

# SINUSOIDAL HARMONIC MODELING\*

Kyle Ringgenberg  
Yi-Chieh Wu

This work is produced by OpenStax-CNXX and licensed under the  
Creative Commons Attribution License 2.0<sup>†</sup>

## Abstract

Approximating the spectral envelope of a tone by estimating its harmonics and harmonic amplitudes.

## 1 Sinusoid Harmonic Modeling

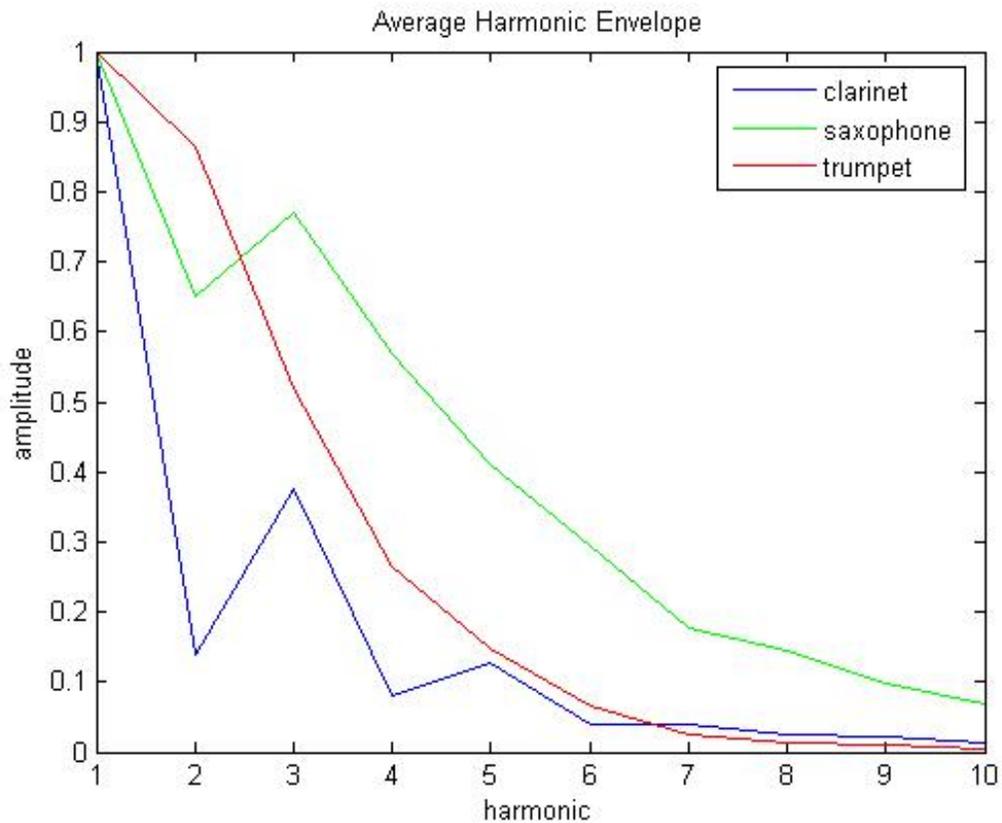
We would like to capture the “typical” spectrum for each instrument, independent of the pitch being produced. This allows us to classify a signal using our model without providing the pitch as another parameter to the model. (We note that this method is not without consequences, as the frequency response of the instrument changes the spectrum depending on the note being played. For example, very low and very high notes are more likely to vary than notes at mid-range. We decided to go with this approach to save time in model training and hopefully reduce the dimensionality of our problem.)

Sinusoidal harmonic modeling (SHM) captures the harmonic envelope of a signal (as opposed to its spectral envelope) and is ideal for tonal sounds produced by wind instruments, as most of the spectral energy is captured in the harmonics. Given a spectrum, SHM finds the fundamental frequency and estimates the harmonics and the harmonic amplitudes, eventually producing an amplitude versus harmonic graph.

---

\*Version 1.1: Dec 14, 2005 10:10 pm -0600

<sup>†</sup><http://creativecommons.org/licenses/by/2.0/>



**Figure 1:** Average Harmonic Envelope for Clarinet (Blue), Tenor Sax (Green), and Trumpet (Red)

---

From this representation, we can then determine characteristic features of the instrument. For example, qualitatively, we can tell that the spectrum of a clarinet declines rather fast, and that most of the energy is in the odd harmonics. Similarly, we can tell that the saxophone declines slower, and that the trumpet has its harmonic energies relatively distributed among the odd and even indices.