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**MEMO Number** CMPE320\_S21\_PROJ4\_CODE

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**SUBJECT: MATLAB Code**

# matlab code

## Design the MAP detector

function part2\_1()

%Plot Tau\_map as a function of p0

p\_0 = (0.01:.01:0.99);

%Sigma^2 = 1/ Gamma = 1/10

var = 0.1;

T\_map = (var/2) .\* log( ((1-p\_0)) ./ p\_0 );%Tau\_map equation

figure(1)

plot(p\_0, T\_map,'Linewidth',2);

title('T\_{map}(p\_{0})');

xlabel('p\_0');

ylabel('T\_{map}');

end

## Investigate the MAP detector

function part2\_2()

A = 1;

var = 0.1;%variance

n = sqrt(var) \* randn(1,100000);%noise

R = -5:0.1:5;%x of plot

x = rand(1,100000) >= 0.6;%1 or 0

s = zeros(1,100000);

%IID samples using x

for i = 1:100000

if x(i) <= 0.6

s(i) = 1;

else

s(i) = -1;

end

end

R\_final = s + n;

f\_r0 = (((0.6)/(sqrt(2\*pi\*var))) \* exp((-(R-A).^2)./(2\*var)));

f\_r1 = (((0.4)/(sqrt(2\*pi\*var))) \* (exp((-(R+A).^2)./(2\*var))));

hold on

histogram(R\_final, 'Normalization', 'pdf');

plot(R,f\_r0,'Linewidth', 3);

plot(R,f\_r1,'b', 'Linewidth', 3);

title('Distribution of Received Signal');

xlabel('R');

ylabel('Probability');

legend('Histogram','Positive A', 'Negative A');

end

## Evaluate the ML Detector

function part2\_3()

g = [1:0.5:8, 8.5:0.25:13];%gamma

var = 10.^(g/-10);%variance

%getting 1 and 0

bk = zeros(1,1000000);

bk\_old = rand(1,1000000);

for i = 1:100000

bk(i) = bk\_old(i);

if bk(i) < 0.5

bk(i) = 0;

else

bk(i) = 1;

end

end

%mapping 1 and 0 to positive and negative

m = zeros(1,1000000);

for i = 1:1000000

m(i) = bk(i);

if m(i) == 0

m(i) = -1;

else

m(i) = 1;

end

end

%adding noise

R = zeros(1,1000000);%recieved signal with noise

errors = zeros(1,1000000);%errors

pb\_X = zeros(1,34);

bk\_hat = zeros(1,1000000);

for i = 1:length(var)

noise = sqrt(var(i)) \* randn(1,1000000);

for j = 1:1000000

R(j) = m(j) + noise(j);

bk\_hat(j) = R(j);

if bk\_hat(j) >= 0

bk\_hat(j) = 0;

else

bk\_hat(j) = 1;

end

errors(j) = xor(bk\_hat(j), bk(j));

end

s = sum(errors(:)==0);

pb\_X(i) = s/1000000;

end

%generate analytical function

analytical = 0.5\*erfc(1./(sqrt(2\*var)));

figure(1)%plot using semilogy

semilogy(g,analytical,'g', 'Linewidth', 3);%plot analytical

hold on;

semilogy(g,pb\_X, '-or', 'Linewidth', 1.5);%plot simulation

xlabel('Gamma');

ylabel('Probability of Error');

legend( 'Analytical','Simulation');

title('ML Detector');

end

# 2.4 Evaluate the MAP Detector

function part2\_4()

g = [1:0.5:8, 8.5:0.25:13];%gamma

var = 10.^(g/-10);%variance

tau = (log10(0.4/0.6).\*var)/2;

%getting 1 and 0

bk = zeros(1,1000000);

bk\_old = rand(1,1000000);

for i = 1:100000

bk(i) = bk\_old(i);

if bk(i) <= 0.6

bk(i) = 0;

else

bk(i) = 1;

end

end

%mapping 1 and 0 to positive and negative

m = zeros(1,1000000);

for i = 1:1000000

m(i) = bk(i);

if m(i) == 0

m(i) = -1;

else

m(i) = 1;

end

end

%add noise in order to get bk\_hat

r = zeros(1,1000000);%received singal

e = zeros(1,1000000);%errors

pb\_X = zeros(1,34);

bk\_hat = zeros(1,1000000);

for i = 1:length(var)

noise = sqrt(var(i)) \* randn(1,1000000);

for j = 1:1000000

if m(j) + noise(j) < tau(i)

bk\_hat(j) = 1;

elseif m(j) + noise(j) >= 0

bk\_hat(j) = 0;

end

e(j) = xor( bk\_hat(j),bk(j));

end

s = sum(e(:)== 0);

pb\_X(i) = s/1000000;

end

%generate analytical function

top = 1-tau;

top\_1 = tau + 1;

analytical = 0.3\*erfc(top./(sqrt(2).\*sqrt(var))) + 0.2\*erfc(top\_1./(sqrt(2).\*sqrt(var)));

figure(1)%plot using semilogy

semilogy(g,analytical,'g', 'Linewidth', 3);%plot analytical

hold on;

semilogy(g,pb\_X, '-or', 'Linewidth', 1.5);%plot simulation

xlabel('Gamma');

ylabel('Probability of Error');

legend( 'Analytical','Simulation');

title('MAP Detector');

end

## Compare the MAP and ML Detector performance

%2.5 = 2.4/2.3

function part2\_5()

g = [1:0.5:8, 8.5:0.25:13];%gamma

var = 10.^(g/-10);

tau = (log10(0.4/0.6) .\* var)./2;

t\_0\_6 = 1 - tau;%p

t\_0\_4 = 1 + tau;%1-p

analytical\_p0\_50 = 0.5\*erfc(1./(sqrt(2)\*sqrt(var)));%2.3

analytical\_p0\_\_60 = 0.3\*erfc(t\_0\_6./(sqrt(2).\*sqrt(var))) + 0.2\*erfc(t\_0\_4./(sqrt(2).\*sqrt(var)));%2.4

figure(1)

semilogy(g,analytical\_p0\_\_60,'g', 'Linewidth', 3);

hold on

semilogy(g,analytical\_p0\_50, '-oR', 'Linewidth', 1);

xlabel('Gamma');

ylabel('Probability of Error');

title('Analytical at p\_0 = 0.6 vs Analytical at p\_0 = 0.5');

legend('Analytical at p\_{0} = 0.6','Analytical at p\_{0} = 0.5');

%rho function

figure(2)

p = analytical\_p0\_\_60 ./ analytical\_p0\_50;

plot(g, p, 'Linewidth', 3);

xlabel('Gamma');

ylabel('Ratio');

title('Ratio of p\_0 = 0.6 / p\_0 = 0.5 as a funtion of Gamma');

end