Activity 3. Compressive Sensing of Audio Signals

# Objective:

1. Apply compressive sensing on a recorded audio signal.
2. Use convex minimization solvers.

# Introduction

Recall that a signal **x** can be expressed as

**(1)**

where **y** is a basis and **s** is a sparse vector. For example **y** can be the discrete cosine transform bases. If we undersample **x** using a measurement matrix **C**, that is

**(2)**

we can recover **x**, given **y** and **Cy** by solving for **s** using minimization of the L1 norm of  **s** subject to Equation 2.

# Procedure:

1. Record a note from a musical instrument for 1 second. Let this be the high fidelity signal **x**. Let the number of samples from the original signal **x** be N**.** If the recording was done at 44,000Hz, 1 second will contain N = 44,000 samples. If you recorded using a cellphone, its sampling rate might be at 8192Hz.
2. Randomly pick 5% of your data **x** and store their values in variable **y** and their indices in **C**. Let M be the number of random samples.
3. Use the indices of **C** to pick the corresponding discrete cosine transform bases. You can form a DCT space **y** which is NxN, the rows correspond to the time axis, the columns are sinusoids of increasing frequencies. **C** picks out the columns of the DCT. Form these selected rows as an MxN matrix **F** .
4. Solve for the sparse vector **s** using L1 norm minimization of **s** subject to **.**
5. Given the solution **s**, reconstruct the signal **x** by multiplying **y** by **s**.

# References

Code and video from Steve Brunton’s book:

[About the Book | DATA DRIVEN SCIENCE & ENGINEERING (databookuw.com)](http://databookuw.com/)

CVX package for MATLAB

[CVX: Matlab Software for Disciplined Convex Programming | CVX Research, Inc.](http://cvxr.com/cvx/)