

Eas sistem pengaturan Berjaringan

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1. The authors

Let's use a simple uniform quantizer for the control law, such that:

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where is a positive control gain, represents the quantization of , and the negative sign indicates that the control is applied in the opposite direction of the state (which is typical in feedback control systems).



This program first sets the system parameters (lambda, simulation time steps T, and control gain K) and quantization parameters (delta). The variables x, u, y, v, and w are initialized, with v and w as random Gaussian noise.

In the main loop, for each time step, the state x is quantized to xq using a uniform quantizer. The control signal u is computed as the negative product of the control gain K and the quantized state xq. The state x is updated according to the system dynamics, including the control signal u and the measurement noise v. The output y is computed as the state x plus the measurement noise w.

Finally, the states x, control signals u, and outputs y over time are plotted.

Please note that in a real-world application, you should carefully choose the control gain K and the quantization step size delta based on the system's requirements and constraints. The selection of these parameters can significantly affect the performance and stability of the control system. The gain K, for instance, must be carefully chosen to ensure stability given that lambda > 1. This program does not include the steps for choosing these parameters optimally, which would typically involve techniques from control theory and signal processing.

1. One of the theorems that connect information theory with feedback control is the Data Rate Theorem. This theorem provides a quantitative link between the amount of information that is needed to control a system and the system's intrinsic dynamics. It implies that any control system, to be stable, needs a certain minimum number of bits per second.

Given a linear system under control with a certain degree of instability, there exists a critical data rate below which no controller can stabilize the system, no matter how clever the design of the controller is.

More formally, if we consider a discrete-time linear time-invariant (LTI) system, the minimum data rate required to stabilize the system is given by:

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where is the topological entropy of the system matrix A. Topological entropy is a measure of the "complexity" or "instability" of the system. For a stable system, is zero, and the data rate required is also zero.

In other words, the more complex or unstable a system is, the more data rate it requires for stabilization.

This theorem is a fundamental result in networked control systems where communication constraints play a crucial role. It provides a lower bound on the communication rate needed for stabilization, allowing engineers to understand the trade-off between the quality of control and the cost of communication.

1. Non-uniform quantization is a method of converting analog signals into digital format, where the quantization levels are not equally spaced. This is opposed to uniform quantization, where all levels are evenly distributed. Non-uniform quantization can be advantageous in certain contexts, especially when dealing with signals that don't have a uniform distribution.

Advantages of Non-Uniform Quantization:

1. Better Signal Quality for Non-Uniform Signal Distributions: Non-uniform quantization can be tailored to the probability distribution of the source signal. This can result in a higher signal-to-noise ratio (SNR) for a given bit rate, improving the quality of the quantized signal.

2. Improved Performance for Signals with High Dynamic Range: Non-uniform quantization can provide more resolution for smaller signal levels and less for larger signal levels. This makes it advantageous for signals with high dynamic range, such as audio signals, where it's important to accurately capture the quiet parts of the signal.

Disadvantages of Non-Uniform Quantization:

1. Complexity: Non-uniform quantizers are generally more complex to implement than uniform quantizers. They require knowledge of the signal's probability distribution, and the design of the quantization levels can be more challenging.

2. Requires More Processing Power: To adapt the quantization levels to the signal's probability distribution, non-uniform quantization often requires more processing power.

3. Risk of Misjudging the Signal Distribution: If the actual signal distribution doesn't match the expected distribution used to design the quantizer, the signal quality can be worse than with uniform quantization.

Example in Networked Control System:

In a networked control system, sensors often send data over a network to a controller. If the sensor data has a non-uniform distribution (for example, if small values are much more likely than large ones), non-uniform quantization can help to use the available bandwidth more effectively.

For example, consider a temperature sensor in a climate control system. Most temperature readings might be within a narrow range (for instance, between 20 and 25 degrees Celsius), with extreme values being much less likely. A non-uniform quantizer could be designed to use fewer bits for the most likely temperature range, thereby saving bandwidth. This would allow for more frequent updates and a more responsive control system, at the cost of less precise readings for unlikely extreme temperatures.

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2. The entropy of a random variable is given by the formula:

where the sum is over all possible outcomes , and is the probability of each outcome.

An octahedron die has 8 faces. Since it's a fair die, each face (or outcome) is equally likely, so for all outcomes .

Substituting these values into the entropy formula gives:

where the sum is over all 8 outcomes.

So, the entropy of the octahedron die is 3 bits. This means that, on average, you need 3 bits of information to describe the outcome of a roll of this die.

1. In the context of control systems, the Mahler measure is a concept used to quantify the degree of instability of a linear system. The measure is named after the mathematician Kurt Mahler, who introduced it in number theory. It has been adopted in control theory because of its relevance in analyzing the behavior of dynamical systems.

The Mahler measure M(P) of a multivariate polynomial is defined as:

where the product is taken over all roots of the polynomial.

In the context of control theory, if we consider a discrete-time linear system described by the equation:

where is the system matrix and is the state at time step , the Mahler measure is used to quantify the growth rate of the state .

The growth rate of the state is proportional to the logarithm of the Mahler measure of the characteristic polynomial of the matrix . Therefore, the Mahler measure provides a measure of the "complexity" or "instability" of the system. The larger the Mahler measure, the more unstable the system is.

As an example, consider a simple system with a single state variable, and a system matrix . The characteristic polynomial of is , and its roots are . Therefore, the Mahler measure of the system is:

This indicates that the state of the system will double at each time step, reflecting the instability of the system.