




Biomedical Signals Processing & Analysis ^①

Konstantinos P. Michmizos, PhD

What this Course will not cover

 Equations

 Definitions

 Theorems

What this Course will try to cover



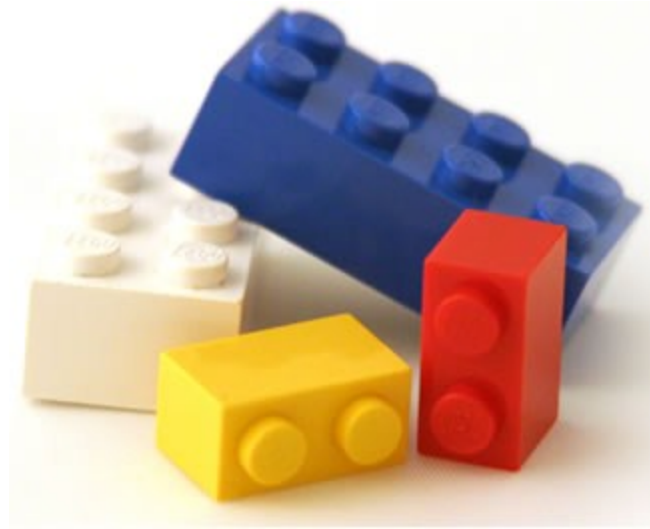
Start from simple blocks



Build the insight

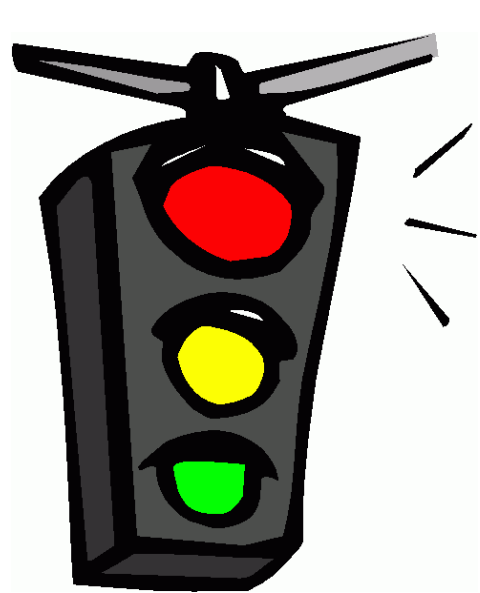


Connect with applications



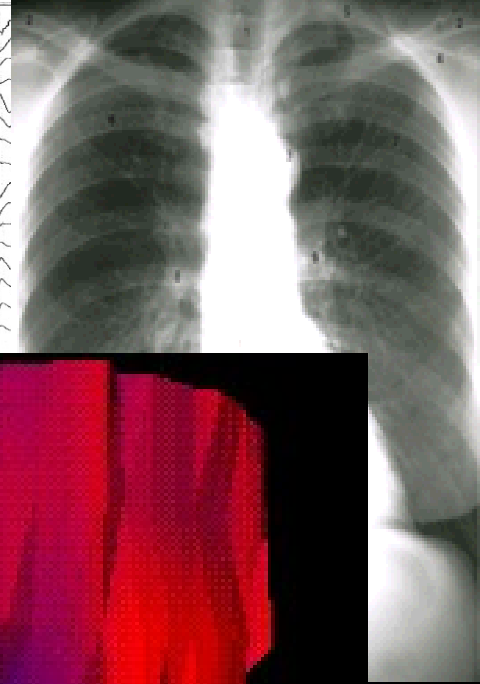
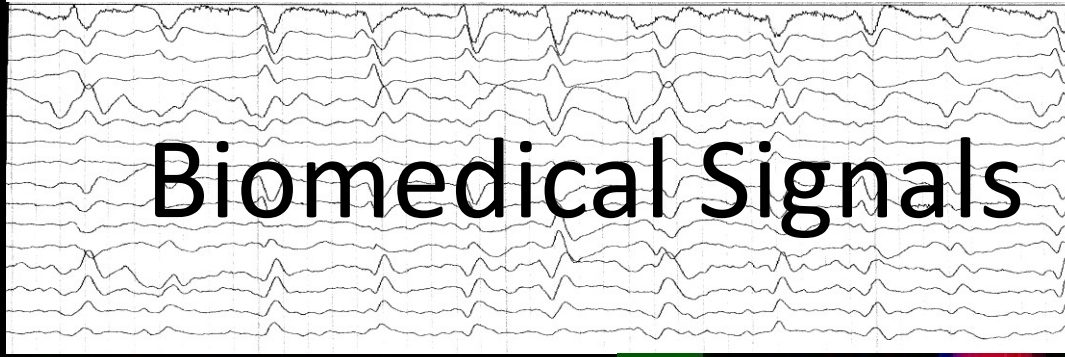
Selection of Interictal and Ictal Epileptiform Signals

All data processing and subsequent computational analyses were performed using MATLAB 7.7 (The MathWorks, Inc.). To increase computational efficiency, raw epileptiform signals were down-sampled to 1 kHz. For experiments using intact mouse hippocampal tissue,

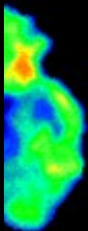
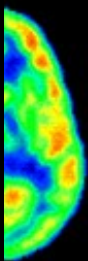
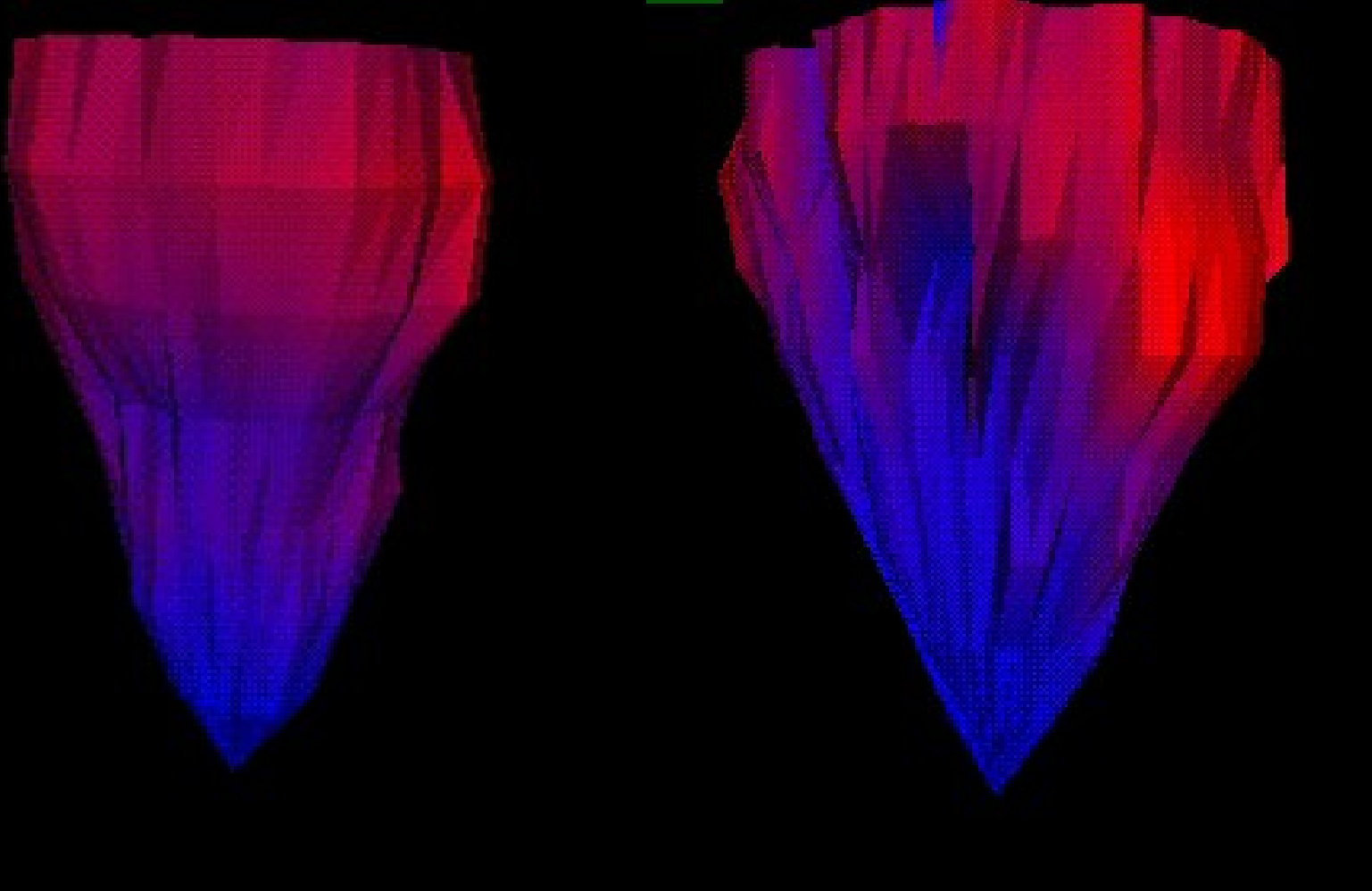


What is a Signal?





Biomedical Signals

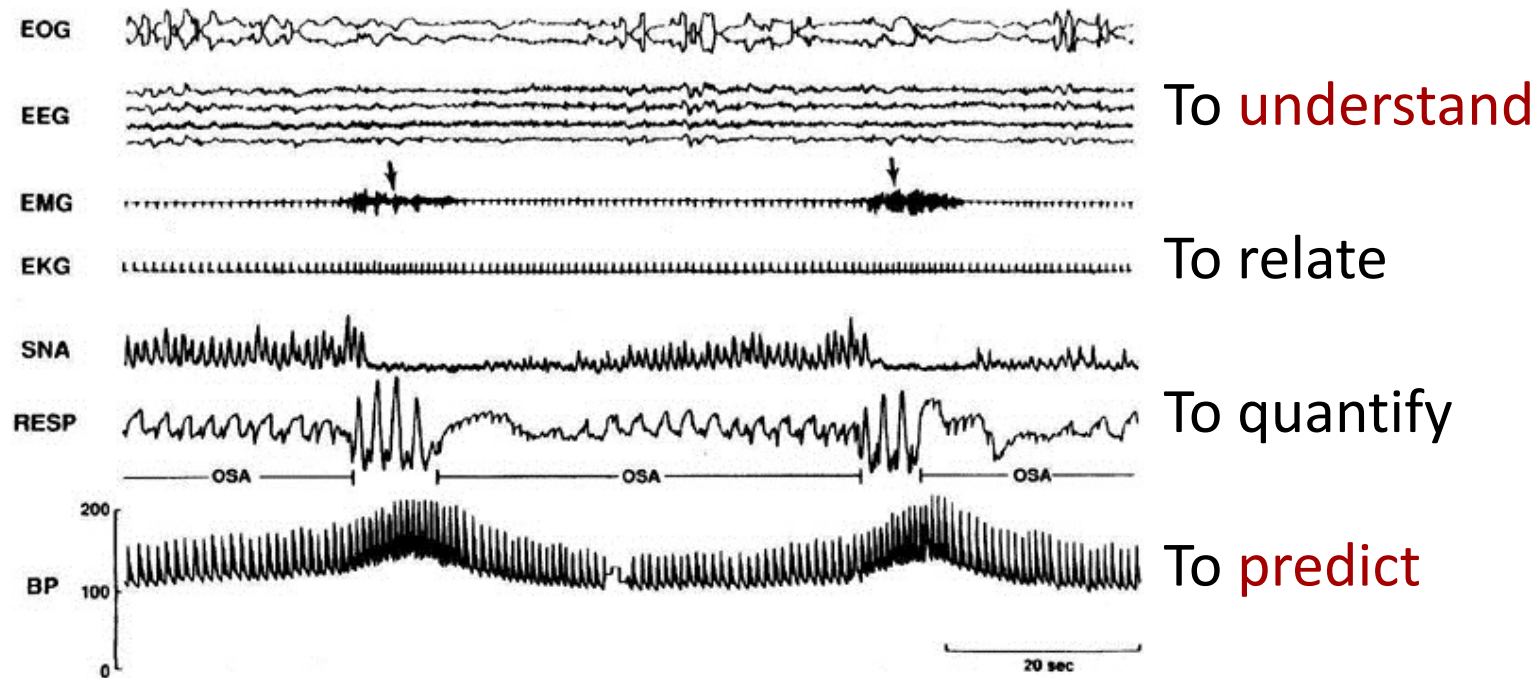




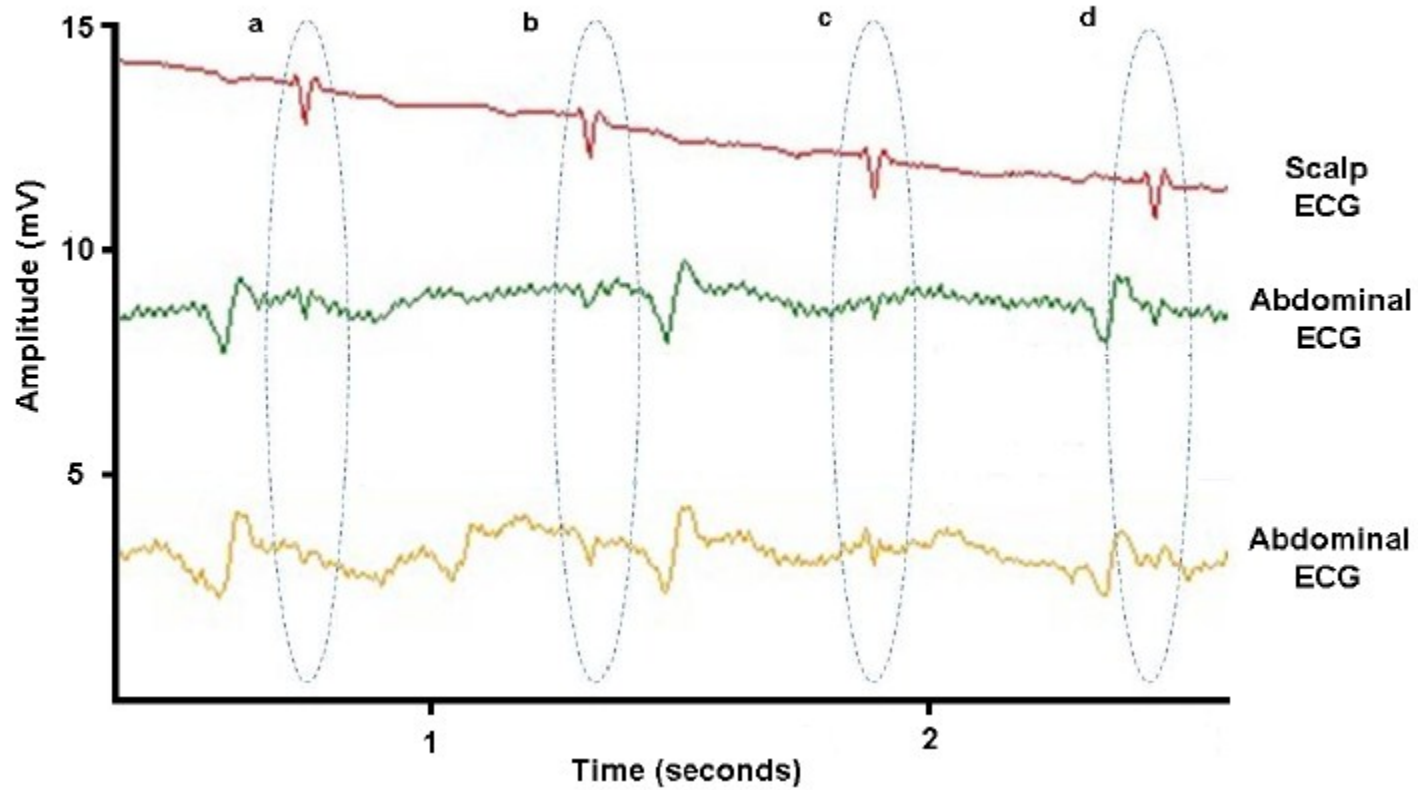
DE
LAUSCULTATION
MÉDIATE
ou
TRAITÉ DU DIAGNOSTIC DES MALADES
DES POUMONS ET DE CŒUR,
FONDÉ PRINCIPALEMENT SUR CE NOUVEAU
MODE D'ÉCOUTATION.
PAR R. T. H. LAENNEC,
D. M. P., Médecin de l'Hôpital Necker, Membre honoraire
des Sociétés de Médecine, Membre de la Société de la Faculté de
Médecine de Paris et de plusieurs autres sociétés nationales
et étrangères.
Mise au jour d'après les épreuves
de l'édition originale.
Troisième édition, en 3 tomes, avec
un grand nombre de planches, gravées
sur bois.
TOME, PREMIER.
A PARIS,
Chez J.-A. ROSSIGNOL et J.-S. CRAUPEL, Libraires,
rue de la Harpe, n° 22.
1819.

Purpose of Signal Analysis

To extract some qualitative or quantitative **information** about the physiological process under observation.

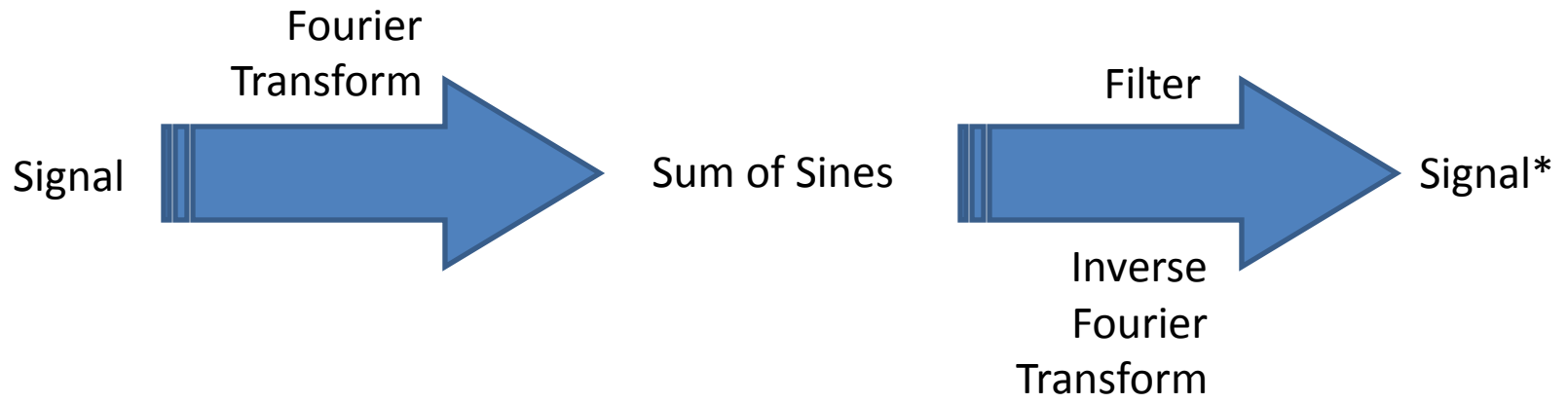
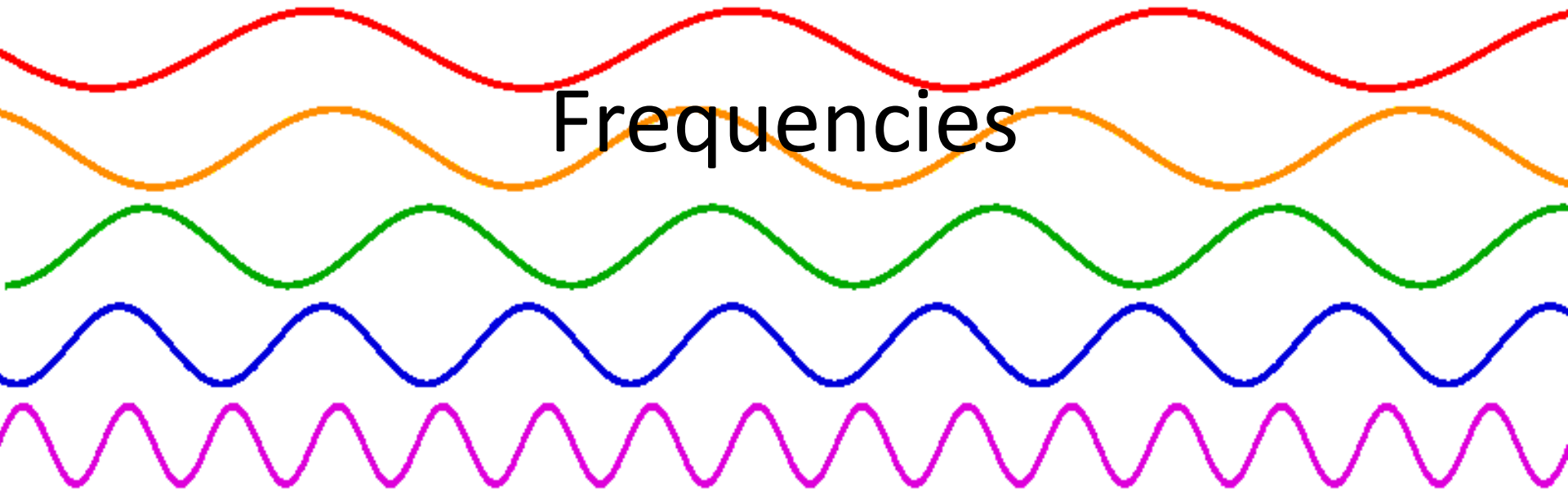


Noise



(Fetal ECG adapted by Sameni and Clifford, 2010)

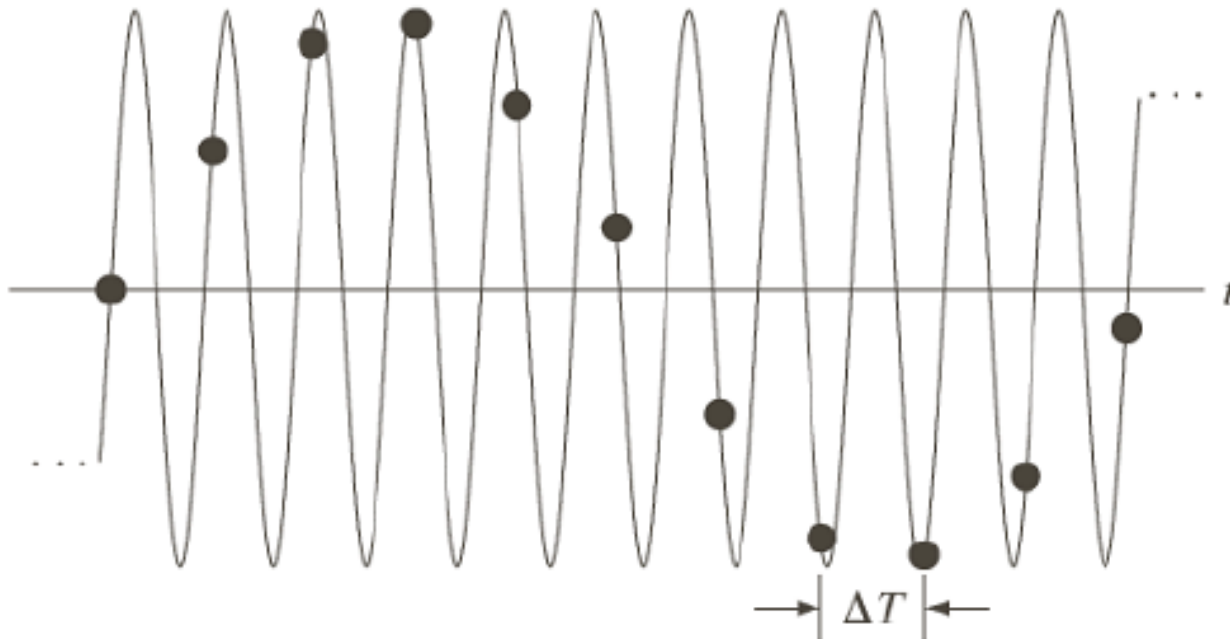
Frequencies



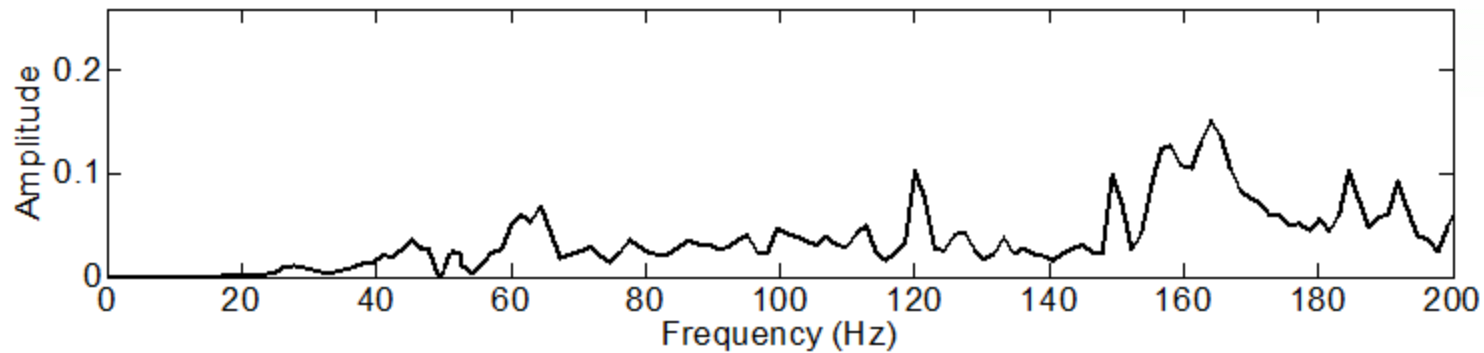
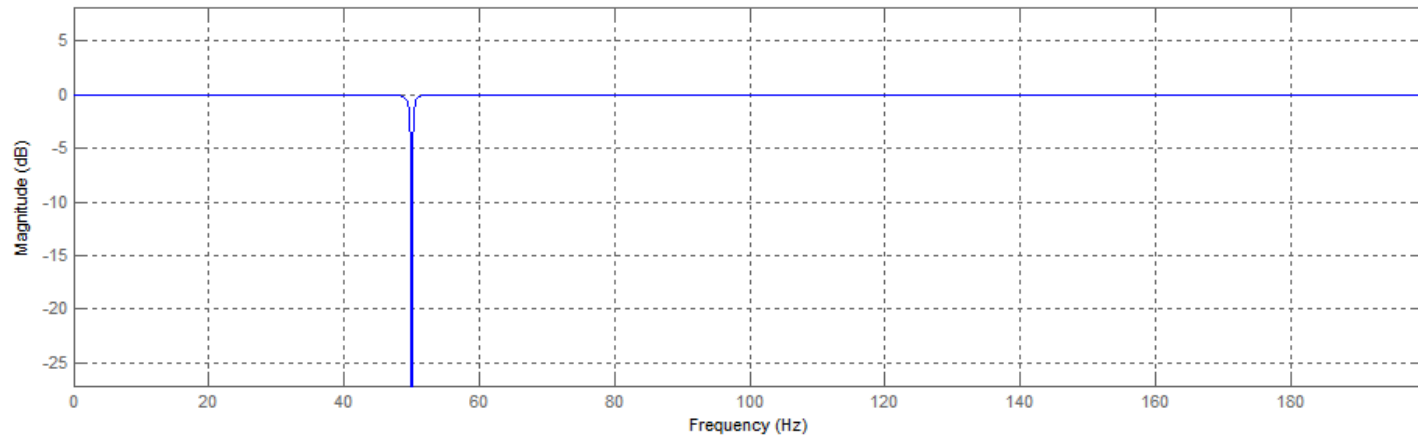
Sampling Frequencies

Selection of Interictal and Ictal Epileptiform Signals

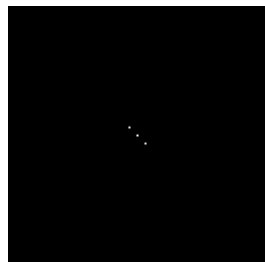
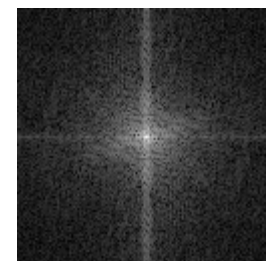
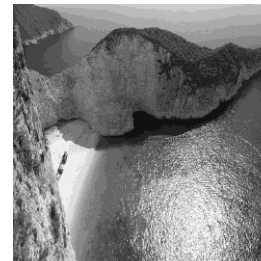
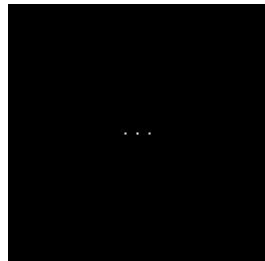
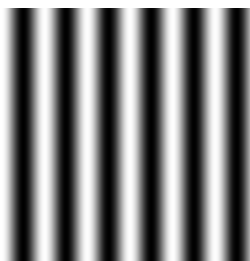
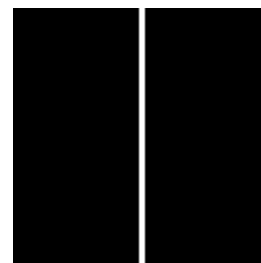
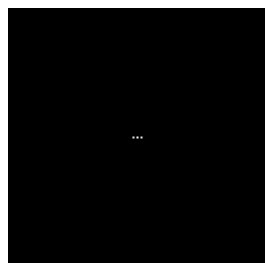
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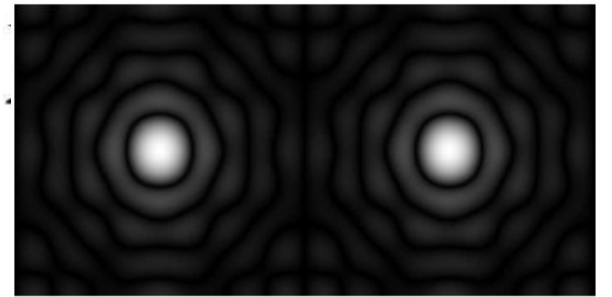
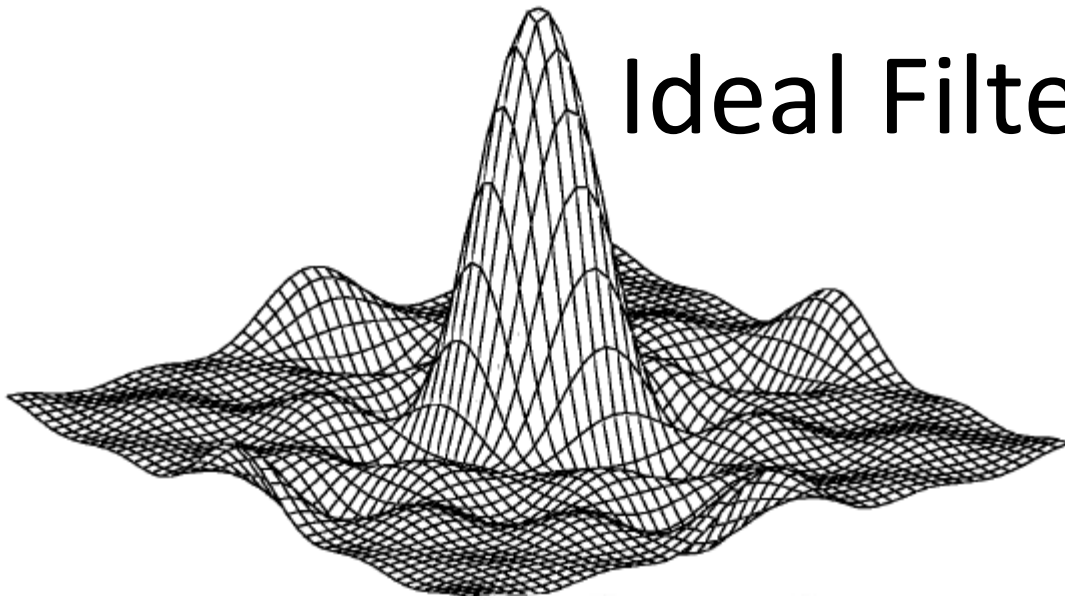
Removing Unwanted Frequencies



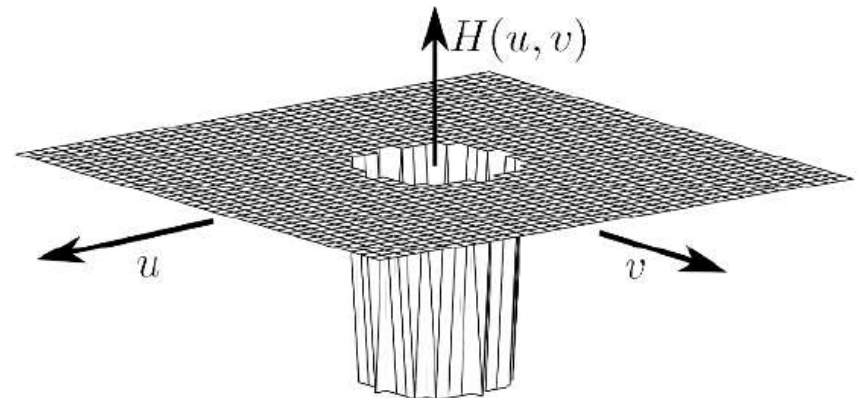
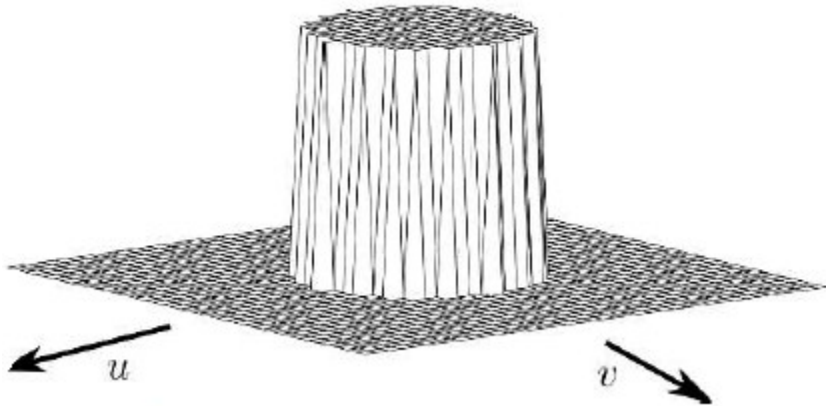
Spatial Frequencies



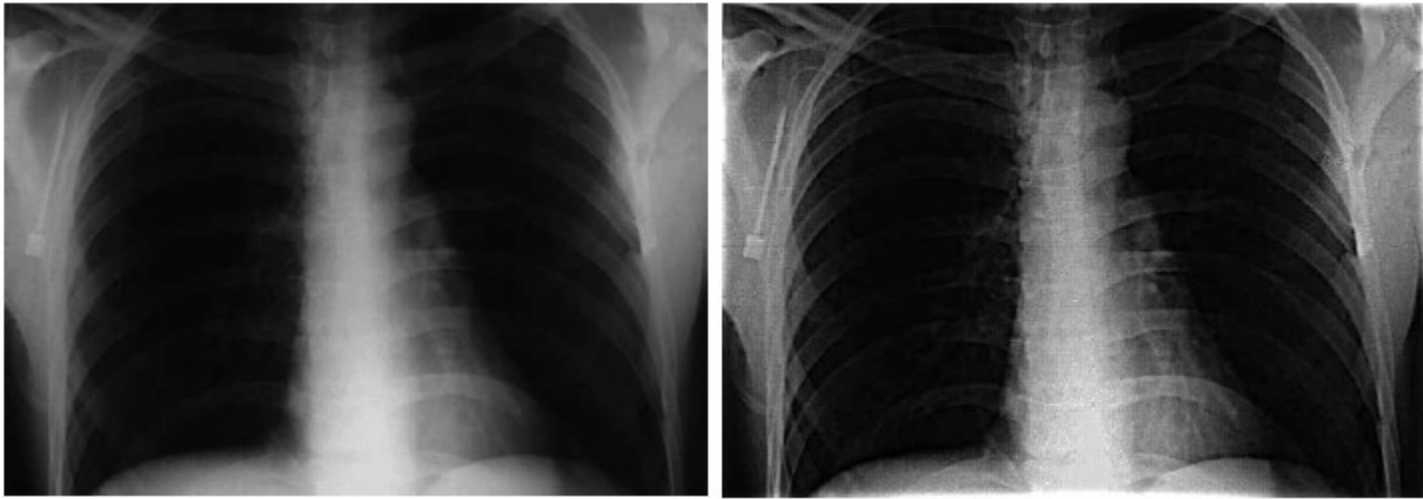
Ideal Filtering



$H(u, v)$



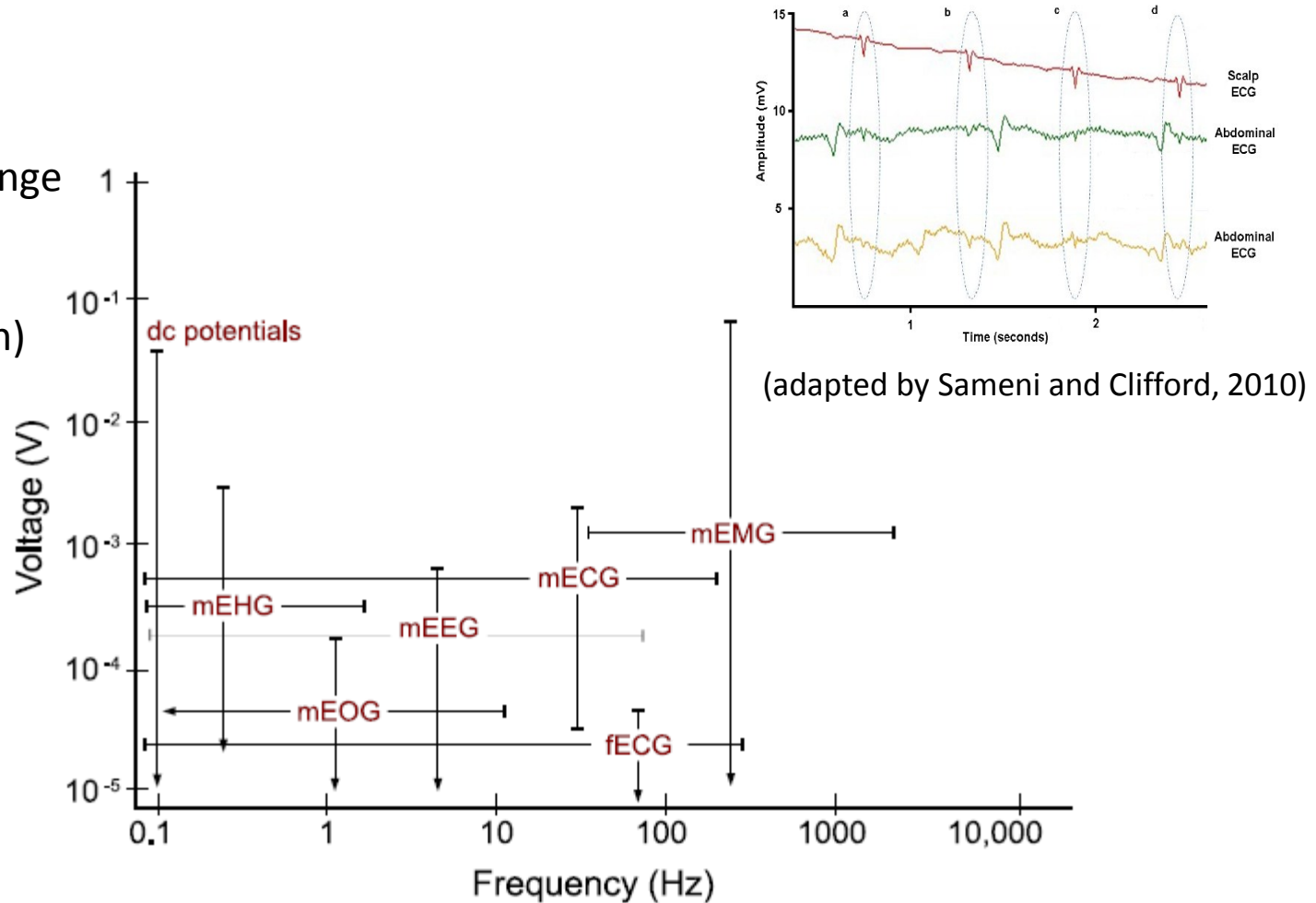
Blurring and Sharpening



When Filtering is not an option

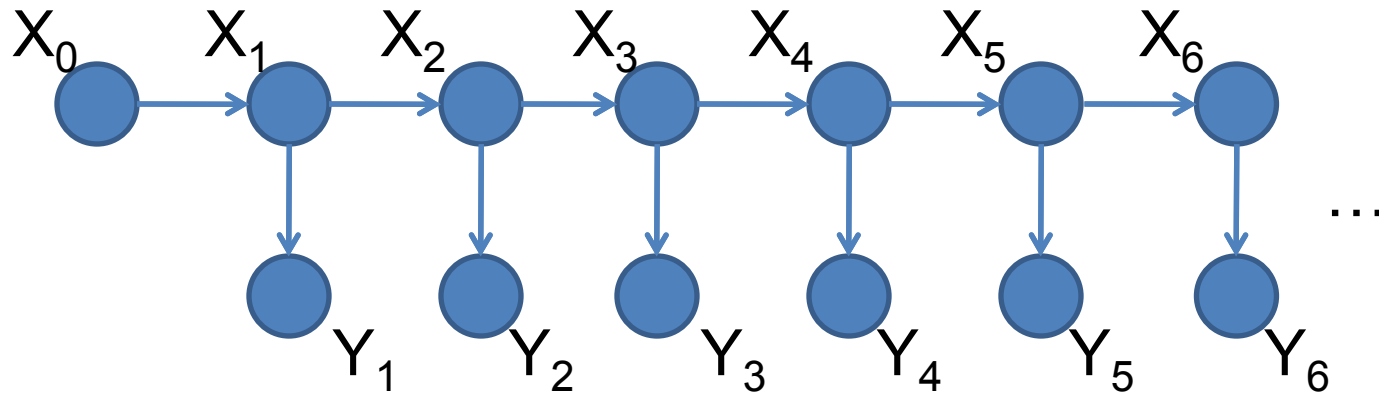
Difficulties

1. Same frequency range
2. Low SNR
3. Morphology = $f(\text{electrode location})$
4. Excess reference electrodes

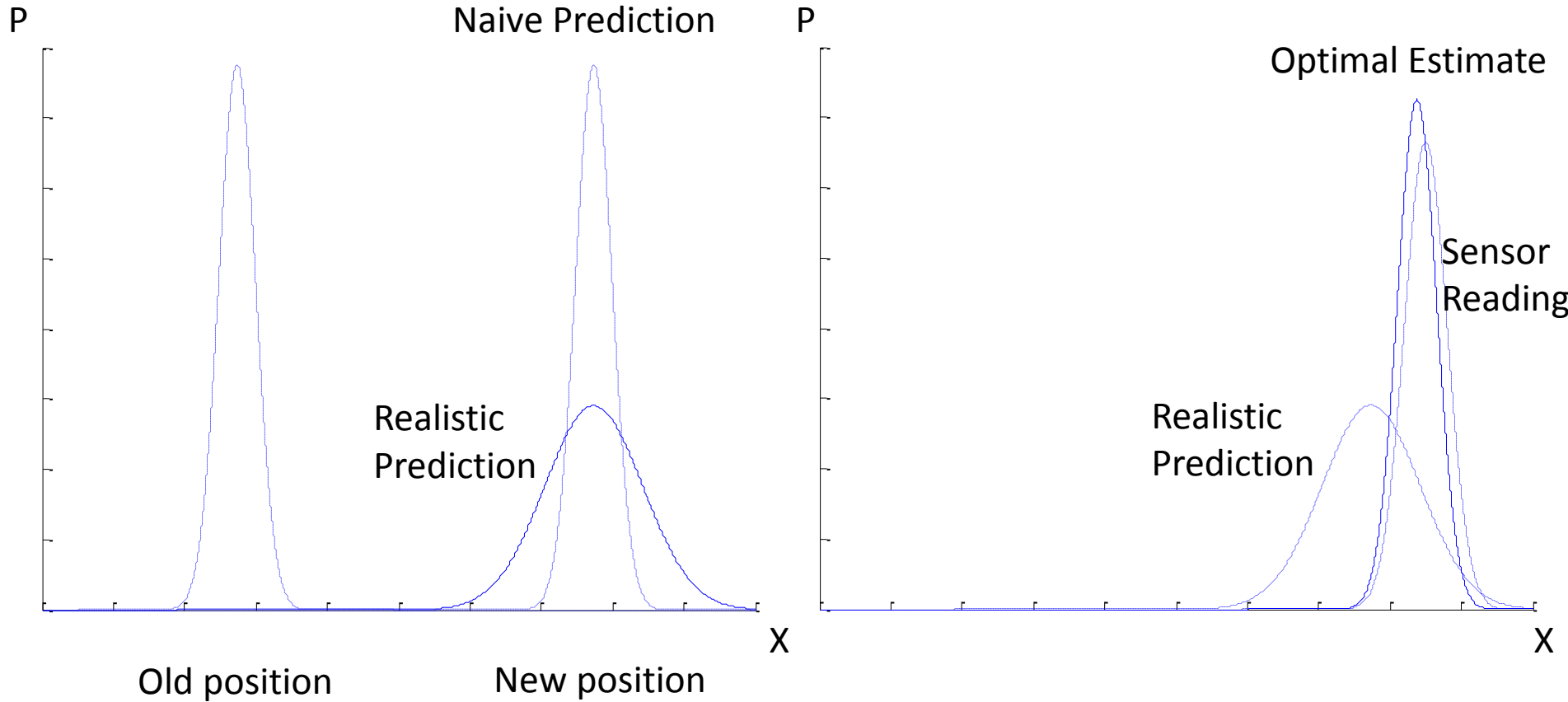


Kalman Filter

X: State
Y: Measurement



Conceptual overview



Kalman Filter

- Predicts:
 - a. linear dynamical system and
 - b. all error terms have a Gaussian distribution
- Corrects:
 - a. system's dynamics model
 - b. known control inputs
 - c. sequential measurements
- Updates:
 - a. If we are sure about measurements, residual is weighted more heavily than prediction
 - b. If we are sure about prediction, prediction is weighted more heavily than residual

Kalman Filter

- Estimator
- Unknown modeled system
- Indirect measurement of the system
- Optimal

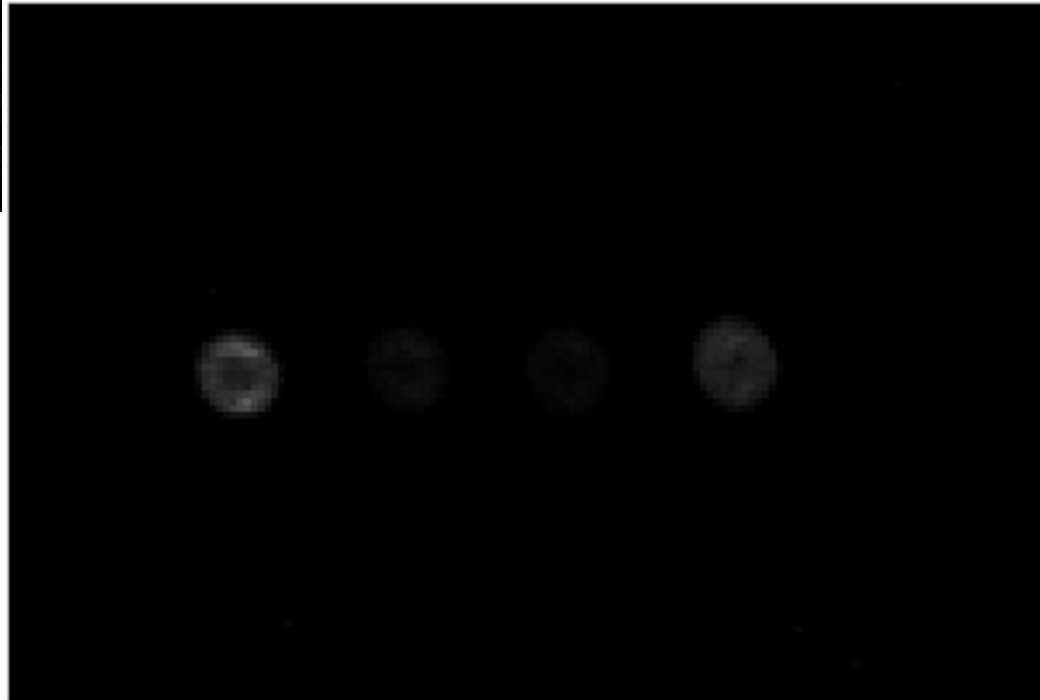
(for linear systems and white Gaussian noise sources)

– Why Gaussian?

- Noise smoothing
- Recursive

(no need to store all previous measurements)

Recursive Algorithm Application on Segmentation of Microarray cDNA spots



Next Lecture

Monday, June 25

Physiological Systems

Physiological signals as inputs/outputs
(Modeling and Simulation)