

Cheng Zhi Anna Huang  
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Ozgur Izmirli and Semih Bilgen (1996). "A Model for Tonal Context Time Course Calculation from Acoustical Input." *JNMR* 25(3).

This paper presents "a two-stage model that calculates tonal context as a continuous function in time". The model is capable of processing polyphonic audios. The first stage is to detect the pitch-classes corresponding to the audio input. The second stage utilizes a bank of leaky integrators. Each integrator holds "the strength value of a specific tonal center". User controllable parameters control the time-span of musical memories. The output of the model is "the tonal context vector retaining normalized values of the leaky integrators".

A tonal center defines the tonal context of a given piece of music, hence giving meaning to all the individual pitches. The tonal centers of sections give global meaning in terms of relaxation or settlement. There are two motivations for context determination. The first being "the calculated context alone carries information about tonal status with respect to all tonal centers and secondly, the context may be used in semantic interpretation". The current model addresses only the first concern. Furthermore, Harmonic function is "only significant when viewed in relation to the pre- and post- harmonic context". Post-harmonic contexts are effective only when learning mechanisms are incorporated. The current model "does not treat this aspect". Instead, it can be viewed as a novel listener with leaky integrators "keeping attention on the current event in the context of previous events".

For the pitch-class detection in the first stage, a single-window analysis technique is employed since the octave does not matter. The constant Q transform with 24 bins per octave is used instead of the conventional FFT for spectrum calculation. To eliminate "the effects caused by transients and noise in the input, the spectrum is lowpass filtered". The algorithm of pitch-class detection "assumes that all notes have spectral energy at their fundamental frequencies. It is not required that the fundamental and the overtones have a specific amplitude relationship". Spectral peaks have to be above a certain absolute threshold to be considered. The pitch-class search starts "from low frequency and the first spectral peak is assigned to be the fundamental of the first note. All overtones of the fundamental are then eliminated and the next remaining spectral peak is assigned as the fundamental of the second note".

In the second stage, each leaky integrator corresponds to a tonal component. Since there are 12 tonal components for each of the major and minor mode, the resultant is a 24-dimensional output vector. As expected, the vector retains normalized values of each of the 24 leaky integrators to represent the strength value of its corresponding tonal center. In the current model, duration effects are "salient, i.e., the longer a tone sounds the more it will dominate in determining the related tonal components".

The strength of each of the 24 dimensions in the output vector is continuously plotted against time. The highest strength at a given time is treated as its tonal center. Hence, the plot shows the shifts in tonal centers throughout the whole piece. These results give insight into form and structures, which are highly dependent on tonal centers, especially in classical period. User's can tune "a set of parameters that control the rate of adaptation and saturation limits of short-term musical memory" to control the system's sensitivity towards short-term modulations.