Laser Induced Fluorescence Imaging using Adaptive Filtering

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Overview

- Introduction of the problem
- Discussion of the physics involved
- Simulation of input signal
- Analysis of this input signal using single input adaptive filter
- Analysis of the results of the filter
- Performance of uranium detection system
- Conclusions and future work

Uranium Contaminated Materials

- Buildings and equipment used in nuclear powered electricity generation plants
- Contaminated by several different compounds of uranium
- Several uranium oxides; UO_2,U_3O_8,U_4O_9, UO_3
- Uranium nitride; UN_2
- Each compound has unique spectral properties

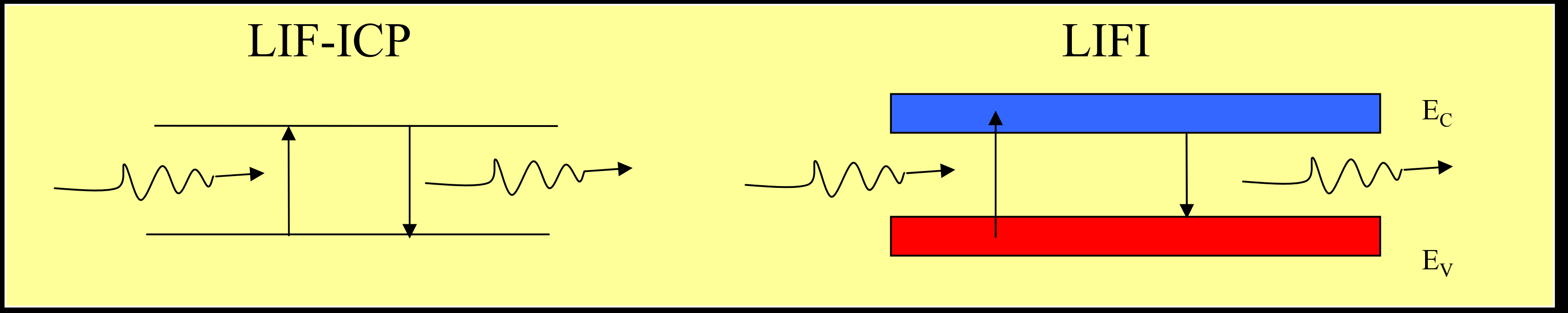
Traditional Analysis

- Take swaps and chemically analyze
- Exposes workers to radiation
- Takes several days to get results
- Creates more contaminated material
- Also, contaminates chemical analysis equipment

LIFI Imaging

- Laser Induced Fluorescence Imaging
- Can be done using a robot, no addition risk to workers
- Is remote, no additional contamination
- Can provide instant results

LIFI vs. LIF-ICP



- In LIF-ICP the wavelength of the laser excitation must match a particular molecular transition
- In LIFI several different laser wavelengths can be used for excitation
- In LIFI several wavelengths can be used by the detector for different compounds
- This provides several channels of data from the scanner as inputs to the filtering system

Sources of Noise in LIFI

- Laser pulse-to-pulse power variation (statistical)
- Variation in the interaction between the laser beam and compounds (statistical)
- Detector performance variation (statistical)
- Variation of background material (causal)

Simulation of input signal

- The input signal for the system has been simulated and its general expression can be give by,

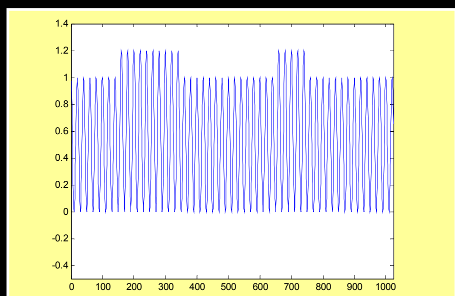
Input Signal = Background + Noise + Template

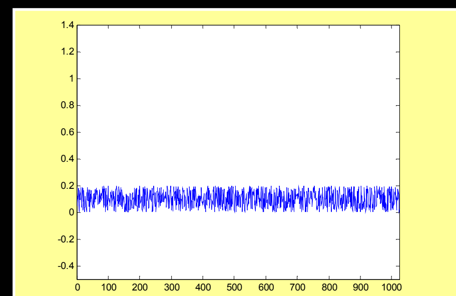
- The signal coming out of the scanner has varying amplitudes

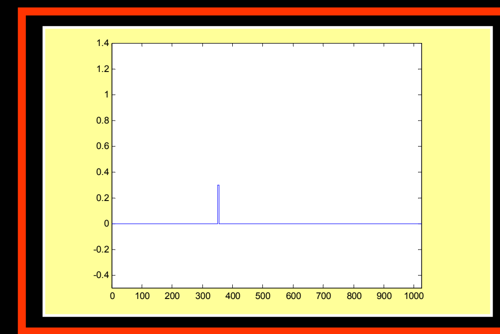
- This is due to the roughness of the wall and also due to different composition of material at various points in the wall

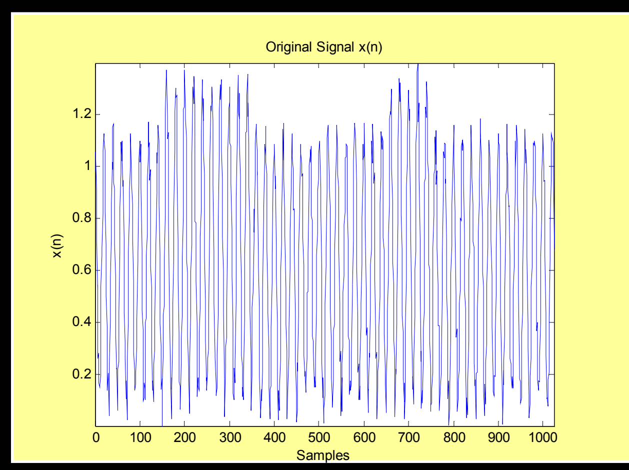
Simulation of input signal (Contd.)

x(n) = cos2 (2*pi*500*0.00005*x) + 0.2*rand(1,1024) + 0.3*ones (1,5)

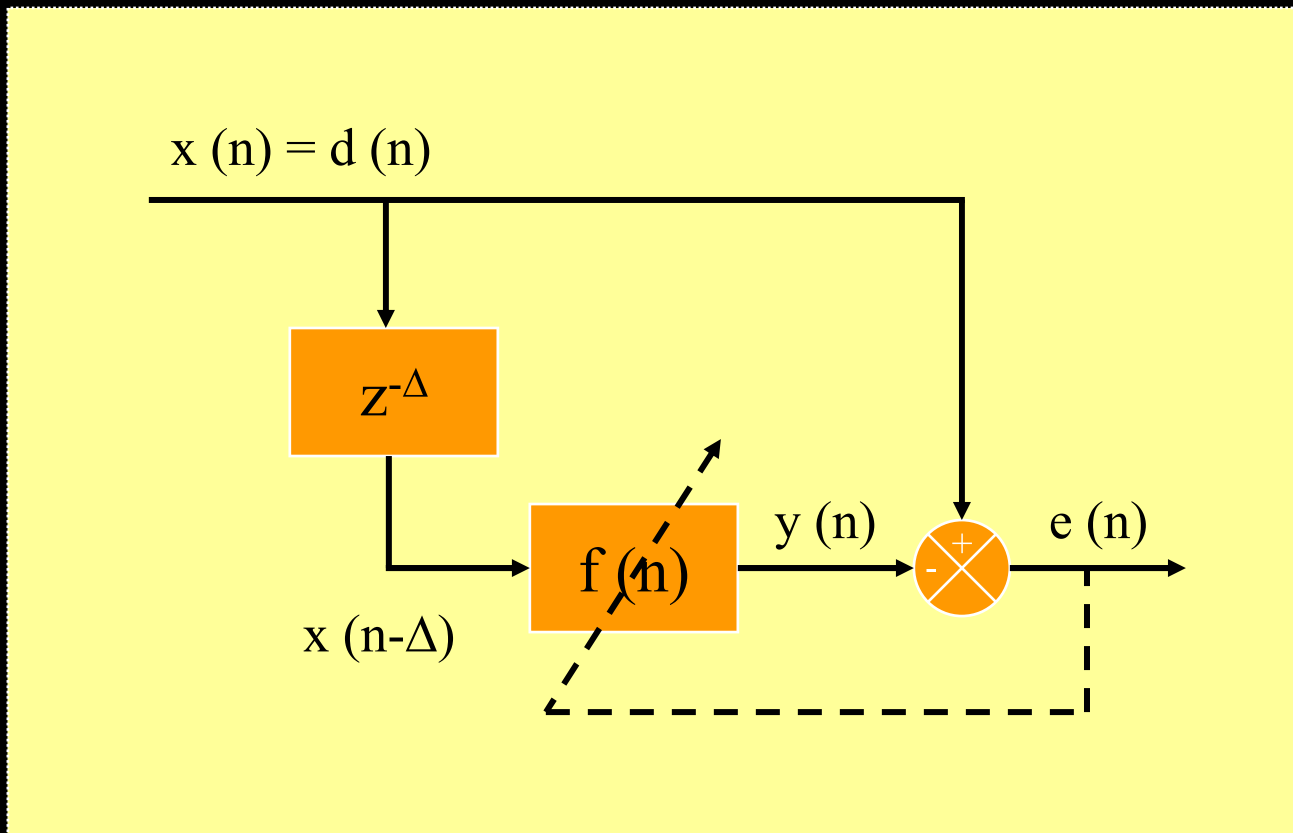








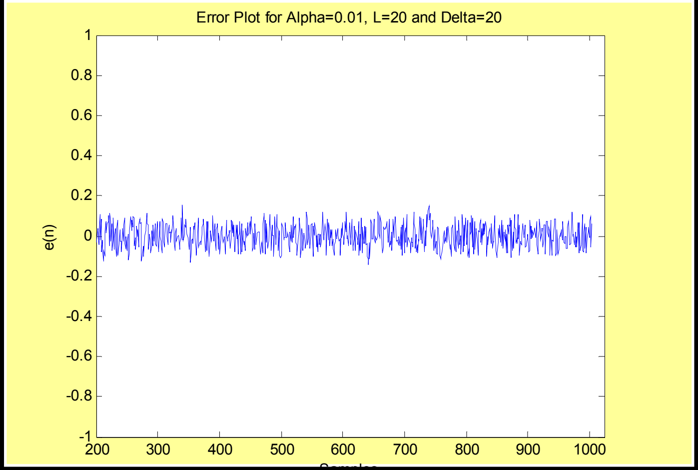
Single input adaptive filter: Block Diagram

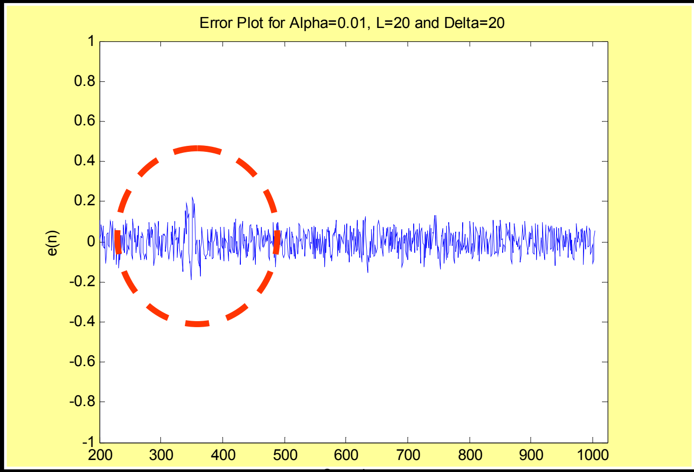


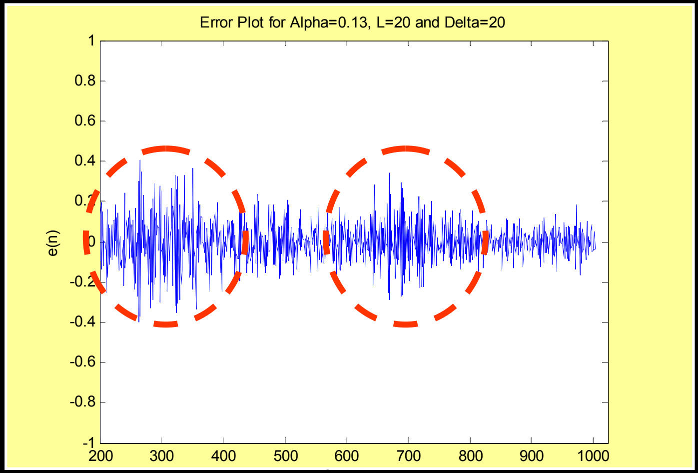
Single input adaptive filter: Algorithm

- Initialize adaptation constant α & filter coefficients:
  - » $f_0 = 0$
- Define input vector x (n) and delay it by Δ, i.e. x (n- Δ)
- Compute output vector as:
  - » $y(n) = f_n^t x_{n-\Delta}$
- Compute error vector as:
  - » $e(n) = d(n) - y(n)$
- Update filter coefficients:
  - » $f_{n+1} = f_n + \alpha e(n) x_{n-\Delta}$

Results & Discussion







Results & Discussion (Contd.)

α	**MSE**	**Uranium**
0.01	0.0140093652476	Absent
0.01	0.0149763423956	Present & detected correctly
0.13	0.0303293418513	Present with false alarms

Performance of Uranium Detector

- Several channels of data available from scanner
- Variations in the material background will effect only one channel at a time
- A positive output from at least two channels will be required to signify the presence of uranium
- False positives from one channel will be ignored unless it occurs simultaneously with a false positive from another channel

Conclusion

- Reviewed the physics involved in LIFI of uranium
- Chose a suitable filtering technique
- Analyzed performance of the filter
- Analyzed the performance of the LIFI uranium detection system using the filter

Future Work

- Test filter using additional simulated data
- Obtain actual data from LIFI system to test filtering technique
- Comparison of additional filtering techniques

References

- DiBenedetto, J., Abbott, R., Capelle, G., Chavez, G., Lutz, S. and Tesar J., Proceeding of Air and waste Management Association, 1995.

- Dimarcq, V., Giordano, P., Cerez, P., Statistical properties of laser-induced fluorescence signals, Applied Physics B, Vol 59, 135-145 (1994).

- Clarkson,C. M., *Optimal and Adaptive Signal Processing*, Boca Raton: CRC Press, 1993.

- ECE-8423: Class notes

Questions & Answers