Approximate Entropy (ApEn) and Sample Entropy (SampEn)

In Time Series Analysis:
Both **Approximate Entropy (ApEn)** and **Sample Entropy (SampEn)** measure the *complexity* or *unpredictability* of a time series. They help us understand how regular or random the data pattern is, which relates directly to forecastability.

1. Approximate Entropy (ApEn)
• Measures the likelihood that patterns in data remain similar on the next comparison.
• **Small ApEn:** Time series is more regular and predictable → **Forecastability is possible**.
• **Large ApEn:** Time series is irregular or random → **Forecasting is difficult**.

Formula:
$ApEn(m, r, N) = \Phi_m(r) - \Phi_{m+1}(r)$
where:
- m = length of compared runs
- r = filtering level (tolerance)
- N = length of the time series

2. Sample Entropy (SampEn)
• Improved version of ApEn that avoids self-matching and is less dependent on data length.
• **Small SampEn:** Time series is regular and has repeating patterns → **Forecastability is possible**.
• **Large SampEn:** Time series is highly irregular → **Forecasting is difficult**.

Formula:
$SampEn(m, r, N) = -\ln [A / B]$
where:
- A = number of (m+1)-length matching patterns
- B = number of m-length matching patterns
- m = embedding dimension
- r = tolerance
- N = data length

Summary:
Both ApEn and SampEn quantify time series complexity. Smaller values indicate higher regularity and stronger forecastability, while larger values suggest randomness and weak predictability.