# Contextual Chord Embeddings for Stylistic Analysis

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Presentation link: https://youtu.be/iSHihr-M7-U

**Table of Contents**

Code
Definitions
Corpora
Word2vec parameters
Mozart model
Rock model
Word2vec mathematics
Acknowledgements
References

## Code

https://www.shrunken.com/ChordEmbeddingsCode

## Definitions

*Computation hermeneutics*: Encoding meaning into a computer
*Class representation*: A class describes a group of objects all belonging to it
*Contextual representation*: Objects gain associated meaning within particular contexts
*Stylistic representation*: The stylistic context defining contextual and class representations
*Vector*: Lists of numbers where there are as many dimensions as the vector is long
*Word embedding*: Vector representations for words made of real numbers
*Dendrogram*: Hierarchical clustering method
*Euclidean distance*: Distance between two vectors $\vec{u}$ and $\vec{v}$ defined as

$$d(\vec{u},\vec{v}) = \sqrt{(u_1 - v_1)^2 + (u_2 - v_2)^2 + \cdots\ (u_n - v_n)^2}$$

*Cosine similarity*: Similarity between two vectors $\vec{U}$ and $\vec{V}$ defined as

$$Cos\theta = \frac{\sum_i^n u_i\, v_i}{\sqrt{\sum_i^n u_i^2}\,\sqrt{\sum_i^n v_i^2}}$$

*Cosine distance*: Distance between two vectors $\vec{u}$ and $\vec{v}$ defined as $1 - Cos\theta$.

## Corpora

Yale Classical Archives corpus (White and Quinn 2016)
Rolling Stone corpus (Temperley and de Clercq 2011/2013)

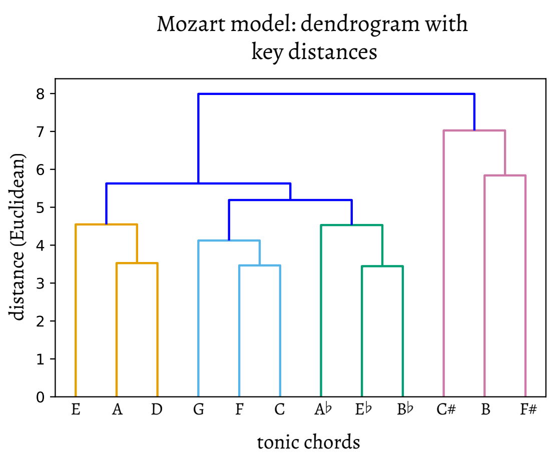
## Word2vec parameters:

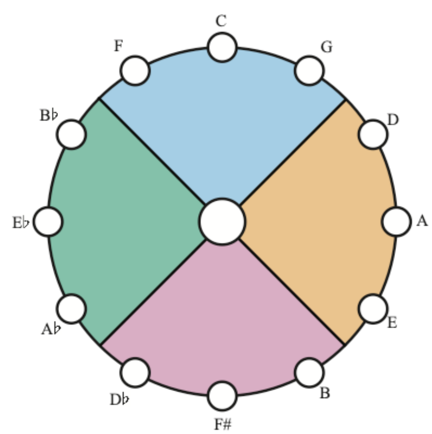
There are a various parameters when using the word2vec algorithm. These are the ones that this paper makes use of:

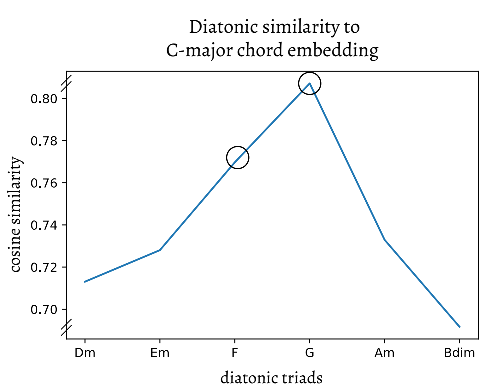
| | |
|---|---|
| **Corpus** | Corpus being parsed |
| **Window size** | Maximum distance between target and contexts |
| **Vector size** | Vector dimensionality |
| **Skip-gram** | {1,0}—whether using skip-gram or continuous bag of words |
| **Epochs** | Number of iterations through the corpus |

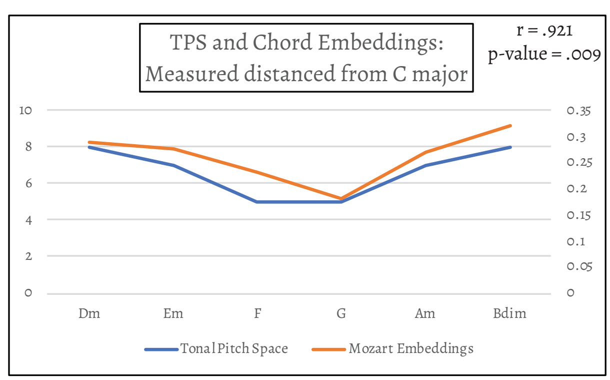
## Mozart model

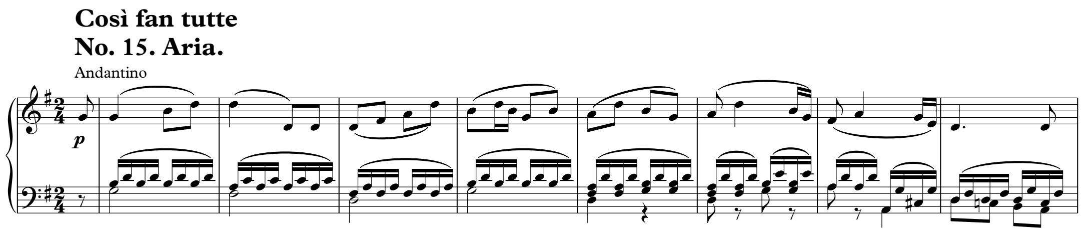
| | |
|---|---|
| **Corpus** | YCAC, Mozart file |
| **Window size** | 4 |
| **Vector size** | 30 |
| **Skip-gram** | 1 : Skip-gram |
| **Epochs** | 40 |

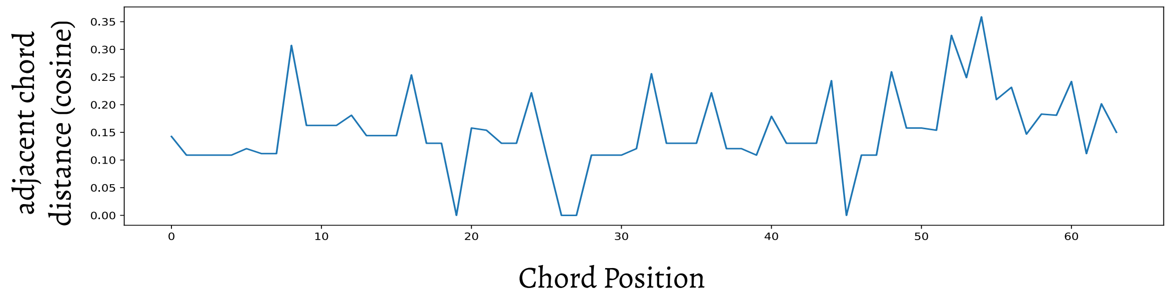


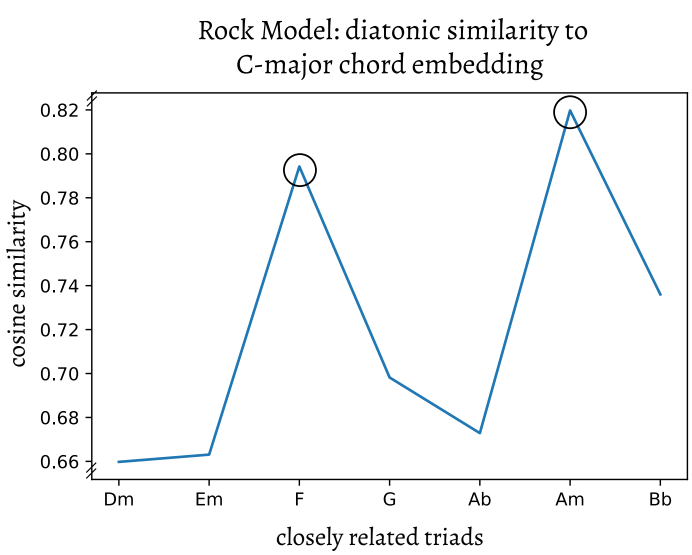



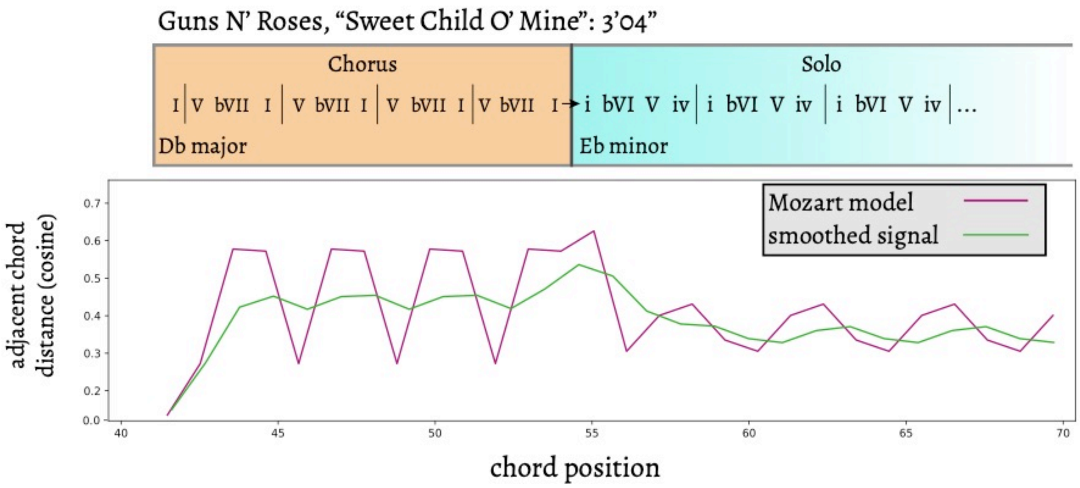


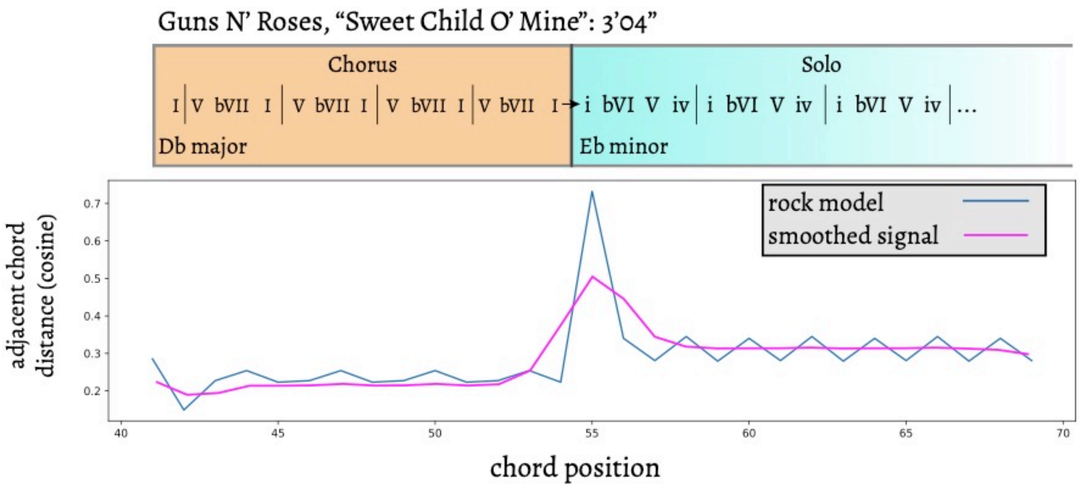




## Rock Model

| | |
|---|---|
| **Corpus** | Rolling Stone corpus |
| **Window size** | 2 |
| **Vector size** | 20 |
| **Skip-gram** | 1 : Skip-gram |
| **Epochs** | 100 |






## Word2vec mathematical details

I've attempted to condense core principles of word2vec, but anyone interested in investigating further should look to the genism documentation page, or Jurafsky and Martin (2020).

**Probability**

The probability of the target word $t$ occurring near a context word $c$ is calculated by taking the dot product between the vectors and turning the dot product into a probability with the sigmoid function.

Given a target and context tuple, the probability that the context word is real: $P(+|t, c)$
Dot product: $Similarity(t, c) \approx t \cdot c$
Sigmoid function: $\sigma(x) = \frac{1}{1+e^{-x}}$
To model the probabilities within the window of $L$ chords:

$$P(+|t,c) = \sum_{i=1}^{L} \log \sigma(t \cdot c_i) = \frac{1}{1 + e^{(-t \cdot c_i)}}$$

**Updating embeddings**

Embedding are changed to maximize the dot product between the target chord and chords that appear near it $c_{pos}$. We also want to minimize the dot product between negative samples (chords that don't occur near one another) $c_{neg}$. The amount of negative samples is specified $k$. To change the embeddings, word2vec uses gradient descent—an operation for finding the minimum of a differentiable function. It therefore requires the derivative of a loss function $E$, modeled as cross entropy.

$$E_{CE} = -\left[\log P\left(+\middle|t, c_{pos}\right) + \sum_{i}^{k} \log P\left(-\middle|t, c_{neg_k}\right)\right]$$

$$= -\left[\log \sigma(t \cdot c_{pos}) + \sum_{i}^{k} \log \sigma(t \cdot c_{neg_i})\right]$$

Iterating through the corpus, the embeddings are updated from chord $n$ to $n$+1. Where $\eta$ is the "learning rate" or the step size for each iteration while moving towards the local minimum.

$$t^{n+1} = t^{n} - \eta\left[\sigma\left(c_{pos} \cdot t^{n}\right) - 1\right]c_{pos} + \sum_{i=1}^{k}\left[\sigma\left(c_{neg_i} \cdot t^{n}\right)c_{neg_i}\right]$$

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