Contents

I Background 1

1 The phenomenon of syntactic repetition 3
- 1.1 Motivating examples . . . 3
  - 1.1.1 Making coffee . . . 3
  - 1.1.2 Comics . . . 3
  - 1.1.3 Classical Chinese poem . . . 3
- 1.2 Cognitive principles underlying syntactic repetition . . . 3
  - 1.2.1 Compossibility . . . 3
  - 1.2.2 Efficient reuse of computations . . . 3
  - 1.2.3 Minimizing description length . . . 3

2 Syntactic repetition in tonal music 5
- 2.1 Hierarchical structure in Music . . . 5
  - 2.1.1 Form, rhythm, harmony . . . 5
- 2.2 Repetition in Music . . . 5
  - 2.2.1 Exact vs varied . . . 5
  - 2.2.2 Syntactic vs non-syntactic . . . 5
  - 2.2.3 Differentiating reuse and repeat . . . 5

3 Bayesian model-based reasoning 7
- 3.1 Generative models . . . 7
- 3.2 Functional Probabilistic Programming . . . 7
  - 3.2.1 Markov category and probability monads . . . 7
  - 3.2.2 Synthetic probability theory and Quasi-Borel space . . . 7
  - 3.2.3 Bayesian non-parametrics . . . 7

II Template Grammar 9

4 Deriving template grammar from first principles 11
- 4.1 Abstraction of composition . . . 11
  - 4.1.1 Tree-substitution grammar . . . 11
- 4.2 Abstraction of repetition . . . 11

4.2.1 Pattern language . . . 11
4.3 Abstraction of composition with repeat . . . 11
4.3.1 Introducing template grammar . . . 11
4.3.2 Template grammar as a probabilistic program . . . 11

5 Parsing of Template grammar **13**
5.1 A polynomial time semi-ring parsing algorithm . . . 13
5.1.1 Parsing as deduction . . . 13
5.1.2 Proof of correctness . . . 13
5.2 Approximate parsing for Template grammar . . . 13
5.2.1 Tree compression . . . 13
5.2.2 A-star parsing . . . 13

III Computational Experiments **15**

6 Pattern discovery in Jazz Harmony Tree Bank **17**
6.1 Quantitative results and discussion . . . 17
6.2 Qualitative analysis . . . 17

7 The plausibility of minimal-sized Template as Jazz harmonic analysis **19**
7.1 Many-to-one mapping from Template to CFG parse tree . . . 19
7.2 Baselines . . . 19
7.2.1 PCFG . . . 19
7.2.2 PACFG . . . 19
7.3 Quantitative results and discussion . . . 19
7.4 Qualitative analysis . . . 19

8 Inducing Template grammar from Jazz chord progressions **21**
8.1 Method 1: Non-parametric Bayesian inference . . . 21
8.1.1 Pitman-Yor process prior . . . 21
8.2 Method 2: A heuristic based on tree compression . . . 21
8.2.1 Straight-line tree grammar . . . 21
8.3 Comparison between the two methods . . . 21

9 Contributions and conclusions **23**

Background Part I

1 The phenomenon of syntactic repetition

1.1 Motivating examples

1.1.1 Making coffee

1.1.2 Comics

1.1.3 Classical Chinese poem

1.2 Cognitive principles underlying syntactic repetition

1.2.1 Compossibility

1.2.2 Efficient reuse of computations

1.2.3 Minimizing description length

2 Syntactic repetition in tonal music

2.1 Hierarchical structure in Music

2.1.1 Form, rhythm, harmony

2.2 Repetition in Music

2.2.1 Exact vs varied

2.2.2 Syntactic vs non-syntactic

2.2.3 Differentiating reuse and repeat

3 Bayesian model-based reasoning

3.1 Generative models

3.2 Functional Probabilistic Programming

3.2.1 Markov category and probability monads

3.2.2 Synthetic probability theory and Quasi-Borel space

3.2.3 Bayesian non-parametrics

Template Grammar Part II

4 Deriving template grammar from first principles

4.1 Abstraction of composition

4.1.1 Tree-substitution grammar

4.2 Abstraction of repetition

4.2.1 Pattern language

4.3 Abstraction of composition with repeat

4.3.1 Introducing template grammar

4.3.2 Template grammar as a probabilistic program

5 Parsing of Template grammar

5.1 A polynomial time semi-ring parsing algorithm

5.1.1 Parsing as deduction

5.1.2 Proof of correctness

5.2 Approximate parsing for Template grammar

5.2.1 Tree compression

5.2.2 A-star parsing

Computational Experiments Part III

6 Pattern discovery in Jazz Harmony Tree Bank

6.1 Quantitative results and discussion

6.2 Qualitative analysis

7 The plausibility of minimal-sized Template as Jazz harmonic analysis

7.1 Many-to-one mapping from Template to CFG parse tree

7.2 Baselines

7.2.1 PCFG

7.2.2 PACFG

7.3 Quantitative results and discussion

7.4 Qualitative analysis

8 Inducing Template grammar from Jazz chord progressions

8.1 Method 1: Non-parametric Bayesian inference

8.1.1 Pitman-Yor process prior

8.2 Method 2: A heuristic based on tree compression

8.2.1 Straight-line tree grammar

8.3 Comparison between the two methods

9 Contributions and conclusions