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% CLASS: Human Operation of Aerospace Vehicles

Housekeeping

```
clear;clc;close all
```

Fixed Values

```
% 4 AOIs
% Each AOI has a saliience, expectancy, and value
% A (primary display)
S_A = 2;
Ex_A = 4;
V_A = 2;

% B (monitor for water levels)
S_B = 3;
Ex_B = 2;
V_B = 1;

% C (communications display)
S_C = 1;
Ex_C = 3;
V_C = 1;

% D (emergency notification)
S_D = 2;
Ex_D = 1;
V_D = 5;

% All the combinations of transition effort:
Ef_AB = 1;
```

```
Ef_AC = 1;
Ef_AD = 5;
Ef_BC = 3;
Ef_BD = 6;
Ef_CD = 4.5;
% Also, we are assuming that effort to transition is symmetric
% meaning Ef_AB = Ef_BA, etc
```

Distributions

fixation --> saccadic eye movement --> fixation --> and so on

```
n_fix = 10; % number of fixations

% Each fixation time modeled as a random variable with lognormal
% distribution
fix_dist = makedist('Lognormal','mu', 0, 'sigma',0.5);

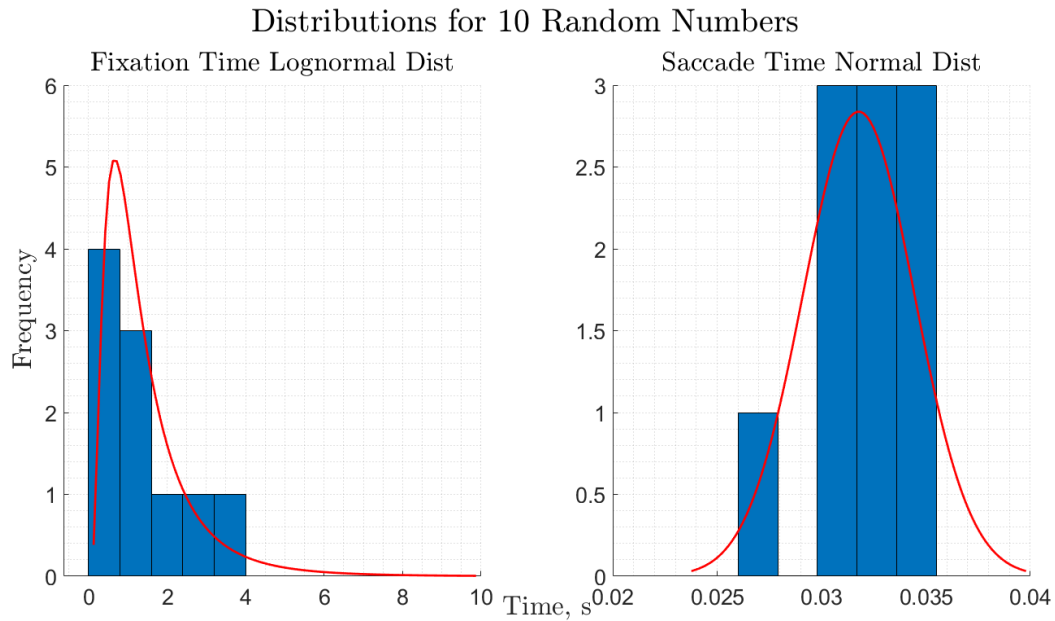
% The duration of each saccadic eye movement can be assumed to be normally
% distributed
sac_dist = makedist('Normal','mu',0.03,'sigma',0.003);

fix_time = random(fix_dist,n_fix,1);
% now visualizing the lognormal distribution:
fig = figure(1);
subplot(1,2,1); hold on; grid minor;
histfit(fix_time,5,'lognormal')
set(gca,'FontSize',20);
title('Fixation Time Lognormal Dist','Interpreter','latex','FontSize',25)

sac_time = random(sac_dist,n_fix,1);
% now visualizing the lognormal distribution:
subplot(1,2,2); hold on; grid minor;
histfit(sac_time,5,'normal')
set(gca,'FontSize',20);
title('Saccade Time Normal Dist','Interpreter','latex','FontSize',25)

han=axes(fig,'visible','off');
han.Title.Visible='on';
han.XLabel.Visible='on';
han.YLabel.Visible='on';
ylabel(han,'Frequency','Interpreter','latex','FontSize',25);
xlabel(han,'Time, s','Interpreter','latex','FontSize',25)

sgtitle('Distributions for 10 Random
Numbers','Interpreter','latex','FontSize',30)
set(gcf,'Position',get(0,'Screensize'));
```



1. Simulation of the Eye Position

```
% Initialize time vector and eye position array
time_points = zeros(2 * n_fix-1, 1);
eye_position = zeros(2 * n_fix-1, 1);

% Start at display A
current_time = 0;
current_display=1;

for i = 1:n_fix

    % Fixation on display
    [~,current_display] = NextDisplay(current_display,false,false);
    eye_position(2*i - 1) = current_display;
    time_points(2*i - 1) = current_time;
    current_time = current_time + fix_time(i);

    % Saccade (if not the last fixation)
    if i < n_fix+1
        eye_position(2*i) = NaN; % No display viewed during saccades
        time_points(2*i) = current_time;
        current_time = current_time + sac_time(i);
    end
end
```

Plot the scan pattern

```
figure(2)
hold on
```

```

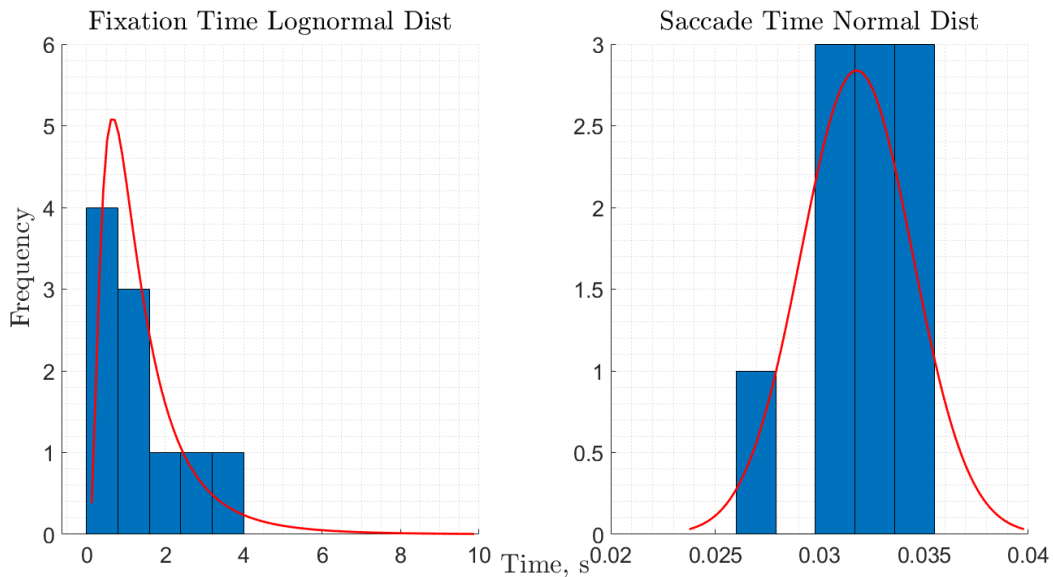
% Plot the fixations (solid lines) using the stairs function
stairs(time_points, eye_position, 'LineWidth', 3, 'Color', 'b');

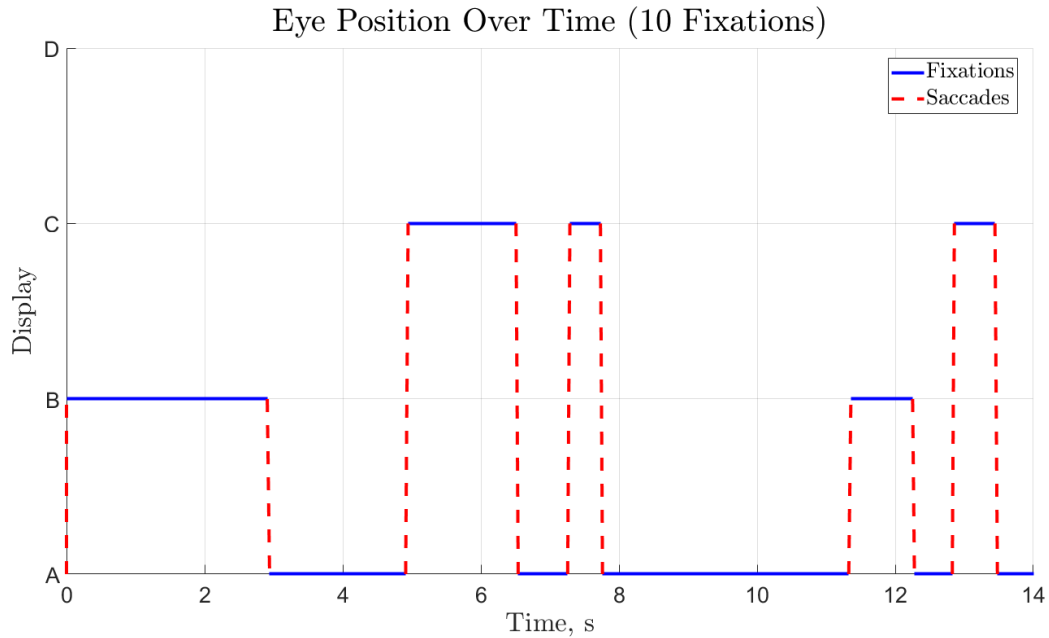
% Plot the saccades (red dashed lines)
plot([0 time_points(1)], [1 eye_position(1)], 'r--', 'LineWidth', 3);
for i = 1:2:(2*n_fix-2) % Iterate over every other element for 9 saccades
    % Plot the saccade as a red dashed line
    plot([time_points(i+1), time_points(i+2)], [eye_position(i),
eye_position(i+2)], 'r--', 'LineWidth', 3);
end

% Labels and formatting
yticks([1 2 3 4]);
yticklabels({'A', 'B', 'C', 'D'});
ylim([1 4]);
set(gca, 'FontSize', 20);
xlabel('Time, s', 'Interpreter', 'latex', 'FontSize', 25);
ylabel('Display', 'Interpreter', 'latex', 'FontSize', 25);
title('Eye Position Over Time (10
Fixations)', 'Interpreter', 'latex', 'FontSize', 30);
grid on;
legend({'Fixations', 'Saccades'}, 'Location',
'best', 'Interpreter', 'latex', 'FontSize', 20);
set(gcf, 'Position', get(0, 'Screensize'));
hold off;

```

Distributions for 10 Random Numbers





2. Monte Carlo Simulations

number of simulations

```
n_sim = 1000;
% number of fixations (updating)
n_fix = 100;
% initializing
current_display = 1;
current_time = 0;
% count of time spent fixating on each display
time_count_fix = zeros(1,4);
time_count_sim = zeros(n_sim,4);

for j = 1:n_sim
    for i = 1:n_fix

        % Fixation on display
        [~,current_display] = NextDisplay(current_display,false,false);

        % fixation and saccade time
        fix_time = random(fix_dist,1,1);
        sac_time = random(sac_dist,1,1);

        current_time = current_time + sac_time + fix_time;

        time_count_fix(current_display) = time_count_fix(current_display)
+fix_time;
    end

    % finding relative time on each display
    time_count_sim(j,:) = time_count_fix./current_time;
```

```

% Note that these do not add up to 1 because we're dividing by the
% TOTAL time (i.e., including the saccade time)

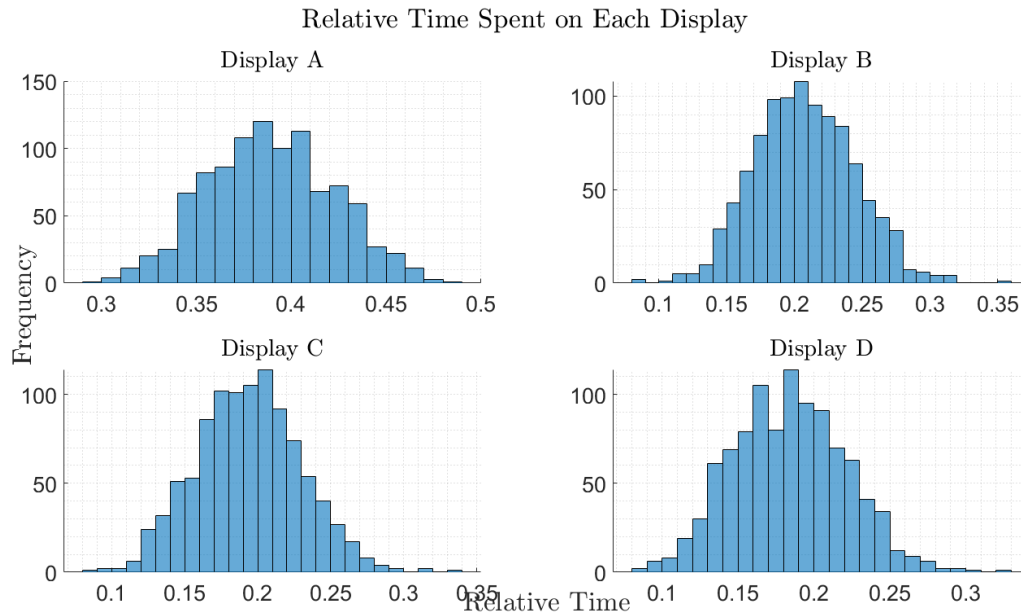
% resetting
time_count_fix = zeros(1,4);
current_time = 0;
current_display = 1;

end

% plotting a histogram for each display
fig = figure(); hold on;
subplot(2,2,1); hold on; grid minor;
histogram(time_count_sim(:,1));
title('Display A','Interpreter','latex')
set(gca,'FontSize',20);
hold off;
subplot(2,2,2); hold on; grid minor;
histogram(time_count_sim(:,2));
title('Display B','Interpreter','latex')
set(gca,'FontSize',20);
hold off;
subplot(2,2,3); hold on; grid minor;
histogram(time_count_sim(:,3));
title('Display C','Interpreter','latex')
set(gca,'FontSize',20);
hold off;
subplot(2,2,4); hold on; grid minor;
histogram(time_count_sim(:,4));
title('Display D','Interpreter','latex')
set(gca,'FontSize',20);
hold off;

han=axes(fig,'visible','off');
han.Title.Visible='on';
han.XLabel.Visible='on';
han.YLabel.Visible='on';
ylabel(han,'Frequency','Interpreter','latex','FontSize',25);
xlabel(han,'Relative Time','Interpreter','latex','FontSize',25)
sgtitle('Relative Time Spent on Each
Display','Interpreter','latex','FontSize',25);
set(gcf,'Position',get(0,'Screensize'));

```



3. Wind Alert Problem

```
% number of simulations
n_sim = 1000;
% initializing
current_display = 1;
current_time = 0;
wind_alert_detected = 0;
% count of time spent fixating on each display
time_count_sim = zeros(n_sim,1);

for j = 1:n_sim
    while wind_alert_detected == 0 % not terminating until wind alert has
        been detected

            % fixation and saccade time
            fix_time = random(fix_dist,1,1);
            sac_time = random(sac_dist,1,1);

            % keeping track of all time
            current_time = current_time + sac_time + fix_time;

            % wind alert occurs at current_time = 10
            if current_time >= 10

                % Fixation on display
                [~,current_display] = NextDisplay(current_display,false,false);

                if current_display == 4
                    % essentially, flipping a weighted coin where the prob
                    % of "success" (detecting the wind alert)=0.8
                    wind_alert_detected = binornd(1,0.8);
                end
            end
        end
    end
end
```

```

        end
    end

end

% time at which wind alert was detected is randomly chosen from a
% uniform distribution from 0 to the fixation time

if current_time-fix_time < 10 % if the wind alert went off while on
display D
    time_detected = unifrnd(0,current_time-10);
    fix_time = 0;
else % if wind alert went off while on any other display
    time_detected = unifrnd(0,fix_time);
end

% we already added the fixation time, so we have to subtract out the
% fixation time and add the time within the fixation that the wind
% alert was detected
current_time = current_time - fix_time + time_detected;

% finding time it takes to detect the wind alarm
time_count_sim(j) = current_time-10;
if time_count_sim(j) < 0
    disp(j)
end

% resetting
current_time = 0;
current_display = 1;
wind_alert_detected = 0;

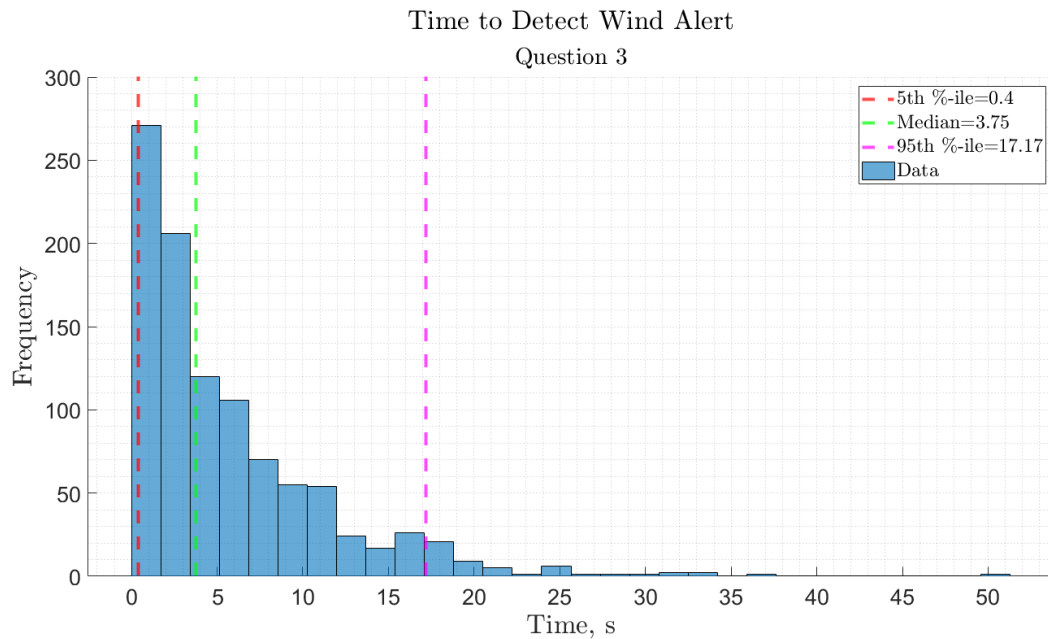
end

% calculating the 50th (median), 5th, and 95th percentiles
ques_3_50prctile = prctile(time_count_sim,50);
ques_3_5prctile = prctile(time_count_sim,5);
ques_3_95prctile = prctile(time_count_sim,95);

% plotting a histogram for each display
figure(); hold on; grid minor;
subtitle('Question 3','FontSize',15,'Interpreter','latex');
xline(ques_3_5prctile,'--','LineWidth',3,'Color','r')
xline(ques_3_50prctile,'--','LineWidth',3,'Color','g')
xline(ques_3_95prctile,'--','LineWidth',3,'Color','m')
histogram(time_count_sim,NumBins=30);
legend(strcat('5th %-ile= ',num2str(round(ques_3_5prctile,2))),...
    strcat('Median=',num2str(round(ques_3_50prctile,2))),...
    strcat('95th %-ile=',num2str(round(ques_3_95prctile,2))), 'Data',...
    'Interpreter','latex');
set(gca,'FontSize',20);
title('Time to Detect Wind Alert','Interpreter','latex','FontSize',25)
xlabel('Time, s','Interpreter','latex','FontSize',25);
ylabel('Frequency','Interpreter','latex','FontSize',25)

```

```
set(gcf,'Position',get(0,'Screensize'));
hold off;
```



4. Wind Alert Problem with Increased Saliency

```
% number of simulations
n_sim = 1000;
% initializing
current_display = 1;
current_time = 0;
wind_alert_detected = 0;
% count of time spent fixating on each display
time_count_sim = zeros(n_sim,1);

for j = 1:n_sim
    while wind_alert_detected == 0 % not terminating until wind alert has
        been detected

        % fixation and saccade time
        fix_time = random(fix_dist,1,1);
        sac_time = random(sac_dist,1,1);

        % keeping track of all time
        current_time = current_time + sac_time + fix_time;

        % wind alert occurs at current_time = 10
        if current_time >= 10

            % Fixation on display
            [~,current_display] = NextDisplay(current_display,true,false);

            if current_display == 4
```

```

        % essentially, flipping a weighted coin where the prob
        % of "success" (detecting the wind alert)=0.8
        wind_alert_detected = binornd(1,0.8);
    end
end

end

% time at which wind alert was detected is randomly chosen from a
% uniform distribution from 0 to the fixation time

if current_time-fix_time < 10 % if the wind alert went off while on
display D
    time_detected = unifrnd(0,current_time-10);
    fix_time = 0;
else % if wind alert went off while on any other display
    time_detected = unifrnd(0,fix_time);
end

% we already added the fixation time, so we have to subtract out the
% fixation time and add the time within the fixation that the wind
% alert was detected
current_time = current_time - fix_time + time_detected;

% finding time it takes to detect the wind alarm
time_count_sim(j) = current_time-10;
if time_count_sim(j) < 0
    disp(j)
end

% resetting
current_time = 0;
current_display = 1;
wind_alert_detected = 0;

end

% calculating the 50th (median), 5th, and 95th percentiles
ques_4_50prctile = prctile(time_count_sim,50);
ques_4_5prctile = prctile(time_count_sim,5);
ques_4_95prctile = prctile(time_count_sim,95);

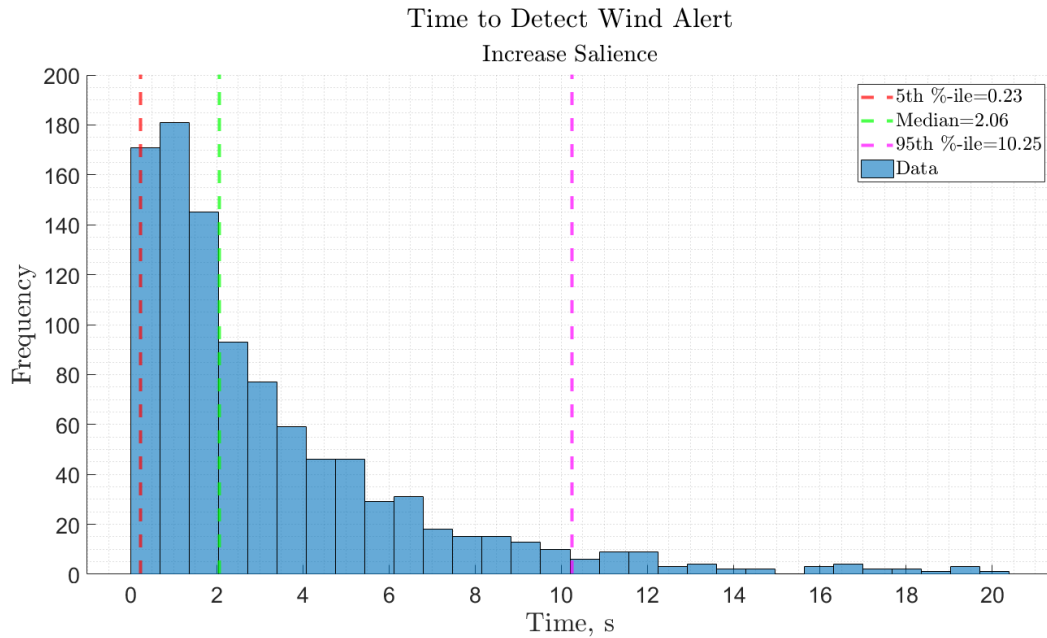
% plotting a histogram for each display
figure(); hold on; grid minor;
subtitle('Increase Saliency','FontSize',15,'Interpreter','latex');
xline(ques_4_5prctile,'--','LineWidth',3,'Color','r')
xline(ques_4_50prctile,'--','LineWidth',3,'Color','g')
xline(ques_4_95prctile,'--','LineWidth',3,'Color','m')
histogram(time_count_sim,NumBins=30);
legend(strcat('5th %-ile= ',num2str(round(ques_4_5prctile,2))),...
    strcat('Median=',num2str(round(ques_4_50prctile,2))),...
    strcat('95th %-ile=',num2str(round(ques_4_95prctile,2))), 'Data',...
    'Interpreter','latex');
set(gca,'FontSize',20);

```

```

title('Time to Detect Wind Alert','Interpreter','latex','FontSize',25)
xlabel('Time, s','Interpreter','latex','FontSize',25);
ylabel('Frequency','Interpreter','latex','FontSize',25)
set(gcf,'Position',get(0,'Screensize'));
hold off;

```



4. Wind Alert Problem with Increased Saliency

```

% number of simulations
n_sim = 1000;
% initializing
current_display = 1;
current_time = 0;
wind_alert_detected = 0;
% count of time spent fixating on each display
time_count_sim = zeros(n_sim,1);

for j = 1:n_sim
    while wind_alert_detected == 0 % not terminating until wind alert has
        been detected

        % fixation and saccade time
        fix_time = random(fix_dist,1,1);
        sac_time = random(sac_dist,1,1);

        % keeping track of all time
        current_time = current_time + sac_time + fix_time;

        % wind alert occurs at current_time = 10
        if current_time >= 10

            % Fixation on display

```

```

        [~,current_display] = NextDisplay(current_display,false,true);

        if current_display == 4
            % essentially, flipping a weighted coin where the prob
            % of "success" (detecting the wind alert)=0.8
            wind_alert_detected = binornd(1,0.8);
        end
    end

end

% time at which wind alert was detected is randomly chosen from a
% uniform distribution from 0 to the fixation time

if current_time-fix_time < 10 % if the wind alert went off while on
display D
    time_detected = unifrnd(0,current_time-10);
    fix_time = 0;
else % if wind alert went off while on any other display
    time_detected = unifrnd(0,fix_time);
end

% we already added the fixation time, so we have to subtract out the
% fixation time and add the time within the fixation that the wind
% alert was detected
current_time = current_time - fix_time + time_detected;

% finding time it takes to detect the wind alarm
time_count_sim(j) = current_time-10;
if time_count_sim(j) < 0
    disp(j)
end

% resetting
current_time = 0;
current_display = 1;
wind_alert_detected = 0;

end

% calculating the 50th (median), 5th, and 95th percentiles
ques_5_50prctile = prctile(time_count_sim,50);
ques_5_5prctile = prctile(time_count_sim,5);
ques_5_95prctile = prctile(time_count_sim,95);

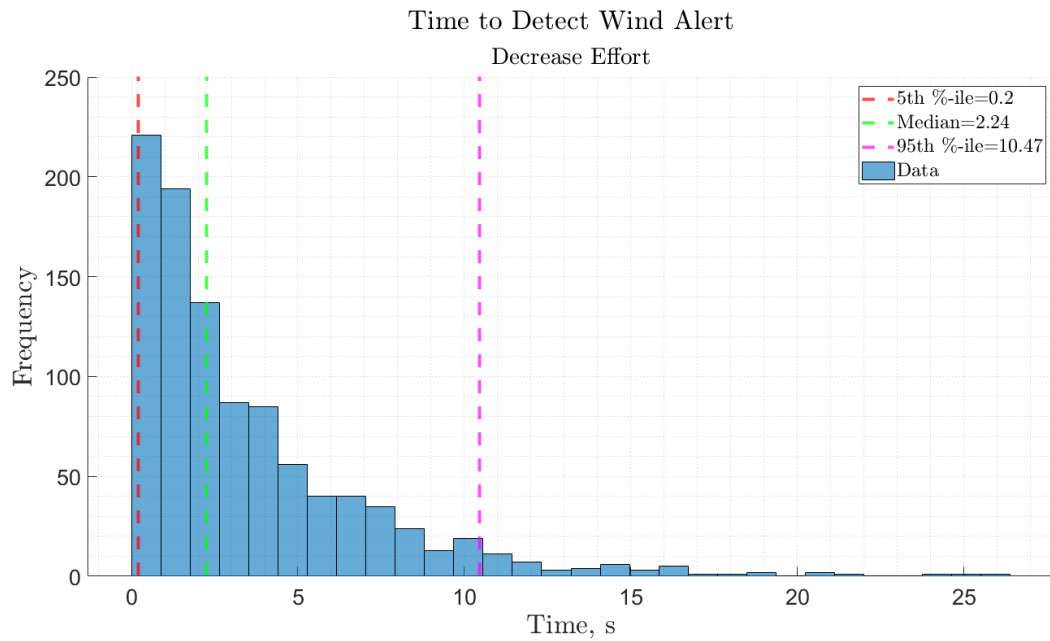
% plotting a histogram for each display
figure(); hold on; grid minor;
subtitle('Decrease Effort','FontSize',15,'Interpreter','latex');
xline(ques_5_5prctile,'--','LineWidth',3,'Color','r')
xline(ques_5_50prctile,'--','LineWidth',3,'Color','g')
xline(ques_5_95prctile,'--','LineWidth',3,'Color','m')
histogram(time_count_sim,NumBins=30);
legend(strcat('5th %-ile= ',num2str(round(ques_5_5prctile,2))),...
    strcat('Median=',num2str(round(ques_5_50prctile,2))),...)

```

```

    strcat('95th %-ile=',num2str(round(ques_5_95prctile,2))), 'Data', ...
    'Interpreter','latex');
set(gca, 'FontSize', 20);
title('Time to Detect Wind Alert', 'Interpreter', 'latex', 'FontSize', 25)
xlabel('Time, s', 'Interpreter', 'latex', 'FontSize', 25);
ylabel('Frequency', 'Interpreter', 'latex', 'FontSize', 25)
set(gcf, 'Position', get(0, 'Screensize'));
hold off;

```



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