapes). In XSeq2 only one set of triggers is output as well as the LFO curves and the difference between the curves (which will be 0 when a trigger is generated). It relies on a master frequency (knob and input) of with relative LFOs rates.

2.2 XSeq3

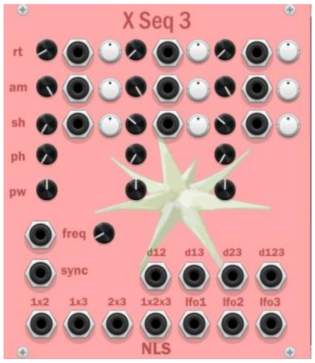

Figure 3: XSeq3 implementation in VCV Rack

XSeq3 is an expanded version of XSeq2 that detects intersections of 3 LFOs producing 4 sets of triggers (1-2, 1-3, 2-3, 1-2-3), 4

[1] To install the plugin, please download the version that corresponds to your OS and place it into the "Plugins" directory located into your Rack user directory.

differences and 3 LFOs. It relies on a master frequency (knob and input) of with relative LFOs rates.

2.3 Ancillary objects

Two main ancillary objects are:

- TrigGate: Turns triggers into gate of variable lengths.
- TrigLogic: parses triggers based on two signals (usually LFOs) letting through triggers according to logic tests on the signals are implemented:

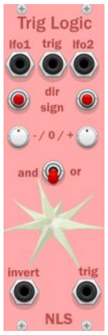

Figure 4: TrigLogic implementation in VCV Rack

3 MAIN PARAMETERS/OUTPUTS

The Cross Sequencer architecture is simple, consisting only of subtraction and edge detection operations. Yet the outputs of these sequences can produce complex patterns, especially when its parameters are modulated in real time.

3.1 Difference

Aside from LFO intersections, these objects output a running difference between the curves. As the difference will always be zero at the intersections, this curve has the interesting property of being "predictive" of the next trigger as it converges to 0 at each trigger.

3.2 Shape

Each LFO shape will produce different intersections and running differences. The shape parameter is continuous, and it interpolates shapes in this order:

sine→triangle→sawtooth→square.

The two latter shapes will produce sharp edges in the difference curve. If one of the two shapes is set to square the resulting triggers will resemble those of a linear sequencer, provided that the rate parameter is not changed.

3.3 Amount

The amounts of the LFOs will change the way the curves intersect. To reiterate, this is another case where a case-by-case heuristic approach, rather than a formalizing one, seems ideal.

Though, one thing can be intuitively grasped: the amplitude of the difference curve will be immediately affected by the amount values to create, for instance, "organic" crescendos/diminuendos.

3.4 Extracted values

The values of each LFO at intersections can be easily extracted at each intersection using sample-and-hold with one of the LFOs (each tuple will report the same value at intersections) and the corresponding trigger as inputs.

3.5 Triple trigger

The XSeq3 features two extra outputs, on top of the ones related to each of the LFO tuples. The difference 1-2-3 which measures the running difference between all three LFOs and the trigger 1-2-3, which is output each time the three LFOs happen to intersect at the same time.[2]

4 MUSICAL MAPPING

NLS in general is designed with a heuristic approach in mind, one that allows for computer musicians to manipulate pattern parameters in real time while being able to map its generative process features in a flexible manner.

4.1 Regularity

The most important predictor of pattern regularity is the ratio between the LFO rates. If the rates are in some form of integer relation, i.e., they have a *lcd* (least common divider), the pattern will be periodic.[3] The shape parameter can also play an important role in the perceived regularity of the pattern in one case in particular: when one or two of the LFO tuple set to square, the trigger output will resemble a traditional grid-based sequencer, provided that the square-LFO rate is fixed. Furthermore, changing the pulse width will provide unevenly spaced, yet regular, triggers (e.g., "swing" feel).

4.2 Variability

Variations in the amount, shape parameters are conducive of pattern variations without changing its ruling tempo. Amount variations will affect both the number of intersections and the corresponding LFO values at each intersection. Similarly with the shape parameter. A general rule for how LFO parameters such as amount, shape, phase, and pulse width will affect the resulting

[2] The intersection detection is implemented differently whether it concerns two or three LFOs. The former is simple a detection of a change in the sign of the difference value; the latter is implemented as a threshold value under which the difference of LFO 1, 2 and 3 will generate a trigger. The former detection does not produce false positives while the latter can, depending on the fudge threshold value. Future upgrades will deal with this problem, possibly adding a "tolerance" value to the UI.

[3] A further discussion of pattern periodicity goes beyond the scope of this paper. See, for instance, [2].

pattern does not exist but graduality and pattern morphing is possible, blurring the threshold between one version of the pattern and another one. This is one feature that distinguishes NLS from traditional sequencers where the pattern variations and transitions must be set and determined through case-specific procedures, cross sequencers are ideal to streamline the process of pattern morphing and variations.

4.3 Value mapping

At each trigger the LFO tuple can produce a single varying value[4]. While the specific pattern of values is not necessarily predictable it will be connected to the generation process and will change consistently with the variation in the process parameters. Furthermore, these values can be relied upon to produce a deterministic kind of variability, one which will always be consistent with the generation parameters, i.e., no stochastic steps will undermine its consistency. Possible mappings for these values are pitch, panning, amplitude. Whether these mappings will produce an organic perception of rhythm and pitch is hard to assess objectively. Sampling the difference curve at triggers on the other hand is not conducive of any pattern as the outputs will always be zero.

4.4 Predictive mapping

Cross sequencers output a running difference between LFOs. As already mentioned, this curve will be predictive of the next trigger as it approaches zero. So, while the pattern itself might be perceived as irregular and varying over time, the difference curve provides representation of the process that can be define as pseudo-gestural, i.e., describing the trajectory that generates the pattern over time.

Early experiments of this kind of mapping to different timbral parameters have produced an "organic" or even expressive perceptual quality.

4.5 Nested-ness

Another interesting feature of the Cross Sequencer is the ability of producing *different levels* of patterns. XSeq3 produces a combined 1-2-3 trigger which is only output when all three LFOs converge at the same time,[5] as well as a running 1-2-3 difference. The former marks the ending/beginning of a larger pattern cycle of which each of the three LFO pairings constitute a smaller subset.

The latter provides a curve that converges to zero as the "triple trigger" approaches. The triple trigger is useful to detect the beginnings and endings of larger scale patterns and can be mapped to parameters related to musical form, e.g., changes in harmony/pitch collections, while being strictly interrelated to the "local" musical generation process.

5 SUBMITTED PATCH

The submitted VCV Patch is available here. The video description is available here. The patch is a proof of concept. The output is illustrative of the capabilities of cross-sequencers in producing morphing patterns. Also, of the ability of creating different levels of musical form (foreground and background so to speak) by daisy-chaining several cross-sequencers.

6 CONCLUSIONS

Much like in the case of the behavior of simple programs such as Cellular Automata as observed by Stephen Wolfram [3], NLS is aimed at exploring the complexity and generative qualities of simple time-based processes generated by simple rules. In the first iteration of NLS, the Fluctuating Phasor, the frequency of sequencer ramp (triggering equally spaced events) had a variable, "fluctuating" nature. Implementing that kind of process, we have demonstrated [6] how the time difference value between the fluctuating-sequencer event and its regular correspondent event possessed expressive qualities. This new iteration of NLS implements the Cross Sequencer process. This process can produce a higher degree of variations in the pattern as it is not constrained to the paradigm:

sequencer ramp → evenly spaced triggers

Furthermore, its behavior is more unpredictable[7]. Yet there are compensating factors that make this process still very capable of being harnessed by the computer musician.

- The pattern "pulse" can be inferred by the arithmetical relations between the rates of the LFOs.
- The difference outputs are "predictive" of the forthcoming triggers as their value converges to zero as the trigger approaches.
- The process is deterministic: given certain parameters the output will not vary, i.e., no stochastic steps are included.

REFERENCES

[1] Michele Zaccagnini, 2020. Nonlinear Sequencer. *Proceedings of Seamus Conference 2020*

[2] Edward W. Large. Periodicity, Pattern Formation, and Metric Structure. *Journal of New Music Research July 3, 2001*

[3] Stephen Wolfram. *A New Kind of Science*. Wolfram Media, Champaign IL, 2002

[4] Since the LFO are intersecting they will have the same value

[5] This trigger will only be produced if the rates of the three LFOs are related to one another, i.e., there exists a least common divider for all three of them.

[6] See Nonlinear Sequencer package in Max8. In particular the "Expressive Rhythmic Mapping" patch in the Example Navigator tab.

[7] The exception being the use of a square wave in one of the LFOs which will re-create the idea of the sequencer's grid.