Computational Statistics - Project 1

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Honor code: I pledge that I have neither given nor received help from anyone other than the instructor or the TAs for all work components included here. – Andrew

Hypothesis

Implementing advanced digital signal processing algorithms, such as adaptive filtering using machine learning, can improve the signal-to-noise ratio of a communication system.

Aim

The aim of this hypothesis is to test and improve upon existing DSP algorithms using adaptive filtering backed by machine learning algorithms. Adaptive filtering involves changing coefficients in a digital filter in such a way that the filter hopefully converges to an optimal state. We can use machine learning to assist in the optimization of these filter coefficients to more effectively reduce the signal-to-noise ratio of communication systems.

Predictor Variables

Below we can see some predictor variables that will need to be gathered in order to judge the success of the research:

- Algorithm Used
  - The type of advanced digital signal processing algorithm as well as machine learning algorithm used. We could run experiments with a variety of DSP algorithms and ML algorithms and see if there are certain combinations of algorithms that produce the best results.
- Signal-to-Noise Ratio
  - The current signal-to-noise ratio of the communication system.
- Channel Conditions
  - The channel conditions, such as fading, multipath, or interference, all of which can affect the performance of the digital signal processing algorithm.
- Data Rate, Bandwidth, and Sample Rate
  - The data rate, bandwidth, and sample rate of the communication system, which can affect the performance of the digital signal processing algorithm.

With these variables, we can hopefully measure the effect of the DSP algorithms on the signal-to-noise ratio of the communication system, and the variables can be used to compare different digital signal processing algorithms.

Experimentation

This is a rough outline of what a basic experimentation setup would look like:

1. Set Up
    - Install a communication system, such as a wireless or wired network, and associated measurement equipment
    - Generate or collect signals to be transmitted through the communication system
    - Add noise to the signal to simulate real-world communication conditions
2. Data Collection
    - Collect data on the predictor variables (e.g. channel conditions, data rate, etc.) over a period of time
    - Collect data on the performance of the communication system (e.g. signal-to-noise ratio, bit error rate, etc.) over the same period of time
3. Algorithm Implementation
    - Implement a machine learning algorithm alongside an adaptive filtering DSP algorithm on the communication system
    - Compare the performance of the communication system with and without the advanced digital signal processing algorithm
4. Data Analysis
    - Analyze the collected data using statistical methods
    - Compare the performance of the communication system with and without the advanced digital signal processing algorithm
    - Test the hypothesis by examining the correlation between the predictor variables and the signal-to-noise ratio of the communication system
5. Conclusion
    - Draw conclusions based on the results of the experimentation and hypothesis testing
    - Identify potential areas for future research

Analysis of Results

Now that we have discussed how the experiment could run, we must discuss how we will analyze the results.

1. Descriptive Statistics
    - Descriptive statistics, like the mean, standard deviation, and other measures of central tendency and dispersion for the signal-to-noise ratio and other performance metrics can help us summarize the collected data
2. Regression Analysis
    - We can model the relationship between the predictor variables and the signal-to-noise ratio of the communication system via linear regression, polynomial regression or other models to estimate relationship between the predictor variables and the model

3. Analysis of Variance

    - We could look at the signal-to-noise ratio of the communication system with and without the advanced digital signal processing algorithm by comparing the means of the signal-to-noise ratio measurements

4. Correlation Analysis

    - With correlation analysis, we can examine the relationship between the predictor variables and the signal-to-noise ratio of the communication system. Correlation coefficients can be calculated to determine the strength and direction of the relationship

5. Time Series Analysis

    - This method can be used to analyze the time series data collected from the communication system, such as trends, patterns, and seasonal variations, which can be useful to understand the performance of the communication system over time

References

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