BME 6717 Data Project 1: MATLAB

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January 2022

1 MATLAB Program

1.1 Angle Object

```
classdef Angle
    properties (Access=protected)
        value %angle
        trajectory %x and y displacements for each occurence of ...
            the angle
    end

    methods
        function angle = Angle(value,trajectory)
            % Usage: angle = Angle(value,trajectory)
            % Purpose: Constructor
            % Input: value        angle
            % trajectory        %x and y displacements for each ...
                occurence of the angle as a
            % cell array
            % Output: angle        Angle object
            angle.value=value;
            angle.trajectory=trajectory;
        end

        function [h_displacements,distance] = xVals(angle)
            % Usage: [h_displacements,distance] = xVals(angle)
            % Purpose: Get the x-values and horizontal distance ...
                for each occurence of the angle
            % Input: angle        Angle object
            % Output: h_displacements  x-values
            %         distance -- horizontal distance

            h_displacements=cellfun(@max,angle.trajectory,...
            'UniformOutput',false);
            distance=cellfun(@max,h_displacements);
        end

        function [v_displacements,height] = yVals(angle)

            % Usage: [v_displacements,height] = yVals(angle)
```

```
34              % Purpose: Get the y-values and vertical height for ...
                    each occurence of the angle
35              % Input: angle        Angle object
36              % Output: v_displacements  y-values
37              %         height -- vertical height
38              v_displacements=cellfun(@min,angle.trajectory,...
39              'UniformOutput',false);
40              height=cellfun(@max,v_displacements);
41          end
42
43          function flightTime = time(angle)
44              % Usage: flightTime = time(angle)
45              % Purpose: Get the time of flight for each ...
                    occurrence of the angle
46              % Input: angle        Angle object
47              % Output:  flightTimes  time of flight
48              flightTime =cellfun(@length,angle.trajectory);
49          end
50
51          function disp(¬,h_displacements,v_displacements,color)
52              % Usage: ...
                    disp(angle,h_displacements,v_displacements,color)
53              % Purpose: plot all trajectories for the angle
54              % Input: ¬ -- Angle object
55              %        v_displacements  y-values
56              %        h_displacements  x-values
57              %        color -- line color
58              % Output: figure showing trajectories
59             for i=1:length(h_displacements)
60                 plot(h_displacements{i},v_displacements{i},...
61                 'color',color)
62                 hold on
63
64             end
65          end
66      end
67  end
```

1.2 Computations

```
1   %BME6717 Data Project 1
2
3   % Creating cell array to store angles and all trials of that angle
4
5   Projectiles=importdata('UnderwaterProjectileData.mat');
6
7   [C,ia,ic] = unique([Projectiles{:,1}]);
8   freq=accumarray(ic,ic,[],@length)
9   n=length(C);
10
11  %angles cell array contains 2 columns
12  %column 1 is the angle
13  %column 2 contains the trajectories of each time that launch ...
        angle was used
```

```
angles = cell(n,2);

for k=1:n
    angles{k,1}=C(k);
    angles{k,2}=Projectiles(ic==k,2);
end


% Soluions
maxDist=cell(n,4);
maxheight=cell(n,4);
variability =cell(n,5);
maxTotDis=zeros(n,1);
cmp=vertcat(hsv(4),turbo(4));
all_times=[];

for i=1:n
    angle=Angle(angles{i},angles{i,2});
    [x,d]=xVals(angle);
    [y,h]=yVals(angle);
    time_of_flights=time(angle);
    all_times=vertcat(all_times,time_of_flights);


    figure(1)
    disp(angle,x,y,cmp(i,:))
    title('Trajectory of projectiles')
    xlabel('horizontal coordinates(m)')
    ylabel('vertical coordinates(m)')

    maxDist{i,1}=angles{i};
    maxDist{i,2}= max(d);
    maxDist{i,3}=mean(d);
    maxDist{i,4}=median(d);


    maxheight{i,1}=angles{i};
    maxheight{i,2}= max(h);
    maxheight{i,3}=mean(h);
    maxheight{i,4}=median(h);

    variability {i,1}=angles{i};
    variability {i,2}= iqr(time_of_flights);
    variability {i,3}=range(time_of_flights);
    variability {i,4}=var(time_of_flights);
    variability {i,5}=std(time_of_flights);


    figure (2)
    for k=1:freq(i)
        maxTotDis(i)=max(maxTotDis(i),max(sqrt(x{k}.^2+y{k}.^2)));
        plot(sqrt(x{k}.^2+y{k}.^2),'color',cmp(i,:))
        ylabel('projectile displacement(m)')
        xlabel('time(s)')
        title('magnitudes of the trajectories')
        hold on
    end
```

```
71
72  end
73
74
75  figure(3)
76  char=[];
77  for i=1:8
78      char=[char,repmat(angles{i},1,freq(i))];
79  end
80  boxplot(all_times,char)
81  ylabel('time of flight(s)')
82  title('time variability of different launch angles')
83
84
85  [m,ix]=max(cellfun(@max, maxDist(:,2:end)));
86  angle_bestDistance= maxDist{ix(1)}
87
88  [m,ix]=max(cellfun(@max, maxheight(:,2:end)));
89  angle_bestHeight= maxheight{ix(1)}
90
91  [m,ix]=min(cellfun(@min, variability(:,2:end)));
92  angle_minVar= variability{ix(1)}
93
94  % How many times was each launch angle used?
95  freq
96
97  %which launch angle had the max total displacement
98  [m,ix]=max(maxTotDis);
99  disp(angles{ix})
100 %%
101 lineHandles = get( gca, 'Children' );
102
103 lineIndex=cumsum(freq,'reverse');
104 lines=zeros(n,1);
105 legends={n,1};
106 for i=1:n
107 lines(i)=lineHandles(lineIndex(i));
108 legends(i)={num2str(angles{i})};
109 end
110 legend(lines,legends)
111 leg = legend('show');
112 title(leg,'Launch Angle')
```

2 Results

2.1 horizontal distance

The horizontal distance for each launch was the last value in the x coordinates. After grouping all x coordinate values that had the same launch angle, the horizontal distance for each group of x coordinates was recorded. The mean, maximum and median of these groups of horizontal distances was computed for each launch angle.
The launch angle that produced the maximum horizontal distance (in terms of

mean, mode and median) was 0.4394

2.2 vertical height

The maximum entry of the y coordinate values for each value was recorded after grouping all y coordinate values based on launch angle. The above computations were performed on these values.
The launch angle that produced the maximum vertical height (in terms of mean, mode and median) was 0.9256

2.3 time variability

The launch angle that produced the minimum time variability was 0.1963

2.4 frequency

The number of times each launch angle was used was computed. The results are presented below.

Angle	Frequency
0.1963	31
0.3179	24
0.4394	11
0.5610	27
0.6825	37
0.8041	22
0.9256	17
1.0472	10

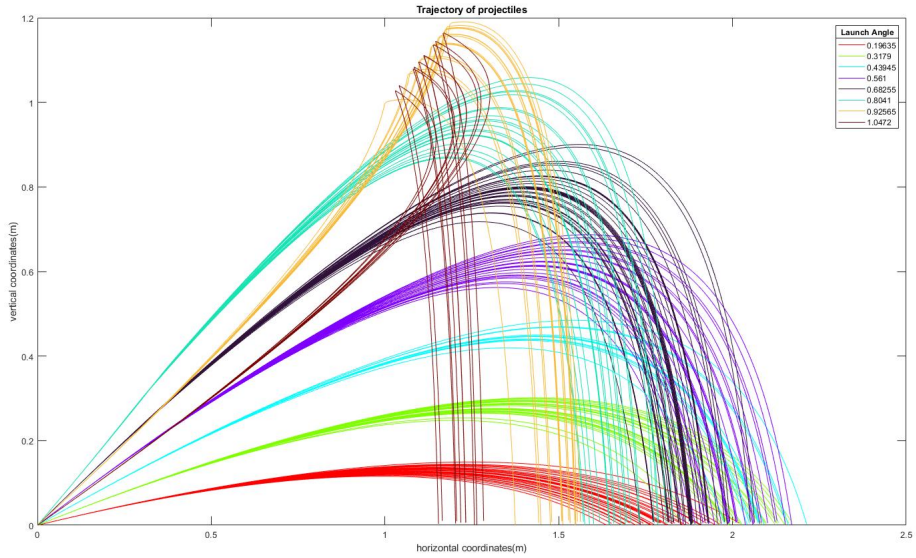
2.5 maximum total displacement

The magnitude of each x,y pair was computed and the launch angle with the maximum total displacement (highest $\sqrt{x^2 + y^2}$ combination) was found to be 0.4394.

3 Plots

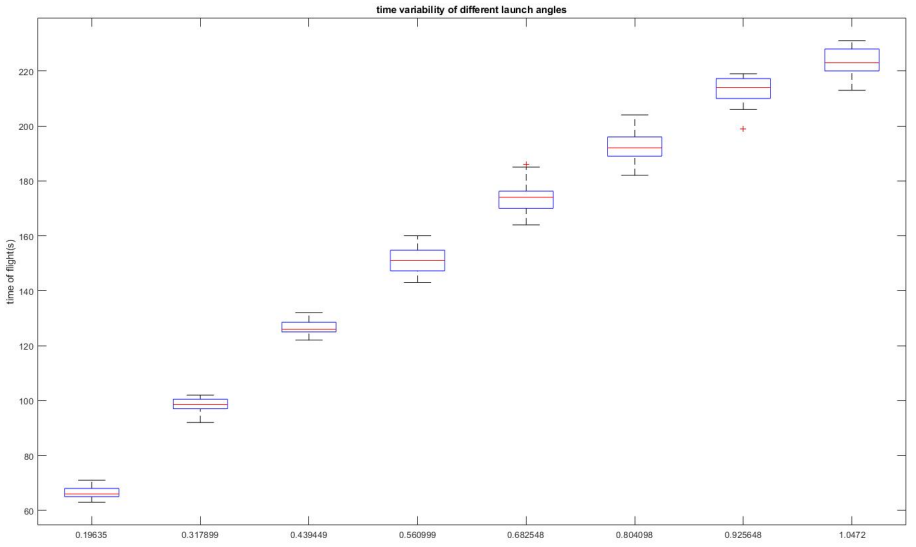
3.1 trajectory

This image shows the path of the projectile with the x coordinates on the horizontal axis and y coordinates on the vertical for all the launches according to groups.



3.2 time variability

This image shows boxplots that show the spread of the different groups of angles



3.3 maximum displacement magnitude

The image shows the magnitudes of the trajectories plotted against time.