Automated Fugue Generation

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♩ Introduction

- This project aims to build a system that generates three-voice fugues in the style of the composer J.S. Bach.
- Our system help novice fugue composers explore musical possibilities beyond their usual thinking capacities.
- A **fugue** is a multi-voice musical composition, built on a **subject** (theme) that **imitates** itself frequently.
- In music, **imitation** is the repetition of a melody in close succession, but in different voice and pitch levels.

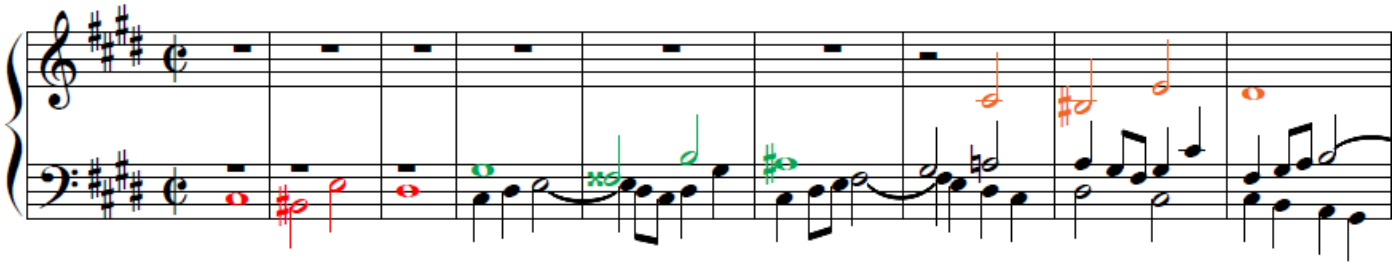


Fig. 1 Beginning measures of J.S. Bach's Fugue No.4 in C♯ minor, BWV 849
The first three subject entries are highlighted in red, green and amber.

♪ Design of Fugue Structure

- Our system formalizes a fugue as a 3 × *n* table where Y-axis represents the voices and X-axis is the timeline.
- Each cell represents a **segment** which is either a subject entry or free counterpoint that lasts for 2 bars.
- All the subject entries must share the exact same melody, but they can be at different keys or pitch levels.
- All segments must conform to the requirements of the chord progression generated from tonal center sequence.
- Each **bundle** (column) contains three segments from the three voices which sound simultaneously.

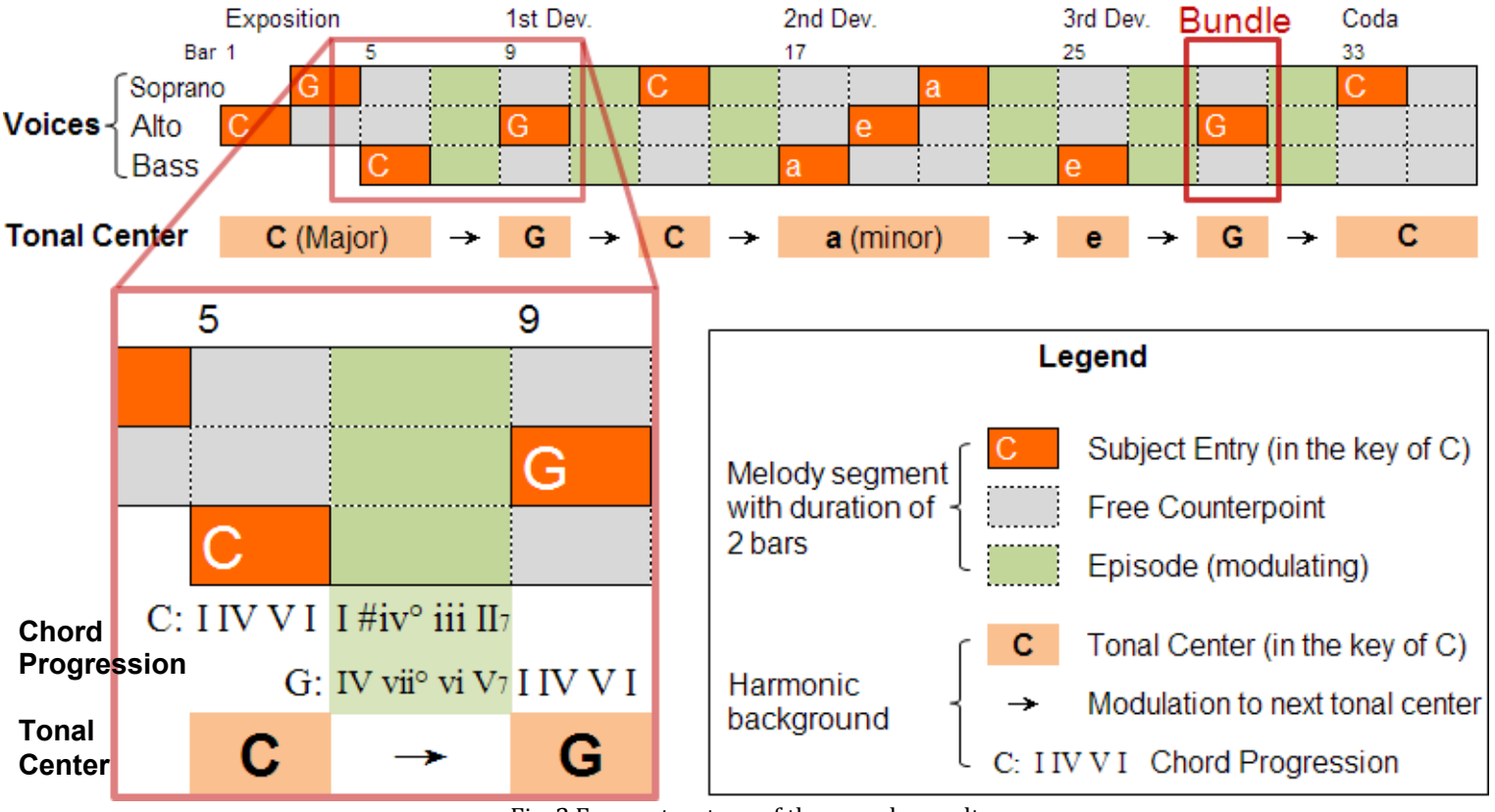


Fig. 2 Fugue structure of the sample result

♫ Design of Bundle Optimization

♮ A bundle is comprised of three segments. Each segment is described by a collection of:

- ♭ The pattern of repetition (e.g. Segment = AAAB where A = DE and B = FF)
- ♭ A set of atomic chunks, each of which describes 4 time steps of attacks / non-attack (e.g. D, E, F below);
- ♭ The way the chunks are linked together (e.g. red & orange arrows below indicate degree difference)

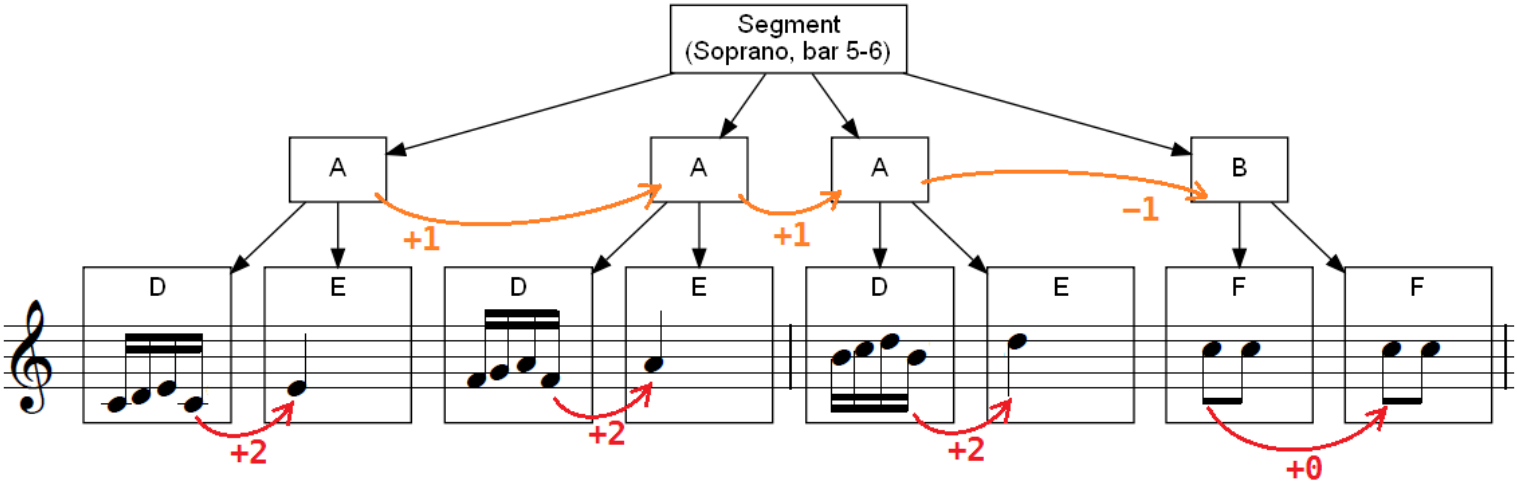
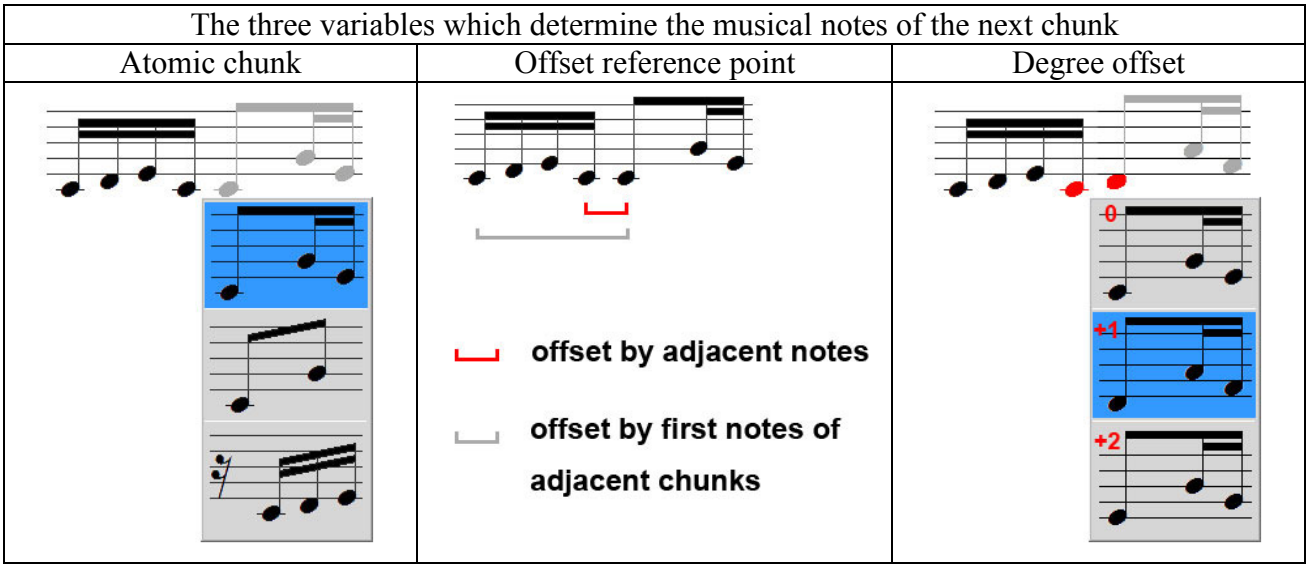


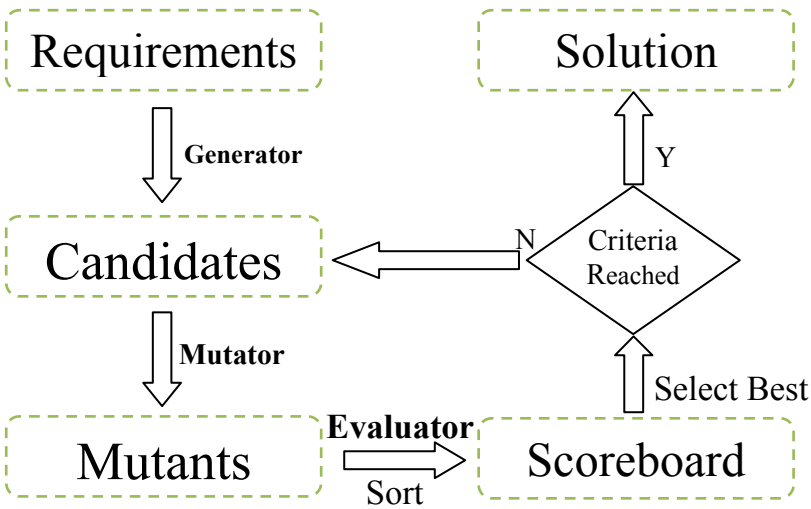
Fig. 3 Segment structure: Soprano of bar 5-6 in the sample result



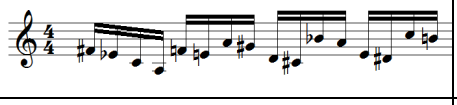
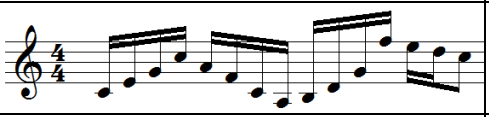
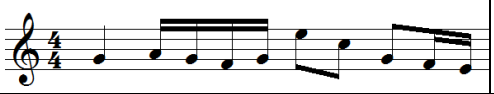
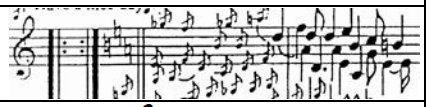
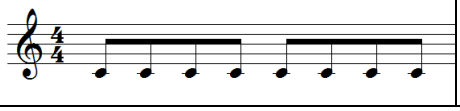
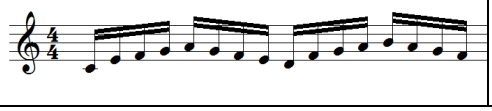
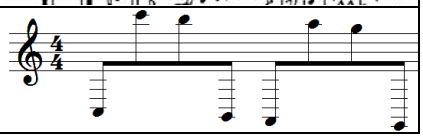
♮ **Genetic Algorithm** is used to optimize a bundle.

♮ The mutator can apply changes to the latter two properties of a segment in a bundle.

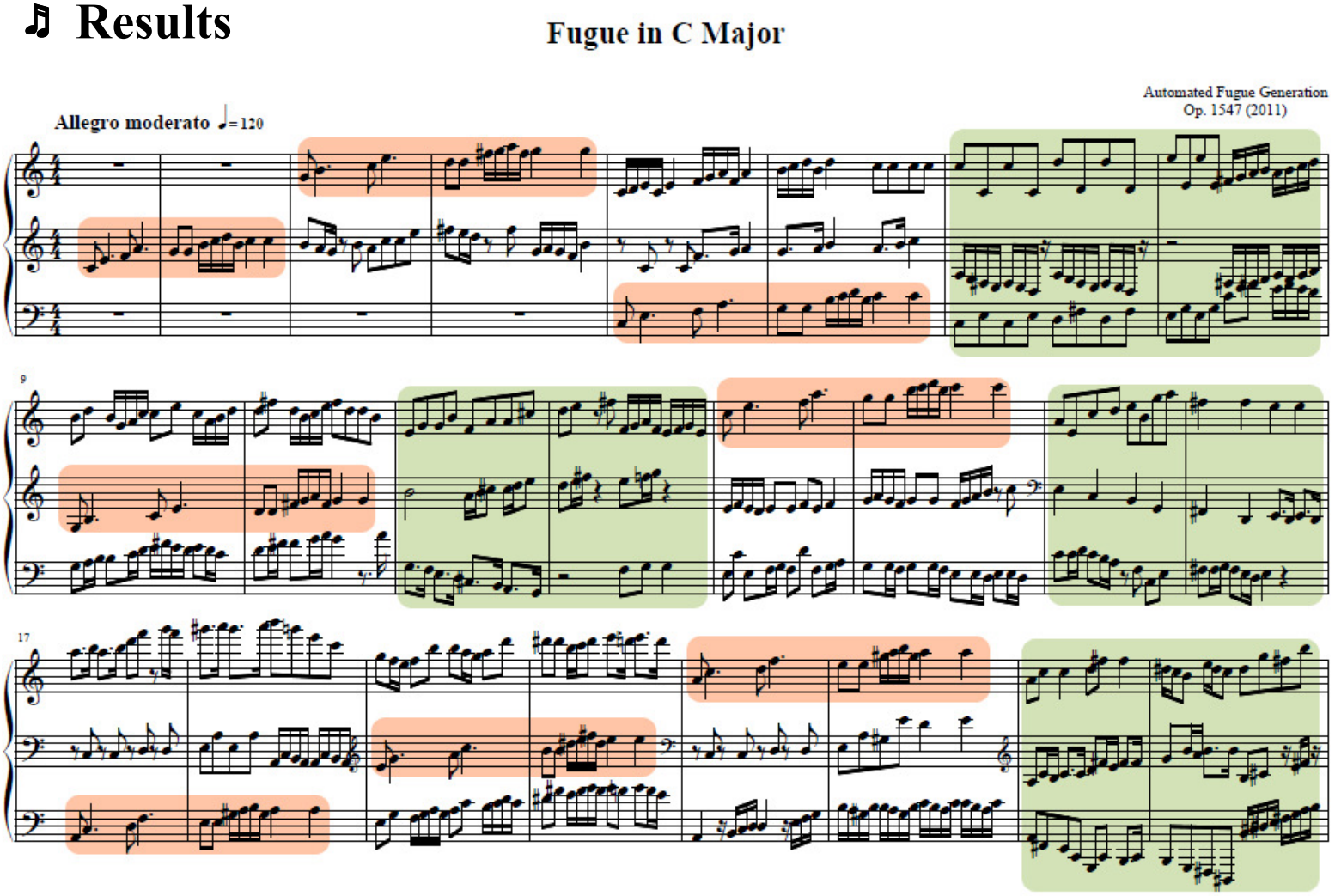
♮ A population of bundle is firstly randomly created, then mutated before the best mutants are chosen by evaluators to form the next generation of population. The process ends when certain criteria are satisfied.



♮ Intra-voice (per-segment) evaluators favor fitness to the chord progression, moderate density of notes, moderate pitch span, and smooth linkage with previous segment in the timeline.

	Bad Too low	**Good** Just right	**Bad** Too high
Fitness to chord			
Note density			
Pitch span			

♫ Results



This sample fugue composition can be heard at http://www.newgrounds.com/audio/listen/417989 (barcode below)

♫ Conclusion & Future Work

♮ Most of the compositions generated by our program are musically interesting except in certain cases the transition might seem unnatural;
♮ The program generates better melodies when subject entry is provided compared to free counterpoint, although the subjects are also generated by the program itself;
♮ Dynamic evaluator can be introduced to avoid trapping in local maximums.