Experiment 7

Aim:-To plot channel capacity versus SNR for different MIMO systems.

Software-Octave

Theory-

MIMO (Multiple Input Multiple Output) systems enhance the channel capacity by using multiple antennas at both the transmitter and receiver.

We'll use the formula for MIMO channel capacity:

$$C = B \cdot \log_2 \left(\det \left(I + \frac{SNR}{N_t} \cdot HH^H \right) \right)$$

Where:

- C is the channel capacity in bits/second/Hz.
- B is the bandwidth (assumed to be 1 Hz for simplicity).
- I is the identity matrix.
- N_t is the number of transmit antennas.
- H is the channel matrix, and H^H is its Hermitian transpose.
- SNR is the signal-to-noise ratio.

SNR Setup:

We define SNR values in dB (SNR_dB = 0:5:30) and convert them to linear scale using SNR = 10.^(SNR_dB/10) because MIMO capacity formulas use linear SNR.

MIMO System Setup:

The code calculates the capacity for different MIMO configurations: 2x2, 4x4, and 8x8. These values are stored in MIMO_systems = [2, 4, 8].

Channel Matrix (H):

We assume a Rayleigh fading channel model, where the channel matrix H is generated with complex Gaussian random values (randn generates the real and imaginary parts).

Capacity Calculation:

For each SNR value, the code computes the MIMO channel capacity using the formula C = log2(det(eye(Nr) + (SNR/Nt) * (H * H'))).

This formula takes into account the number of transmit antennas, the SNR, and the channel matrix H.

Plotting:

The channel capacities for different MIMO systems are plotted against SNR. Each system (2x2, 4x4, and 8x8) is represented by a different line.

Conclusion-

Code in Octave(Don't write code in writeup)

```
% Parameters
SNR_dB = 0:5:30;   % SNR values in dB (0, 5, 10, ..., 30)
SNR = 10.^(SNR_dB/10);  % Convert SNR from dB to linear scale
num_SNR = length(SNR);  % Number of SNR points

% MIMO system sizes (2x2, 4x4, 8x8)
MIMO_systems = [2, 4, 8];
num_systems = length(MIMO_systems);

% Pre-allocate capacity matrix
Capacity = zeros(num_systems, num_SNR);

% Loop over different MIMO systems
for sys = 1:num_systems
  Nt = MIMO_systems(sys);  % Number of transmit antennas
  Nr = Nt;              % Assume same number of receive antennas (Nt x Nt)
  H = (1/sqrt(2)) * (randn(Nr, Nt) + 1j*randn(Nr, Nt));  % Random MIMO channel matrix

  for i = 1:num_SNR
    % Capacity calculation using the MIMO capacity formula
    C = log2(det(eye(Nr) + (SNR(i)/Nt) * (H * H')));
    Capacity(sys, i) = C;
  end
end

% Plotting
figure;
```

```
hold on;

for sys = 1:num_systems

   plot(SNR_dB, Capacity(sys, :), '-o', 'DisplayName', sprintf('%dx%d MIMO',
MIMO_systems(sys), MIMO_systems(sys)));

end


xlabel('SNR (dB)');

ylabel('Channel Capacity (bits/sec/Hz)');

title('MIMO Channel Capacity vs SNR');

legend('show');

grid on;

hold off;
```