Final Year Thesis MM1a-10

Signal Processing for Interference Mitigation in MIMO networks

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OVERVIEW

Multiple-input multiple-output (MIMO) is now regarded as one of the most promising research areas of wireless communications, due to its significant increase in spectral efficiency without requiring additional bandwidth or transmitting power.

This concept of MIMO has been extended to cellular networks. Multicarrier MIMO (MC-MIMO) has been intensively investigated because it provides maximum diversity and high antenna resources without propagating limitations, but suffers greatly from intercell interference.

In order to mitigate this interference, Network MIMO, which connects all the base stations to a central processing unit through high-speed backhaul links, is introduced. It is regarded as a key enabling technique for 5G/LTE-Advanced. Despite the great potential in mitigating intercell interference, several implementations of network MIMO are needed to be carefully evaluated to determine the robust conditions for network MIMO, such as imperfect channel state information (CSI), suboptimal linear receivers, limited feedback capacity.

In this project, we will focus on analyzing the effect of suboptimal linear MMSE receivers on the throughput of the optical network in the low SNR regime.

BACKGROUND

For low SNR, it is often appropriate to investigate the capacity in terms of the normalized transmit energy per information bit, $C_{	ext{opt}}$ is the capacity representation. The capacity expression is well approximated by [1, Van Hoyt].

$$C_{	ext{opt}} = \frac{\log_2(1 + \frac{E_{\text{rms}}}{N_0})}{N_0}$$

ACCOMPLISHMENTS

SYSTEM MODEL

- Wyner's model has been used
- Base stations are arranged in a circle
- Each of the BS has two neighboring BSs
- The transmit antenna gain is not the same
- Wyner's interference

CONCLUSIONS

- Interference affects MIMO more than single-user MIMO
- Interference affects MIMO more than MIMO in cooperative case
- The determinant factor for the choice of MIMO is the SIR

Figure 1: Wyner's extended model of a cellular system in [2, Jin].

Figure 2: Non-cooperative spectrum optimization in a 2x2 MIMO system.

Figure 3: The low SNR parameters $C_{\text{opt}}$ and wideband steps are respectively given by:

$$C_{\text{opt}} = \frac{\log_2(1 + \alpha \beta \log_2 E_{\text{rms}})}{N_0}$$

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Non-cooperative Case with ML (Not New)

The result is presented in [3, McKay], which serves as a comparison with the new results. The signal received by the BS is:

$$y = h_x x + n$$

where $y$ is the received signal, $h_x$ is the channel gain, $x$ is the transmitted signal, and $n$ is the noise. The intracell channel gain is 1, while intercell channel gain is assumed to be known to the eavesdropper.

Wyner's extended model has been used to evaluate the robust conditions for network MIMO, such as imperfect channel state information (CSI), suboptimal linear receivers, limited feedback capacity.

Non-cooperative Case with MMSE (New)

Theorem 1: The peak achievable rate is measured in bits/sec/Hz for MMSE receiver in non-cooperative case.

$$C_{\text{mmse}} = \frac{\log_2(1 + \beta \log_2 E_{\text{rms}})}{N_0}$$

where $\beta = \frac{\alpha \log_2 E_{\text{rms}}}{N_0}$.

Observations:
- MMSE is optimal in terms of $C_{\text{opt}} / N_0$
- Channel interference factor reduces the achievable rate

Theorem 2: The peak achievable rate is measured in bits/sec/Hz for ML receiver in non-cooperative case.

$$C_{\text{ml}} = \frac{\log_2(1 + \beta \log_2 E_{\text{rms}})}{N_0}$$

where $\beta = \frac{\alpha \log_2 E_{\text{rms}}}{N_0}$.

Observations:
- ML receiver in optimal in terms of minimum required energy per bit
- The difference between ML and MMSE is small

Theorem 3: For the case of collaboration between BSs with MMSE receivers, $C_{\text{coll}} / N_0$, and the wideband slope are respectively given by:

$$C_{\text{coll}} = \frac{\log_2(1 + \beta \log_2 E_{\text{rms}})}{N_0}$$

where $\beta = \frac{\alpha \log_2 E_{\text{rms}}}{N_0}$.

Joint Decoding with ML (New)

In [Part IV], [Theorem 1, Figure 1], gives a strong conical on wideband steps. The central results will be given here. In this scenario, the BSs are assumed to jointly decode the signal. The peak achievable rate is:

$$C_{\text{opt}} = \frac{\log_2(1 + \beta \log_2 E_{\text{rms}})}{N_0}$$

where $\beta = \frac{\alpha \log_2 E_{\text{rms}}}{N_0}$.

Observations:
- The peak achievable rate is significantly increased with the increase of intercell interference
- The performance of joint decoding is highly due to the reduction in $\beta$, but not the wideband step.

Conclusion

- Interference affects MIMO more than single-user MIMO
- Interference affects MIMO more than MIMO in cooperative case
- The determinant factor for the choice of MIMO is the SIR

Figure 4. Non-cooperative spectrum optimization in a 2x2 MIMO system.

Figure 5: The peak achievable rate is measured in bits/sec/Hz for MMSE receiver in non-cooperative case.

Figure 6: The peak achievable rate is measured in bits/sec/Hz for ML receiver in non-cooperative case.

Figure 7: The peak achievable rate is measured in bits/sec/Hz for MMSE receiver in non-cooperative case.

Figure 8: The peak achievable rate is measured in bits/sec/Hz for ML receiver in non-cooperative case.