Spectmore: Automatic Notation Generation for Spectral Transcription Processes

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Abstract
This paper introduces a newly developed software tool designed to automatically produce instrumental scores based upon spectral analysis and re-synthesis processes using sound-file input. The original software, Spectmore, and its various components will be described and an initial musical work produced using the software will be presented.

Keywords
Automatic Transcription, Automatic Notation, Algorithmic Music, Spectral Analysis, Notation Software, Field Recordings, Python, Interactive Music Composition

1. Introduction

This paper introduces a newly developed software tool designed to automatically produce instrumental scores based upon spectral analysis and re-synthesis processes using sound-file input. The original software, Spectmore, and its various components will be described and an initial musical work produced using the software will be presented. Overall this project has drawn significantly upon ideas and insight gained from previous projects (specifically, see Barrett, 2006) and is much indebted to the work of a key set of composers: the large-ensemble works of the Itineraire Spectral composers, along with many works of Peter Ablinger, and the algorithmic music of James Tenney. In addition to providing an overview of the program's general functionality, an attempt will be made to illustrate the value of Automatic Notation Generators (ANG’s), (see Barrett, et al, 2007) and their ability to provide a

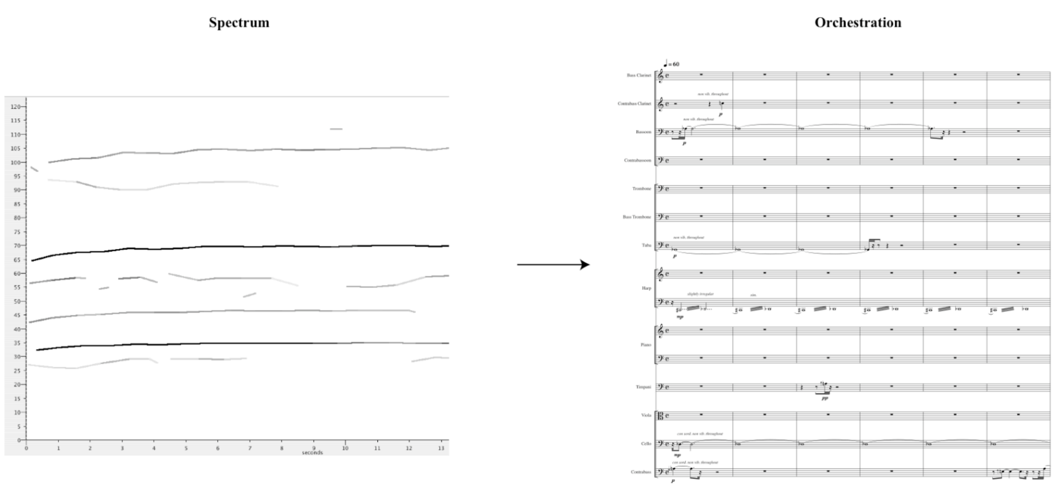

Figure 1 Spectral Orchestration.

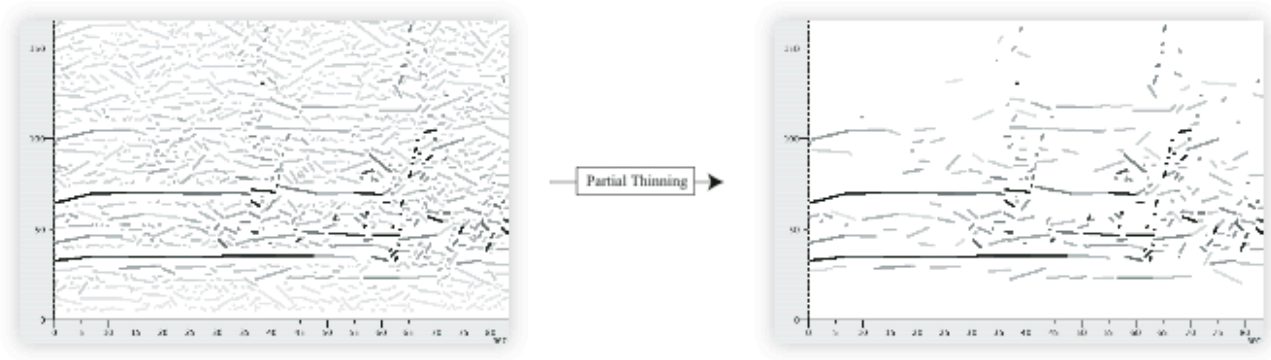

Figure 2 Illustration of Partial Thinning.

user with rapid feedback and fast prototyping when composing music using algorithms and spectral analysis.

An interest, which grew from experimental works produced with Spectmore's predecessor, Spectore, was the use of environmental field recordings of extended duration, along with an exploration of their spectral properties. Peter Ablinger's *Quadraturen* series is similarly concerned with creating instrumental pieces from spectral analyses from a variety of sources, including field recordings. Central to these works is the use of polyphonic instrumental textures that can be considered analogous to the original recorded material with respect to certain morphological properties. With these interests in mind, a central goal of the Spectmore project has been to create a working environment in which various configurations of spectral analysis, algorithmic orchestration, and automatic notation generation could be rapidly and flexibly configured.

2. Spectral Orchestration

Spectral orchestration is the term given to the assignment of an instrumental tone with somewhat analogous properties – frequency to pitch, amplitude to dynamic – for each significant partial found in a spectral analysis of a recorded sound file. A partial is defined as significant when it passes tests for its duration, pitch, and amplitude. This process creates a collection of partials that shares structural properties with the original recorded material. Significant partials are assigned to instruments (Figure 3) based upon a complex set of time-variant and static criteria (see section 4.2 Statistical Orchestration).

3. Notation

Notation in Spectmore is handled by a specialized Python module (mxml.py), which contains certain musical and notational functionality to facilitate quick mapping schemes of input data. This module, uses as its eventual output format the widely accepted Music XML standard (Recordare, 2003). The module is constructed hierarchically as illustrated in Figure 3: a Note belongs to a Measure, which belongs to a Part, which belongs to the entire Orchestra. As differentiated from the Note object, the Plank describes a single tone that may span several measures and is attached directly to the Part object.

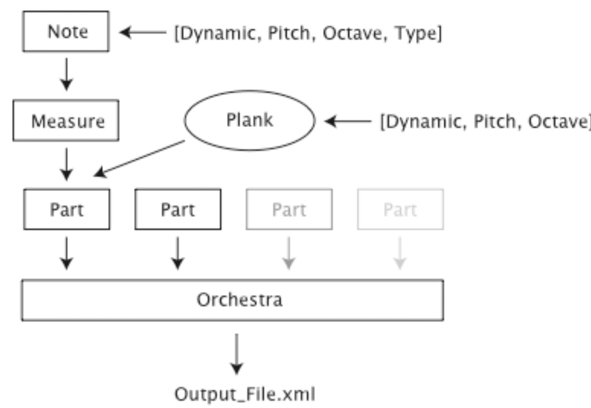

Figure 3 Internal structure of Notation Module (mxml.py).

4. Functionality

4.1 Spectral Analysis

Spectmore uses as its analysis engine Loris, the open-source software package, which implements the reassigned bandwidth-enhanced additive sound model. Loris provides a set of time-varying amplitude and frequency envelopes with initial phase values and noise energy (Fitz, et al, 2003). After obtaining a list of partials from a Loris analysis instance, the Spectmore analysis module performs a thinning function, which removes partials below user-specified amplitude and duration thresholds (Figure 2). Then, the changes in frequency throughout the duration of each partial are averaged to provide single frequency values. A similar averaging process is performed for amplitude. This collection of partials, to be referred to as a *spectral separation*, is then arranged in order of decreasing amplitude throughout time. This ordering gives more prominent partials priority when the spectral separation is handed to the Statistical Orchestration module.

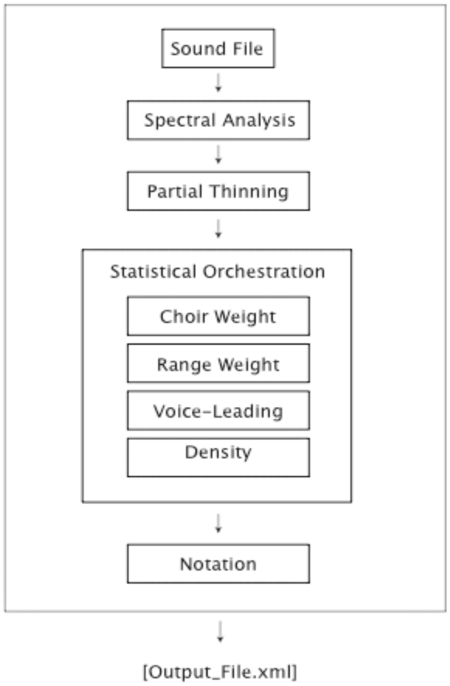

Figure 4 Spectmore: Genral Program Overview

4.2 Statistical Orchestration

For each partial contained within a spectral separation, an instrument is chosen from a previously defined collection, contained within the Orchestra object, based upon a system of statistical weightings (Figure 4). These weightings are specified by user-defined criteria such as fixed instrumental properties and time-variant states of the instrumental texture. Each of the following static weightings relate to instrumental properties and can be more or less emphasized by a user-defined factor (0-9): the *choir weight*, a weighting based simply upon the choir to which the instrument belongs (i.e. strings, woodwinds, brass, percussion); and the *range weight*, the partial's relative distance from a 'sweet-spot' chosen for each instrument (default, the middle of the instrument's range). Time-variant weightings include functions relating to voice-leading and the control of overall density. A distance in semi-tones from the last note of each instrument determines the voice-leading weight while the duration from each instrument's last note is used to control density.

5. Music

Derivation V. for the S.E.M Ensemble is the first piece created using Spectmore and received its first performance on February 15, 2007 in Brooklyn, New York. The piece uses as its source material a recording of a busy street corner, Hollywood and Vine, located in Hollywood, California. The piece lasts approximately 11 minutes and consists of an instrumental texture, which moves from extremely sparse to moderately dense. Due to a concentration in low-frequency spectral energy, an ensemble of instruments with strong lower registers was chosen. While an adjustment could have easily “corrected” or equalized the spectral distribution, this unusual concentration of low-registral material seemed to bear an interesting relationship to similar observations about the city soundscape (most notably, see *Increased Bass Response in Music and the Soundscape,* Schafer, 1977).

6. Conclusion

Spectmore provides a robust interface for algorithmic, spectral composition. This software facilitates the kind of rapid prototyping and flexibility, which is integral to working with experimental configurations of algorithmic music, transcription, and spectral analysis.

6. References

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Appendix

A page from Derivation V. for the S.E.M. Ensemble,
G. Douglas Barrett, 2007