CSCI 367
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Problem 1:

You need to implement two Matlab functions:

1. The first one,uses a two level nested loop, iterating through all pairs (i,j) and compute the corresponding entry Z(i,j).

File: WithLoops.m

```
function Z = WithLoops(X)
   N = size(X, 1);
   Z = zeros(N, N);

   for i = 1:N
       for j = 1:N
           xi = X(i, :);
           xj = X(j, :);
           Z(i, j) = sqrt(sum(xi.^2) - 2 * dot(xi, xj) + sum(xj.^2));
       end
   end
end
```

2. The second function, compute Z without any loop, but use basic matrix operations, including element-wise operations.This is vectorization.You are not allowed to use any built-in functions,such as plist() and squareform(), for this job.

File: Vectorized.m

```
function Z = Vectorized(X)
   sumX = sum(X.^2, 2);
   sumX = sumX(:, ones(1, size(X, 1)));
   sumXTrans = sumX';
   Z = sumX + sumXTrans - 2 * (X * X');
   Z(Z < 0) = 0;
   Z = sqrt(Z);
end
```

3. Output

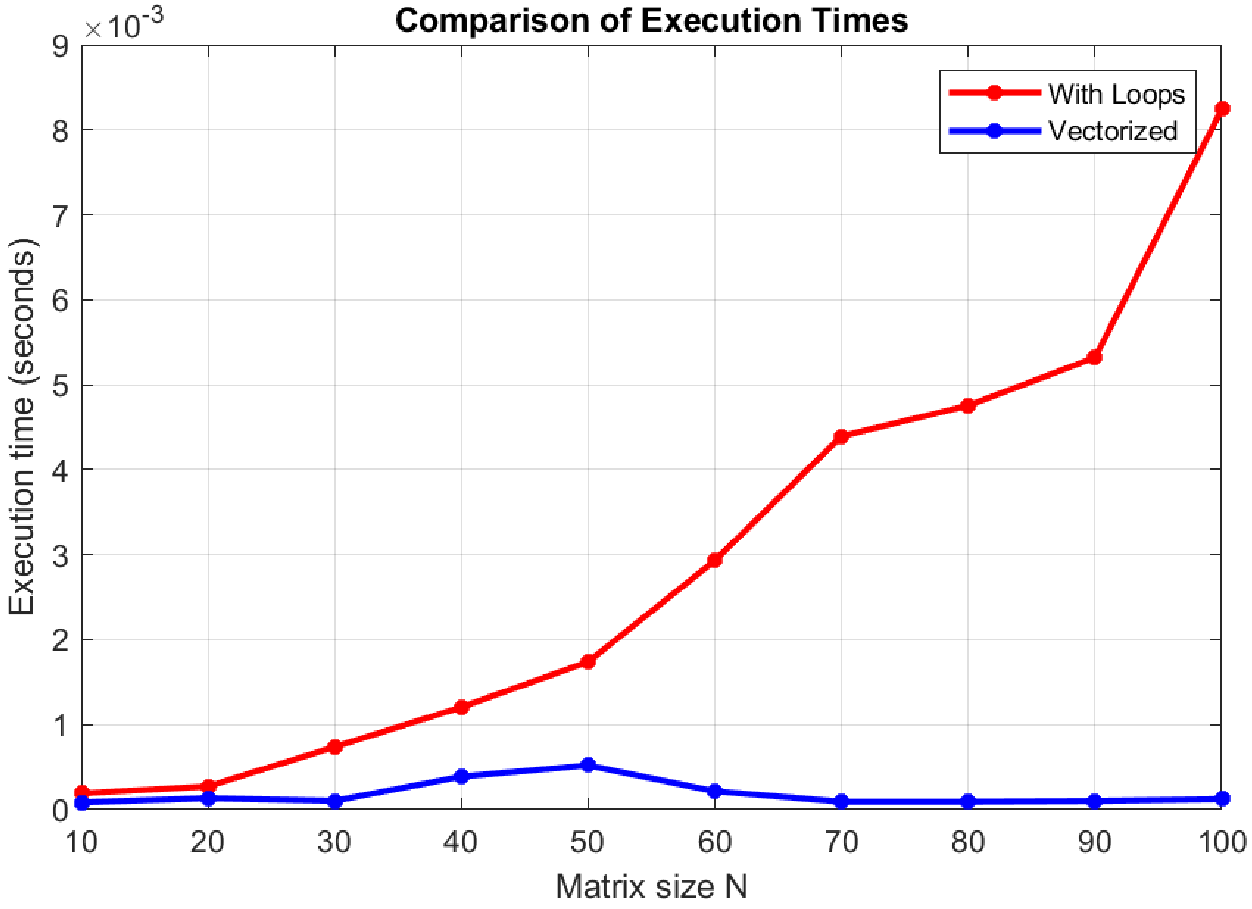
File: Test.m

```
sizes = 10:10:100;
timesWithLoops = zeros(length(sizes), 1);
timesVectorized = zeros(length(sizes), 1);
for i = 1:length(sizes)
   N = sizes(i);
   D = 5;
   X = rand(N, D);

   tic;
   Z = computeZWithLoops(X);
   timesWithLoops(i) = toc;

   tic;
   Z = computeZVectorized(X);
   timesVectorized(i) = toc;
end
figure;
plot(sizes, timesWithLoops, 'r-*', 'LineWidth', 2, 'MarkerSize', 5);
hold on;
plot(sizes, timesVectorized, 'b-*', 'LineWidth', 2, 'MarkerSize', 5);
hold off;
xlabel('Matrix size NXN');
ylabel('Execution time (seconds)');
title('Comparison of Execution Times');
legend('With Loops', 'Vectorized', 'Location', 'northeast');
grid on;
```

Generate random matrices of various sizes and profile the performance by plotting data size against execution time. The x-axis represents the control variable in the experiment, and the y-axis displays the results of the experiments.



My Algorithms

Algorithm 1: Nested Loops Method

This algorithm goes through each pair of points.
It finds the difference between the coordinates of one point and the other, giving us a vector.
It squares each element of that difference vector. Then it adds up all those squared values to give us the squared distance. Atter takes the square root of that squared distance to get the actual euclidean distance. This is repeated for every pair of points. It will give us this square matrix of size n x n, where n is the number of points we have.

Algorithm 2: Vectorized Method

This algorithm also computes the pairwise euclidean distances but it uses matrix operations
Starts by squaring the numbers, then adds up the squares for each group of data to get a single number representing the average size of each group.It will create two matrices with the same number of rows and columns. One table shows the size of each group and the other shows the sizes of each column.
Then to find out how much each pair of data groups overlap we multiply the set of data by transposing.
It combines the matrices and adjusts them by removing duplicates. It will give a new matrix that is almost what we want. We can take the square root of each number in our matrix.

We get the same result as calculating each distance one by one in a loop but faster by using operations that our computer already has.

Results

Control Variable

The control variable is points of algorithm one, we are comparing algorithm one to the test subject which is algorithm 2 the vectorized method.

Observation

When n increases the execution time for both of the methods increases but the rates of each are different. The algorithm with loops takes longer over time and the algorithm that is vectorized increases over time but not as long as algorithm one.

What did I learn from this observation

Vectorizing or making functions with operations that the computer already has can dramatically improve performance.

Problem 2:

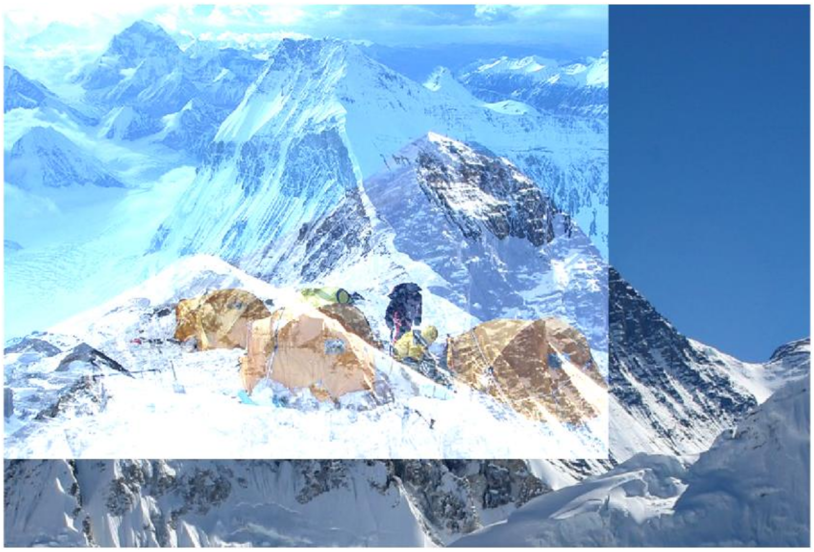
Implemented Function:

File: addDoubleExposure.m

```
function outputImage = addDoubleExposure(imagePath1, imagePath2)
   image1 = imread(imagePath1);
   image2 = imread(imagePath2);
   outputImage = zeros(max(size(image1,1), size(image2,1)),
max(size(image1,2), size(image2,2)), 3, 'uint8');
   outputImage(1:size(image1,1), 1:size(image1,2), :) = image1;
   outputImage(1:size(image2,1), 1:size(image2,2), :) =
outputImage(1:size(image2,1), 1:size(image2,2), :) + image2;
   outputImage = min(outputImage, 255);
end
```

File: test.m

```
outputImage =
addDoubleExposure('C:\Users\Daymon\Desktop\CSCI367\HW1\Problem2\Everes
t_expedition.jpg',
'C:\Users\Daymon\Desktop\CSCI367\HW1\Problem2\Everest_kalapatthar.jpg'
);
imshow(outputImage);
```



My Algorithms

Algorithm:

To combine the two images into a double exposure effect we have to first load the images by letting the program know where the path of the pictures are. Then we have to make a space for where the output of the image will be. We do this by taking the maximum width and height of both images. Then we will place the first image in the output space at the top left corner. We will do the same thing to the second image on the same corner. Now for where the two images are sharing the same space we put the pixels together by adding the pixels. The maximum intensity for saturation is 255 so we set the function to equal 255 to avoid saturation. Then we will have to display the image on the screen using the builtin imshow command.

Results

Does the output meet your expectation?

The output met my expectations. It was better than I expected because the quality of the image was still good. Nothing was blurred out even though we added the pixels together.

How did you check the correctness of your work?

To check the correctness of my work I inspected the picture carefully. I checked the brightest parts of the picture to see if it was any different. I also looked for the resolution size of the image and it retained the same size if you cut the image in paint.exe.

Resources that Helped Me:

https://www.mathworks.com/help/parallel-computing/nested-parfor-loops-and-for-loops.html

https://www.mathworks.com/matlabcentral/answers/64764-nested-for-loops-using-a-value-from-first-loop-within-the-second-loop

https://www.youtube.com/watch?v=GC7KsQYne2I

https://www.mathworks.com/matlabcentral/answers/446989-how-to-automatically-introduce-a-nested-layer-of-for-loop

https://www.reddit.com/r/matlab/comments/gag87b/use_of_i_vs_ii_for_iterative_variable_in_for_loop/

https://www.mathworks.com/matlabcentral/answers/1623130-how-to-iterate-through-all-combinations-within-a-for-loop

https://www.mathworks.com/matlabcentral/answers/2024722-iterate-through-a-matrix-to-find-specific-entry

https://stackoverflow.com/questions/758736/how-do-i-iterate-through-each-element-in-an-n-dimensional-matrix-in-matlab

https://www.mathworks.com/help/matlab/math/basic-matrix-operations.html

https://www.mathworks.com/help/matlabmobile/ug/matrix-operations.html

https://www.mathworks.com/help/matlab/ref/sqrt.html

https://www.mathworks.com/help/matlab/ref/dot.html

https://www.mathworks.com/help/matlab/matlab_prog/array-vs-matrix-operations.html

https://www.mathworks.com/matlabcentral/answers/2077656-the-fastest-method-to-perform-sum-of-function

https://www.mathworks.com/matlabcentral/answers/409515-how-can-i-change-marker-size-when-plotting

https://www.mathworks.com/matlabcentral/answers/761421-how-to-change-linewidth-and-markersize-in-plot-fit-curve

https://www.mathworks.com/matlabcentral/answers/6537-how-do-i-change-the-marker-size-for-a-plot

https://www.mathworks.com/matlabcentral/answers/480655-how-to-find-the-x-y-combinations-that-make-z-0

https://www.youtube.com/watch?v=7f50sQYjNRA

https://www.mathworks.com/matlabcentral/answers/127891-x-0-0-1-10-what-s-going-on-really

https://www.mathworks.com/matlabcentral/answers/716238-how-do-i-make-a-10x10-showing-all-numbers-1-to-100

https://www.mathworks.com/help/matlab/ref/tic.html

https://www.mathworks.com/help/matlab/ref/toc.html

https://www.youtube.com/watch?v=xtzI1F4k2N8

https://www.youtube.com/watch?v=c0nJWZp4SoU
https://www.youtube.com/watch?v=zE243a_s4L0
https://www.mathworks.com/help/matlab/ref/zeros.html
https://www.mathworks.com/help/matlab/ref/xlabel.html
https://www.mathworks.com/help/matlab/ref/title.html
https://www.mathworks.com/help/matlab/ref/legend.html
https://www.mathworks.com/matlabcentral/answers/1977544-image-2-1
https://www.mathworks.com/help/matlab/ref/image.html
https://www.mathworks.com/matlabcentral/answers/460413-appdesigner-questions-1-image-path-2-numerical-value-output
https://www.mathworks.com/help/matlab/matlab_env/specify-file-names.html
https://www.reddit.com/r/matlab/comments/sqzlge/matlab_file_path_errors_i_am_very_new_to_matlab/
https://www.reddit.com/r/matlab/comments/gzpvq9/newbie_question_add_to_path_vs_change_folder/
https://www.mathworks.com/help/matlab/ref/size.html
http://www.ece.northwestern.edu/local-apps/matlabhelp/techdoc/ref/size.html
https://www.educba.com/size-function-in-matlab/
https://www.youtube.com/watch?v=7L32uA3N5Z8
https://www.mathworks.com/help/matlab/ref/imread.html
https://www.mathworks.com/help/images/read-image-data-into-the-workspace.html
http://www.ece.northwestern.edu/local-apps/matlabhelp/techdoc/ref/imread.html
https://www.youtube.com/watch?v=lTuNuyUS7zM
https://www.mathworks.com/help/images/ref/imshow.html