

# Signals and Systems

## Lecture 2. Examples of Signals

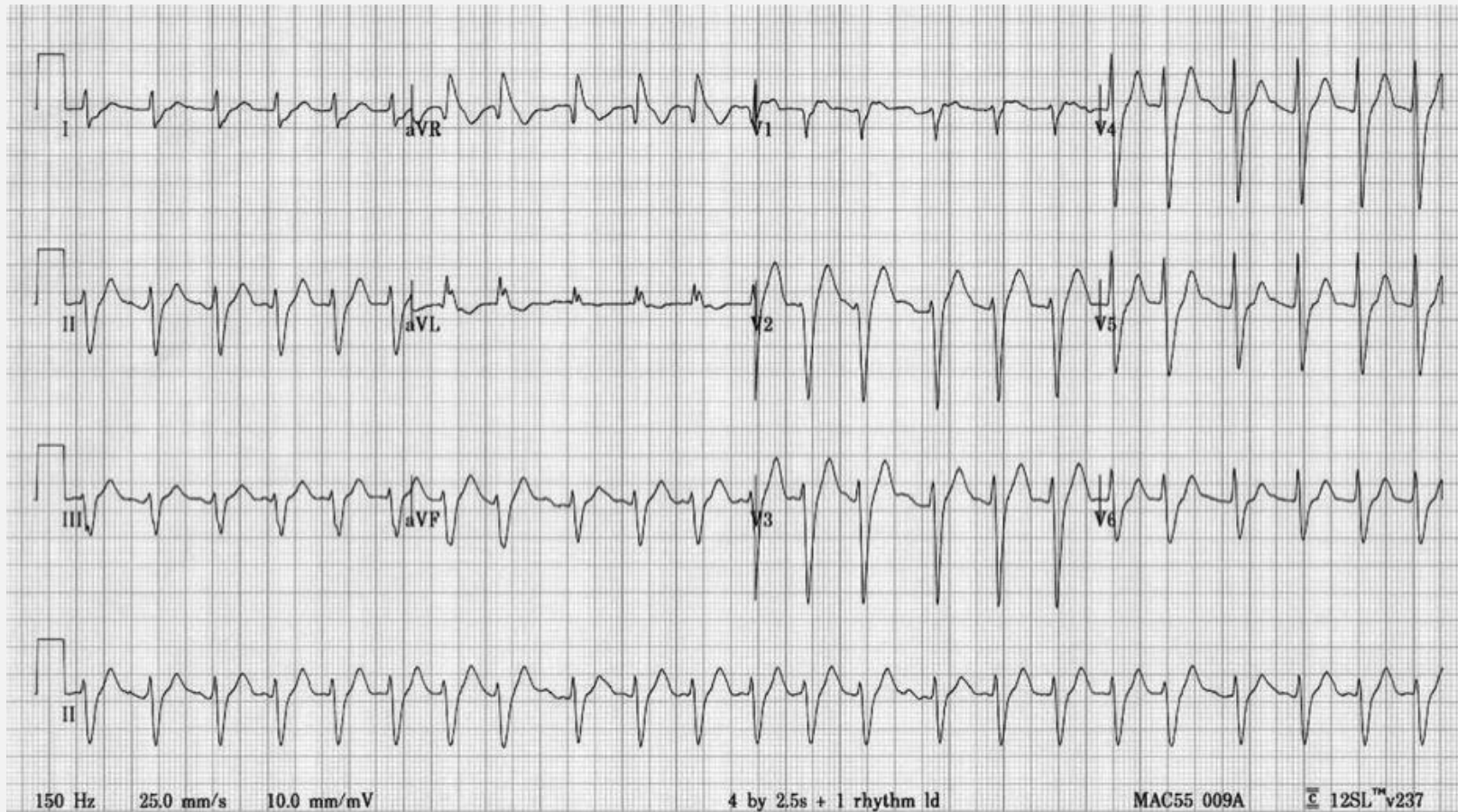
Assist. Prof. Dr. Görkem SAYGILI 2019-2020 Fall Semester

# Examples of Signals

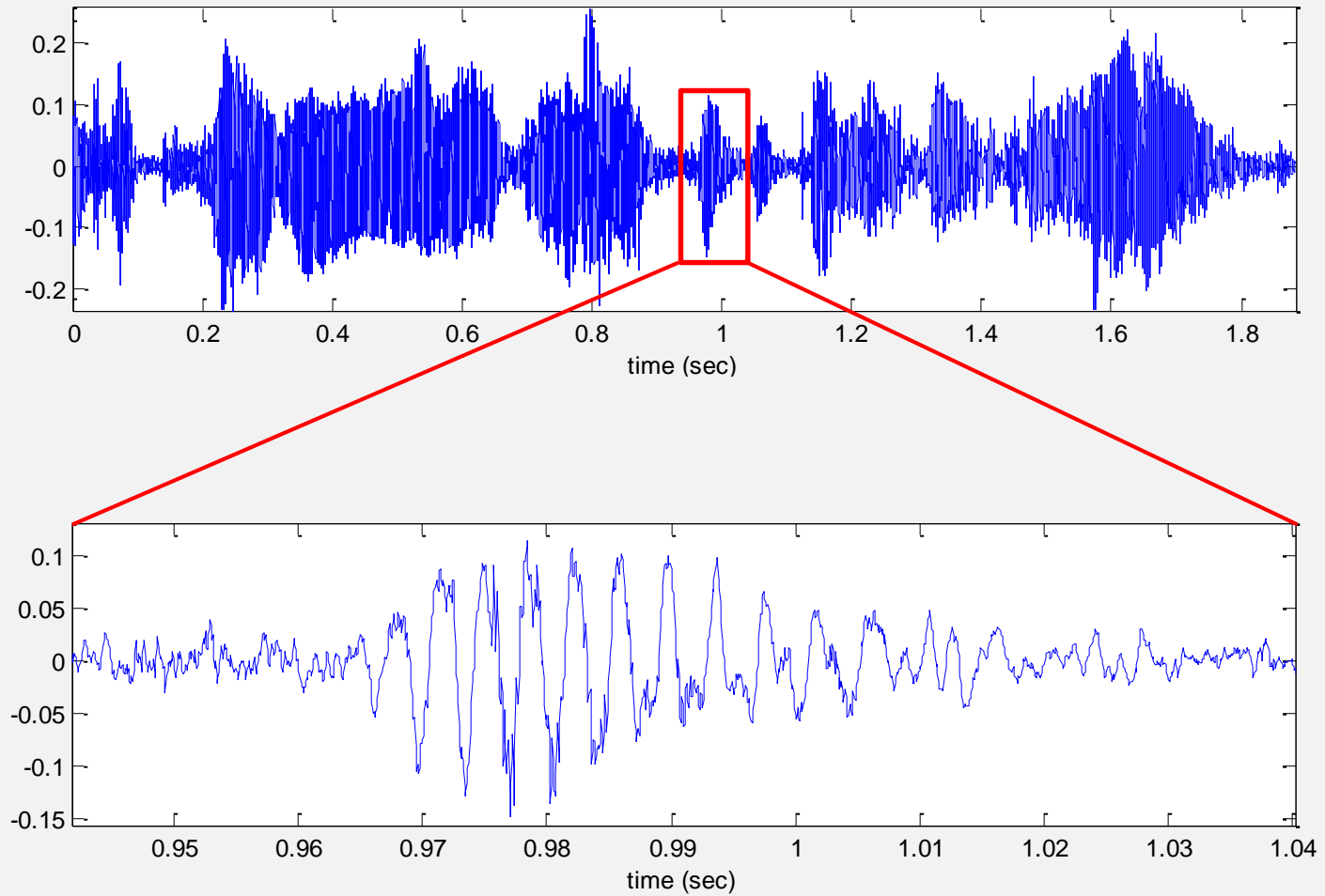
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- Variation of electrical potential on heart surface with time
- Audio signals
- Daily variation of IMKB100 index
- Variation of temperature with respect to time or location
- A medical image acquired with any medical imaging system
- ...

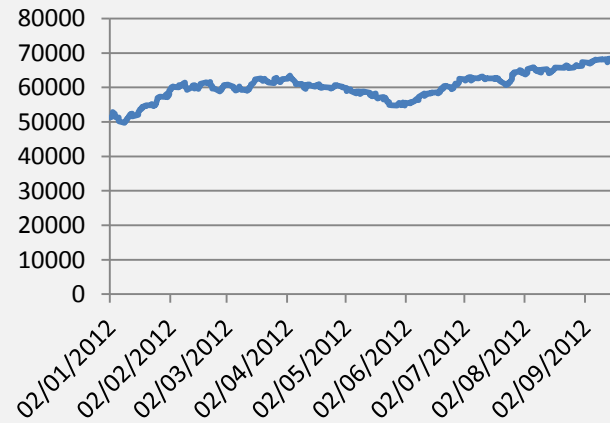
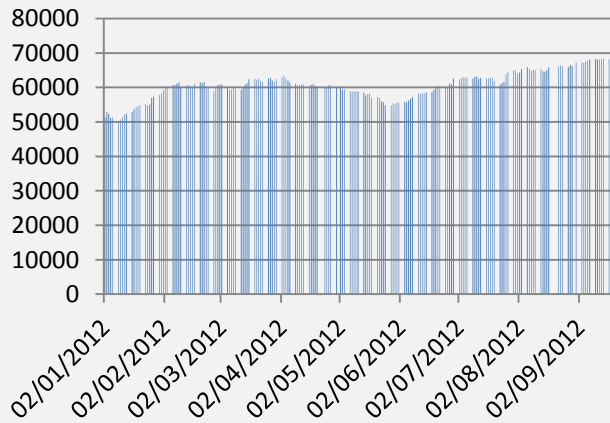
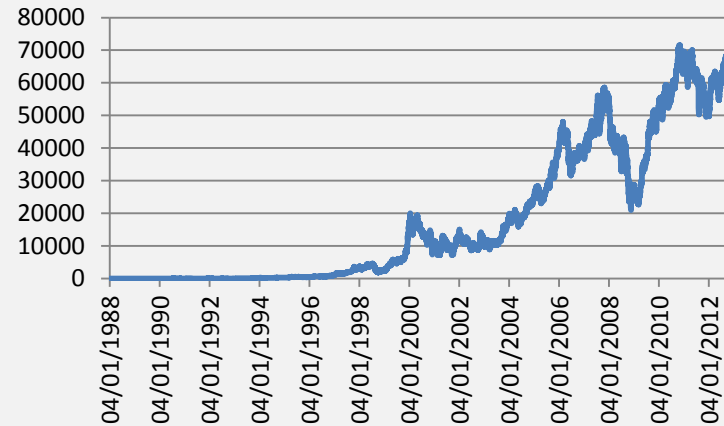
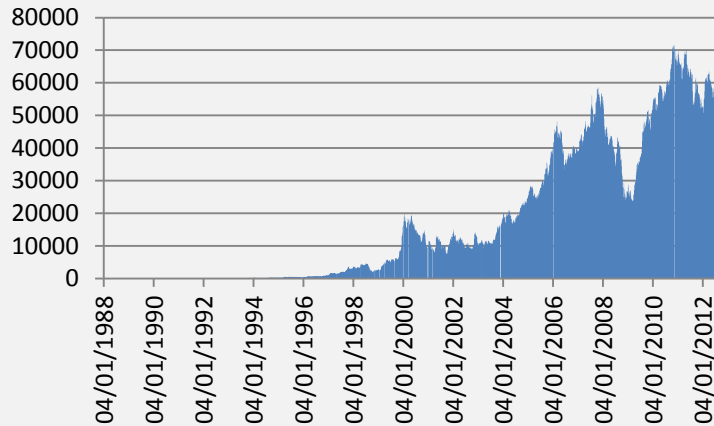
# ECG Signal



# Audio Signal

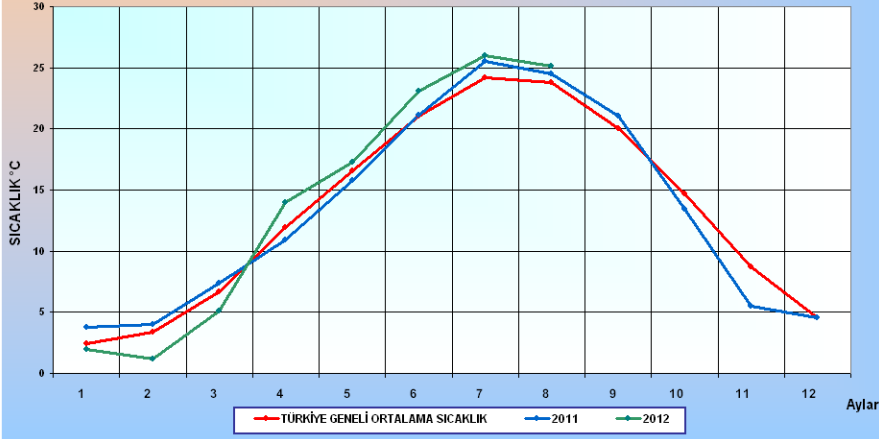


# XU100 Data



# Variation of Temperature

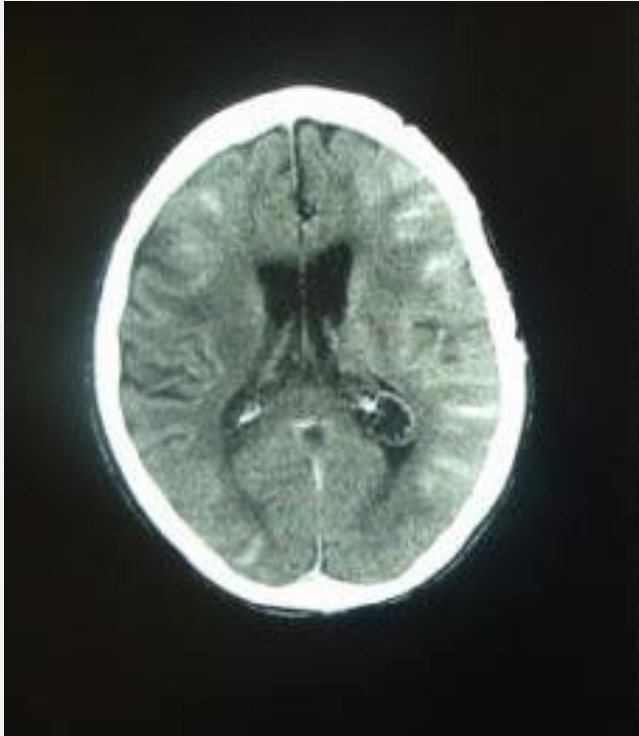
2012 YILI ORTALAMA SICAKLIKLARININ UZUN YILLAR VE GEÇEN YIL İLE MUKAYESESİ



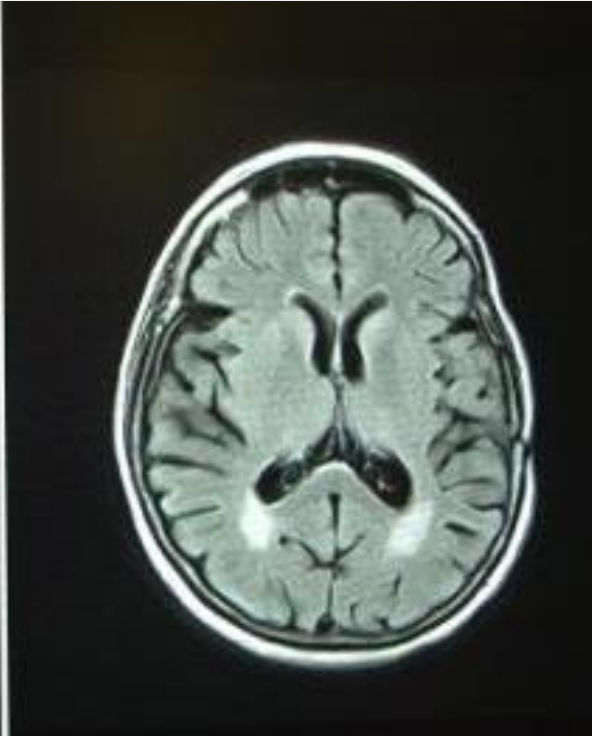
# Medical Images

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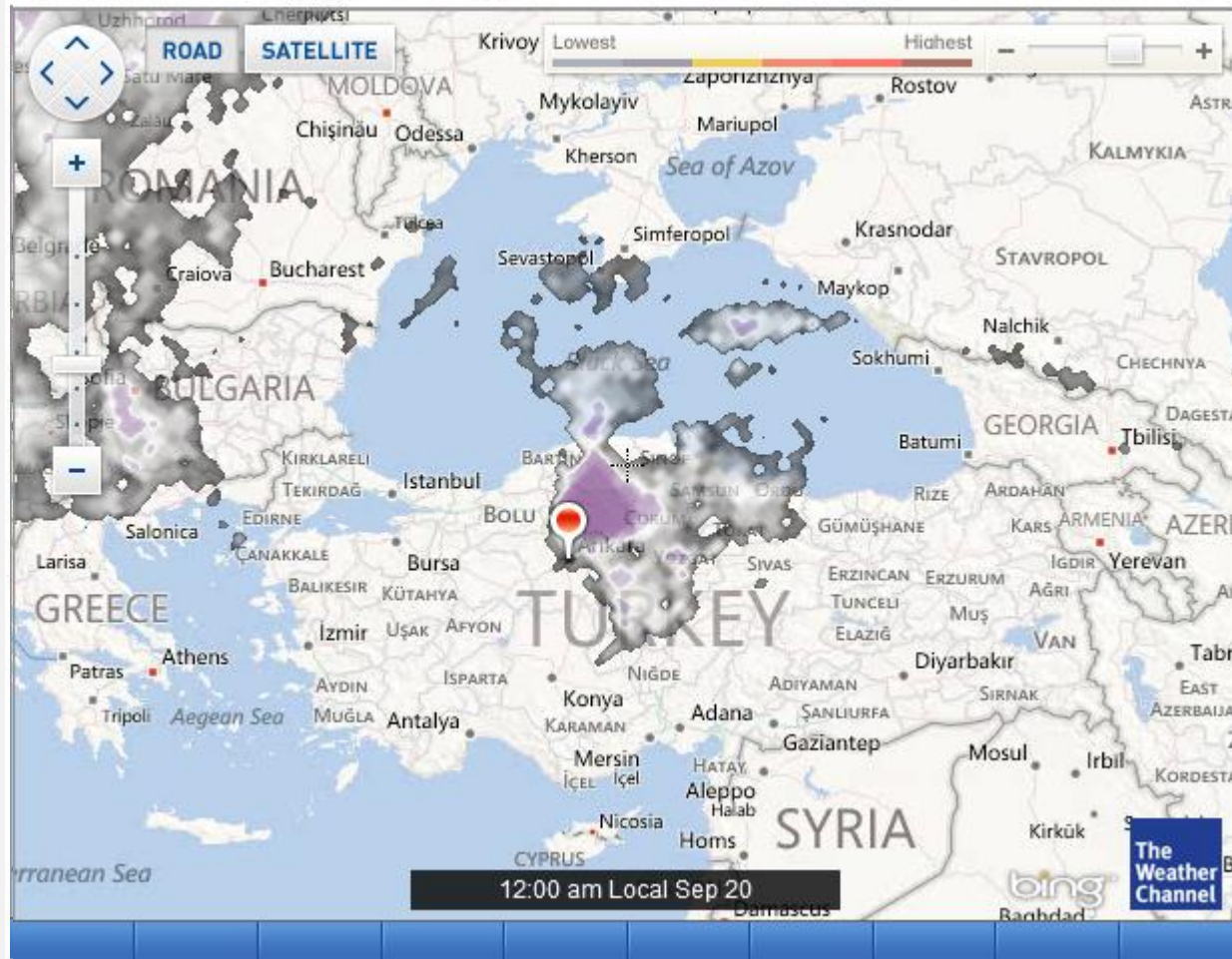
CT



MRI



# Cloud Map changing with time and location





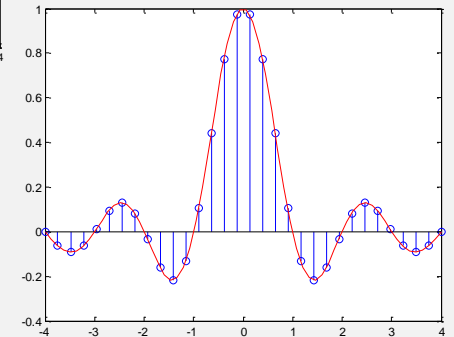
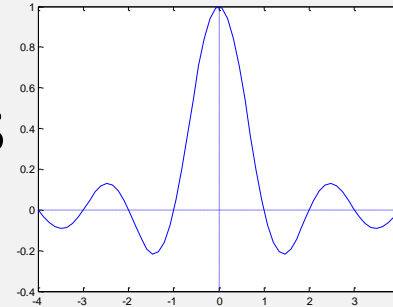
# Angiogram

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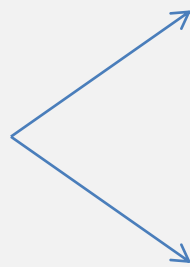


# Types of Signals wrt. Time and Amplitude

- Continuous time signals  
(*analog, sürekli zamanlı sinyaller*)
- Discrete time signals  
(*Ayrık zamanlı sinyaller*)

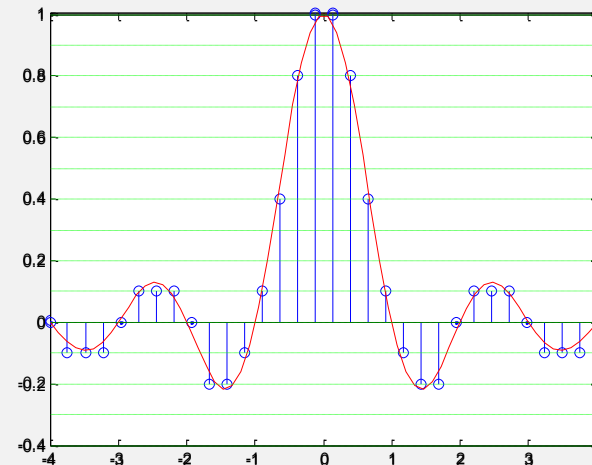


Amplitude?



Cont.

Discrete  
(*digital signals*)



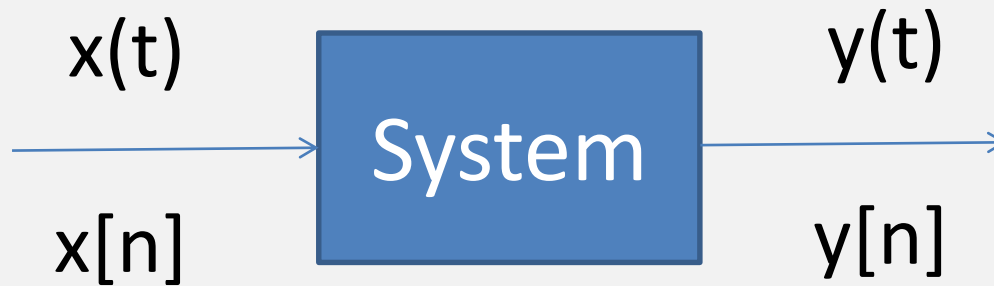
# Representation of Signals

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- One dimensional signal in continuous time  
 $x(t)$
- One dimensional signal in discrete time  
 $x[n]$
- Images  
Intensity(horizontal coordinate, vertical coordinate)
- Video signals  
 $v(x, y, t)$
- Multidimensional discrete signals  
 $x[n_1, n_2, n_3, \dots]$

# Systems

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## LTI Systems

linear  
*doğrusal*

time invariant  
*zaman değişmez*

nonlinear  
*doğrusal olmayan*

time varying  
*zaman değişimli*

# Transformations

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Time Space

$x(t)$

$x[n]$

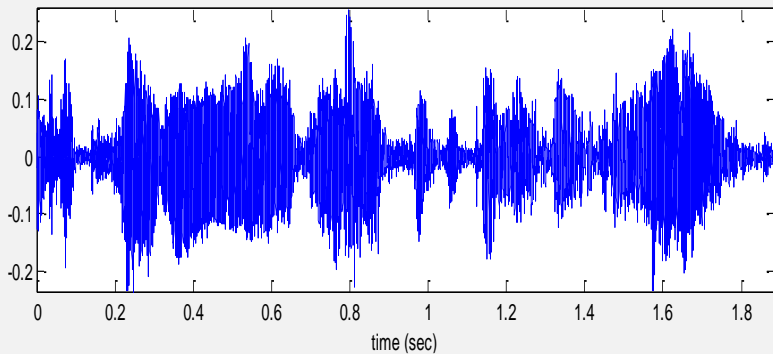
Frequency Space

Fourier Transform,  $X(\omega)$

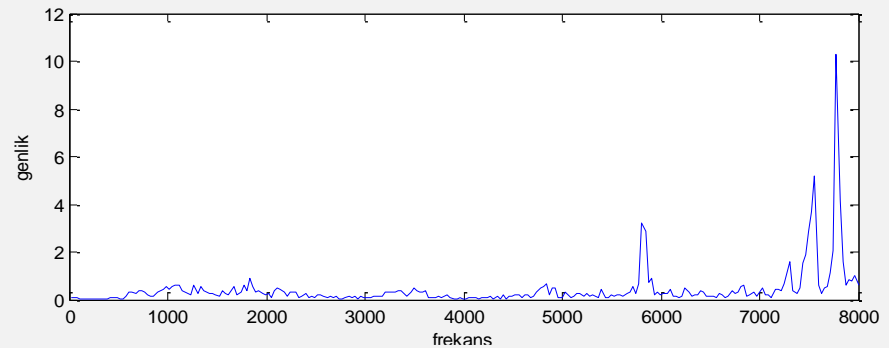
Z-transform,  $X(z)$

Laplace Transform

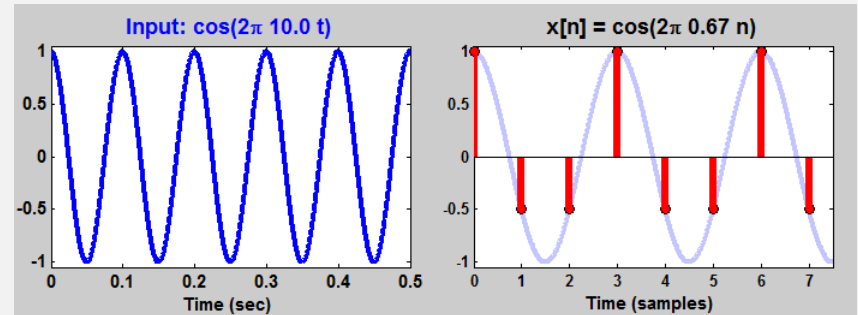
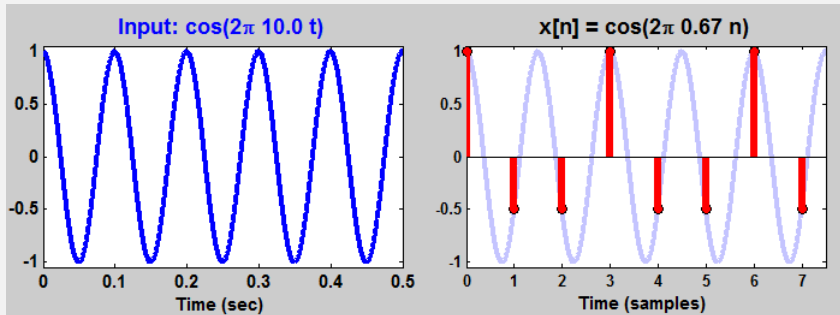
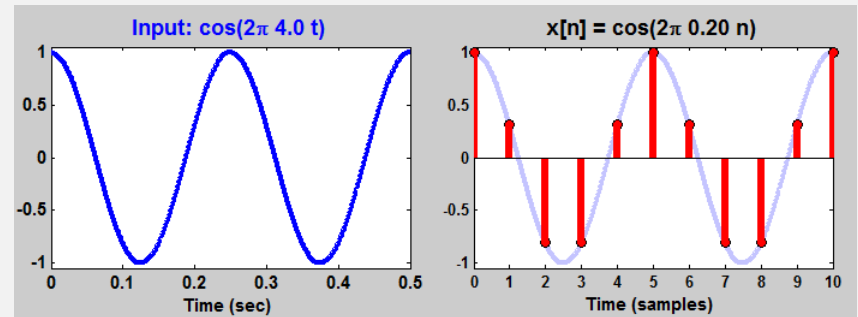
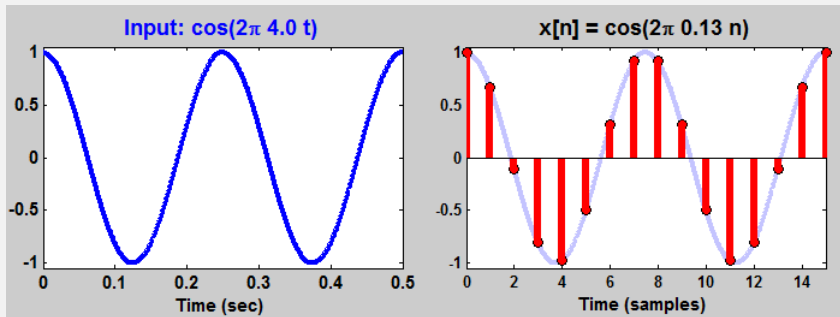
...



FT  
→

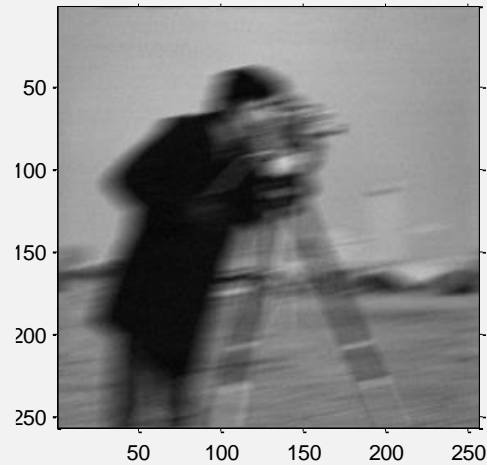


# Sampling

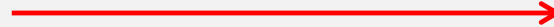


# Filtering

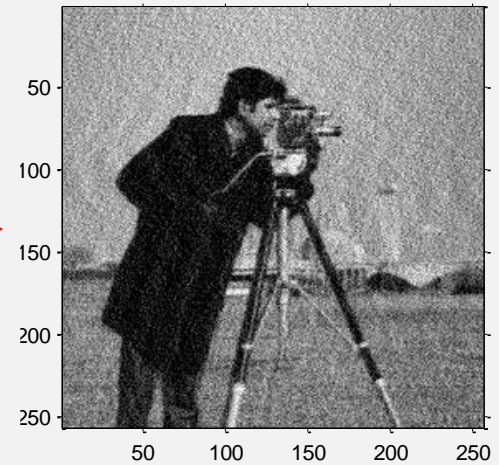
Blurring and noise



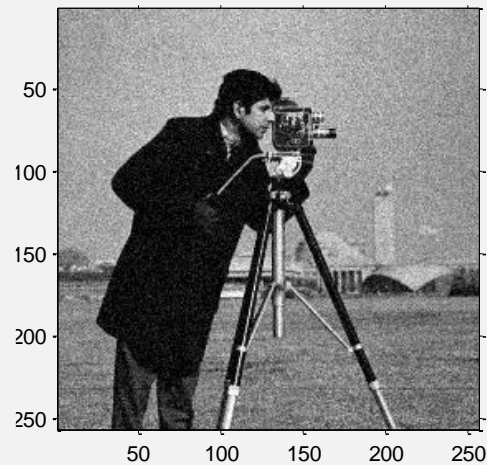
deconvolution with  
Wiener filter



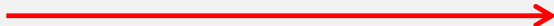
Filtered Image



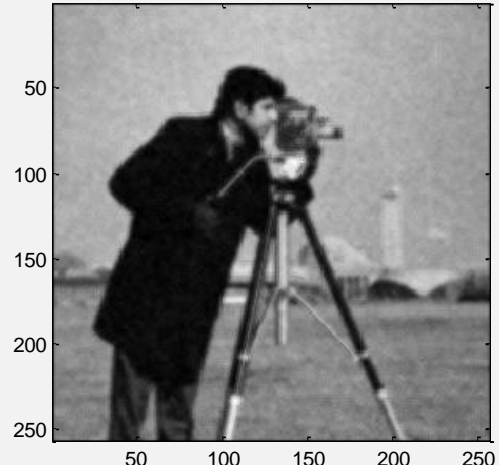
Noise



Convolution with  
low pass filter



Filtered Image



# Content of This Course

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- What is a signal?
- Examples of signals
- Types of Signals
- Systems
- Time and Frequency Spaces
- Sampling
- Filtering