USC Viterbi School of Engineering

Ming Hsieh Department of Electrical Engineering

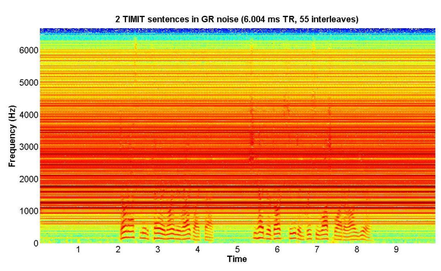
A Two-step Technique for MRI Audio Enhancement Using Dictionary Learning and Wavelet Packet Analysis

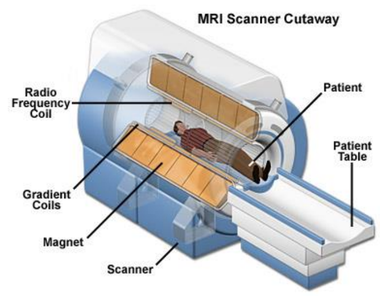
Colin Vaz, Vikram Ramanarayanan, Shrikanth Narayanan

Ming Hsieh Department of Electrical Engineering

Motivation

- MRI provides a non-invasive method for imaging the vocal tract.
- **Problem**: MRI scanners produce high-energy broadband noise.

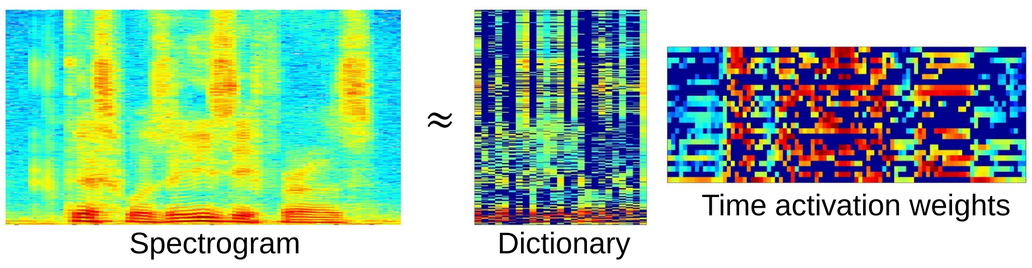




Approach

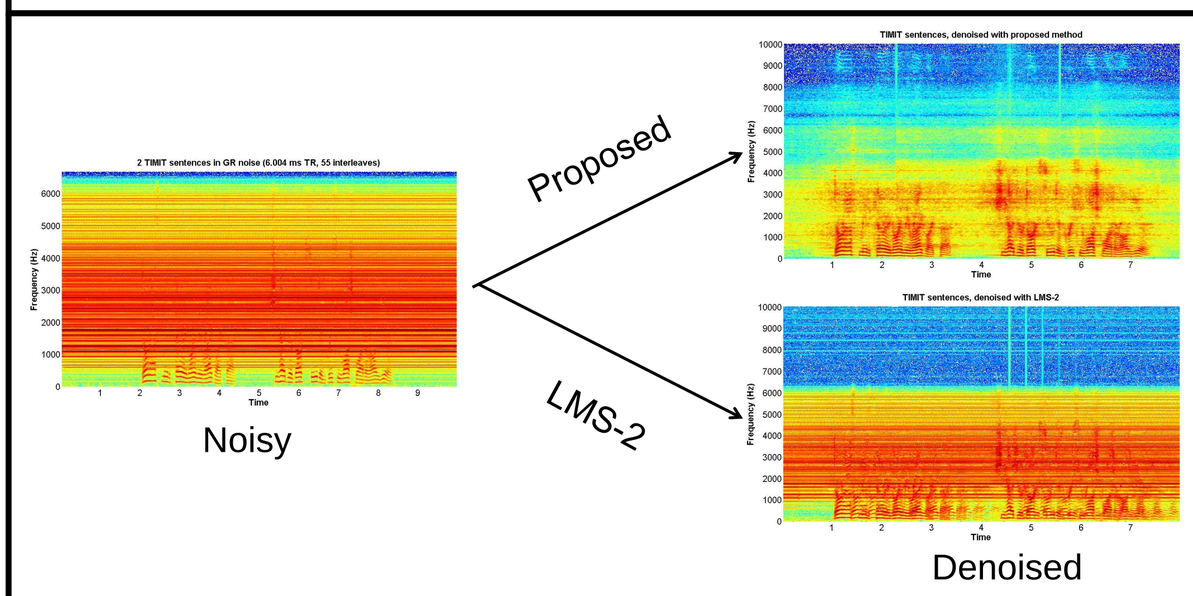
Noisy signal → PLCA → Wavelets → Denoised signal

- Dictionary learning with non-negative matrix factorization (NMF).



  - Separate speech and MRI noise.
- Further signal denoising with wavelets.
  - Analyze signal subbands and reduce noise in noisy subbands.

TIMIT Results

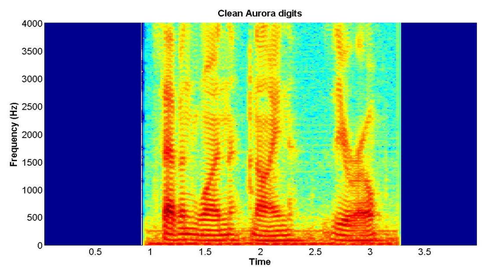


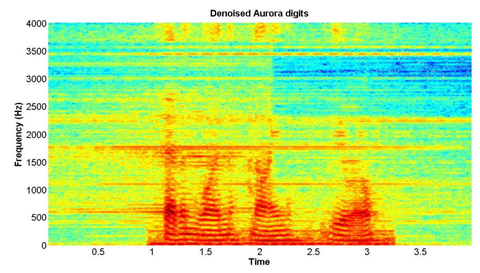
Noise suppression (dB) results

	Proposed	LMS-1	LMS-2
seq1	19.27	18.01	18.79
GR	24.1	18.37	9.17

Aurora Digits Results

- Added MRI noise to clean spoken digits.
- Allows comparison between clean and denoised speech.





Metric	Sequence	Proposed	LMS-1	LMS-2
Noise suppression (dB)	seq1	30.23	32.55	26.53
	GR	24.14	27.88	10.91
LLR	seq1	0.17	0.4	0.42
	GR	0.11	0.41	0.33
Distortion variance ($\times 10^{-5}$)	seq1	7.52	34.8	21.4
	GR	9.56	35.8	37.7

Listening Test Results

- Presented sets of TIMIT sentences and Aurora digits to listeners.
- Each set contained a noisy audio clip, 3 denoised versions, and a clean version for Aurora.
- Listeners ranked each clip within a set from 1 (best) to 4 or 5 (worst).

Environment	Sequence	Algorithm				
		Clean	Proposed	LMS-1	LMS-2	Noisy
TIMIT	seq1		2	3	1	4
	GR		1	2	3	4
Aurora	seq1	1	3	4	2	5
	GR	1	2	3	4	5

Discussion & Future Work

- Achieved 24 dB noise reduction.
- Low speech distortion: key for speech analysis.
- Improve MRI noise modeling.
- Use time regularization in NMF.
- Implement real-time denoising algorithm.
- Extend idea beyond MRI.

We would like to acknowledge the support of NIH Grant DC007124.

Ming Hsieh Institute

Ming Hsieh Department of Electrical Engineering