Induction and Recapitulation of Deep Musical Structure

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Overview

- Constructing artists
- Factoring out critical criteria/cultures
- Genetic programming
- Genetic programming of a bebop musician
- Audio examples
- Automatic generation of critics
- Neural network critics
- Hybrid critics
- The future

Constructing Artists

Uses of AI technology in the arts

- art understanding systems
- intelligent tools for human artists
- constructed artists

Constructed artists create artworks on their own, with minimal human intervention.

Aesthetic Judgements

Conflicting philosophical theories abound

We can't wait for the resolution of these debates

We desire quantitative assessment of *system* quality

Separate aesthetic judgement from system judgement
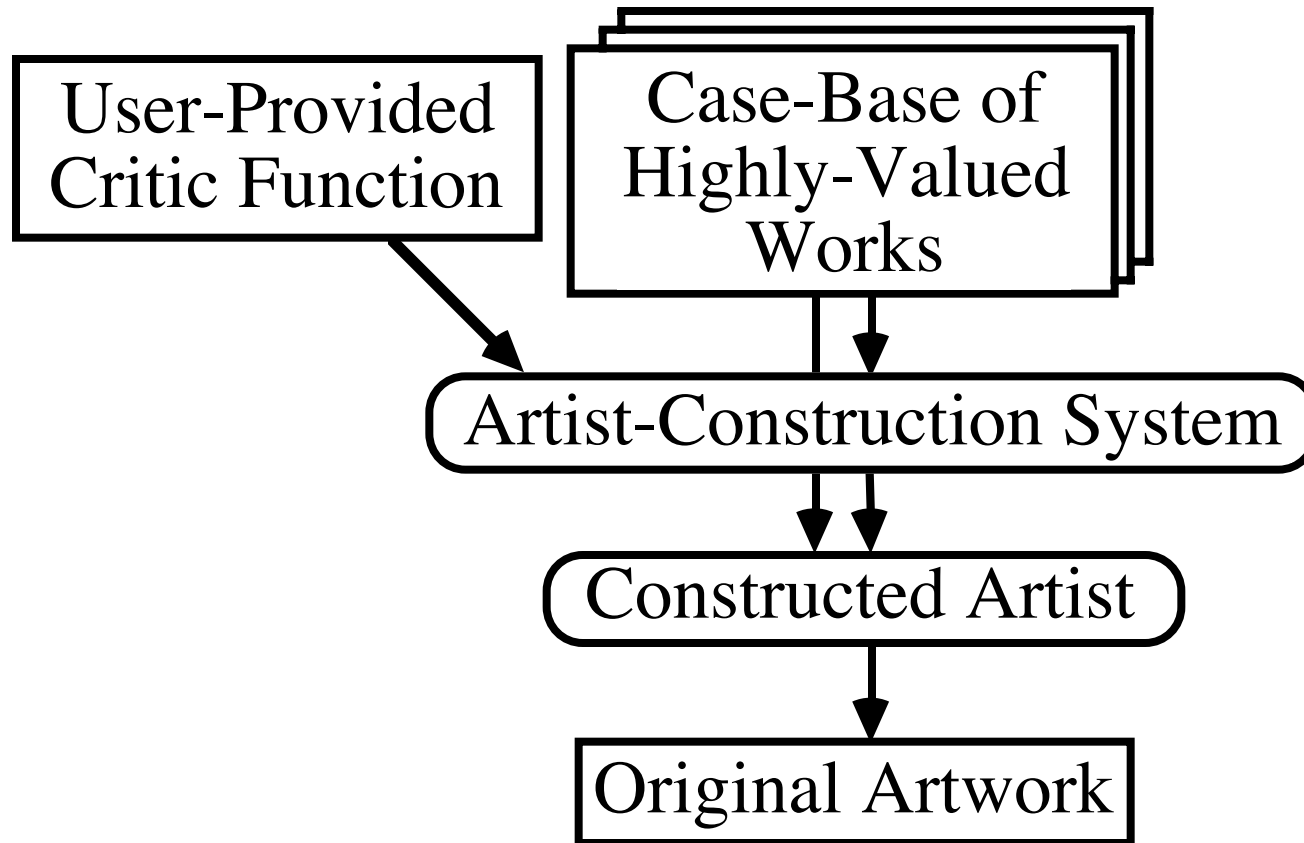
Critics as parameters

An Artist's Culture
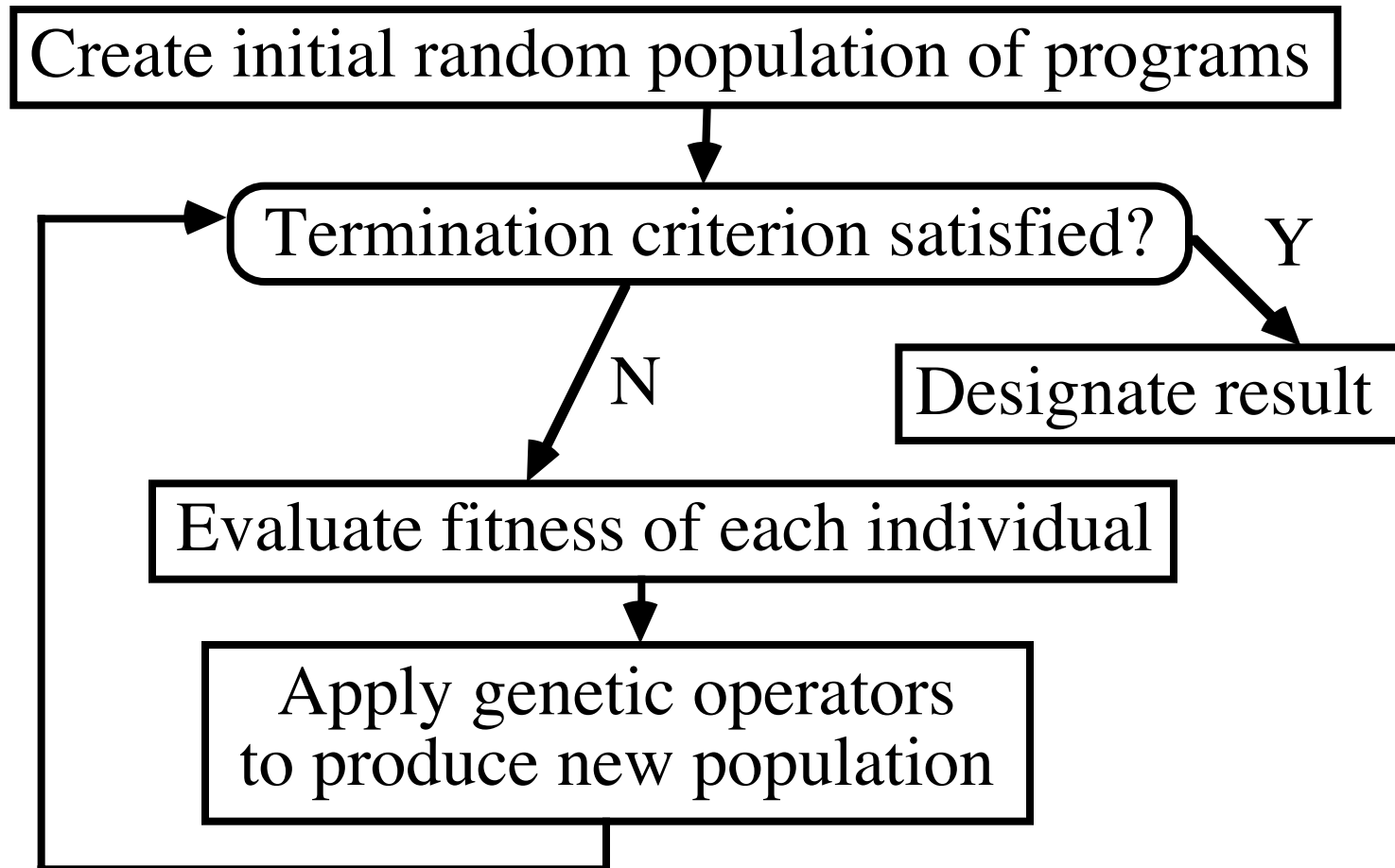
Art production relies on cultural context

Art assessment relies on cultural context
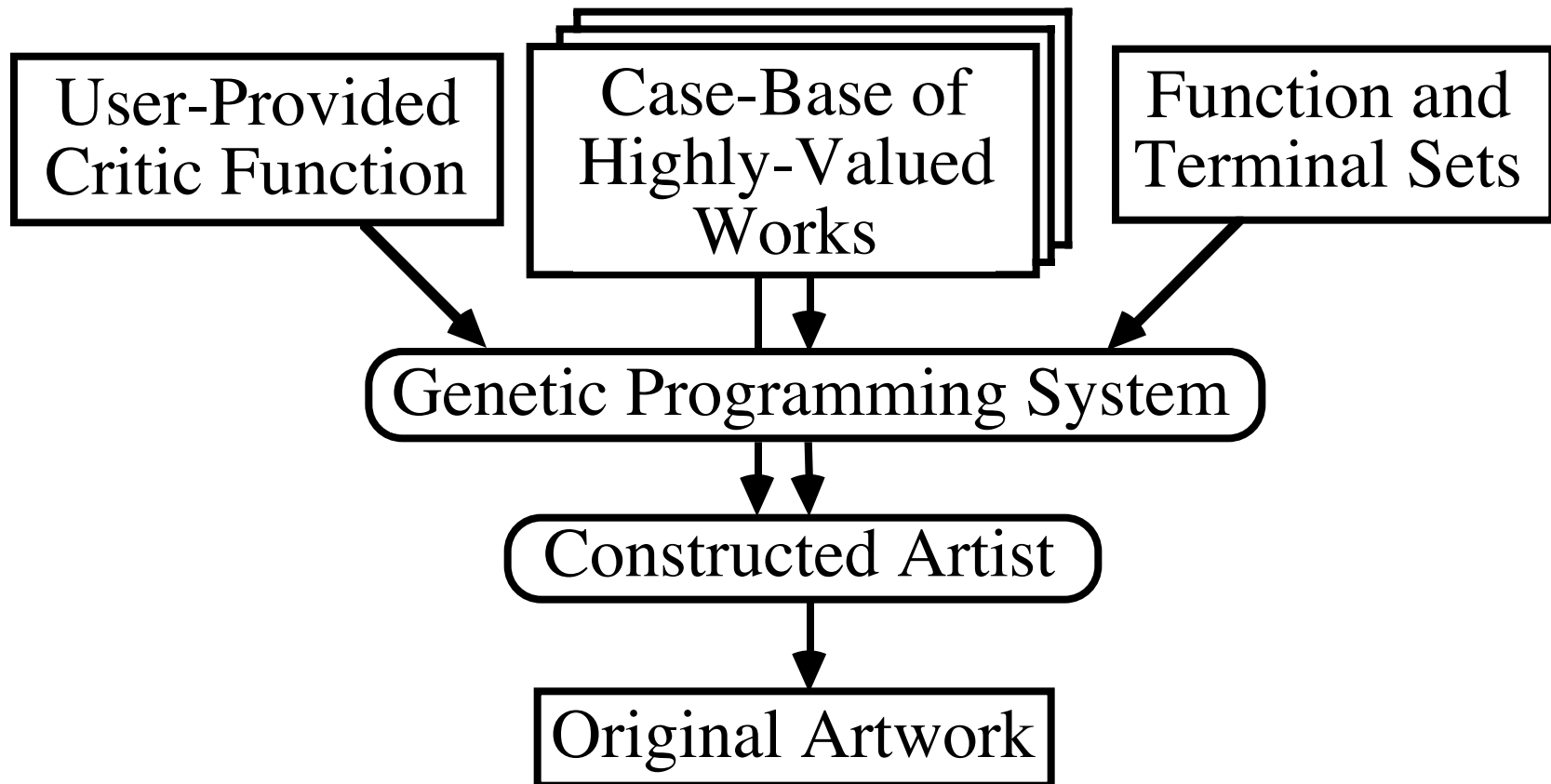
Cultures as parameters
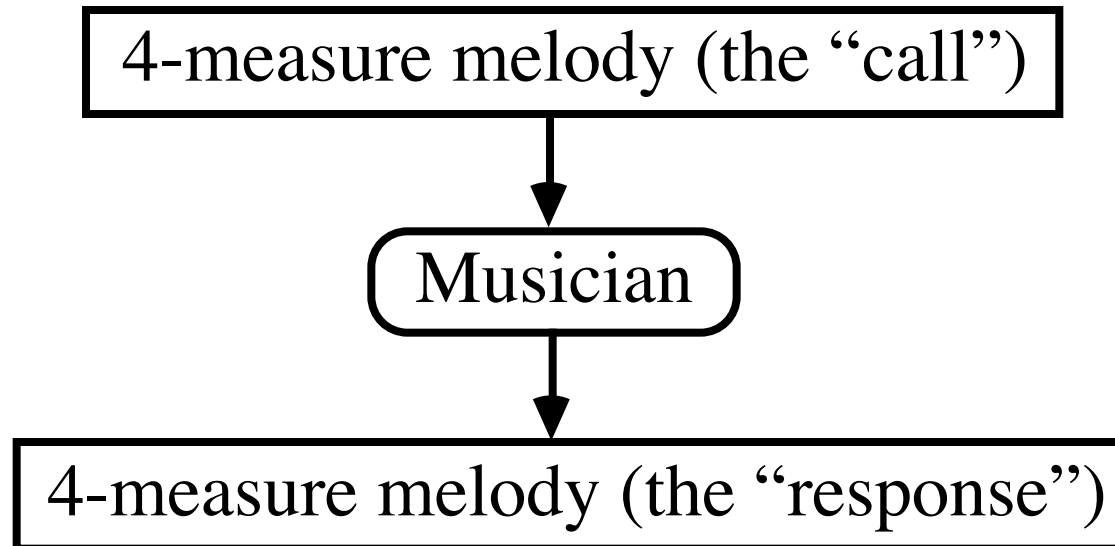
"Factoring Out" Critical Criteria and Culture

```
┌──────────────────┐   ┌──────────────────┐
│  User-Provided   │   │  Case-Base of    │
│  Critic Function │   │  Highly-Valued   │
│                  │   │     Works        │
└──────────────────┘   └──────────────────┘
           │                  │    │
           └──────────┐       │    │
                      ▼       ▼    ▼
        ╭──────────────────────────────╮
        │  Artist-Construction System  │
        ╰──────────────────────────────╯
                      │    │
                      ▼    ▼
            ╭──────────────────────╮
            │   Constructed Artist │
            ╰──────────────────────╯
                      │
                      ▼
            ┌──────────────────────┐
            │   Original Artwork   │
            └──────────────────────┘
```

Genetic Programming (Koza 1992)

Create initial random population of programs

Termination criterion satisfied? — Y → Designate result

N

Evaluate fitness of each individual

Apply genetic operators
to produce new population

Genetic Programming
of Constructed Artists

User-Provided Critic Function	Case-Base of Highly-Valued Works	Function and Terminal Sets

Genetic Programming System

Constructed Artist

Original Artwork

Trading Four

The Bebop Melody Critic

Critical criteria derived from (Baker 1988):

- Tonal novelty balance
- Rhythmic novelty balance
- Tonal response balance
- Skip balance
- Rhythmic coherence

Trade-4 Function and Terminal Sets

Functions derived from (Baker 1988): Rep, 8va, Iva, Extend, Trunc, Diminute, Augment, Fragment, Invert, Retrograde, Most-Familiar, Compare-Transpose, Rotate

Each function takes one or more melodies and produces a result melody.

Some functions access the case base.

Call-Melody is the only terminal.

Other GP parameters

Maximum number of Generations: 21
Size of Population: 250
Maximum depth of new individuals: 6
Maximum depth of new subtrees for mutants: 4
Maximum depth of individuals after crossover: 17
Fitness-proportionate reproduction fraction: 0.1
Crossover at any point fraction: 0.2
Crossover at function points fraction: 0.7
Number of fitness cases: 5
Selection method: FITNESS-PROPORTIONATE
Generation method: RAMPED-HALF-AND-HALF
Randomizer seed: 1.0

Genetic Programming
of a Bebop musician

Bebop Melody Critic Function	Case-Base of Charlie Parker Melodies	Trade-4 Function and Terminal Sets

Genetic Programming System

Constructed Trade-4 Musician

Call

Response
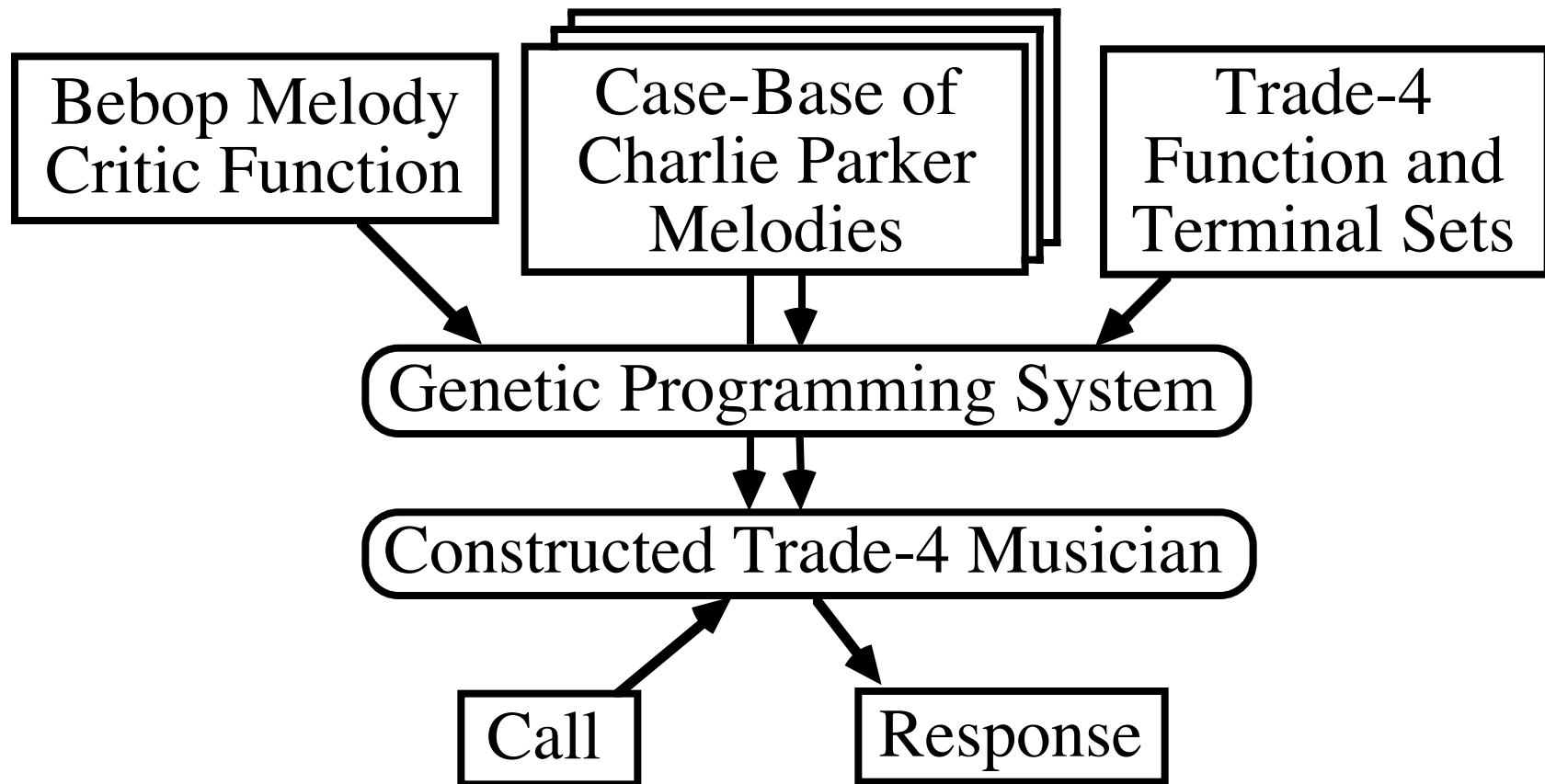
Best Program from Generation 0

```
(FRAGMENT
    (AUGMENT CALL-MELODY)
    CALL-MELODY)
```

Fitness Graph
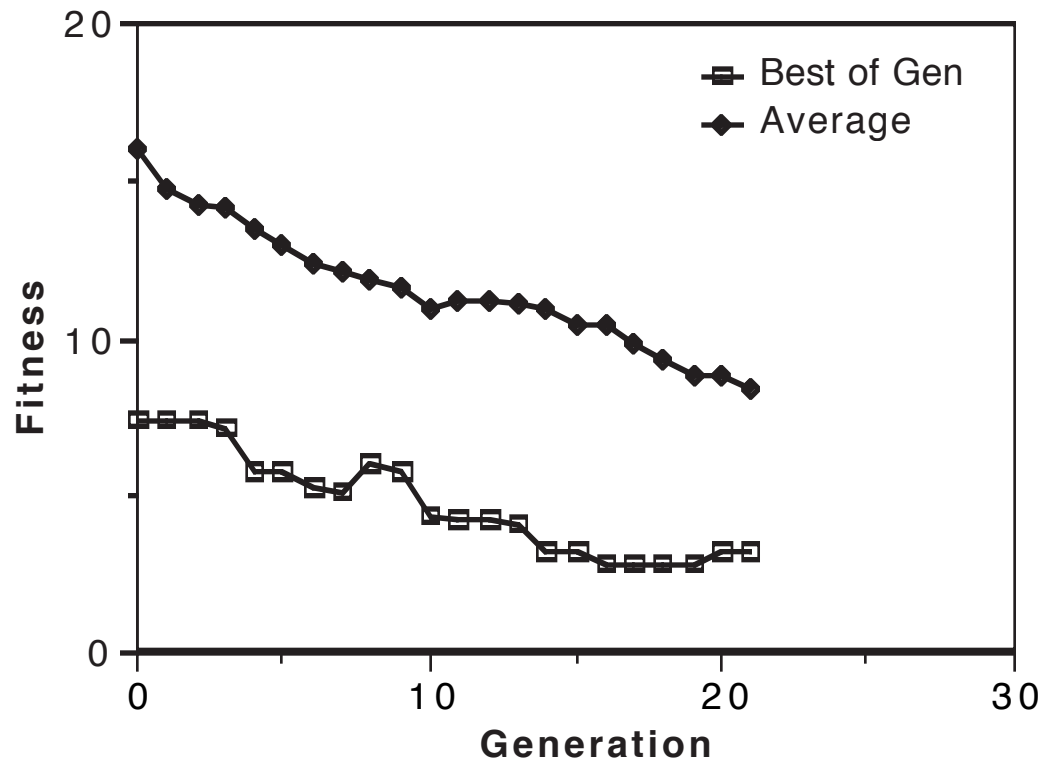
Best-of-Run Program

```
(FRAGMENT
  (COMPARE-TRANSPOSE (8VA (COMPARE-TRANSPOSE
    (FRAGMENT
      (IVA (DIMINUTE (EXTEND CALL-MELODY)))
      (FRAGMENT
        (EXTEND CALL-MELODY)
        (AUGMENT (RETROGRADE (RETROGRADE
          (ROTATE
            (FRAGMENT CALL-MELODY
                      CALL-MELODY))))))))))
  (MOST-FAMILIAR  (INVERT CALL-MELODY)
                  (IVA CALL-MELODY)))
```

A Call/Response Pair

Yardbird Suite by Charlie Parker

Response generated by the constructed musician

Audio Examples

(play)

In the Critic Lies the Power

"The teacher can't give students an ear for dialogue, but he can show the differences between good and bad dialogue. He can't teach students how to invent a plot, but he can teach them to see the flaws and weaknesses of a plot."

—Irwin R. Blacker in *The Elements of Screenwriting*

Automatic Generation of Critics

induce structural features from a corpus

neural network technology

Architecture for Neural Network Critic
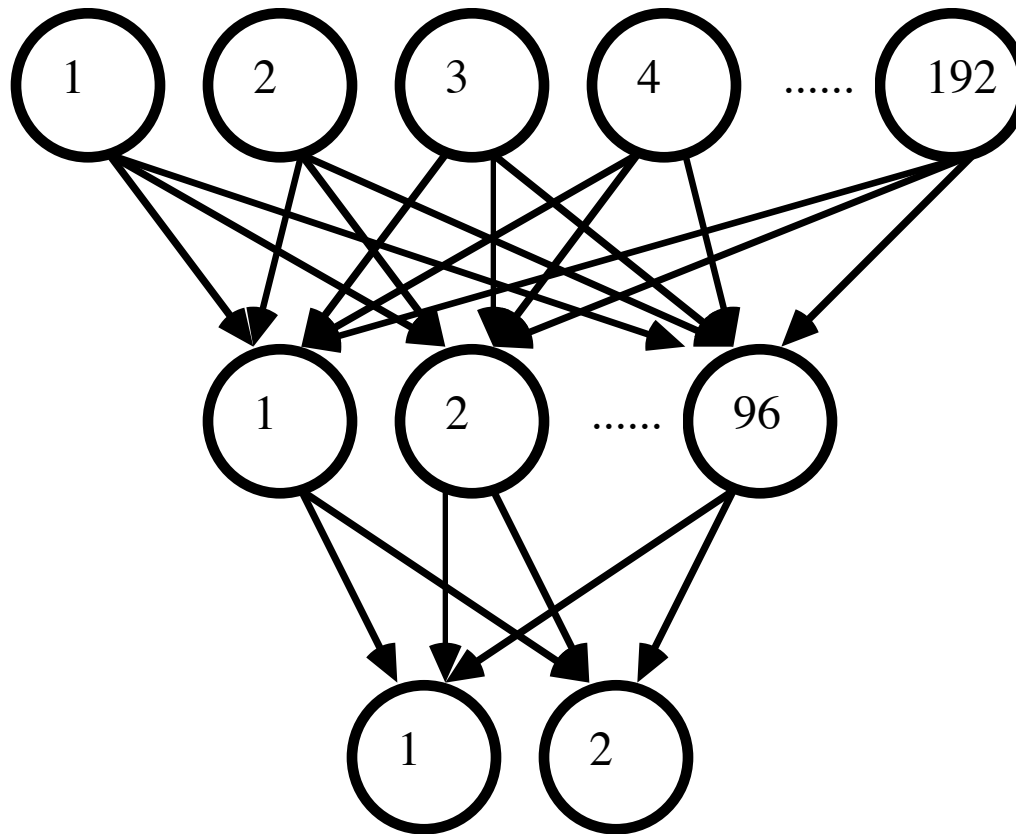
Improvements to GP/Music Framework

Integer terminal set
$$0, 1, 2, ..., 95, i, \text{arg}0, \text{arg}1, \text{arg}2$$

Generic function set
$$+, \text{if-less}, \text{do-times}, \text{copy}, \text{call-copy},$$
$$\text{case-call-copy}, \text{case-response-copy}, \text{transpose}$$

Automatically defined functions
$$\text{adf}0, \text{adf}1$$

Tournament selection

Program evolved under neural criticism

(transpose (+ (if-less (if-less 16 14 35 86) (case-response-copy 38 i i) (if-less 57 33 60 i) (adf0 i 39 6)) (case-response-copy (transpose i i i) (if-less i 67 94 86) 95)) (adf1 78 86 41) (do-times (if-less 20 (do-times 10 i) (transpose i 11 i) (case-response-copy i 63 i)) (copy 28 (adf0 67 i i) (+ i i))))

(defun adf0 (arg0 arg1 arg2) (call-copy arg2 (copy (copy i arg0 (if-less i i i arg1)) (transpose arg1 (case-call-copy 0 79 arg2) (+ arg2 arg1)) i)))

(defun adf1 (arg0 arg1 arg2) (+ (case-response-copy (copy arg1 (if-less i 65 arg2 66) (adf0 18 57 22)) (adf0 (do-times arg1 arg0) (case-response-copy arg1 i arg2) (do-times arg0 i)) i) (call-copy (copy (adf0 i i arg2) (case-response-copy i arg1 arg1) 60) (+ arg2 (call-copy i arg0)))))

Billie's Bounce

Charlie Parker's first measure:

Program evolved under hybrid criticism

(case-response-copy (if-less (copy (copy i 53 i) (transpose (call-copy (+ i 79) i) (call-copy i 95) (adf0 (case-response-copy 59 81 i) (transpose i i i) (do-times (case-call-copy 42 77 i) (case-call-copy i i i)))) (+ 36 37)) i (do-times (call-copy i 95) (if-less i 56 i 8)) (do-times (adf0 i 34 i) (if-less i 51 i i))) i (transpose (call-copy (+ i 79) (copy i 53 i)) (copy i 53 i) (adf0 (case-response-copy 59 81 i) (transpose i i i) (copy i 20 i))))

(defun adf0 (arg0 arg1 arg2) (case-response-copy 32 (transpose (copy arg1 (+ i arg1) (transpose 67 i arg2)) i i) (transpose (case-call-copy (copy i i i) (case-response-copy (case-call-copy (copy i i i) (case-response-copy (case-response-copy (+ (case-call-copy arg1 i arg2) (call-copy arg1 arg1)) (case-response-copy (+ 25 arg1) (+ 7 arg0) (transpose i arg2 arg2)) (transpose i arg2 arg2)) (case-response-copy (+ 25 arg1) (+ 7 arg0) (case-call-copy (copy i i i) (case-response-copy (+ (case-call-copy arg1 i arg2) (call-copy arg1 arg1)) (case-response-copy (+ 25 arg1) (+ 7 arg0) (transpose i arg2 arg2)) (transpose i arg2 arg2)) (case-response-copy arg2 arg2 arg2))) (transpose i arg2 arg2)) (case-response-copy arg2 arg2 arg2)) (case-response-copy (+ 25 arg1) (+ 7 arg0) (transpose i arg2 arg2)) (case-call-copy (call-copy arg1 i) (case-call-copy 44 arg2 arg2) (+ 7 arg0))) (case-response-copy arg2 arg2 arg2)) (copy arg2 (case-call-copy arg0 arg0 13) 63) (call-copy 1 (call-copy 59 54)))))

Billie's Bounce

Charlie Parker's first measure:

Response from the program beyond under played by musician improvising by...

My Little Suede Shoes

Charlie Parker's first measure:

What's Next?

More sophisticated neural network architectures

Communities of critics

Automatically defined macros