Session 4pMU

Musical Acoustics: Spectral Analysis, Synthesis and Perception of Musical Instrument Sounds II

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Invited Papers

1:00

4pMU1. Analysis of concurrent timbres with an auditory model. Gregory J. Sandell (Exp. Psychol., Univ. of Sussex, Brighton BN1 9QG, UK)

Concurrently sounding timbres (two or more instruments playing on the same or different pitches) sometimes yield unexpected qualities of sound which are exploited in orchestration. A model simulating spectrum analysis by the human auditory periphery is used to explore the differing contributions of individual instruments to the sum sound. Signals are passed through a bank of overlapping bandpass filters whose center frequency spacing corresponds to equal physical distances along the basilar membrane. Thus sinusoidal components do not fall into single "bins" as in a Fourier analysis, but rather spread excitation over a large number of channels. Some partials are resolved in separate channels while other partials are processed in a single channel with others, leading to interactions that determine the overall timbre of the combination. Sampled musical instrument tones are combined into concurrent arrangements and analyzed with the method.

1:30

4pMU2. Sharpness: A perceptually based measure of the spectral dimension of musical timbre. Pamela Goad (Systematic Musicology Program, School of Music, DN-10, University of Washington, Seattle, WA 98195)

In order to assess the perceptual relationship between musical timbre and its physical properties, an effective measure should combine those factors considered important to perception with the common attributes of musical timbres. *Sharpness* is a perceptually based measure of timbre originally tested and put forth by Bismarck [Acustica **30**, 146–172 (1974)] and later refined by Aures [Acustica **59**, 130–141 (1985)] which applies a weighting to higher frequencies of a loudness pattern. Two-octave ranges from the brass, clarinet, saxophone, double reed, and string families of musical instrument timbres were analyzed across a musical dynamic range of *pianissimo* to *fortissimo*. Particular attention was paid to similarities in sharpness in three categories: Musical instrument families, instruments of like voice, and performance comparisons on the same instrument with different performers. Evidence suggests that most similarities in sharpness occur at the lower playing levels in every category. In addition, sharpness proved to be sensitive to idiosyncrasies of instrumental design and performer-specific techniques. Some comparisons to spectral centroids and centroids of loudness patterns [Grey and Gordon, J. Acoust. Soc. Am. **63**, 1493–1500 (1978)] will be presented in addition to implications for application to subjective responses of musical blend.

2:00

4pMU3. Additive analysis and synthesis using partial tracking, spectral envelopes, and inverse fast Fourier transform. X. Rodet, P. Depalle, and G. Garcia (IRCAM, 31 rue Saint Merri, 75004, Paris, France)

Additive methods developed and used at IRCAM and CNMAT are presented. Analysis includes new techniques to find spectral peaks, estimate their parameters, track partial sinusoids, and separate sinusoidal components from the residual considered as noise. Partials are tracked by identifying trajectories in successive set of spectral peaks using a combinatorial hidden Markov model. Control is made easier by use of spectral envelopes instead of the classical time functions. Characteristic features of sounds are given in term of fundamental frequency, spectral envelopes for amplitude, phase, deviation from harmonicity, noise components, etc. This procedure renders user control much more economical and efficient. To reduce the computational cost of the synthesis algorithm, a method has been developed that is based on the short-time Fourier model of a sound signal allowing for the synthesis and control of hundreds of sinusoidal partials and noise components in real time on a desktop computer without custom hardware. Very high quality sound examples are obtained showing that a limited cost real-time multitimbral instrument can easily be designed based on inverse FFT. This would have all the possibilities of present day synthesizers, plus many others such as the precise modifications of sampled sounds, speech, and singing voice synthesis.

2:30

4pMU4. Residual minimization in a musical signal model based on a deterministic plus stochastic decomposition. Xavier Serra (Phonos-Inst. de l'Audio-visual, Univ. Pompeu Fabra, Rambla Santa Monica 31, 08002 Barcelona, Spain)

Spectral modeling synthesis (SMS) is a spectrum modeling technique that models time-varying spectra as (1) a collection of sinusoids controlled through time by piecewise linear amplitude and frequency envelopes (the "deterministic" part), and (2) a time-varying filtered noise component (the "stochastic" part). This technique has proved to give general, high quality transformations for a wide variety of musical signals. As part of the analysis process of SMS the deterministic component is subtracted in the time domain from the original sound resulting into a residual signal. For a good deterministic-stochastic decomposition this

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