EC700 Project Report
Reinforcement Learning on Harmonic Progression

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1 Introduction

The intersection of music theory and artificial intelligence has long been a fascinating area of study, with researchers consistently uncovering novel ways to analyze, compose, and understand music. In this report, we explore a unique approach to this interdisciplinary challenge, focusing on the application of reinforcement learning to harmonic progression in music theory. By examining the complex relationships between chords and progressions, we aim to create a computational model that can learn, predict, and generate harmonic sequences using the principles of reinforcement learning.

Harmonic progression lies at the heart of Western music, providing the foundation for the listener's sense of tension and resolution, as well as contributing to the overall emotional impact of a piece. Traditionally, music theorists have devised rules and guidelines for creating harmonically pleasing progressions, which are based on centuries of musical practice and observation. However, these rules are often complex and difficult for both humans and machines to navigate. In this project, we seek to teach an artificial intelligence agent the principles of harmonic progression through the use of reinforcement learning, allowing it to autonomously learn and adapt its knowledge of these rules as it interacts with its environment.

By leveraging reinforcement learning, our project aims to develop a model that can intelligently navigate the intricate world of harmonic progressions, learning from experience and refining its understanding of music theory over time.

This report will detail the methodology, implementation, and results of our reinforcement learning approach to harmonic progression, as well as discuss the broader implications of our findings for the future of music composition and analysis. We will begin by providing an overview of the relevant background in music theory and reinforcement learning, followed by an in-depth explanation of our proposed model and its implementation. Finally, we will present the results of our experiments and discuss their implications for the field of music theory and artificial intelligence.

2 Problem Formulation

Given a sequence of chords (e.g., I, vi, IV, ii), the objective is to generate 4-part voicings for each chord in the sequence. This problem can be viewed from two distinct perspectives: as a sequence of chords and as four separate musical lines, each representing one of the four voice parts (soprano, alto, tenor, and bass). While harmonic progression provides us with the notes that must be present in each chord, it does not dictate which voice part should play which note. This absence of specific guidance leads to numerous possible voicing combinations, making the problem inherently complex.

2.1 General Challenges

There are a couple of challenges involved. For example, generating 4-part voicings requires adherence to the principles of **voice leading**, which aim to create smooth and coherent transitions between successive chords. Voice leading ensures that each individual voice part maintains its independence while also contributing to the overall harmony. Complying with these principles often involves minimizing leaps, avoiding parallel fifths and octaves, and preserving common tones between chords whenever possible.

In addition, different **inversions** of a chord can significantly alter the overall sound and harmonic function. For instance, a first inversion chord will have a distinct sonic character compared to its root position counterpart. The model must be capable of intelligently determining which inversion is the most appropriate for a given context, taking into consideration the surrounding chords and overall harmonic progression.

Musical context is another real challenge for musicians to addreass, as the optimal 4-part voicing for a specific chord may vary depending on its context within a piece. Factors such as melody, rhythm, and texture can all influence the ideal voicing choice. However, to simplify our problem, this issue will not be tackles at the current stage. We assume that each short sequence of chords are indepent and is considered good as long as it's consistent within its own scope.

2.2 Constraints & Simplifications

In order to make the problem of generating 4-part voicings more manageable and computationally tractable, we introduce certain constraints and simplifications to our study. These assumptions allow us to focus on the essential aspects of the problem, while reducing the complexity of the learning task for our reinforcement learning model.

1. **Fixed Harmonic Progression** - For the purpose of this study, we assume that the harmonic progression is already given and our primary objective is to provide the appropriate voicings for each chord in the sequence. This allows us to concentrate on the intricacies of voicing generation and voice leading, without the additional challenge of predicting or generating chord progressions.

2. **C Major Only** - To further simplify the problem, we restrict our study to the key of C major. This constraint allows us to avoid complications that arise from key changes and to focus on the fundamental principles of harmony and voice leading. Although this limitation reduces the scope of the study, the insights gained can still be applied to other keys with appropriate transposition.

3. **Root Position Chords** - We consider only chords in root position, meaning that the bass note of each chord is the lowest note of the chord. By excluding chord inversions, we reduce the number of possible voicings and streamline the learning process for our model. This simplification, however, comes at the cost of limiting the harmonic variety and richness that inversions can provide.

4. **Voice Part Range Restrictions** - In order to maintain the realism and practicality of our generated voicings, we restrict the range of each voice part as follows:

   - Bass: E2 (MIDI note 40) to C4 (MIDI note 60)

   - Tenor: C3 (MIDI note 48) to G4 (MIDI note 67)

   - Alto: G3 (MIDI note 55) to D5 (MIDI note 74)

   - Soprano: C4 (MIDI note 60) to G5 (MIDI note 79)

While these assumptions do limit the overall complexity and scope of the

study, they allow us to focus on the core aspects of harmony and voice leading, providing valuable insights that can be further extended to more complex scenarios in future research.

2.3 Voice Leading Rules

3 Methods

4 Results

5 Discussions