Computer Music
Musical Composition
with Stochastic CFG

Abstract.

We present a method for learning the harmonic structure of musical phrases by applying recent techniques for learning context-free grammars.A series of steps were abstracted to reflect composition as a sequential flow of data refination; also each step involved in this process was modeled to gain each one of their functions. Specifically, in the case of the main structure of the suggestion a stochastic context-free grammar was developed to generate harmonic progressions, in the case of rhythms.

Musical Composition

The basic principle that guides and aims the primary objective in a musical composition is the creation of musical sequences that share an idea. Although this goal is the composer's intention, the form of communicating such idea and its internal details (called harmonization) vary in a high degree from age to age.

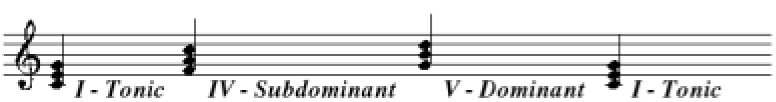


Fig. 2. Chord Progression: C (I) - F (IV) - G (V) - C (I)

The most common and elemental harmonic progression is probably I - IV - V - I (tonic, subdominant, dominant, tonic). The figure 2 shows an example of this progression. This flow of chords, apart from containing the three most important degrees from a scale, establishes well a tonality due to the interval of I - V (tonic, dominant). This last interval soundly marks to the ear the tonality in which the whole song or part from it is developed.

Grammar Learning Methods
Stochastic CFGs

Most of the learning methods for FAs translate to those for CFGs. Because the expressive power of CFG's is greater than that of regular languages, we would hope that learning methods could provide a better representation of music. The equivalent of HMMs for CFGs are the SCFGs, stochastic context-free grammars. SCFGs keep information about the likelihood of non-terminals being parsed into specific right-hand sides of the productions based on the sample data.

Context-Free Grammars

A grammar is a set of rules to describe strings that belong to a language and are syntactically valid; these strings are made upon an alphabet. Formally, a grammar is a tuple G = <N, Σ, P, S> where N is a set of non-terminal symbols, Σ is a set of terminal symbols (the alphabet), P is a set of production rules, and S is the initial non-terminal symbol.
To exemplify this concept we can take a grammar that generates all the powers of 10. This grammar has the set of non-terminals {S, P, C}, the set of terminals {1, 0, ∅}, the initial symbol S and the next production rules:

$$\begin{aligned} S &\rightarrow P \\ P &\rightarrow 1P \\ C &\rightarrow 0C \\ C &\rightarrow \emptyset \end{aligned}$$

A grammar is context-free if for each one of the production rules, its right side is made up of only one non-terminal symbol, meaning if the production rules follow the next form:

$$A \rightarrow E$$

where $A \in N$, and E is any string in $(\Sigma \cup N)^+$
A stochastic context-free grammar is an extension of context-free grammars where each production rule has an associated probability representing the plausibility of the rule. Then, a stochastic context-free grammar can be seen as production rule with the following form:

$$A_i \rightarrow E \qquad [p_i]$$

where $A \in N$, E is any string in $(\Sigma \cup N)^+$ and pi is the probability of the rule A_i.
The probabilities must fulfill the next statements:
1. $0 \leq p_i \leq 1$
2. $\Sigma_i\, p_i = 1$, where pi is associated with A_i.

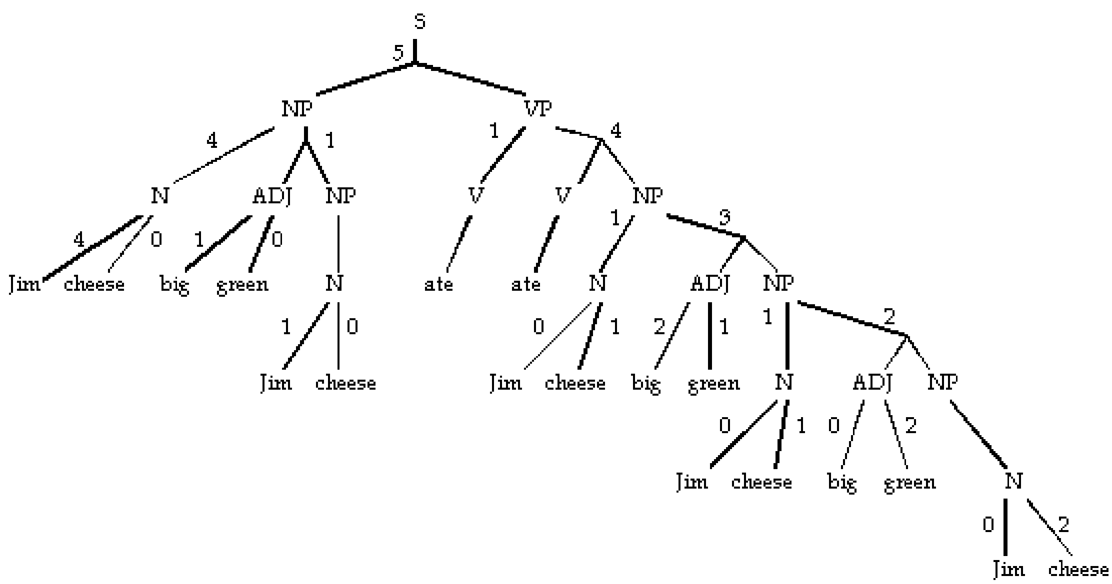
A very trivial example of a stochastic context-free grammar is one that defines a two-coins tossing result. The set of non-terminals is {S, T}, the set of terminals is {head, tails}, the initial symbol is S and the production rules are the following:

S → T T $[1, 0]$
T → head $[0, 5]$
T → tails $[0, 5]$

Another example, suppose the following SCFG :

S ⇒ NP VP
NP ⇒ N | ADJ NP
VP ⇒ V | VP NP
ADJ ⇒ big | green
N ⇒ Jim | cheese
V ⇒ ate

Jim ate
Jim ate cheese
Jim ate green cheese
Jim ate big green cheese
big Jim ate big green cheese



Concluding.

The automated generation of music has been a research area since mid 1900's. Several advances from this time are still used today. The main focus was to generate consistent musical sequences; for this purpose statistical methods were established that made use of models and algorithms of artificial intelligence. The reader may see to get a complete survey of music generation from statistical models.The generation of music through computational models is not new, in fact there are a variety that have been used conform the interest in the subject has grown.

References.

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