**Experiment No. 05**

**1. Problem Statement:** A multiple-input multiple-output (MIMO) channel is equipped with n**T** transmitting antennas, n**R** receiving antennas, and n**I** interfering antennas

**(a) Derive the expressions of** the channel capacity

**(b) Write the programs of** channel capacity for MIMO interference channel using MATLAB

**(c) Explain the numerical results of** the channel capacity for MIMO interference channel

**2. Derivation of the channel capacity** **for MIMO channel**

Let,

Received signal:

Where,

𝒚 ∈ = Received Signal Vector

𝑯 ∈ = Channel Coefficient between the Transmitter and Receiver

𝑮 ∈ = Channel Coefficient between the Interferer and Receiver

𝒙 ∈ = Transmitted Signal Vector from the Transmitter

𝒔 ∈ =Transmitted Signal Vector from the Interferer

𝒛 ∈ = Noise Vector

w = Interference plus Noise Vector

**(i) Covariance of Received Signal:**

𝑹*y* = 𝐸[] = 𝐸[(𝑯𝒙+𝒛)]

= 𝐸[(𝑯𝒙+𝒛){+ }]

= 𝐸[(𝑯𝒙+𝑧){+}]

= 𝐸[+++]

= 𝐸 + 𝐸 + 𝐸 + 𝐸

= 𝐸 + 𝐸

= *H*𝐸 + 𝐸

= *H* {} + + *G* {}

=

Where,

**(ii) Covariance of Interference plus Noise signals**

𝑹*w* = 𝐸[] = 𝐸[]

= 𝐸[+ 𝐸[]

= 𝐸[+ 𝐸[]

= + *G* {}

**(iii) Entropy of Received Signal**

𝑯(𝒚)=(𝜋𝑒𝑹*y*) = {𝜋𝑒}

**(iv) Entropy of interference plus noise signal**

𝑯(**w**)=(𝜋𝑒𝑹*w*) = {𝜋𝑒}

**v) Mutual information between x and y**

𝐼(𝒙;𝒚)=𝑯(𝒚)−𝑯(w) =(𝜋𝑒𝑹𝒚)−(𝜋𝑒𝑹w)

=, which is the Mutual Information.

**(vii) Capacity at the Receiver:**

*C =*

*=* ,which is the channel capacity.

**3. Program for the channel capacity for MIMO interference channel**

* **MATLAB Code for plotting the capacity**

clc

clear all;

%%%%%%%% Initialization %%%%%%%%

N=30000; % Number of Iterations for H

No=1; % Noise Variance

%%%%%%%% Number of antennas %%%%%%%%

nt=2; % Number of Transmit antennas

ni=2; % Number of interference antenna

nt=Nt+ni;

nr=6; % Number of Receive antennas

%%%%%%%% Correlation of antennas %%%%%%%%

rhot=0; % Correlation coefficient (Transmitter)

rhor=0; % Correlation coefficient (Receiver)

ExponencorrMrtx=ones(nt);%%%%%%%% Creation of SNR from 1 to L %%%%%%%%

for i=1:nt

for j=1:nt

if i==j

ExponencorrMrtx(i,j)=1;

end

if i>j

ExponencorrMrtx(i,j)=rhot^(i-j);

else

ExponencorrMrtx(i,j)=rhot^(j-i);

end

end

end

Rt=ExponencorrMrtx;

% generate an nxn exponential correlation matrix for Rr

ExponencorrMrtx=ones(nt);

for i=1:nr

for j=1:nr

if i==j

ExponencorrMrtx(i,j)=1;

end

if i>j

ExponencorrMrtx(i,j)=rhor^(i-j);

else

ExponencorrMrtx(i,j)=rhor^(j-i);

end

end

end

Rr=ExponencorrMrtx;

SNRdB=[0:1:35];

l=length (SNRdB);

SNR=zeros (1,l);

for i=1:l

SNR (i)=10^(0.1\*SNRdB (i));

P(i)=SNR(i)\*No;

end

Erg\_Cap\_unknown=zeros (1,l);

for i=1:l

C\_unknown=zeros (1,N);

for j=1:N

H=CGM (nr,nt,Rr,Rt);

C\_unknown (j)=log (det (eye (nr)+(SNR (i)/nt)\*(H\*H')));

end

Erg\_Cap\_unknown (i)=mean (C\_unknown);

fprintf ('% e\t% e \n',SNRdB (i),Erg\_Cap\_unknown (i));

end

Erg\_Cap\_unknown=zeros (1,l);

for i=1:l

C\_unknown=zeros (1,N);

for j=1:N

G=CGM (nr,nt,Rr,Rt);

C\_unknown (j)=log (det (eye (nr)+(SNR (i)/nt)\*(G\*G')));

end

Erg\_Cap\_unknown (i)=mean (C\_unknown);

fprintf ('% e\t% e \n',SNRdB (i),Erg\_Cap\_unknown (i));

end

plot (SNRdB,Erg\_Cap\_unknown)

xlabel ('SNR (dB)');

ylabel ('Ergodic capacity (bits/sec/Hz)');

title ('Ergodic capacity versus SNR');

grid on

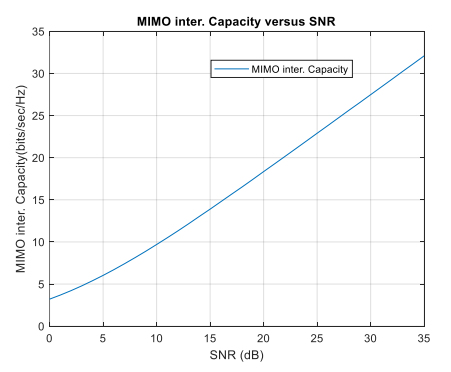
hold on

**4. Numerical results of the MIMO channel**

**(a) Numerical data for measuring capacity at different SNR (dB)**

|  |  |  |  |
| --- | --- | --- | --- |
| **SNR (dB)** | **Capacity(bits/sec/Hz)** | **SNR (dB)** | **Capacity(bits/sec/Hz)** |
| 0 | 3.21022 | 16 | 14.7718 |
| 1 | 3.68846 | 17 | 15.6565 |
| 2 | 4.21794 | 18 | 16.5476 |
| 3 | 4.77797 | 19 | 17.4404 |
| 4 | 5.38851 | 20 | 18.3512 |
| 5 | 6.02162 | 21 | 19.2530 |
| 6 | 6.69693 | 22 | 20.1611 |
| 7 | 7.40800 | 23 | 21.0785 |
| 8 | 8.14525 | 24 | 21.9772 |
| 9 | 8.90590 | 25 | 22.8973 |
| 10 | 9.69533 | 26 | 23.8161 |
| 11 | 10.4940 | 27 | 24.7259 |
| 12 | 11.3237 | 28 | 25.6441 |
| 13 | 12.1671 | 29 | 26.5609 |
| 14 | 13.0249 | 30 | 27.4844 |
| 15 | 13.8944 |  |  |

* **Graphical representation**

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**Figure 5.1:** Capacity of MIMO interference channel with respect to Signal to noise ratio.

**8. Discussion and Conclusion**

**a) Discussion:** The picture and data table depict the capacity variation of a MIMO interference channel. It It has been shown that as SNR increases, capacity increases. As we all know, interference occurs when the primary signal from one transmitter collides with another signal from another transmitter of the same frequency. Interference distorts the transmission, and the power of the signal can be raised or diminished. To solve this problem, many multiplexing techniques like as CDM, TDM, SDM, and FDM are used.

**b) Conclusion:** From our investigation, we can draw the following conclusions:

* **Capacity of MIMO interference channel increase with SNR.** MIMO communication systems increase channel capacity with signal-to-noise ratio (SNR), enabling higher reliability and spatial diversity. This improves robustness, modulation schemes, and resistance to noise and interference, resulting in a larger MIMO system capacity.
* **There is an effect of interfering antenna on the capacity of the channel.** Interfering antennas in communication environments impact channel capacity by introducing unwanted signals and noise, reducing signal quality and data rate. Factors like interference strength and proximity contribute to channel capacity reduction.
* **For better capacity interference should be avoided.** Minimizing interference is crucial for improving communication channel capacity, as it introduces errors and reduces SINR. Planning frequency allocations, antenna placements, and transmission strategies helps achieve higher SINR and improved channel capacity. Techniques like smart antenna design and interference cancellation are employed.