BUILDING AN NMF SOURCE SEPARATION TOOLBOX FOR MUSICAL AUDIO

MIDTERM REPORT

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# Abstract

Non-Negative Matrix Factorization (NMF) has proven to be an effective tool in source separation problems for musical audio. This report presents a MATLAB framework for source separation using NMF. Several related algorithms have been implemented and benchmarked, and the software is highly modular and extensible. We also present a discussion and timeline of future work, including score-aware implementations and public release as a MATLAB toolbox.

# Introduction

*Source Separation* is the name given to the problem of extracting a set of individual sound *sources* from one or several *mixtures*, where a mixture is a weighted sum of the sources whose weighting may change with time. Mixtures may be *Instantaneous* – affected only by the present values of the sources – or *convolutive* – affected by present and past values. In some cases, the problem can be exactly solved, in theory allowing perfect reconstruction of the source signals. There are inherent ambiguities, however, in *underdetermined* mixtures with more sources than mixture channels. Algorithms for this class of problems must make prior assumptions about the source signals, such as statistical independence, harmonicity, or sparseness under some frequency transform.

Applications of source separation algorithms are numerous and include noise reduction, speech enhancement and analysis of hyperspectral images [1]. In music, source separation can be used for *upmixing* mono to stereo or stereo to surround sound, and for *remastering* existing recordings – perhaps by extracting the sound of a single instrument, editing it, and replacing it in the mix. More exotic uses include automatic generation of karaoke backing tracks [2]. These applications often involve underdetermined mixtures while requiring high quality reconstruction, placing heavy demands on the source separation algorithm. Musical Source Separation is an area of active research.

This project aims to create a robust MATLAB framework for Source Separation of musical audio using Non-Negative Matrix Factorization (NMF), a technique which approximates the Short Time Fourier Transform (STFT) matrix of a mixture as a product of two non-negative matrices of much smaller rank. There are a range of possible NMF-based algorithms depending on the choice of approximation cost function and the application of various constraints. *Score-aware* approaches which incorporate information from a musical score will be a particular focus.

The goals of the project are as follows:

1. Produce a flexible software framework for source separation using NMF which can accommodate a wide range of algorithms
2. Produce a framework which is modular and trivially easy to extend, and therefore useful for other researchers
3. Implement a range of blind and score-aware source separation algorithms, and compare their performance using established benchmarks.
4. Distribute the project codebase online for free as a MATLAB toolbox

For these goals to be met, the code must be production quality throughout the codebase, with effective error handling, extensive documentation and commenting, and minimal coupling between modules. High performance, though desirable in the end product, is a secondary concern at present. Reproducibility of results is ensured by versioning and publicly releasing code, using publicly available datasets, and benchmarking with standard benchmarks. A detailed project plan and logbook have been maintained throughout and will be taken forward into the second half of the project.

This Report is structured as follows:

<blah blah>

# LITERATURE REVIEW