

Tugas IV sistem pengaturan Berjaringan

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1. Consider a discrete controller.

for length 5 bits, determine

1. **Advantages of Non-uniform Quantization**
2. Better SNR for Lower Amplitude Signals: The main advantage of non-uniform quantization is the improved performance for signals with a wide dynamic range or signals whose statistics are not uniform. The quantization error (noise) can be controlled by the choice of quantization levels, which can be closely matched with the signal amplitude distribution.
3. Efficient use of Quantization Levels: By giving more quantization levels to the values that are more likely to occur, a higher SNR can be achieved with the same number of bits per symbol compared to uniform quantization. This can provide a more efficient use of bandwidth.
4. Reduction of Quantization Error: In non-uniform quantization, the quantization error can be managed and reduced, especially for low-amplitude signals. This can improve the overall quality of the processed signals, especially for signals with a large dynamic range.

**Disadvantages of Non-Uniform Quantization**

1. Higher Complexity: Non-uniform quantization requires knowledge of the statistical properties of the source and a mapping (companding) function. This increases the complexity of the quantizer compared to uniform quantization.
2. Requires More Processing Power: Due to its complexity, non-uniform quantization typically requires more computational power and resources to implement effectively.
3. Inefficient for Uniform Distribution: If the signal follows a uniform distribution, non-uniform quantization can be less efficient and may not provide any significant improvement in SNR compared to uniform quantization.

**Example of Non-uniform Quantization Application**

Non-uniform quantization is commonly used in telecommunications, especially in speech and audio coding. Human speech and hearing follow a logarithmic perception law known as Weber-Fechner law. This means that we perceive changes in intensity on a logarithmic scale rather than a linear one. The μ-law algorithm in North America and the A-law algorithm in Europe are examples of non-uniform quantization used in the pulse-code modulation (PCM) of voice frequencies. These standards allocate more bits to lower sound levels, which are more sensitive to the human ear, improving the overall quality of compressed speech.

1. The Nyquist-Shannon Sampling Theorem, often referred to as the Nyquist criterion, states that a continuous signal must be sampled at a rate that is at least twice its highest frequency component to be accurately represented in the sampled (discrete) domain. This critical rate is known as the Nyquist rate. When the sampling frequency is less than twice the maximum frequency of the signal , we say that the signal is undersampled, leading to a phenomenon known as aliasing.

**Aliasing**

Aliasing is a consequence of undersampling, where high-frequency components in the signal are incorrectly interpreted as lower frequency components. This happens because, at a lower sampling rate, these high-frequency components coincide with the sample points in the same way that a lower frequency would. This causes distortions and inaccuracies in the reconstructed signal, as these false low-frequency components (aliases) cannot be distinguished from the true low-frequency components of the signal.

**Example**

Consider a continuous sinusoidal signal with a frequency of . According to the Nyquist criterion, it should be sampled at a rate of at least to accurately capture the signal's characteristics.

However, if we sample this signal at a frequency of , which is less than , we will not meet the Nyquist criterion, and the signal will be undersampled. As a result, we won't correctly capture the variations of the signal in the sampled domain.

The signal that we obtain from this sampling process would appear to have a frequency of 50 Hz, which is the difference between the sampling rate and the signal frequency. This is the alias frequency, and in the discrete domain, the 100 Hz signal is indistinguishable from a true 50 Hz signal, leading to inaccurate representation and reconstruction of the original signal.

1. a). 50, 5-bit binary

5-bit quantizer with a range

Convert 8 to 5-bit binary

There is no error in this case.

b). 0.05, 10-bit binary

10-bit quantizer with a range

Convert 26 to 5-bit binary

The error in this case

c). 35, 5-bit binary

3-bit quantizer with a range .

Convert 3 to 5-bit binary

The error in this case

1. Robustness: Ensuring second moment stability can lead to a more robust networked system. It means the network can handle random perturbations or noise, as the expected energy of the system remains bounded.

Predictability: By keeping the second moment of the system bounded, we can ensure the predictability of the system's behavior. If the second moment were unbounded, it could suggest that the system might exhibit wildly varying behavior, potentially causing issues for control or communication.

Safety: In some applications, a high second moment could suggest a high amount of energy in the system, which could be a safety concern. By ensuring the second moment is bounded, we can limit the maximum energy of the system.

Why second moment? The choice of the second moment is due to its connection to variance and energy in a system. In stochastic processes, the second moment often relates to the variance of the process. For a signal, its second moment is proportional to its energy. In both cases, bounding the second moment provides a meaningful measure of stability. It ensures that the variance of the process does not grow without bound and that the signal's energy remains finite, both of which are useful properties in the context of networked systems.

1. Design a controller (for a negative-feedback closed-loop system) in a discrete-time domain.

Here, Kp, Ki, and Kd represent proportional, integral, and derivative gains, respectively.

Where T is the sampling period.

or in the z-domain for the discretized system:

Simulation: The output signal can be obtained by simulating the response of the system to a step input. The control signal in a negative-feedback system is given by