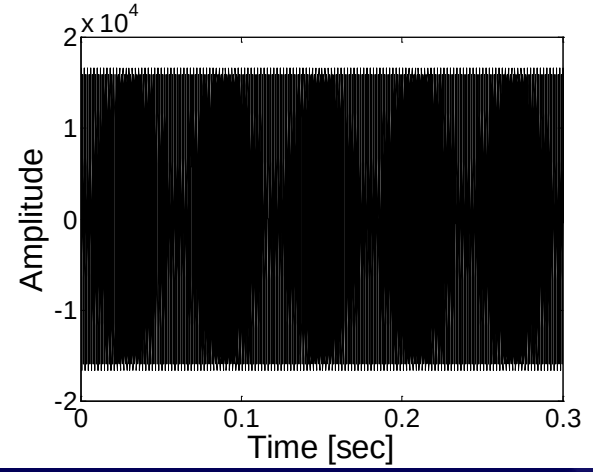

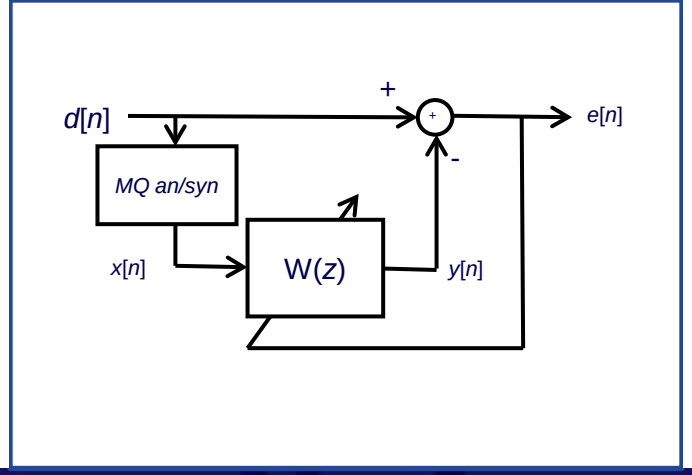

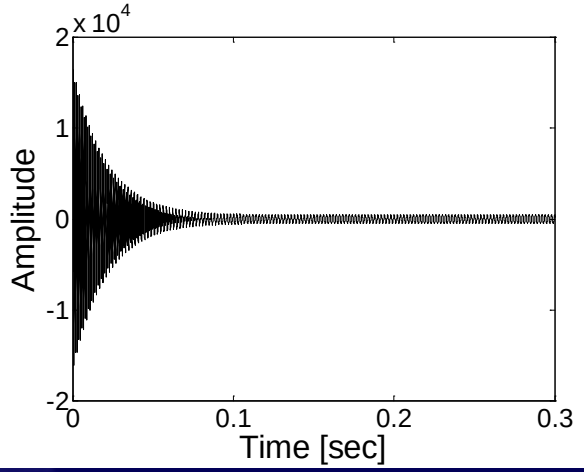

A method for enhancement of background sounds in forensic audio recordings

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The Problem: Sound Mixture

- Mono recording containing a mixture of high-level foreground sound + low-level background sound
- Background sound is of interest for an investigation
- *Can we improve the audibility and intelligibility of the background sound?*

The Idea: differential noise reduction

- Model the loud foreground sound alone
- Synthesize “noise reduced” foreground signal
- Subtract synthesized signal from the original

  (…*cross fingers*…)
- Residual should be desired background signal

Outline

- Introduction
  - Audio forensic analysis
  - Adaptive interference cancelling
  - Sinusoidal modeling
- Test implementation
- Example processing
- Conclusion

Audio Forensics

- Audio Forensics is the field of forensic science relating to the acquisition, analysis, and evaluation of sound recordings that may ultimately be presented in court or some official venue.
- Primary forensic concerns:
  i. *authenticity*
  ii. *enhancement*
  iii. *interpretation and documentation*

Forensic Enhancement

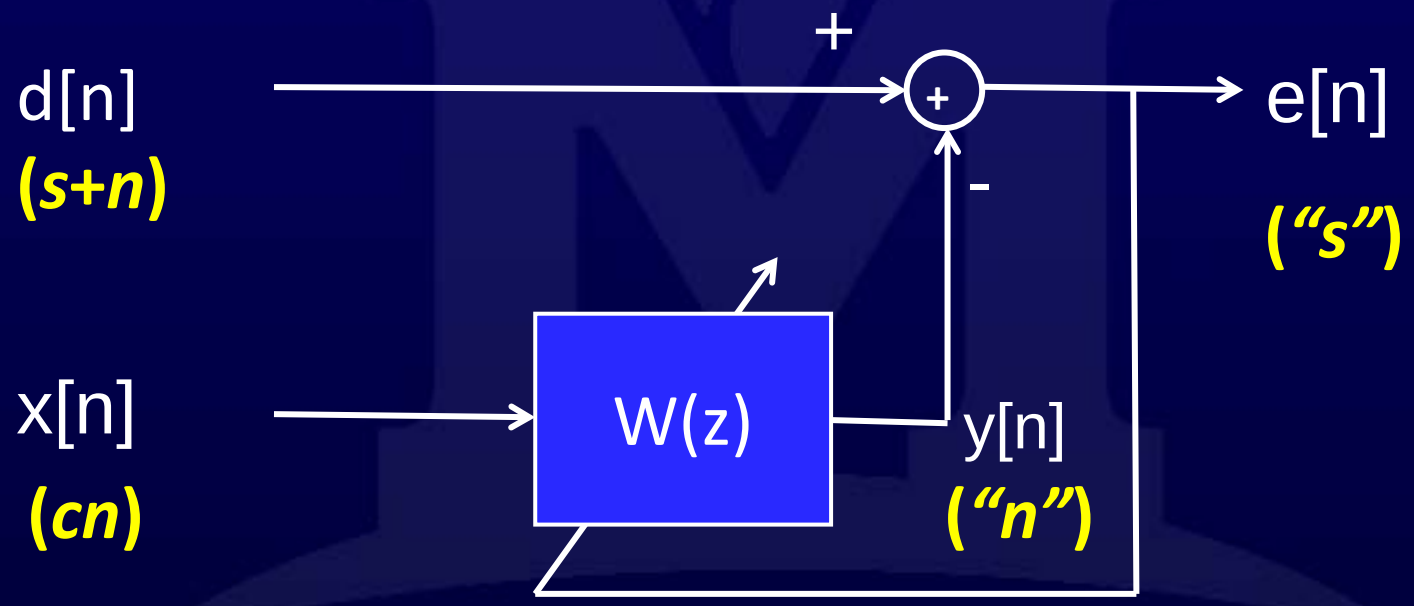
- Improve speech intelligibility
- Improve audibility of subtle sounds
- Recognize tell-tale sonic attributes

- Example: *The Fugitive* (1993)

The More Common Situation in Chicago…

- Emergency call center excerpt… 

Adaptive Interference Cancellation



AIC Formulation

- Concept good, but *two inputs* required
  - We have mono audio forensic recording
- Derive or “invent” the second signal?

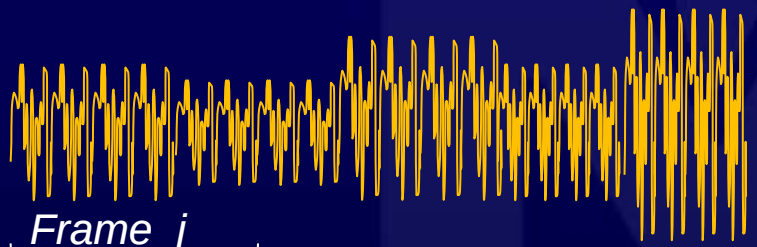
- Plan:
  - Model strong foreground signal as “*cn*”
  - Use mono forensic recording as “*s*+*n*” (weak background *s*, strong foreground *n*)

Strong Foreground Model

- Model the strong signal using sinusoidal analysis (McAulay – Quatieri method)
- For MQ analysis, adjust threshold to pass the strong signal but ignore the weak background material

MQ Procedure

Input Signal:



…

Frame j

Frame j+1

Frame j+2

Frame j+3

…etc…

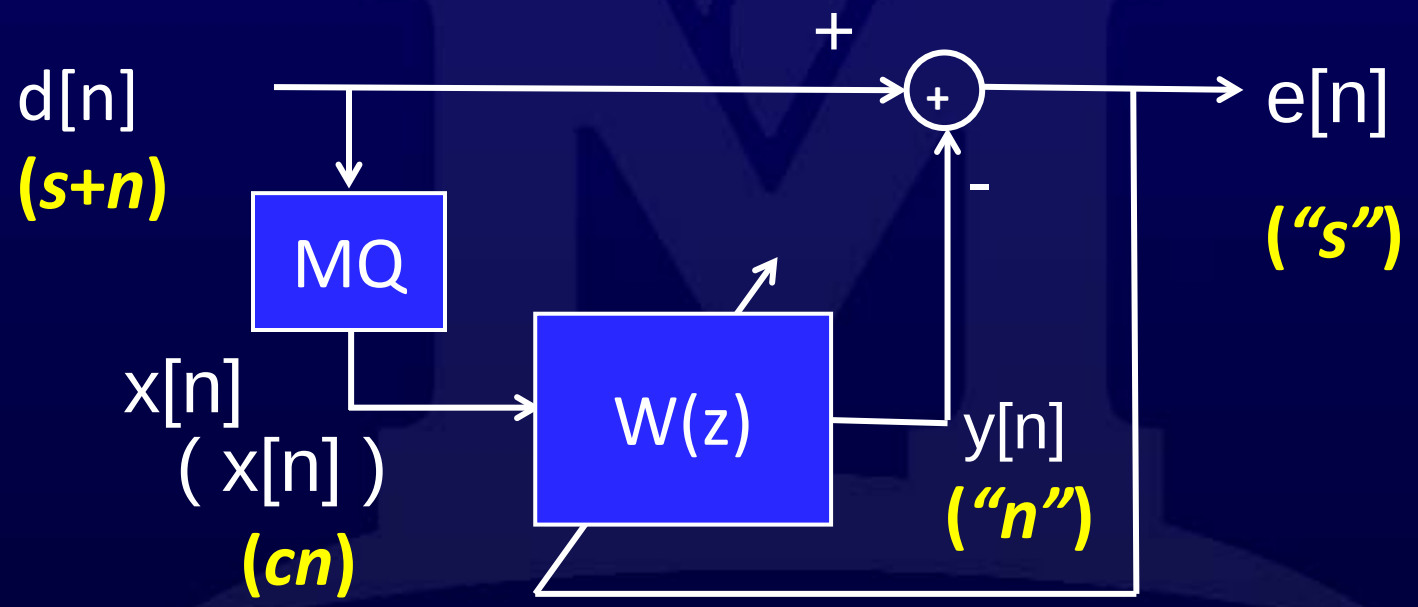
For each frame:

Window, zero-pad, FFT magnitude

Identify spectral "peaks"

Calculate magnitude, frequency, and phase for each peak

AIC-combined Procedure



Test Examples

- 1kHz + weak 500 Hz
- MQ synthesis with threshold
- Adaptive canceller output
- TouchTone on Speech
- MQ synthesis with threshold
- Adaptive canceller output

Case Example

- Original recording
- MQ synthesis with threshold
- Processed output (+20dB)



Conclusions

- Adaptive modeling and foreground interference cancellation can work:
  - Temporal and spectral overlap issues
  - Adaptation rate and modeling issues
- Further work needed to refine the foreground model approach
- Pristine recordings are unlikely in most practical audio forensic scenarios

Thank you for your attention.

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