

Senior Design Project Description

Log-Linear Model

We would like to apply a log-linear model based on those found in machine translation systems to the problem of creating a harmony for a given melody. The log-linear model will consist of two main components: the language model and the translation model. The language model will model the likelihood of a given harmony line $H = \{h_0, h_1, \dots, h_{l-1}\}$ where $l = |H|$. We propose it use 3-grams for context and apply a penalty function d to discourage large differences in notes' positions on the staff. More formally, the language model can be defined as:

$$p_{LM}(H) = \prod_{i=1}^l P[h_i | h_{i-1}, h_{i-2}, h_{i-3}] * d(h_i - h_{i-1})$$

The second component of our model will be the translation model, which will model the probability that a harmony H is a good translation for a melody M . It can be defined as:

$$p_{TM}(M|H) = \prod_{i=1}^l P[m_i | h_i]$$

Putting these two components together, given a melody M we would like to find a harmony H s.t.

$$H = \operatorname{argmax}_H p(H|M) = p_{TM}(M|H)p_{LM}(H).$$

To simplify computation, we will actually minimize the log of the function above so that

$$\begin{aligned} H &= \operatorname{argmax}_H \log(p_{TM}(M|H)) + \log(p_{LM}(H)) \\ &= \operatorname{argmax}_H \sum_{i=1}^l \log(P[m_i | h_i]) + \log(P[h_i | h_{i-1}, h_{i-2}, h_{i-3}]) + \log(d(h_i - h_{i-1})) \end{aligned}$$

The problem of melody to harmony translation is somewhat simpler than the standard problem of translating between two natural languages because there is no concept of reordering in the former problem. Based on how we have chosen to define the problem, a harmony note corresponding to some melody note will always occur in the same position as the melody note. Additionally, our harmonies and melodies will be of the same length, so no reordering or length penalties need be applied.

In order to minimize the function above, we plan to build up the potential translations $H^j = \{h_0, \dots, h_j\}$ for $M^j = \{m_0, \dots, m_j\}$ where $0 \leq j \leq l$ and prune the potential translations by some threshold value for each increment of j .

Extensions

Chord Inference

The chord that a particular melody note is a part of in a composition can give us a hint as to what notes might make sense to harmonize with that melody note. If we were aware of the note's chord, we could train the translation model both on the pitch of the note itself and the chord that the note participates in. For example, say we see the note A in the melody harmonized with the note B in one instance and the note C in another instance. Then, our translation model will tell us that both B and C are good choices of notes to harmonize with A . However, if we knew that when A was harmonizing with B , the chord that A was a part of was the B chord and that when A was harmonizing with C , the chord that A was a part of was the C chord, our translation model could then tell us that B is better choice of harmony note than C when A is a part of the B chord.

In order to make use of this information, we need some way to be aware of a note's chord. Since we have some composition data whose notes are labeled with their chords, we suggest training a one vs. all logistic regression model that will classify a given note into a set of chord classes. Some preliminary features we suggest using in order to train the models are: the key of the song, the pitch of the note, the pitches of surrounding notes, and whether or not the note occurs on a dominant beat in the measure. After our model is trained, we can use it to classify the chords of notes in unlabeled composition data.