Algorithmic Rhythms
From Juggling Patterns to Sound Sequences

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THE IDEA

"algojuggledrum", a new algorithm for translating juggling patterns into musical loops which can be played back at a given tempo.

These **juggling patterns** are based on a notation for juggling sequences known as **siteswaps**, which was developed around 1985. The idea behind it is to keep track of the order that balls are thrown and caught.

- The balls are thrown at a constant beat, i.e., at equidistant points in time.
- At every beat, at most one ball gets caught, and that same ball immediately gets thrown again.
- When thrown, each ball stays in the air for a prescribed number of beats.
- Patterns are periodic, i.e., they repeat indefinitely.

Just like juggling as a visual art, rhythm in music also emerges from a measured succession of sounds in time, characterized by repeating patterns.

How can these visual juggling patterns be translated into auditory perception?

BACKROUND

Modern grooveboxes let you program beats by employing a combination of MIDI sequencing and sampling techniques.

An alternative, lesser-known approach has been the **algorithmic generation of rhythms**, most notably in Clarence Barlow's rhythmic "indispensabilities" (musiquantics) and Godfried T. Toussaint's "Euclidean rhythms" (toussaint2019). Also worth mentioning here is the (mostly British) art of "change ringing" which can be described with group-theoretical concepts (harkleroad2006).

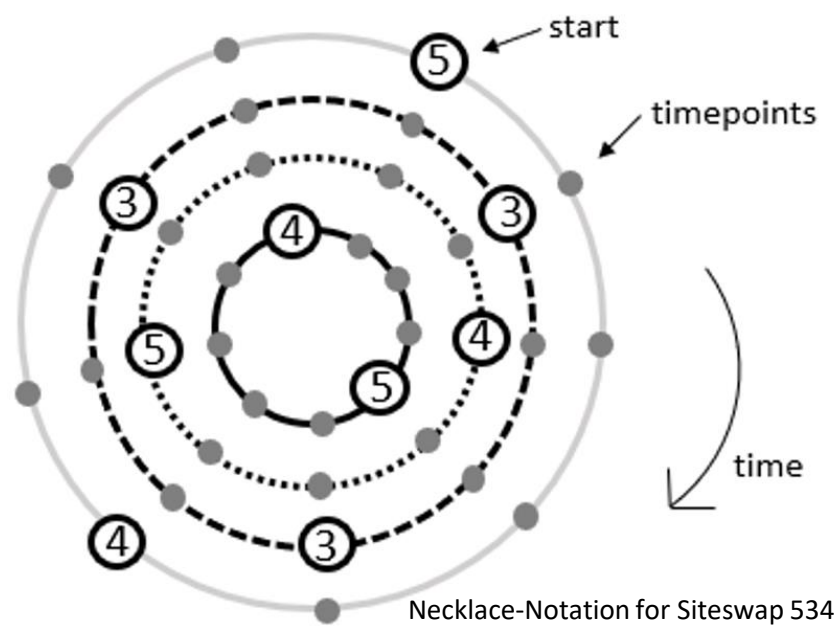
In contrast to grooveboxes, which are programmed like MIDI sequencers, these algorithmic approaches are **based on mathematical models** which allows rhythmic sequences to be generated in a more or less **automatic fashion**.

This is also the approach taken in this thesis. The novel aspect of the method presented here is that we employ so-called "siteswap" patterns.

MAPPING JUGGLING PATTERNS TO RHYTHMIC SEQUENCES

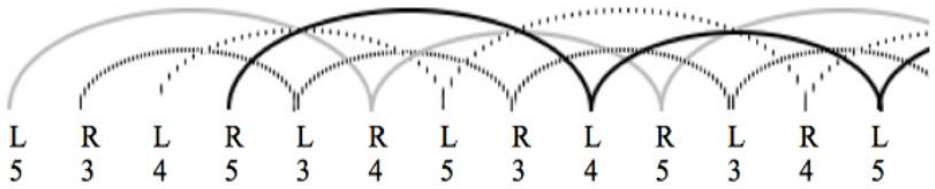
Imagine that we can map
- **each ball** to a **MIDI note number** and
- **each throw height** to a **velocity**,

giving us a single MIDI note to play for each beat. This data can then be fed into some kind of synthesizer or sampler device to hear the sequence.

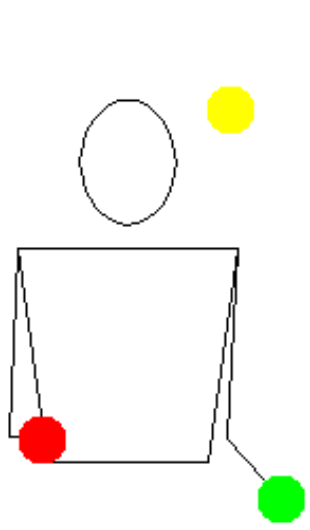


Necklace-Notation for Siteswap 534

Example Siteswap: 534



Space-Time-Diagramm for Siteswap 534



534-GIF

Breakdown of the Throws:
- **5** = a **high throw** (takes 5 beats to come down)
- **3** = a **medium throw**, like in the basic cascade (3 beats)
- **4** = a **slightly higher throw**, to the **same hand** (even numbers stay in the same hand; 4 beats)

Pattern Features:
- **Four balls are used** (= average throw: sum of throws divided by length of sequence -> (5+3+4)/3 = 4)

A cyclically repeating rhythm can be understood in terms of geometric or linear distances and is therefore represented using a **'necklace' notation**.
- Each ring (time-cycle of one ball) runs throw the rhythmic sequence of 9 beats or timepoints
- A big dot (throw of one ball) is an onset or attack of a sound
- Each number (throw height) is the relative 'weight' of this attack