MaxPy: An open-source Python package for programmatic construction and manipulation of MaxMSP patches

Ranger Liu
Parsons School of Design
66 5th Avenue
New York, NY 10011
rangerliu@newschool.edu

Satchel Peterson
Columbia University
70 Morningside Drive
New York, NY 10027
sp3914@columbia.edu

Richard Lee
Columbia University
2960 Broadway
New York, NY 10027
rtl2118@columbia.edu

Mark Santolucito
Barnard College
3009 Broadway
New York, NY 10027
msantolu@barnard.edu

ABSTRACT

MaxMSP is a visual programming language for creating interactive audiovisual media that has found great success as a flexible and accessible option for computer music. However, the visual interface requires manual object placement and connection, which can be inefficient. Automated patch editing is possible either by visual programming with the [thispatcher] object or text-based programming with the [js] object. However, these objects cannot automatically create and save new patches, and they operate at *run-time* only, requiring live input to trigger patch construction. There is no solution for automated creation of multiple patches at *compile-time*, such that the constructed patches do not contain their own constructors. To this end, we present MaxPy, an open-source Python package for programmatic construction and manipulation of MaxMSP patches. MaxPy replaces the manual actions of placing objects, connecting patchcords, and saving patch files with text-based Python functions, thus enabling dynamic, procedural, high-volume patch generation at *compile-time*. MaxPy also includes the ability to import existing patches, allowing users to move freely between text-based Python programming and visual programming with the Max GUI. MaxPy enables composers, programmers, and creators to explore expanded possibilities for complex, dynamic, and algorithmic patch construction through text-based Python programming of MaxMSP.

Author Keywords

MaxMSP, visual languages, automation, generation, metaprogramming

CCS Concepts

•**Applied computing** → **Sound and music computing;**

Licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0). Copyright remains with the author(s).

NIME'23, 31 May–2 June, 2023, Mexico City, Mexico.

1. INTRODUCTION

Programming languages have long held foundational importance in sound synthesis and audio processing, driving the frontier of computer music. Both text-based languages like CSound [2] and SuperCollider [7] as well as visual programming languages like PureData [8] and MaxMSP [1] have given computer musicians many options for writing code. In particular, visual languages have allowed non-programmers to create complex computational artifacts with relative ease due to their accessible and intuitive interfaces.

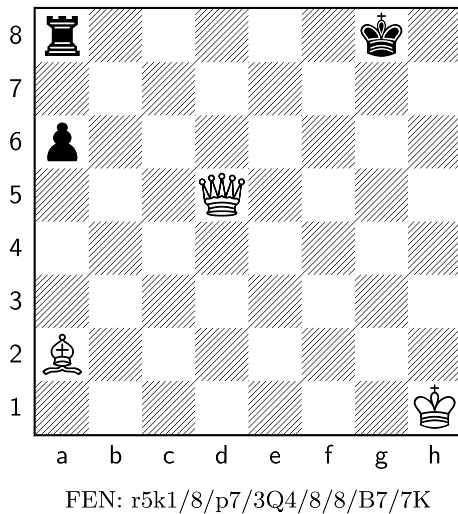
However, the main drawback of visual languages is the amount of manual interaction required to create a program. In MaxMSP, objects and patchcords must be manually placed and connected, which becomes inefficient for large or complex patches. These manual actions can be automated with the [thispatcher] object, which takes message inputs to create, destroy, connect, or disconnect objects within the current patch. The [js] object also provides text-based programming control over [thispatcher] functionality.

These automations can be considered a limited form of *metaprogramming*, which refers to languages that enable the programmatic manipulation of other programs. In this case, Javascript is used to manipulate MaxMSP code, or MaxMSP code itself is used to manipulate MaxMSP code. However, neither [js] nor [thispatcher] can be used to create or save new patches, and neither allows for *compile-time* behavior that would enable patch construction to occur outside of MaxMSP.

In this paper, we introduce MaxPy, an open-source tool for true metaprogramming of MaxMSP using Python, enabling compile-time creation, editing, and saving of Max patches. Metaprogramming has found enormous success in traditional programming contexts, including C++11's constexpr [5], Template Haskell [9], and Scala macros [3]. Following the success of metaprogramming in other domains [6], we believe that MaxPy will empower new modes of interaction with visual programming languages for human-centered audio programming and computer-aided composition.

2. MOTIVATING EXAMPLE

We first consider a motivating example of generating patches from chess data. Given the Forsyth-Edwards Notation (FEN) for a particular board configuration, we want to 1) place an abstraction for each piece in play, 2) input their color and position coordinates as messages, and 3) connect their outputs to an [~ezdac] (Fig. 1).



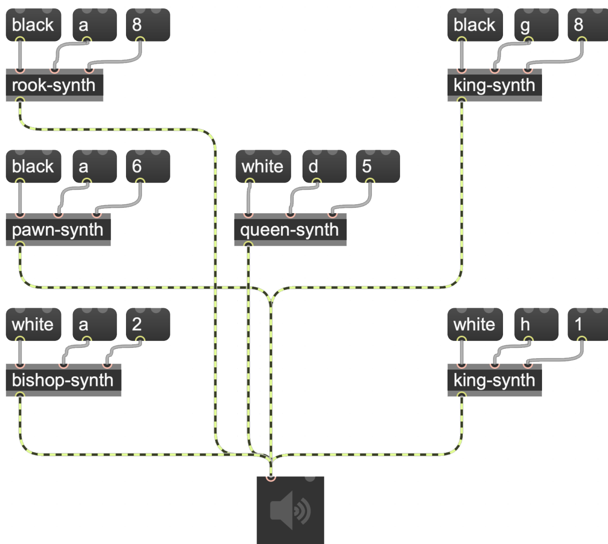


Figure 1: Example of chess-to-maxpatch generation.

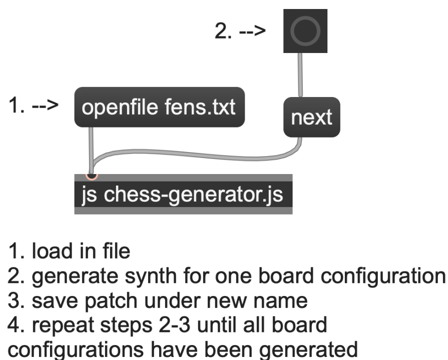


Figure 2: Single-patch generation from chess data using [js]. This patch must be manually saved after each iteration.

Manually creating the patch shown in Fig. 1 is not difficult. However, generating new patches based on different configurations becomes challenging, as MaxMSP lacks automated control over creating and saving patch files. Parsing FEN strings, placing objects, and connecting patchcords can all be automated with [thispatcher] or [js], but saving each generated patch as a separate file requires manual input (Fig. 2). This tedious process scales poorly at high volumes: imagine generating a different patch for every state of every game in the Games of the Day Archive [4] from the past year. Without metaprogramming, such a task would be insurmountable. MaxPy thus offers an efficient solution for automated patch generation, especially at high volumes[1].

3. MAXPY USAGE

This section gives a basic, non-comprehensive overview of MaxPy usage. Most recent code and documentation can be found at `https://github.com/Barnard-PL-Labs/MaxPy`.

3.1 Creating An Empty Patch

To use MaxPy, we first import the library and instantiate a `MaxPatch`.

```
import maxpy as mp

patch = mp.MaxPatch()
```

When given no arguments, the default `MaxPatch` constructor creates an empty patch.

3.2 Creating and Placing Objects

We can use `MaxPatch.place()` to create and place multiple objects at once:

```
counter, button = patch.place(["counter",
    "button"])
```

Alternatively, we can first create a “floating” `MaxObject` and then place it in the `MaxPatch`:

```
counter_obj = mp.MaxObject("counter")
button_obj = mp.MaxObject("button")
patch.place([counter_obj, button_obj])
```

MaxPy currently supports all max/msp/jit objects from a vanilla MaxMSP installation. External MaxMSP package support is discussed in Sec. 5.

3.3 Object Arguments and Attributes

Arguments and attributes are specified in the object creation string:

```
patch.place(["counter 4 @carryflag 1"])

#or...
counter_obj = mp.MaxObject("counter 4
    @carryflag 1")
patch.place([counter_obj])
```

Common box attributes are specified during object creation:

```
counter_obj = mp.MaxObject("counter",
    ignoreclick=1)
```

[1] Code for the [js] and MaxPy implementations can be found at `https://github.com/Barnard-PL-Labs/MaxPy/tree/main/examples/chess-paper-example`.

3.4 Connecting Patchcords

Each `MaxObject` contains `MaxObject.ins`, a list of `Inlets`, and `MaxObject.outs`, a list of `Outlets`, both numbered left-to-right starting from 0. We connect patchcords by specifying (`Outlet`, `Inlet`) pairs:

```
outlet = button_obj.outs[0]
inlet = counter_obj.ins[0]
patch.connect( (outlet, inlet) )
```

3.5 Saving Patches

Patches can be saved to the `.maxpat` format by specifying a file name:

```
patch.save("my.maxpat")
```

3.6 Loading Existing Files

Instead of instantiating an empty patch, MaxPy can also load in an existing .maxpat file:

```
patch = mp.MaxPatch(load_file="my.maxpat")

```

This loaded patch can be manipulated like any MaxPy-generated patch, allowing users to easily switch between the Max GUI and MaxPy.

3.7 Abstractions and .js Files

MaxPy will locate and link abstraction files and .js files as long as they are saved in the current directory.

```
abstraction = mp.MaxObject("my-abs")
linked_js = mp.MaxObject("js script.js")
```

4. CASE STUDIES

4.1 Quantum Audiovisualizer

This data sonification project shows MaxPy's ability to dynamically generate patches based on data processed with external Python libraries[2].

Given a number of quantum circuit components, MaxPy creates one oscillator per component (Fig. 3). These oscillators are symmetrically detuned and panned, with exact amounts depending on the total number of components (Fig. 4). MaxPy saves these custom oscillator blocks as individual patch files and places them inside the main synth patch as abstractions.

The quantum circuit is then simulated and the results are used to generate a sequence of notes for five synth voices. MaxPy is used to create and place a sequencer for each synth voice (Fig. 5). Python then uses OSC messages to trigger each sequencer.

In creating the synth and sequencers, MaxPy leverages Python's data-processing capabilities to calculate detune and pan amounts, convert quantum data into a sequence of notes, and parse the sequence into separate voice tracks. The entire project hinges on MaxPy's ability to easily integrate with Python's `qiskit` package, which enables quantum data to be used directly. As exemplified in this project, MaxPy's access to Pythonic data processing creates enormous potential for data-driven sonification and visualization.

[2]Code for this project can be found at `https://github.com/ryurongliu/quantum-audiovisualizer/blob/main/quantfinal.py`.

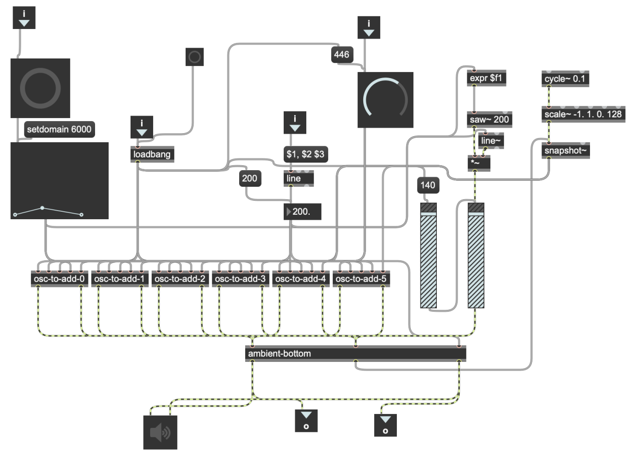


Figure 3: MaxPy-generated additive synth with a variable number of added oscillators.

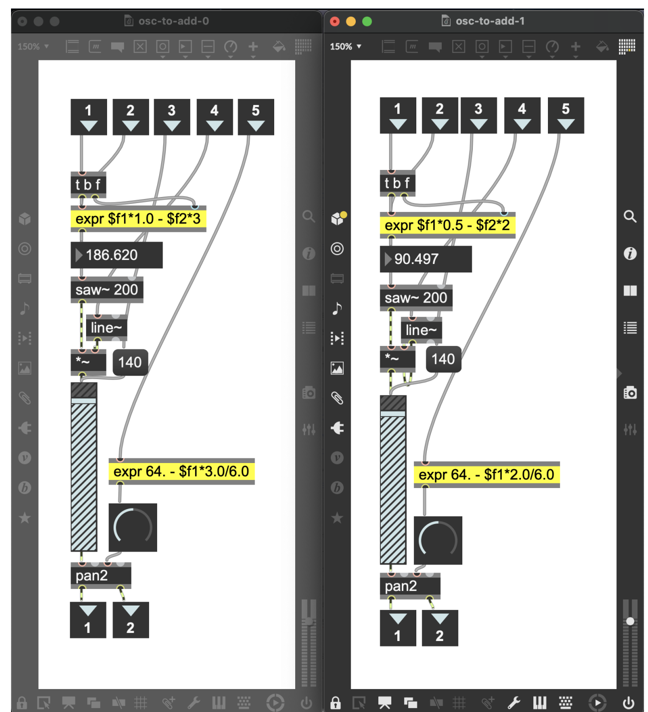


Figure 4: A comparison of two MaxPy-generated oscillators for the additive synth. The highlighted [expr] objects are uniquely calculated for each oscillator.

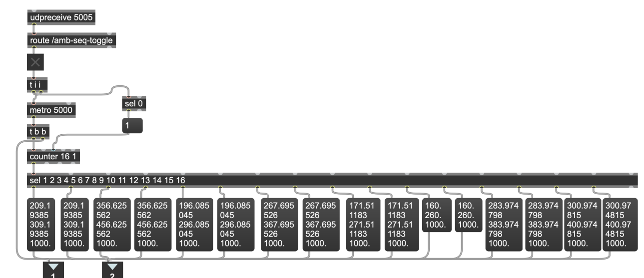


Figure 5: A MaxPy-generated sequencer with hardcoded frequency and duration amounts.