EE 574 Detection and Estimation Theory

Lecture Presentation 1

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☞ *Chapter 1: Introduction*

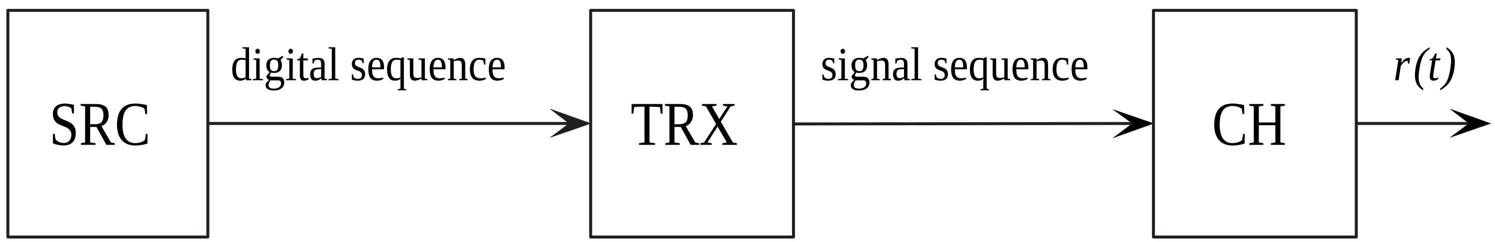
☞ Statistical Inference

➢ **Decision Theory:** Observe an output that has a random character and decide on the possible causes (usually 2) which produced it. -Thomas Bayes

➢ **Estimation Theory:** The output is observed and we try to estimate the value of the parameter. -Legendre, Gauss

☞ Detection Theory

➢ 1st Type of Detection Problem



$$s_1(t) = \sin \omega_1 t \quad \Rightarrow r(t) = s_1(t) + n(t) \;\; 0 \le t \le T$$

$$s_0(t) = \sin \omega_0 t \quad \Rightarrow r(t) = s_0(t) + n(t) \;\; 0 \le t \le T$$

The decision device observes $r(t)$ and guesses whether $s_1(t)$ or $s_0(t)$ was transmitted according to some set of rules. Noise is the only possible source of error. This is a known signal in noise problem.

- 2nd Type of Detection Problem

$$r(t) = \sin(\omega_1 t + \theta_1) + n(t) \quad 0 \leq t \leq T$$

$$r(t) = \sin(\omega_0 t + \theta_0) + n(t) \quad 0 \leq t \leq T$$

where θ_1 and θ_0 are unknown phase shifts. Here we have the noise and phase shifts as sources of error. This is the signal with unknown parameters in noise problem.

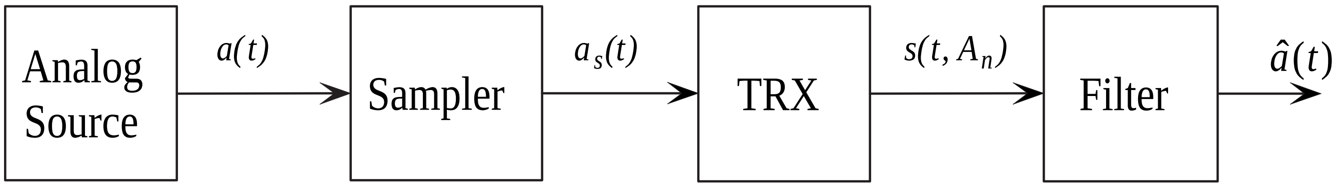
- 3rd Type of Detection Problem

$$r(t) = s_\Omega(t) + n(t)$$

$$r(t) = n(t)$$

The signal is a sample function from a random process. This is the random signal in noise problem.

☞ Estimation Theory



➢ 1st Type of Estimation Problem

Known signal in noise problem.

$$r(t) = s(t, A_n) + n(t)$$

➢ 2nd Type of Estimation Problem

Signal with unknown parameters in noise problem.

$$r(t) = \begin{cases} V_T \sin[(\omega_c + \omega_d)(t-\tau) + \theta_r] + n(t) & \text{for } \tau \le t \le \tau + T, \\ n(t) & \text{for } 0 \le t \le \tau, \tau + T < t < \infty \end{cases}$$

➢ 3rd Type of Estimation Problem

Random signal in noise problem.

$$r(t) = s_\Omega(t, A) + n(t)$$

There is a strong parallelism between detection and estimation.

☞ **Modulation Theory (Waveform Estimation)**

This is the continuous estimation problem.

E.g. Amplitude Modulation: DSB-AM

$$s[t, a(t)] = [1 + ma(t)] \sin(\omega_c t)$$

Frequency Modulation

$$s[t, a(t)] = \sin[\omega_c t + \int_{-\infty}^{t} a(u)du]$$

➢ Type I

$$r(t) = [1 + ma(t)] \sin(\omega_c t) + n(t)$$

➢ Type II

$$r(t) = [1 + ma(t)] \sin(\omega_c t + \theta) + n(t)$$

➢ Type III

$$r(t) = \underbrace{V(t)}_{random} \sin[\omega_c t + \int_{-\infty}^{t} a(u)du + \underbrace{\theta(t)}_{random}] + n(t)$$

Approach to Problems

- Structure
- Criterion
- Information