

SIGNIFICANCE OF FREQUENCY VS. TIME VARIATIONS  
AND AMPLITUDE BEATING IN ADDITIVE SYNTHESIS OF  
PIANO TONES

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Two features that are prominent in piano tone analyses are undulating amplitudes (beats) and slightly inharmonic frequencies, factors which have been noted by several previous researchers (e.g., Fletcher et al, 1962; Weinreich, 1977; Hundley et al, 1978). In this study we closely examine instantaneous frequency as well as amplitude variations of the individual harmonics of three piano tones (performed at C2, C4, and C6). To obtain these variations we use the the heterodyne/filter phase vocoder technique. Rates of beating and amounts of frequency deviation and inharmonicity are noted for each partial of each tone. Then we synthesize tones (by harmonic addition) under the following conditions:

- 1) All amplitude and frequency time-varying data used.
- 2) Frequencies set to average (inharmonic) values.
- 3) Frequencies set to constant harmonic values.
- 4) Amplitude undulations replaced by smooth decays.

We will precede the presentation of our piano analysis/synthesis results by presenting data on the accuracy of our analysis program based on artificial input signals. The relative importance of departures from harmonicity and of the beating patterns will be illustrated by tape playback.

References:

- 1) Fletcher, H.; Blackman, E.D.; Stratton, R., "Quality of Piano Tones", J. Acoust. Soc. Am., Vol. 34, pp. 749 - 761 (1962).
- 2) Weinreich, G., "Coupled Piano Strings", J. Acoust. Soc. Am., Vol. 62, pp. 1474 - 1484 (1977).
- 3) Hundley, T.C.; Benioff, H.; Martin, D.W., "Factors Contributing to the Multiple Rate of Piano Tone Decay", J. Acoust. Soc. Am., Vol. 64, pp. 1303 - 1309 (1978).