

SUMMER INSTITUTE AT UIUC

Hunerkada Session

LUMS School of Science and Engineering

Presentation by:

Umer Hassan

August 13, 2010

Venue:

Conference Room

SSE Bld, 2nd Floor

BSBA summer institute



National Science Council (NSC) of Taiwan, together with U.S National Science Foundation (NSF), conducted a summer school from 12-23 July, 2010 at the University of Illinois at Urbana Champaign (UIUC), USA. The school was based on “Biosensing and Bioactuation”.

Inspiration of BSBA-SI

The inspiration behind summer institute is to develop new research frontiers that will profoundly impact both engineering and biological sciences in the areas of sensing and actuation.

It was a multidisciplinary institute which brought people from engineering, biology, chemistry, material science and others.

Participating research centers

- ▣ Micro and Nanotechnology Laboratory (MNTL),
- ▣ Center for Nanoscale Science and Technology (CNST),
- ▣ Center for Cellular Mechanics (CCM),
- ▣ Siteman Center for Cancer Nanotechnology Excellence,
- ▣ Department of Mechanical Science and Engineering (MechSE),
- ▣ Department of Agricultural Sciences.

Participants

- ▣ There were about 50 participants; most of them were graduate students and young faculty members from National Taiwan University and various US Universities.
- ▣ Most of them came from an engineering background (electrical and mechanical engineering), but there were also some from diverse fields cellular biology, biochemistry, and physical chemistry.

Lecture Program

- ▣ The Summer institute arranged a series of stunning lectures given by distinguished professors from around the US including UIUC, MIT, Berkeley, North Western, Purdue and UC Merced.
- ▣ Everyday, before lunch-time, three lectures were held on various topics of Biology and Engineering.

Laboratory Modules

- ▣ Cellular Biology lab module
- ▣ Agricultural Lab module
- ▣ Enabling Technologies lab
- ▣ Micro and Nano Fabrication lab module

Cellular Biology lab module

- ▣ Learned Aseptic techniques
- ▣ transfected the cells with green fluorescent proteins
- ▣ Pipettors, culture dishes, pipettes biosafety cabinets, incubators

Agricultural Lab module

- ▣ Measured chlorophyll in the field
- ▣ Fractal analysis to do corn root analysis
- ▣ Corn Stalk Counter

Enabling Technologies lab

- ▣ Polydimethylsiloxane (PDMS) device fabrication. It is widely used silicon based organic polymer used in many applications ranging from medical devices to lubricating oils.
- ▣ We develop the PDMS devices

Micro and Nano Fabrication lab module

- ▣ Experiment 1: Lithography
- ▣ Experiment 2: Deposition
- ▣ Experiment 3: Dry Etching
- ▣ Experiment 4: Inspection

Poster session

- All participants presented a poster of their work. I gave a short presentation of my poster before the poster session.

Reducing Noise by Repetition: Introduction to Signal Averaging

Umer Hassan

Lab. Engineer & Instructor
LUMS School of Science & Engineering

Publication

Umer Hassan, M. Sabieh Anwar, "Reducing Noise by Repetition: Introduction to Signal Averaging", Eur. J. Phys. 31, 453-465, 2010.

What's the need?

Small Scale signals are usually swamped by undesired noise. This is evident in many areas, e.g.

1. Nanotechnology, e.g. measuring resistance of a gold Nano wire.
2. NMR spectroscopy when the spectral peaks from carbon-13 nuclei are too small.
3. Biomedical or Physiological signals e.g. ECG, Pulse Oximetry, EEG are embedded with noise.

Solution to Problem

1. Acquire signal for longer duration or repetitions
2. Perform Base line correction i.e. removing offset voltages.
3. Finally, averaging the repetitions

An Averaging Process

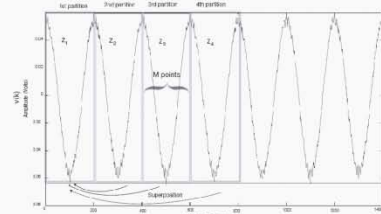
Consider $v(k)$ is the contaminated signal. Mathematically,
 $v(k) = v_s(k) + v_{noise}(k)$,
where

$v_s(k)$ being the desired periodic signal
 $v_{noise}(k)$ the unwanted noise

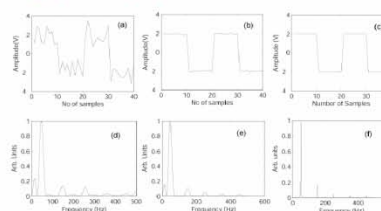
Recipe:

Signal averaging is performed by accumulating and partitioning $v(k)$, and adding the partitions with the hope that the noise adds destructively while the desired signal builds up.

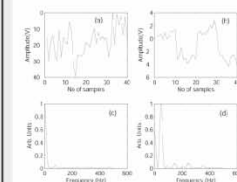
Averaging Explained....



Averaging of Noisy Square Wave for 400 scans

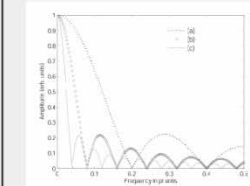


Averaging of pink noise



Averaging as a digital filter

For 10, 25 and 50 Scans



Mathematical description...

$$g(k) = \frac{\sum_{n=1}^N z_n(k)}{N}$$

$$h(k) = \frac{\sum_{n=1}^N \delta_n(k)}{N}$$

$$h(k) = \delta(0) + \delta(M) + \delta(2M) + \dots + \delta(M(N-1))$$

$$H(e^{j\omega}) = \frac{1 + e^{-j\omega M} + e^{-j\omega 2M} + \dots + e^{-j\omega M(N-1)}}{N}$$

$$= \frac{1}{N} \left(\frac{1 - e^{-j\omega MN}}{1 - e^{-j\omega M}} \right)$$

Effect of averaging on the autocorrelation

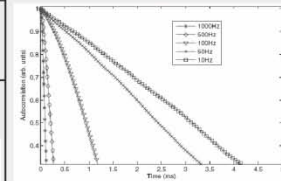
$$G(l) = \frac{1}{M} \sum_{k=1}^M v(k)v(l+k)$$

$$= \frac{1}{M} \sum_{k=1}^M (v_s(k) + v_{noise}(k))(v_s(l+k) + v_{noise}(l+k))$$

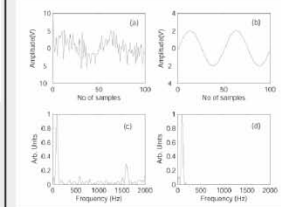
$$\sum_{k=1}^M v_{noise}(k)v_s(l+k) \text{ and } \sum_{k=1}^M v_s(k)v_{noise}(l+k) \text{ will be zero}$$

$$G(l) = \frac{1}{M} \left[\sum_{k=1}^M v_s(k)v_s(l+k) + \sum_{k=1}^M v_{noise}(k)v_{noise}(l+k) \right]$$

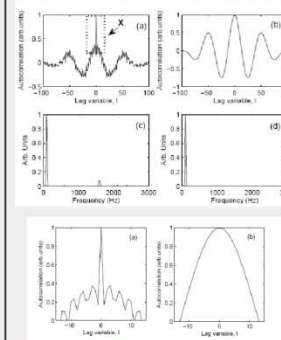
Normalized autocorrelation plot for different cut-off frequencies of Gaussian



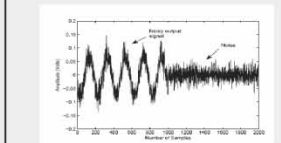
Averaging with 1000 repetitions Frequency 100 Hz



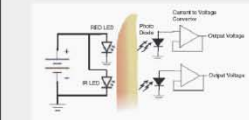
Effect of Averaging on autocorrelation...



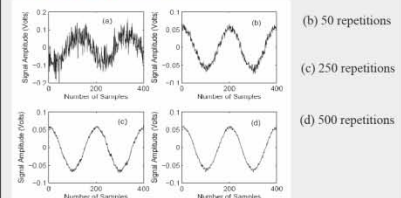
Identifying Signal and Noise



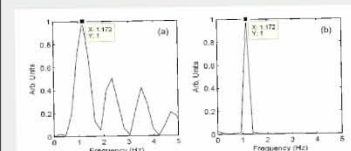
Experimental Setup for Pulse Oximetry



Averaging Results

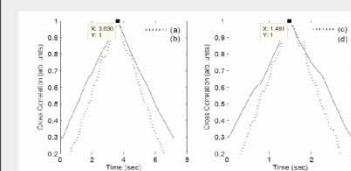


Effect of averaging on the frequency spectrum

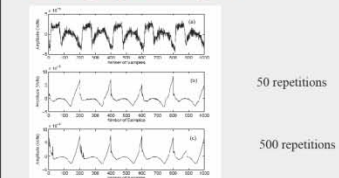


Using correlation data for estimating blood flow velocity

$$S(l) = (1/M) \sum_{n=1}^M f(n) g(l+n)$$



Averaging ECG Signal



Excursion Trip to Chicago

- ▣ Field Museum
- ▣ Millennium Park
- ▣ John Hancock Observatory
- ▣ Navy Pier

Some pictures

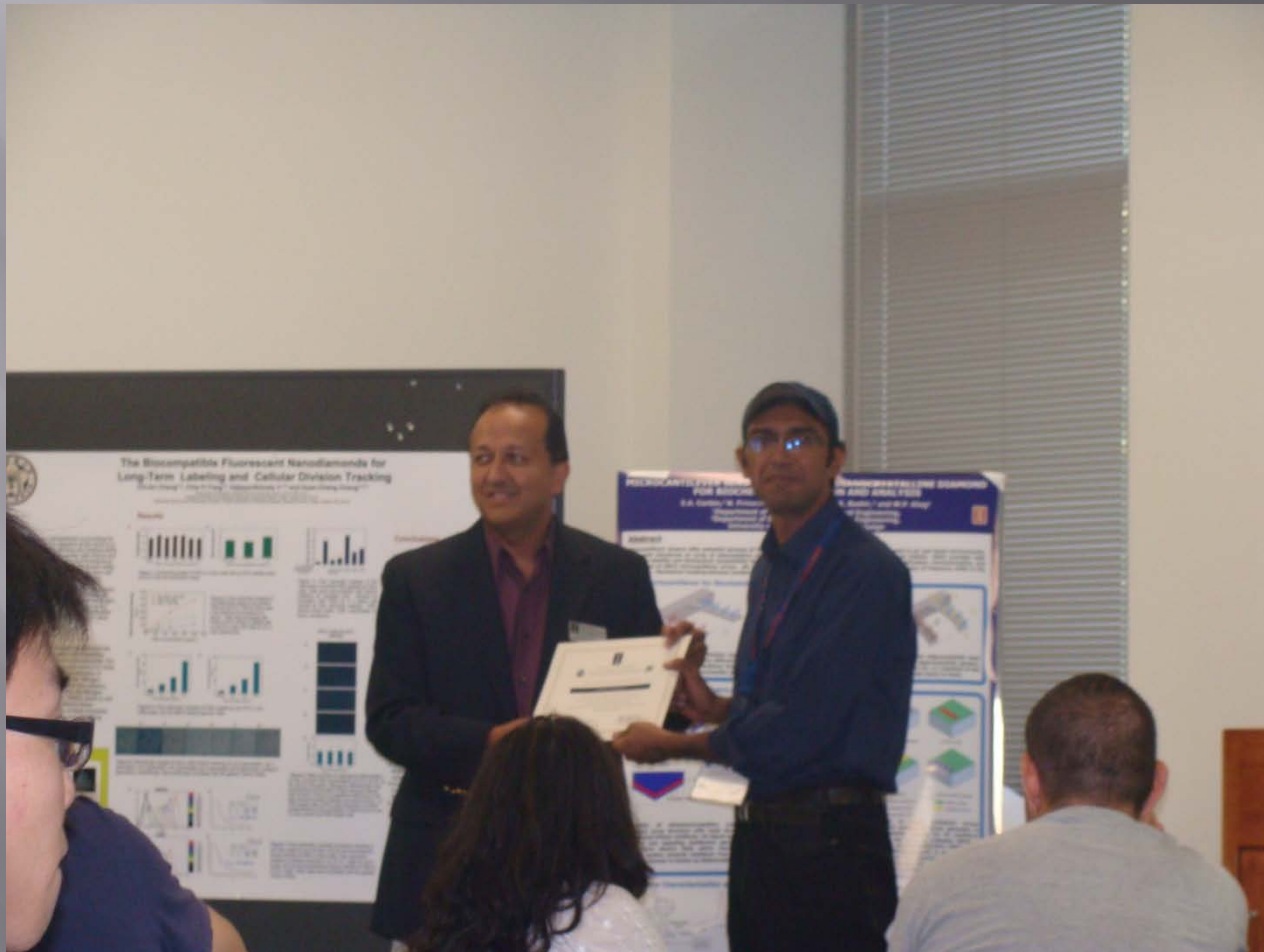


Group Presentation

I was selected as a leader of my group and gave a final presentation at graduation ceremony



Graduation Ceremony



It was a great trip

Thanks