

# 7. Introduction to Random Processes

- definition
- types of random processes
- examples
- statistics
- statistical properties
- analysis of wide-sense stationary process

# From RV to RP

extension of how to specify RPs

- definition, elements of RPs
- pdf, cdf, joint pdf
- mean, variance, correlation, other statistics

# Types of random processes

- continuous/discrete-valued
- continuous/discrete-time
- stationary/nonstationary

# Typical examples

- **Gaussian:** popularly used by its tractability
- **Markov:** population dynamics, market trends, page-rank algorithm
- **Poisson:** number of phone calls in a varying interval
- **White noise:** widely used by its independence property
- **Random walk:** genetic drifts, slowly-varying parameters, neuron firing
- **ARMAX:** time series model in finance, engineering
- **Wiener/Brownian:** movement dynamics of particles

## Examples of random signals

- sinusoidal signals with random frequency and phase shift
- a model of signal with additive noise (received = transmitted + noise)
- sum process:  $S[n] = X[1] + X[2] + \dots + X[n]$
- pulse amplitude modulation (PAM)
- random telegraph signal
- electro-cardiogram (ECG, EKG)
- solar/wind power
- stock prices

above examples are used to explain various concepts of RPs

# Statistical properties

- stationary processes (strict and wide senses, cyclostationary)
- independent processes
- correlated processes
- ergodic processes

# Wide-sense stationary processes

- autocovariance, autocorrelation
- power spectral density
- cross-covariance, cross-correlation
- cross spectrum
- linear system with random inputs
- designing optimal linear filters

# Questions involving random processes

- dependency of variables in the random vectors or processes
- probabilities of events in question
- long-term average
- statistical properties of transformed process (under linear system)
- model estimation from data corrupted with noise
- signal/image/video reconstruction from noisy data

and many more questions varied by application of interest



# References

Chapter 9-11 in

A. Leon-Garcia, *Probability, Statistics, and Random Processes for Electrical Engineering*, 3rd edition, Pearson Prentice Hall, 2009

Chapter 8-10 in

H. Stark and J. W. Woods, *Probability, Statistics, and Random Processes for Engineers*, 4th edition, Pearson, 2012