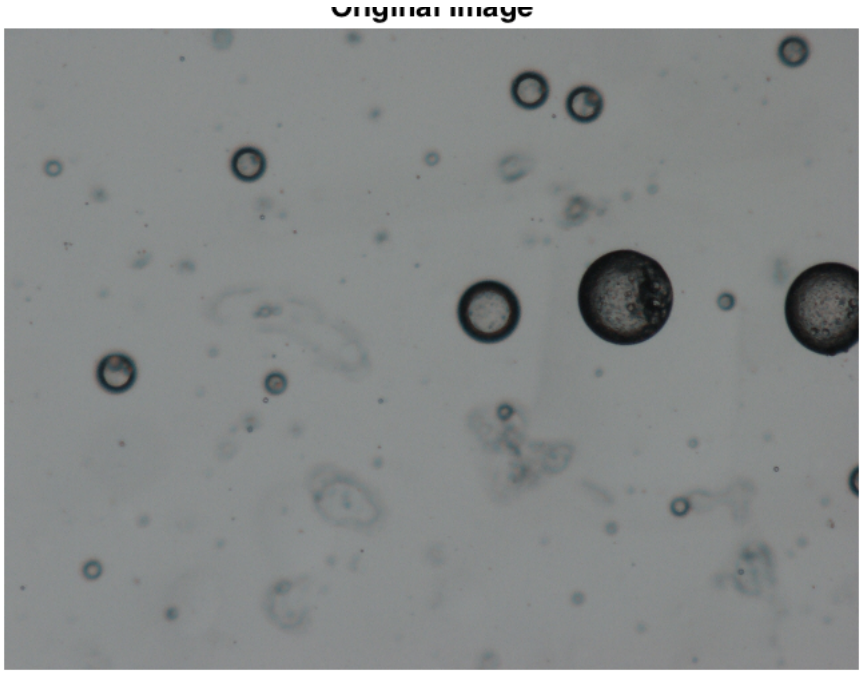
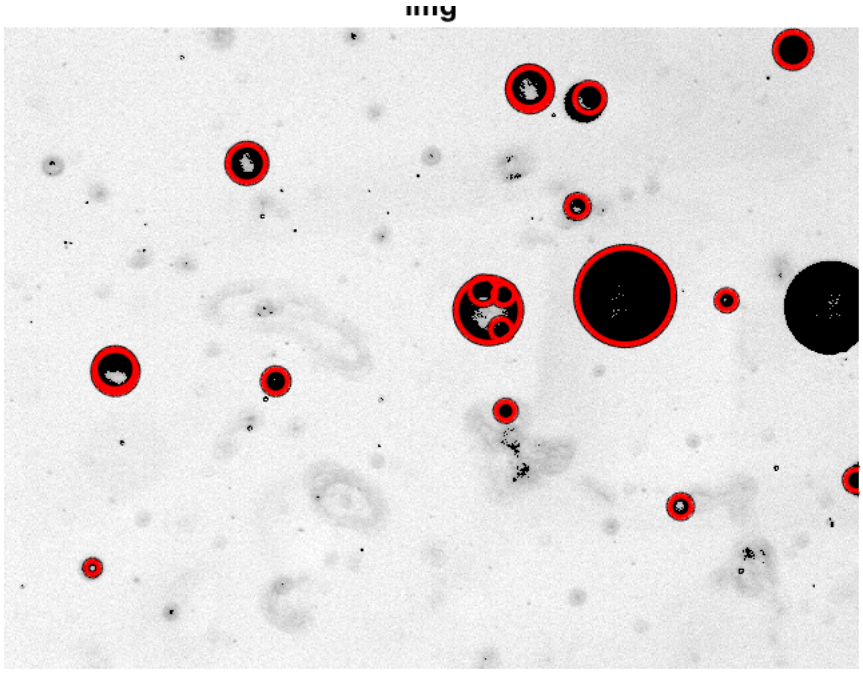
```
clc, clear all, close all % Boilerplate

% Careful ignore the circle algorithm warnings :)
warning('off','all')
warning

% Manually Measure Scale
% 1     439     127.015 87.450  139.792 -4.709  438.444
OneMM = 438.444; % pixels
OneMicro = OneMM/1000;

NetDiameters = [];

%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Pick Photo files to analyze
[PhotoNames, PhotoPath] = uigetfile('.jpg', 'Select Image To Measure', 'MultiSelect', 'on');
% Determine the number of cells selected
CheckCell = iscell(PhotoNames);
if CheckCell == 0
    CountLimit = 1;
else
    CountLimit = max(size(PhotoNames));
end

%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Loop Through Files
for PhotoCount = 1:CountLimit
  % Parse path
  if CheckCell == 0
      filename = strcat(PhotoPath, PhotoNames);
  else
      filename = strcat(PhotoPath, PhotoNames{PhotoCount});
  end
  [ParentPath, PhotoName, ext] = fileparts(filename);
  % Path = strcat(ParentPath, '/Output');

  %%%%%%%%%%%%%%%%%%%%%%%%%%%%
  % Import Image
        img = imread(filename);
        figure
        imshow(img)
        title('Original Image')

        % % Good spot for image analysis
        % figure
        % imshow(img(:, :, 1))
        % title('Red')

        %%%%%%%%%%%%%%%%%%%%%%%%%%%%
        % Improve Image Quality prior to analysis
        img = img(:, :, 3); % only show blue
        img = imsharpen((img)); % sharpen
        img = imadjust(img); % increase contrast of grayscale image
        [~, img] = createMask(img); % use manually calibrated colorThresholder mask

        figure
        imshow(img)
        title('img')
        disp(sprintf('Analyzing Photo: "%s"', PhotoName))

        %%%%%%%%%%%%%%%%%%%%%%%%%%%%
        % Alternate Notes
        % d = imdistline;
        % delete(d);

        % [SmallCenters, SmallRadii] = imfindcircles(img,[3 15],'ObjectPolarity','dark');
        % length(SmallCenters)
        % h = viscircles(SmallCenters, SmallRadii);

        % [MediumCenters, MediumRadii] = imfindcircles(img,[16 48],'ObjectPolarity','dark', 'Sensitivity',0.9);
        % length(MediumCenters)
        % h = viscircles(MediumCenters, MediumRadii);

        % [LargeCenters, LargeRadii] = imfindcircles(img,[49 120],'ObjectPolarity','dark', 'Sensitivity',0.9);
        % length(LargeCenters)
        % h = viscircles(LargeCenters, LargeRadii);
        %%%%%%%%%%%%%%%%%%%%%%%%%%%%

        %%%%%%%%%%%%%%%%%%%%%%%%%%%%
        % Identify Circles in Image
        % MATLAB Guide: http://www.mathworks.com/help/images/examples/detect-and-measure-circular-objects-in-an-image.html
        % Init Variables
        PlotCenters = []; PlotRadii = []; Search = []; Loops = 5;
        CountCircles = zeros(Loops, 1);
        MinR = 5;
        for ii = 1:Loops
                % Find Circles
                MaxR = floor(MinR*3);
                [Centers, Radii] = imfindcircles(img,[MinR MaxR],'ObjectPolarity','dark', 'Sensitivity',0.9, 'Method','twostage');
                % Store Data
```

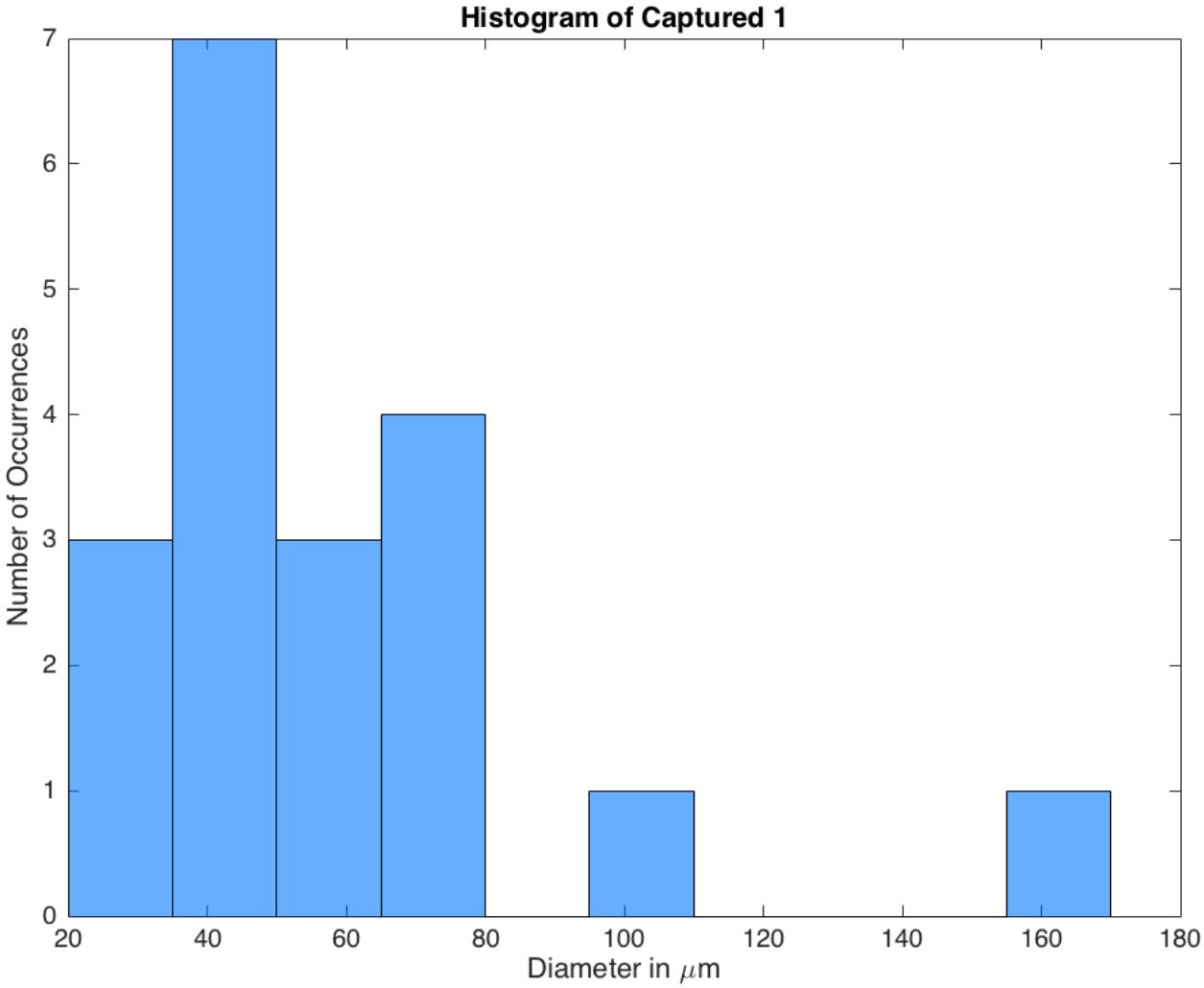
```
                CountCircles(ii) = length(Radii);
                PlotCenters = [PlotCenters; Centers];
                PlotRadii = [PlotRadii; Radii];
                % Update Counters
                Search = [Search; MinR, MaxR];
                MinR = MaxR+1;
                Radii = [];
        end
        % Output some cool data
        Headers = {'MinRadius';'MaxRadius';'NumberOfCircles'};
        T = table(Search(:,1), Search(:,2), CountCircles, 'VariableNames',Headers)
        % disp(sprintf('Analyzing %s and found %d circles in this distribution:', PhotoName, sum(CountCircles)))

        %%%%%%%%%%%%%%%%%%%%%%%%%%%%
        % Plot Histogram of real world results
        h = viscircles(PlotCenters, PlotRadii);
        ConvertedDiameter = PlotRadii.*2./OneMicro;
        figure
        histogram(ConvertedDiameter, 10, 'FaceColor', [0, 120, 256]./256) % dark blue
        % 'FaceColor', [173, 216, 230]./256) % light blue
        title(sprintf('Histogram of %s', PhotoName))
        xlabel('Diameter in \mum')
        ylabel('Number of Occurrences')

        %%%%%%%%%%%%%%%%%%%%%%%%%%%%
        % Store Diameter values for meta-analysis
        NetDiameters = [NetDiameters; ConvertedDiameter];

        %%%%%%%%%%%%%%%%%%%%%%%%%%%%
        % Remove redundant circles as need...but proved not needed :)
        % Also look into: http://www.mathworks.com/matlabcentral/answers/19042-finding-duplicate-values-per-column
        % PlotCenters = [2 4 5 6 4]
        % % prellocating memory
        % Rep = zeros(size(PlotCenters));
        % count = 0;
        % for i = 1 : size(PlotCenters,2)
        %       for j = 1 : size(PlotCenters,2)
        %               if PlotCenters(1,i) == PlotCenters(1,j)
        %                       count = count +1;
        %               end
        %       end
        %       Rep (1,i) = count; % vector that store the number of repetitions of each element of A.
        %       % if 0 no repetitions if ~= from 0 it the number is repeated that number of times
        % end
        %%%%%%%%%%%%%%%%%%%%%%%%%%%%
end

%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Plot Histogram of real world results
figure
histogram(NetDiameters, 10, 'FaceColor', [100, 200, 100]./256) % green
title(sprintf('Histogram of %d Analyzed Agarose Bead Photos', CountLimit))
xlabel('Diameter in \mum')
ylabel('Number of Occurrences')
```

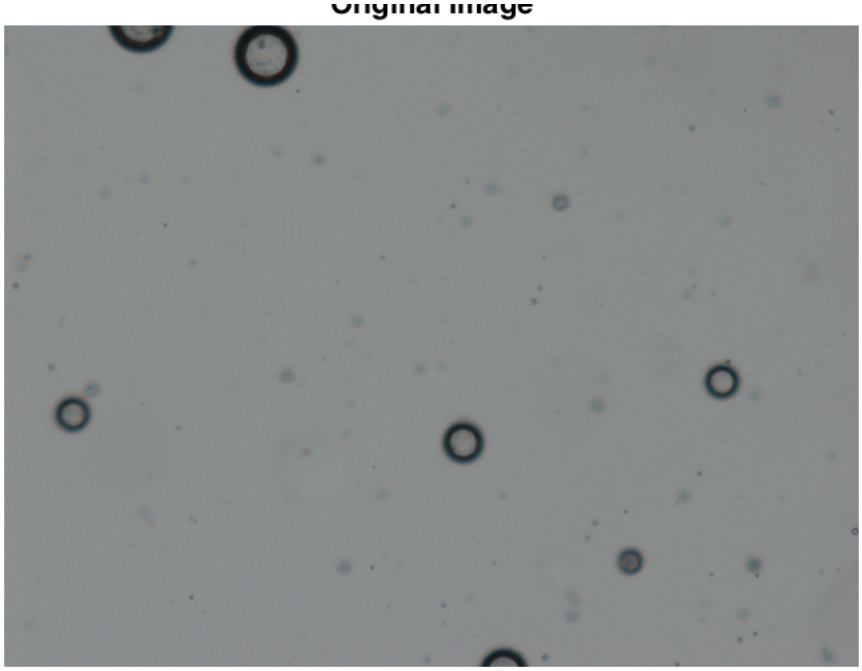
```
All warnings have the state 'off'.
Analyzing Photo: "Captured 1"

T =

    MinRadius    MaxRadius    NumberOfCircles
    _________    _________    _______________

       5            15          15
      16            48           4
      49           147           0
     148           444           0
     445          1335           0

Analyzing Photo: "Captured 2"

T =

    MinRadius    MaxRadius    NumberOfCircles
    _________    _________    _______________

       5            15          15
      16            48           3
      49           147           0
     148           444           0
     445          1335           0

Analyzing Photo: "Captured 3"

T =

    MinRadius    MaxRadius    NumberOfCircles
    _________    _________    _______________

       5            15          13
```

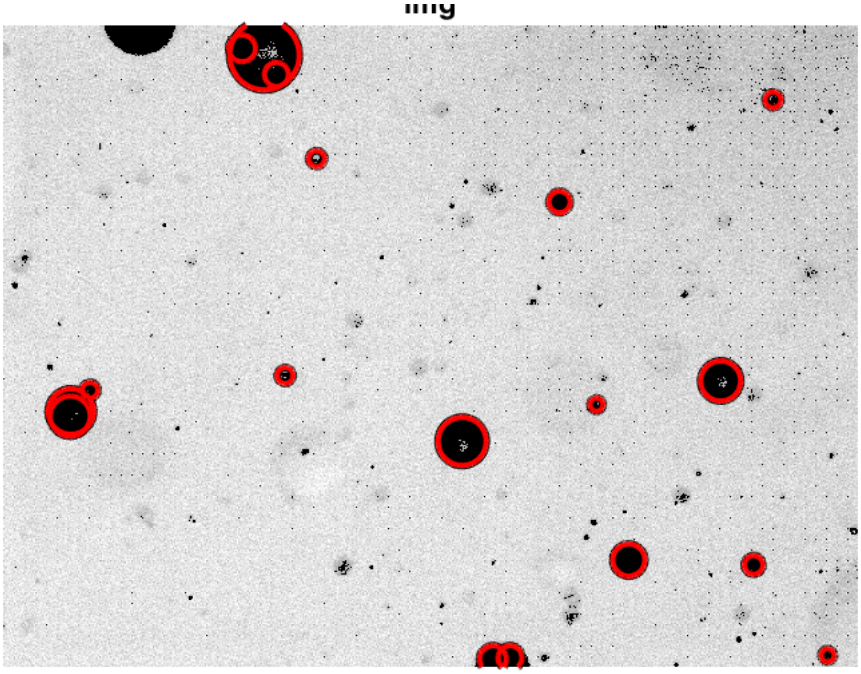
```
    16          48          4
    49         147          0
   148         444          0
   445        1335          0

Analyzing Photo: "Captured"

T =

    MinRadius    MaxRadius    NumberOfCircles
    _________    _________    _______________

      5            15         18
     16            48          5
     49           147          0
    148           444          0
    445          1335          0
```

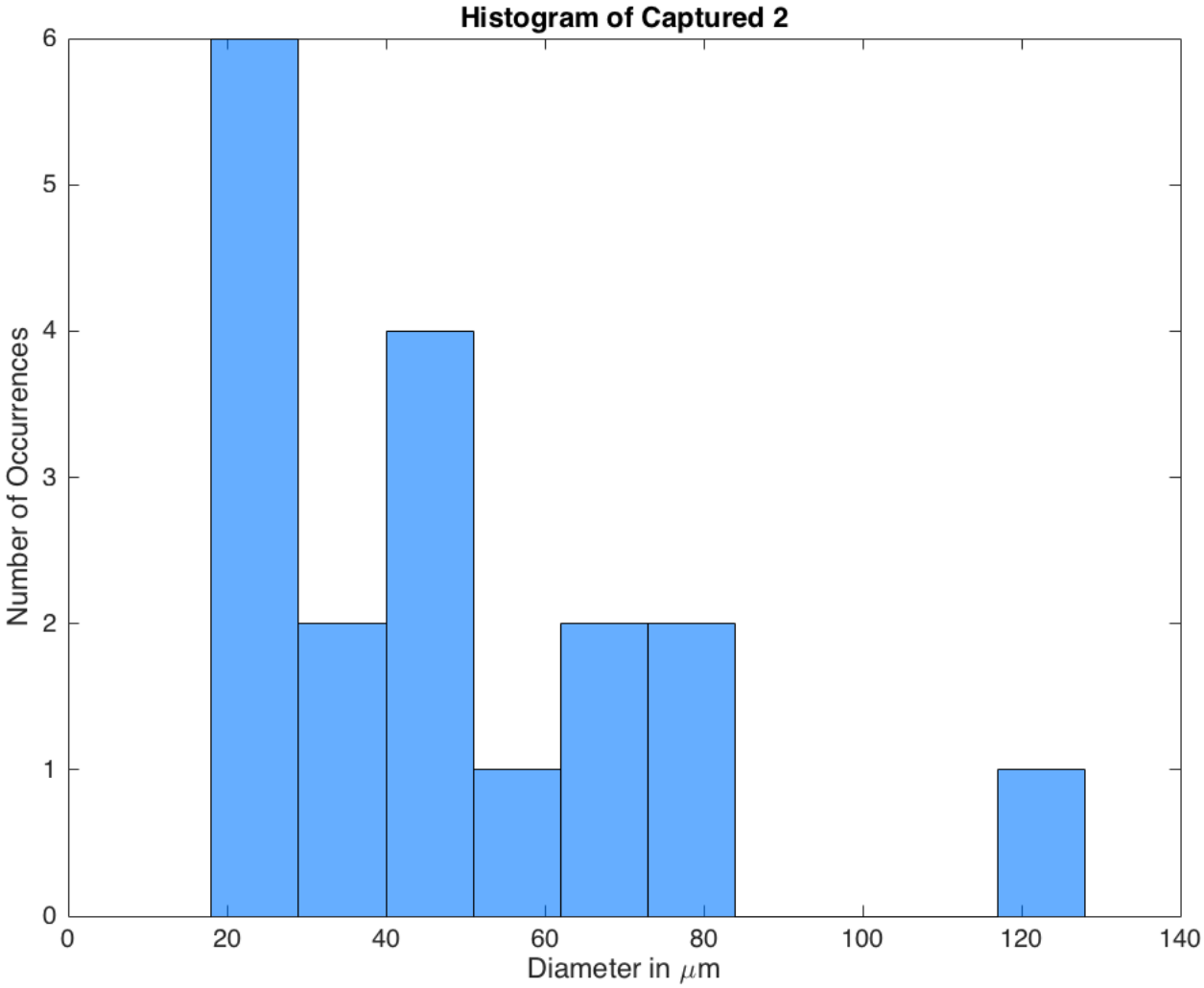




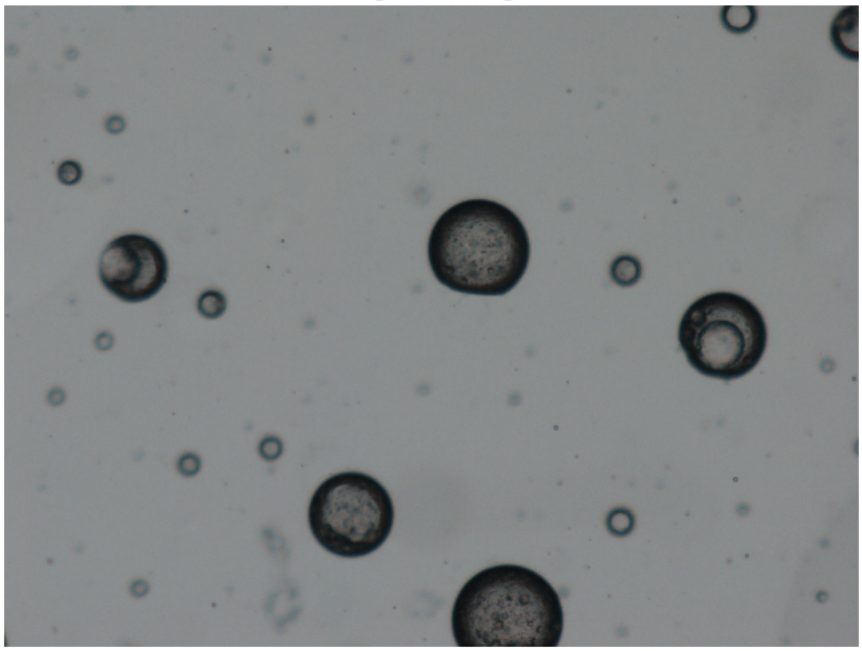

Histogram of Captured 1
Number of Occurrences
Diameter in μm
0
1
2
3
4
5
6
7
20
40
60
80
100
120
140
160
180

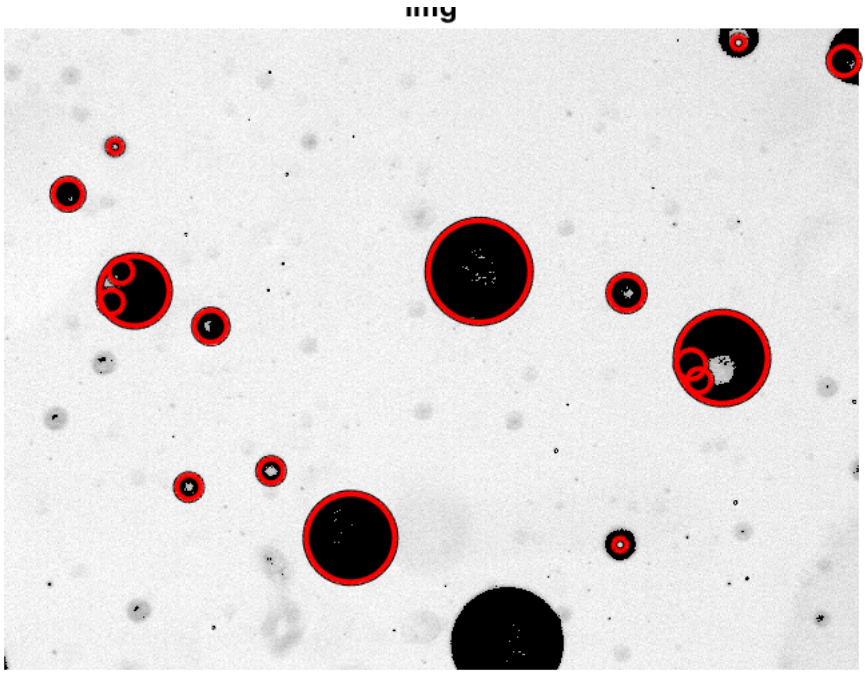


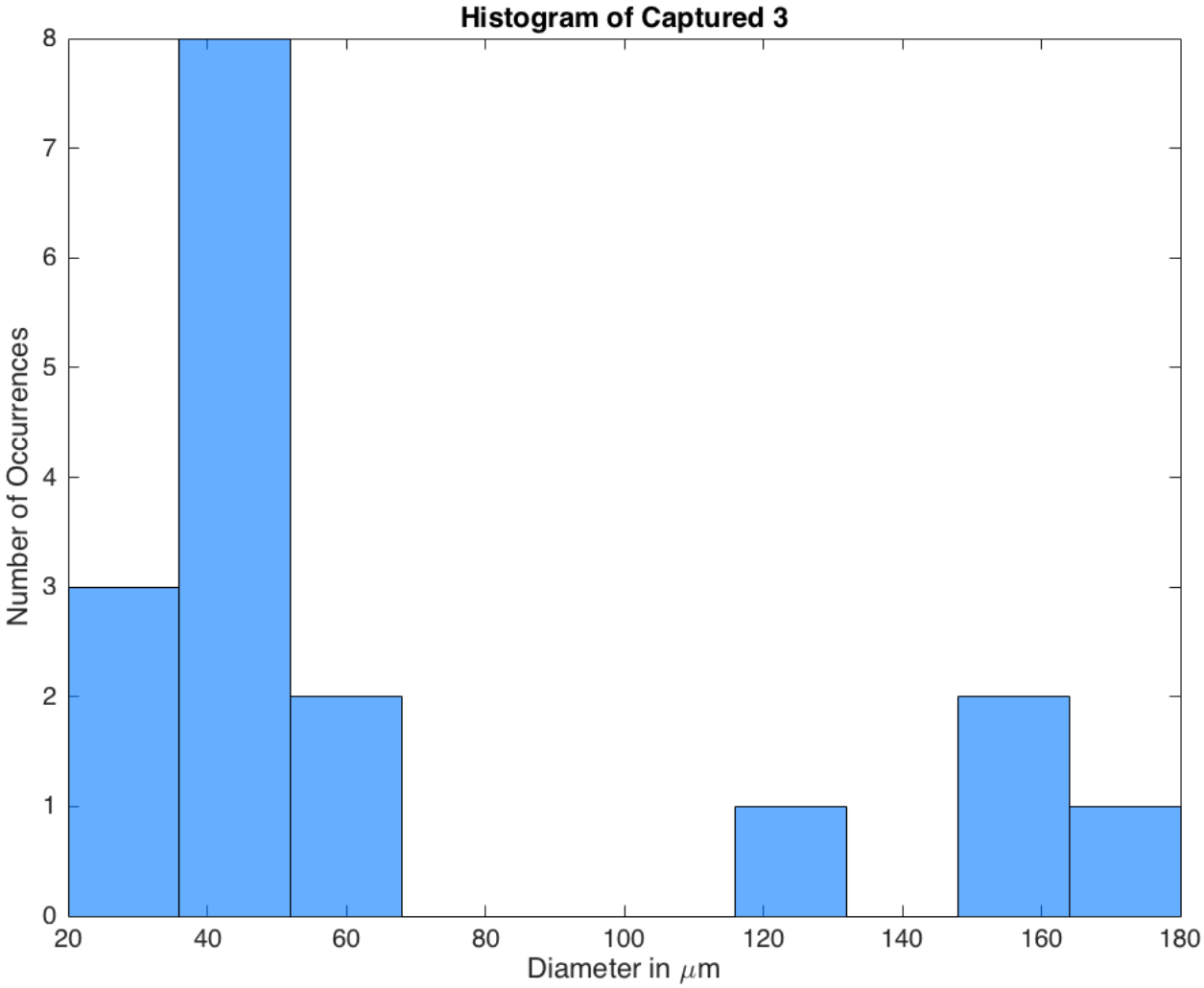


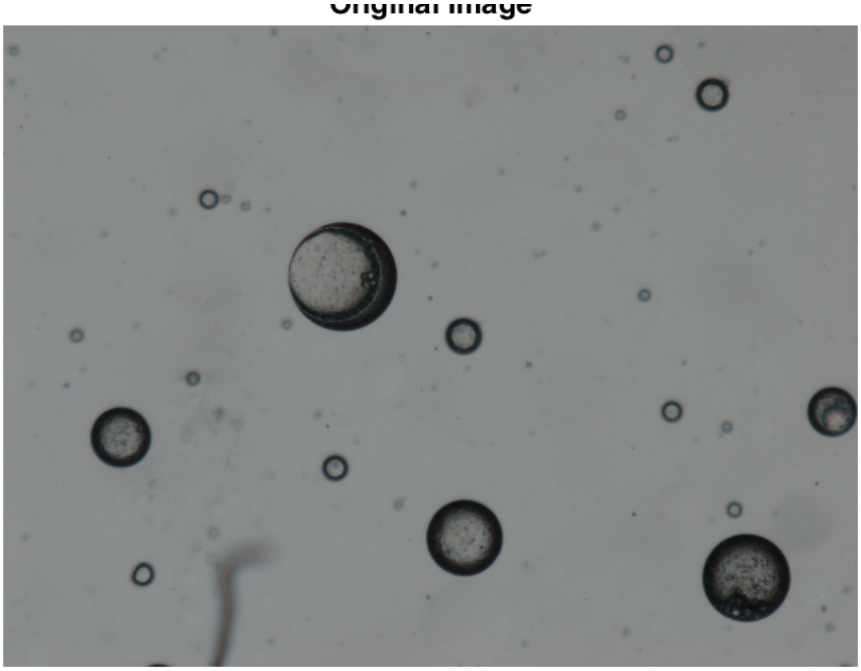

Histogram of Captured 2
Number of Occurrences
Diameter in μm
0
1
2
3
4
5
6
0
20
40
60
80
100
120
140

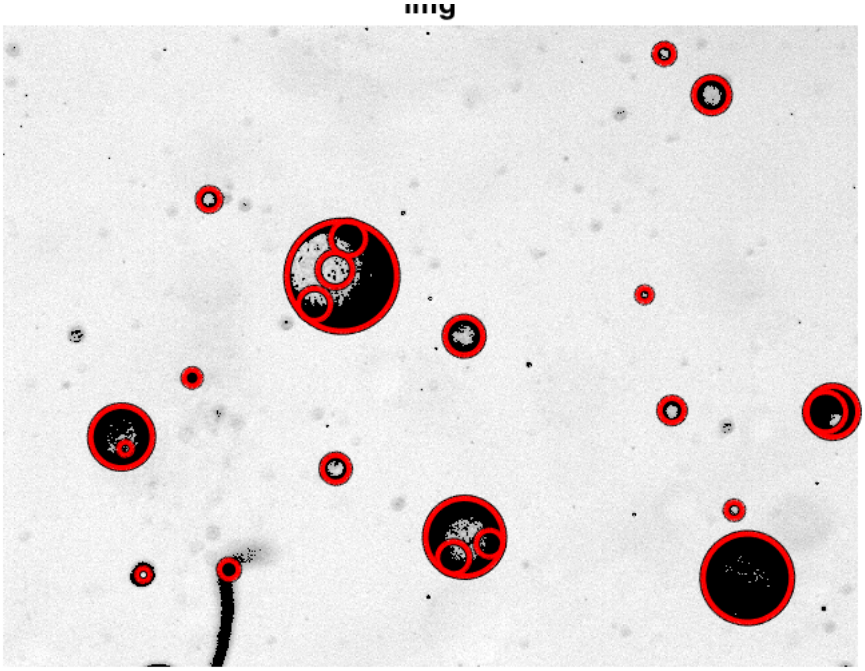
Original Image

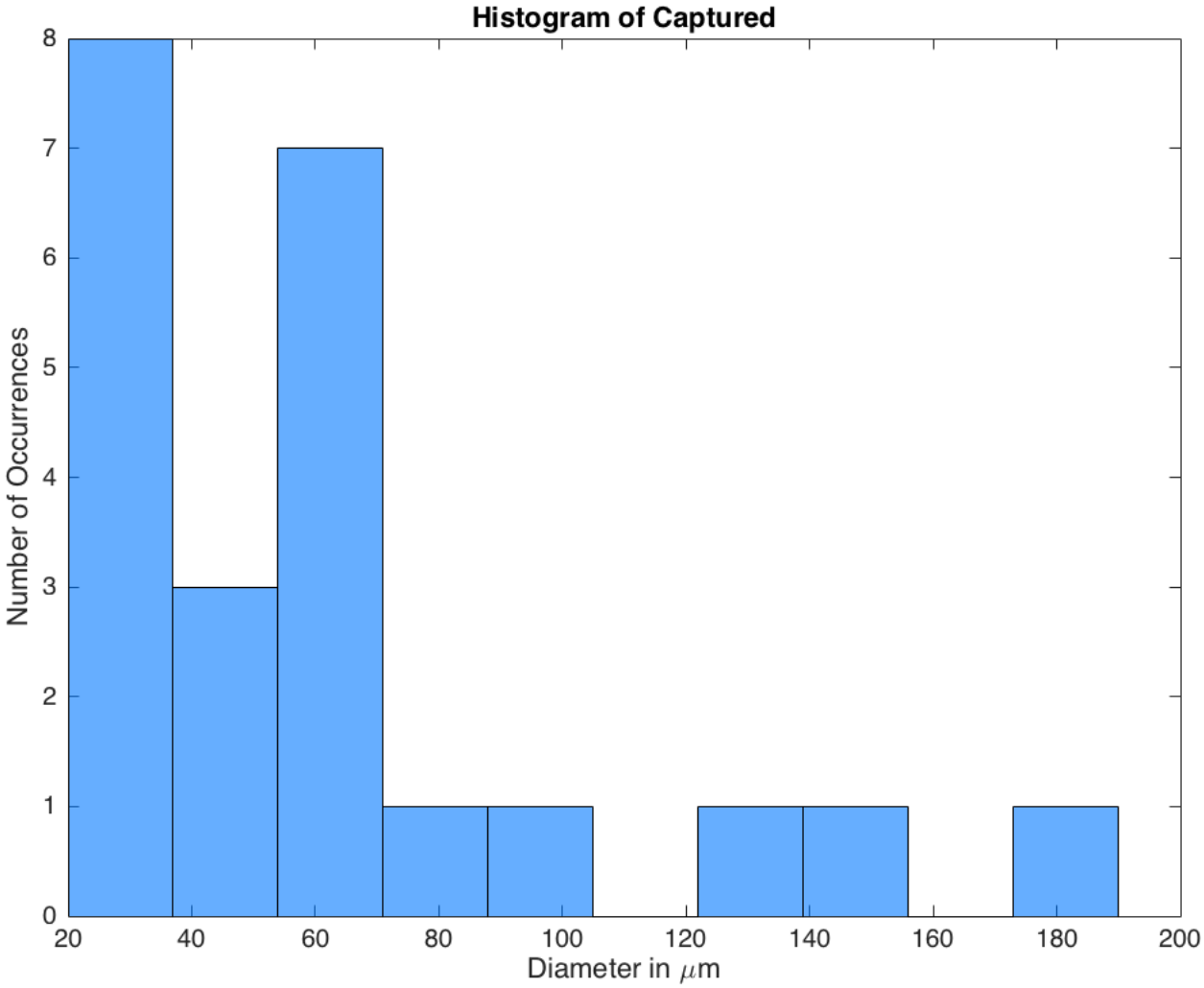


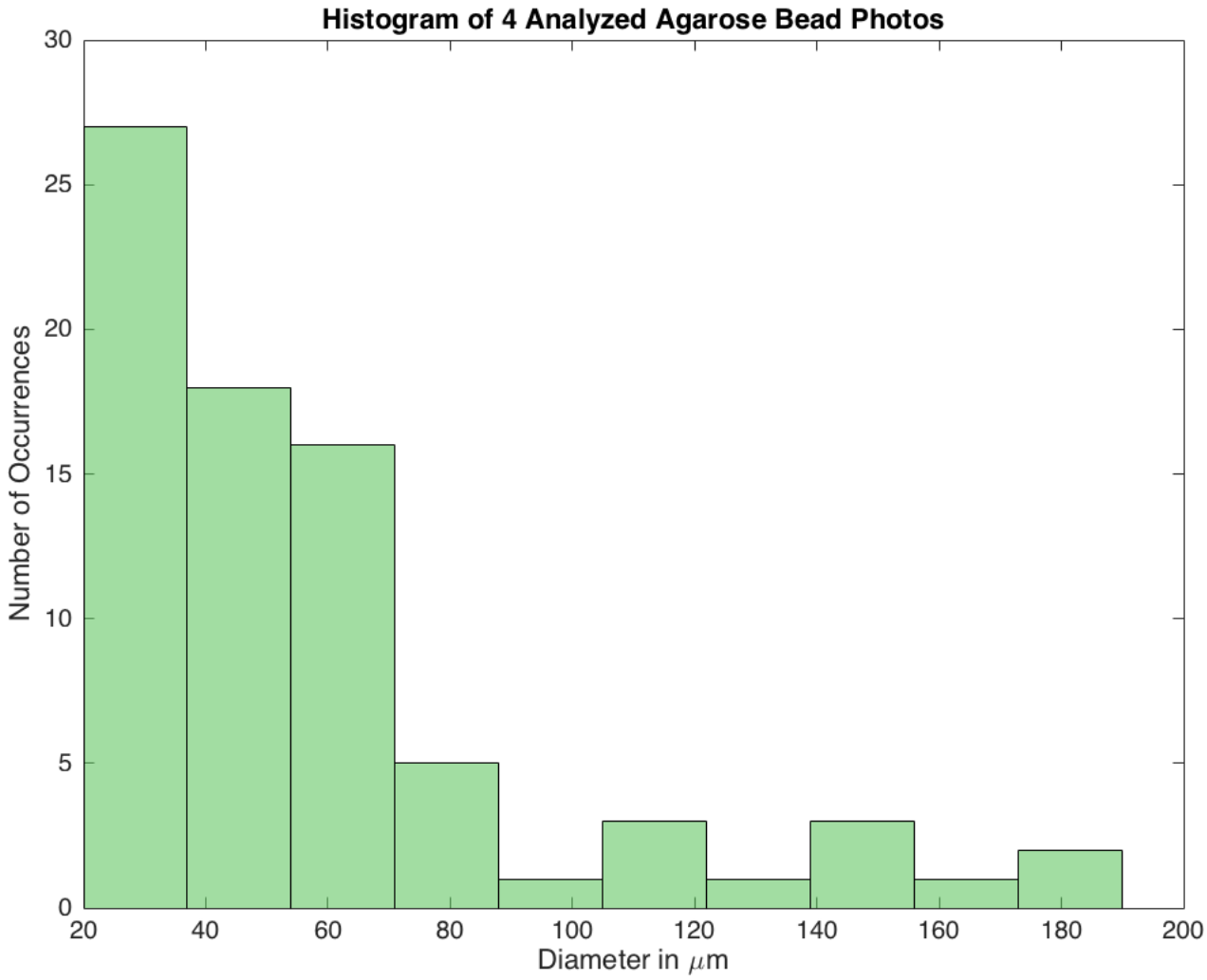



Histogram of Captured 3
Number of Occurrences
Diameter in μm
0
1
2
3
4
5
6
7
8
20
40
60
80
100
120
140
160
180






Histogram of Captured
Number of Occurrences
Diameter in μm
0
1
2
3
4
5
6
7
8
20
40
60
80
100
120
140
160
180
200



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