Online Detection of Unusual Events in Audio via Dynamic Sparse Coding

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1 Introduction

1.1 What is dictionary learning - Sean

foo

1.2 What is online learning - Sean

Why it can provide advantages over batch learning

1.3 Why we prefer sparsity - Sean

2 Methodology - Courtney to start

equations, formal statement of algorithm for online dictionary learning, probably similar to Mairal.

This is how to add a reference (Insert > Citation):[Mairal et al., 2009]

This is how to add an algorithm float. See LaTeX preamble for algpseudocode.

Algorithm 1 Fast Fourier Transform

function FFT($\mathbf{x}, n$)
  if $n = 1$ **then**
    return x
  else
    $\mathbf{x}^{\text{even}} \leftarrow \begin{bmatrix} x_0 & x_2 & \cdots & x_{n-2} \end{bmatrix}^{\mathsf{T}}$
    $\mathbf{v} \leftarrow \text{FFT}(\mathbf{x}^{\text{even}}, n/2)$
    $\mathbf{x}^{\text{odd}} \leftarrow \begin{bmatrix} x_1 & x_3 & \cdots & x_{n-1} \end{bmatrix}^{\mathsf{T}}$
    $\mathbf{w} \leftarrow \text{FFT}(\mathbf{x}^{\text{odd}}, n/2)$
    for $j \in \{0, 1, \ldots, n/2 - 1\}$ **do**
      $y_j \leftarrow v_j + \mathrm{e}^{-2\pi\iota \cdot j/n} \cdot w_j$
      $y_{j+n/2} \leftarrow v_j - \mathrm{e}^{-2\pi\iota \cdot j/n} \cdot w_j$
    end for
   return y
  end if
end function

2.1 Definition of unusual event / change point detection / whatever

algorithm for unusual event detection, probably similar to [Zhao et al., 2011]

3 Application - TBD after code done

3.1 Structure of an audio signal

why might we want to do online learning for an audio signal (consider a stream, or a huge data set, or whatever), but biggest idea is that online learning allows us to detect unusual events (if we learn on the whole data set, then possibly our dictionary will learn the unusual events, impeding our ability to identify them)

3.2 What kind of dictionary could we learn for an audio signal

maybe insert image of different waveforms, e.g., as in http://www.seaandsailor.com/dictlearning.html

3.3 Unusual event as applied to an audio signal

Change in meter, key change, whatever

3.4 Test case - Meredith/Sean

"Bohemian Rhapsody" WAV or whatever, walk through the code, include graphics, especially SSE/MSE whatever reconstruction, and map peaks in error to "events" (hopefully, unusual) in song

This is how to add a Python 3 code chunk. knitr does not support Python plotting out of the box, but fortunately the knitron package makes it possible:

https://github.com/fhirschmann/knitron

Follow the instructions there to set it up, then load the package in hidden chunk.

```
## Error in library(knitron):  there is no package called 'knitron'
```

We are now ready to run some Python code. Notice chunk option engine = 'ipython'. You'll need to install scipy, matplotlib, and numpy, which can be done with pip3 install scipy, matplotlib (numpy is a scipy dependency).

```
# knitron already imports matplotlib for us
# import matplotlib.pyplot as plt
import scipy as sc
import numpy as np

# Load signal used to build the dictionary
from scipy.io import wavfile

import os
fs, data = wavfile.read("03 Shot In The Back Of The Head.wav")
data = data / 2.0**15
print(data.shape)

plt.rcParams.update({'font.size': 10})

plt.plot(data[0:fs*5])
```

4 Discussion - TBD

how did the algorithm perform, how could it be extended

References

[Mairal et al., 2009] Mairal, J., Bach, F., Ponce, J., and Sapiro, G. (2009). Online dictionary learning for sparse coding. In *Proceedings of the 26th Annual International Conference on Machine Learning - ICML '09*, pages 689–696, New York, New York, USA. ACM Press.

[Zhao et al., 2011] Zhao, B., Fei-Fei, L., and Xing, E. P. (2011). Online detection of unusual events in videos via dynamic sparse coding. In *CVPR 2011*, pages 3313–3320. IEEE.