Automatic Tuning of the OP-1 Synthesizer Using a Multi-objective Genetic Algorithm

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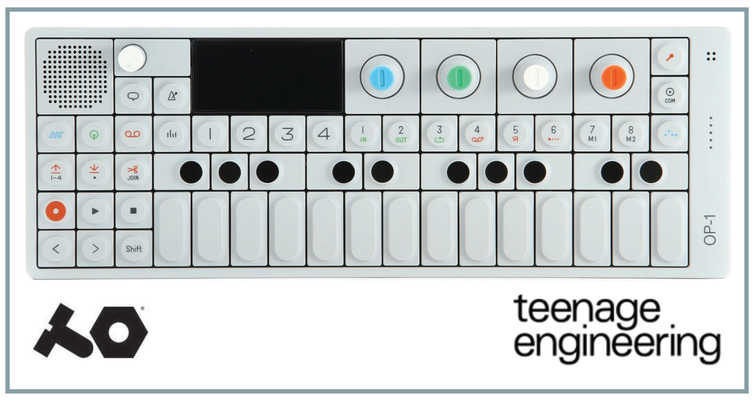
Introduction

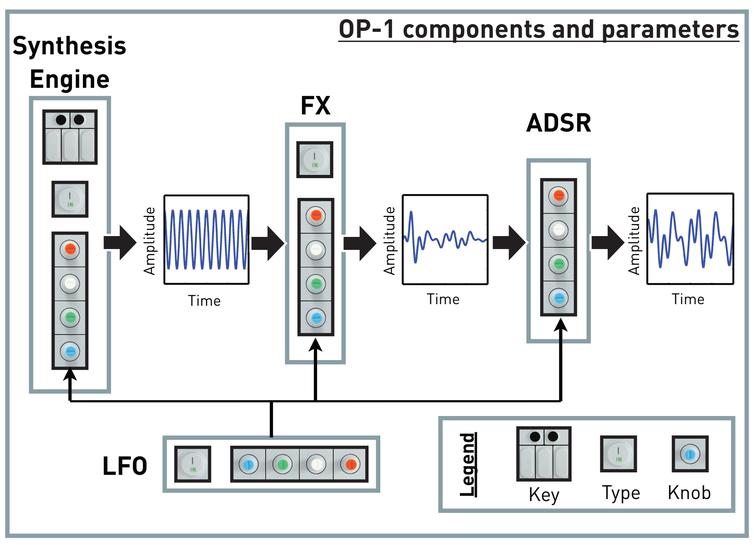
Efficient control and exploration of a synthesizer's sound space requires theoretical and/or empirical knowledge of the related synthesis technique. For a modern synthesizer, exploring large parameter spaces can become a tedious and time-consuming activity.

OP-1 Synthesizer

In this research, we use the OP-1, the all-in-one portable synthesizer, sampler and controller developed by Teenage Engineering (TE):



TE provided us with a library that embeds most of the functionalities of the OP-1. It includes several synthesis engines, FXs and LFOs:



OP-1 component types

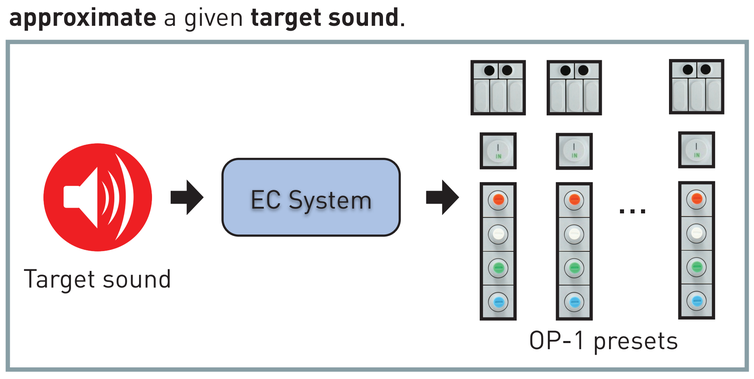
Engine types	
FM	Phase
String	Cluster
Digital	Pulse
DrWave	

FX types	
Delay	Spring
Grid	Punch
Inactive	

LFO types	
Tremolo	Element
Value	Inactive

Goal

In this research, we explore how **Evolutionary Computing** (EC) can be used to identify **multiple OP-1 presets** to **replicate or approximate** a given **target sound**.



Challenges

Searching the OP-1 parameter space to approximate a given target sound has all the characteristics of a real-world problem:

- Large search space **complexity** (10^{76} possible distinct OP-1 presets),
- **Discontinuous** search space (ex: when switching from one synthesis engine to another),
- **Not fully deterministic** output.

A multi-objective approach

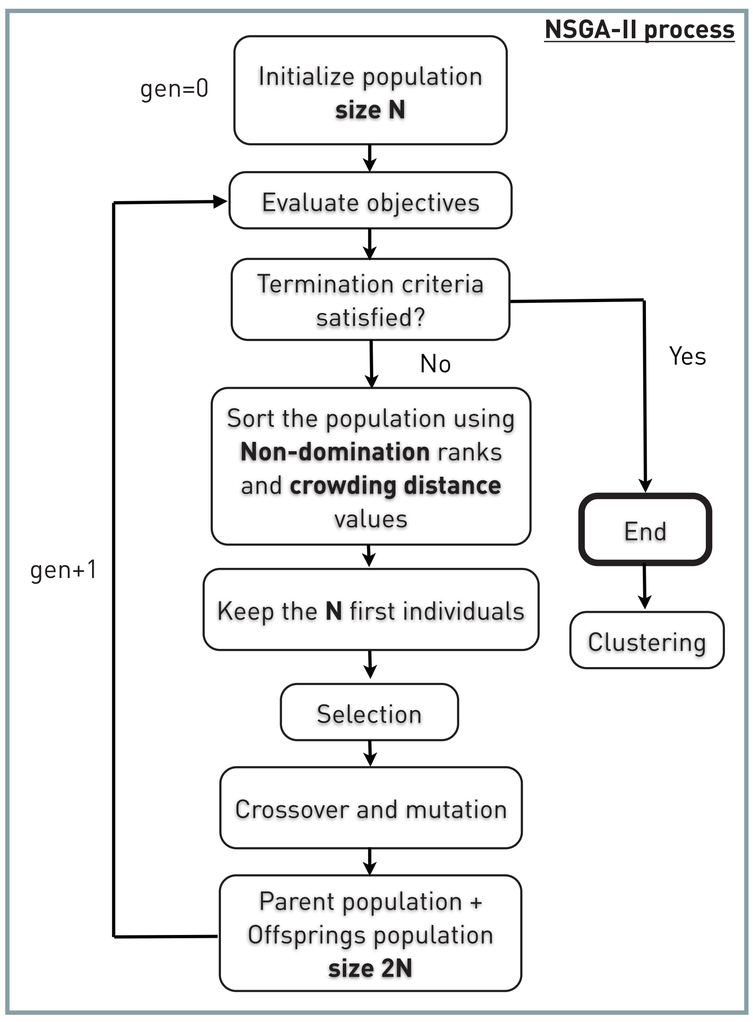
We consider **3 objective functions** to minimize in parallel. These functions are the **Euclidian distances** between the target sound and the candidate sound for the 3 following features:

- The **Fast Fourier Transform** (FFT) on the entire sound,
- The **amplitude envelope**,
- The **Short-Time Fourier Transform** (STFT).

NSGA-II

The **Non-dominated Sorting Genetic Algorithm-II** (NSGA-II) is a common technique to solve multi-objective optimization problems. The principal characteristics of this algorithm are the following:

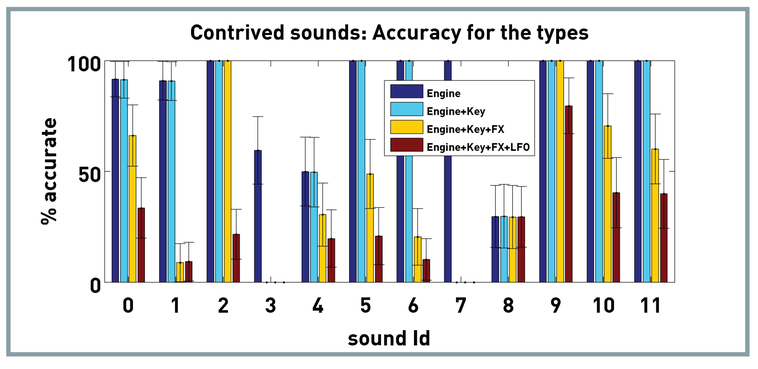
- **Elitism**
- **Non-dominated sorting**
- **Diversity preservation**



When the returned **set** of OP-1 presets is **too large** to be easily handled by an user, we implement a **k-mean clustering** method and return the **OP-1 preset** the closest to the **centroid** for each cluster.

Evaluation - Contrived sounds

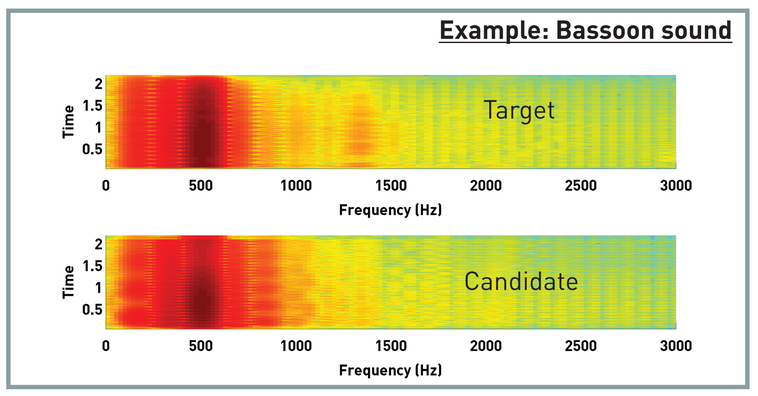
This evaluation used **OP-1 generated sounds** as target sounds for our system. This way, the **target preset is known** and we ensure that **a solution exists**.



- For most of the sounds, our system is able to successfully identify the right engine and the right key (> 90% accurate).
- The accuracy drops with the FX and LFO.
- The results are variable given the nature of the target sound (engine, FX and LFO used).

Evaluation- Non-Contrived sounds

The second evaluation used **recorded sounds** or **synthesized sounds** generated by a synthesizer other than the OP-1.



- Candidate sounds **perceptually** similar to the targets.
- **Spectra and envelopes** similar to the targets.
- Performance dissimilarities given the nature of the target.

Conclusions

- A **Non-dominated Sorting Genetic Algorithm-II** (NSGA-II) is presented that enables the user to receive **a set of solutions** rather than a unique solution as with previous systems.
- A **3 objective fitness function** including **FFT, Envelope and STFT** is developed which addresses some of the difficulties associated with the exploration of a **multi-modal search space** such as the OP-1 parameters space.
- A **k-mean clustering** method has been developed to better analyze and explore the set of final solutions.
- An **evaluation** is proposed using **contrived** and **non-contrived** sounds. The experiments revealed the **capabilities of our system** to optimize the parameters of the OP-1 synthesizer to approximate both kinds of target sounds.

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