PB3-REPORT

December 12, 2024

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Document: REPORT.pdf, ***Type:*** Laboratory

Languages used: LaTeX, Julia (in lieu of MATLAB)

Tools used: Jupyter, nbconvert (converting to PDF)

Permanent Link: https://github.com/setrar/MobCom/blob/main/Lab/REPORT.ipynb

MATLAB PROJECT for MOBCOM

EURECOM
November 21st, 2024
Class Instructor: Petros Elia
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- Read carefully the following questions, and using MATLAB, provide the answers/plots in the form of a report.
- The report should include a title page, and should be properly labeled and named. The report should be in the form of a PDF.
- Graphs should include labels, titles, and captions.
- Each graph should be accompanied with pertinent comments.
- Use optimal (maximum likelihood) decoders, unless stated otherwise.
- To compare the empirical results with the corresponding theoretical result, you should superimpose the two corresponding graphs and provide comments and intuition on the comparison.
- For each plot, describe the theoretical background that guides the proper choice of parameters for simulations (i.e., power constraint).
- You can work in groups of two or three.
- Regarding Grading:
  - All questions are weighted equally.
  - Submit your report (labeled and named) via email, to Hui Zhao (Hui.Zhao@eurecom.fr) and to myself.
  - Submission deadline is December 12th, 2024.

Enjoy!

PROBLEM 3

Use simulations to establish the probability of deep fade

$P(\|\tilde{h}\|^2 < \mathrm{SNR}^{-1})$

where $\|\tilde{h}\|^2$ now comes from the χ^2-squared fading distribution with $2 \times 3 = 6$ degrees of freedom.

- **What do you observe compared to the previous two problems?**

In all the above, the y-axis is the probability of deep fade, in log scale ($\log_{10}(\text{Prob})$), and the x-axis is the SNR, in dB.

Import Required Libraries

[1]:
```
using Random
using Distributions
using LinearAlgebra
using Plots, LaTeXStrings, Measures
using FFTW
```

[2]:
```
# functions and variables to increase readability
include("modules/operations.jl");
```

[3]:
```
# Define base values and offsets
base_values = [-0.00, -0.50, -1.00, -1.50, -2.00]
offsets = [-0.0, -0.02, -0.10, -0.15, -0.20, -0.30, -0.40, -0.70]
include("modules/view_helper.jl");
```

1 Deep Fade Probability with χ^2-Squared Fading Distribution

This problem requires simulating the deep fade probability: $P(\|\tilde{h}\|^2 < \mathrm{SNR}^{-1})$, where: - $\|\tilde{h}\|^2$ follows a χ^2-squared distribution with 6 degrees of freedom (2×3, for 3 independent Rician-like variables).

1.0.1 Key Differences

Compared to Problems 1 and 2: 1. Instead of Rician fading, we directly simulate a χ^2-squared random variable to represent $\|\tilde{h}\|^2$. 2. Degrees of freedom affect the distribution: - Higher degrees of freedom reduce variability and deep fade probability.

1.0.2 Simulation Steps

Step 1: Simulating χ^2-Squared Distribution A χ^2-squared random variable with k degrees of freedom is defined as the sum of squares of k independent standard normal random variables: $\|\tilde{h}\|^2 \sim \chi^2(k)$.

[4]:
```
# Generate  ²-squared random variables
function generate_chisq(n, k)
    return rand(Chisq(k), n)  # Generate n samples from  ²(k)
end;
```

Step 2: Probability of Deep Fade Compute the probability: $P(\|\tilde{h}\|^2 < \mathrm{SNR}^{-1})$, for a range of SNR values.

[5]:
```
# Compute deep fade probability for  ² distribution
function deep_fade_probability_chisq(h::Vector{Float64}, SNR_range::
 ↪Vector{Float64})
    probabilities = Float64[]
    for SNR_dB in SNR_range
        SNR_linear = 10^(SNR_dB / 10)  # Convert dB to linear scale
        threshold = 1 / SNR_linear
        fade_count = count(x -> x < threshold, h)
        push!(probabilities, fade_count / length(h))
    end
    return probabilities
end;
```

Step 3: Monte Carlo Simulation Simulate χ^2-squared fading for 6 degrees of freedom and compute the deep fade probabilities.

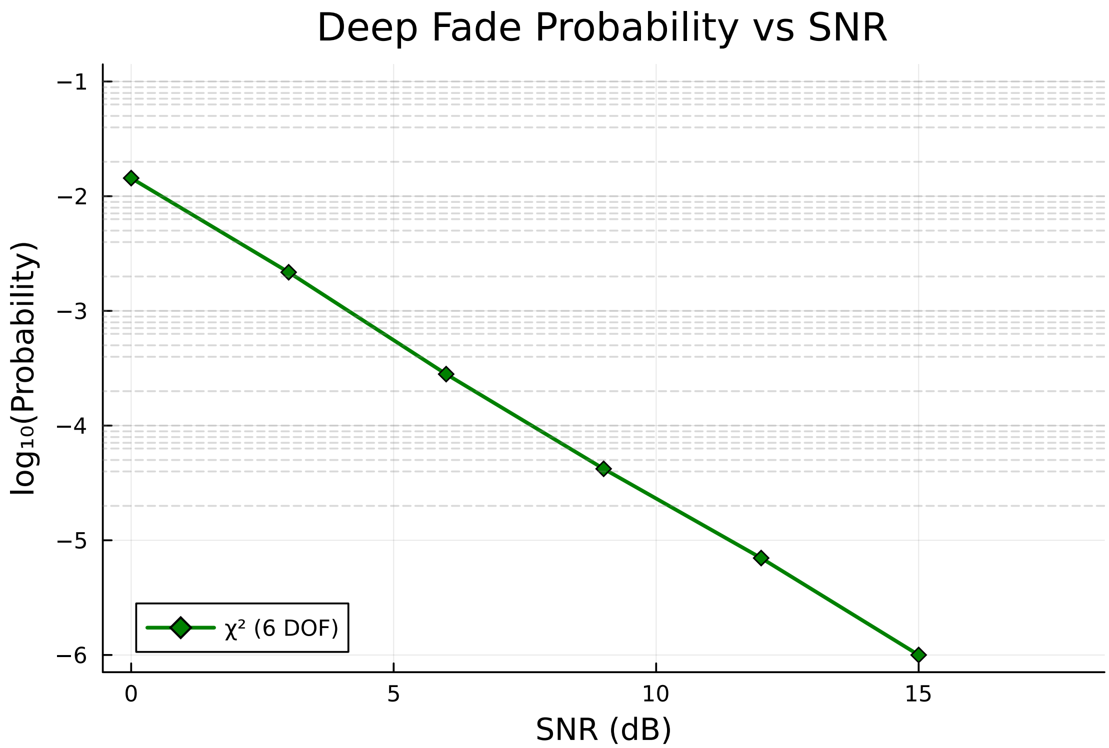
[14]:
```
# Parameters
n_samples = 10^6  # Number of samples
degrees_of_freedom = 6  # 2 x 3 for 3 independent Rician variables
SNR_dB_range = 0:3:20;  # SNR range in dB
```

Step 4: Plot Results Plot the deep fade probability for χ^2-squared fading, in comparison with previous results from Problems 1 and 2.

[15]:
```
# Convert SNR_dB_range to Vector{Float64}
SNR_dB_vector = Float64.(SNR_dB_range)  # Explicit conversion to Vector{Float64}

# Generate  ²-squared random variables
h_chisq = generate_chisq(n_samples, degrees_of_freedom)

# Compute deep fade probabilities
prob_chisq = deep_fade_probability_chisq(h_chisq, SNR_dB_vector)

# Plot  ² results
```

```
plot(SNR_dB_vector, log10.(prob_chisq),
     label=" ² (6 DOF)", marker=:diamond, lw=2, color=:green,
     xlabel="SNR (dB)", ylabel="log (Probability)", title="Deep Fade Probability vs SNR",
     grid=true)
add_combined_hlines!(offsets, base_values, linestyle=:dash, lw=1, color=:gray, alpha=0.3)
```

[15]:



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