Zero-crossing rate

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By looking at different speech and audio waveforms, we can see that depending on the content, they vary a lot in their smoothness. For example, voiced speech sounds are more smooth than unvoiced ones. Smoothness is thus a informative characteristic of the signal.

A very simple way for measuring smoothness of a signal is to calculate the number of zero-crossing within a segment of that signal. A voice signal oscillates slowly - for example, a 100 Hz signal will cross zero 100 per second - whereas an unvoiced fricative can have 3000 zero crossing per second.

To calculate of the zero-crossing rate of a signal you need to compare the sign of each pair of consecutive samples. In other words, for a length N signal you need $O(N)$ operations. Such calculations are also extremely simple to implement, which makes the zero-crossing rate an attractive measure for low-complexity applications. However, there are also many drawbacks with the zero-crossing rate:

- The number of zero-crossings in a segment is an integer number. A continuous-valued measure would allow more detailed analysis.
- Measure is applicable only on longer segments of the signal, since short segments might not have any or just a few zero crossings.
- To make the measure consistent, we must assume that the signal is zero-mean. You should therefore subtract the mean of each segment before calculating the zero-crossings rate.

An alternative to the zero-crossing rate is to calculate the autocorrelation at lag-1. It can be estimated also from short segments, it is continuous-valued and arithmetic complexity is also $O(N)$.

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