

Machine Perception Assignment One

Due Date: Week 10 - Monday 5 October 2020 at 5pm

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Abstract—write at this at the end of your report :)

Index Terms—Histograms, I don't know what this is tbh...

I. INTRODUCTION

do this are the end

II. TASK ONE: IMAGE HISTOGRAM, HARRIS CORNERS AND SCALE-INVARIANT FEATURE TRANSFORM (SIFT) KEY POINTS

The Harris corner detection algorithm, and the SIFT algorithm can be thought of algorithms which will pick the key features of an image with the pre-dominant implementations of these algorithms detect the corners of the image [2] [3]. Corners can be thought of as regions in an image with large variation of intensities in all directions [2]. Therefore, the SIFT and the Harris algorithm, are algorithms for detecting the corners in an image the key differences is the invariance and variance to certain image transformations [3]. Harris corner detection algorithm is mainly invariant to rotation, and the SIFT algorithm is mainly invariant to scaling and is also invariant to rotations due to the orientation assignment stage of the SIFT algorithm [3], which is explored in greater detail in section IV subsection IV-A.

A. Harris corner detection

The Harris corner detection is an algorithm whereby a window function will scan through the image to locate local maximums, these local maximums can be thought as potential candidates for key features detected by the Harris corner detection algorithm [4] [2]. This following behaviour can be modelled by the following equation:

$$E(u, v) = \sum_{(x, y)} w(x, y) [I(x + u, y + v) - I(x, y)]^2 \quad (1)$$

Whereby:

- $w(x, y)$ represents the window which is scanning over each section of the image,
- $I(x + u, y + v)$ represents the intensity neighbouring pixels, and
- $I(x, y)$ represents the intensity of the current pixel.

Thereafter, the function is through Taylor expansion to form the following system of equations

$$E(u, v) \approx [u \ v] M \begin{bmatrix} u \\ v \end{bmatrix} \quad (2)$$

Whereby, M is represented by the following equation

$$M = \sum_{(x, y)} w(x, y) \begin{bmatrix} I_x I_x & I_x I_y \\ I_x I_y & I_y I_y \end{bmatrix} \quad (3)$$

Thereafter, a plethora of potential corners are found in the image matrices, the Harris algorithm will then go through each window function to determine if the found corner is most likely going to be an actual corner, this process is determined by the following equation [2]:

$$R = \det(M) - k(\text{trace}(M))^2 \quad (4)$$

Where by $\det(M)$ is the multiplication of eigen values of the matrix M, and $\text{trace}(M)$ is the addition of the eigen values of the matrix M [2]. Therefore, if one of the eigen values is significantly greater than the other eigen value found points are most likely to be an edge, and if the eigen values are large and approximately the same value that point is a corner otherwise, that point is a flat region [2].

Harris corner detection is an algorithm which can be mainly thought of as a rotation invariant algorithm meaning, no matter the angles you rotate a given image, the algorithm is going to detect the same key-features [2] [4]. This is due to that a corner will always go to remain a corner no matter what orientation the image because a corner is just a high intensity pixel, and the algorithm only looks at a pixel and its neighbouring pixels thus, no matter what orientation the image the pixels will still have the same neighbouring pixels [2]. Albeit, if you scale the image, a pixels neighbouring pixels will be transformed hence, the window function may determine those clusters of pixels as a non-corner when it's a corner, or as a corner when it's a non-corner. Therefore, the conducted experiments should show consistencies through the set of rotated images, and inconsistencies through the scaled images.

B. Harris Corner detection: Results - Diamond

- 1) *Rotational Results:*
- 2) *Scaling results:*

C. SIFT Results - Diamond

- 1) *Rotational results:*
- 2) *Scaling results:*

D. Harris Corner detection: Results - Dugong

- 1) *Rotational Results:*
- 2) *Scaling results:*

E. Discussion about produced results

To determine if an image is invariant to a certain transform we have to determine how many corners that image is detecting relative to the performed corners. Hence, the first experiment is to get the returned corners from the Harris corner detector, and the SIFT transform and find the difference relative to the original image for each transform. Therefore, for perfect results we would assume that the difference should be 0 for invariant feature as they should've picked up the same number of corners in the image. Although, to greater consolidate this claim, we must determine if the corners are been picked up in the same region hence, we calculate the histograms of the image in the same channel as the corners, and theoretically for invariant features the histograms must follow perfectly after each other as the detected pixels should lay in the same region. Finally, to determine how well the histograms follow each other we calculate the distance between each transformed histogram relative to the original histogram of the image.

Look at figure 24 we can see that through each rotated image, they is irregularities in the number of keypoints found in each transformed image. It's natural to conclude that this experiment dis-prove harris corner detection invariance to rotation. Albeit, we have to consider the manner the image is rotated. As can be seen in figures 25, 26, 27, and 28 you can see when you rotate the image they is an increase of black space around the image, and the borders of the image may have been picked up as a corner. In figure 25 you see the borders of the image are detected as a corner but, in the other images the borders are not detected as a corner. Therefore, with this observation we should expect irregularities in the data produced. Furthermore, revisiting figure 24 we can see the produced histograms follow a clear sinusoidal pattern implying that although they is irregularity between the number of corners found in each transformed image but atleast they is consistency of the number of corners found relative to the angle of rotation of the image. Therefore, we can infer that the harris corner detection algorithm would produce the same number of corners if each rotated image had a tightly bounded box around the image thus removing the corners picked up by the borders of the image. Therefore, counting for the extra corners found due to the borders of the image we can infer that the number of corners found for each transformed image will be very similar to the original transformed image. This

same concepts will apply for the images found in the dugong images in section??.

Looking, at the scaled results of the experiment we will expect the same to hold for invariance properties for the image, and the opposite to be true for variance to a specific image transform. Therefore, we should be expecting no clear pattern in the produced histograms for the first experiment, we should see great irregularity in the produced histograms, and we should see great irregularity in the distances between the produced histograms. Therefore, as seen in figures

III. I AM EDITING HERE, FOR THE REPORT

Counting only for the numbers of corners found by the harris corner detection is not enough to prove the invariance of the algorithm. For the diamond playing card the only two visible colors are white, and red hence we can use the cards characteristic to our advantage by drawing the found corners in the green channel, the same can be said about the dugong image by drawing the found corners onto the red channel as seen in section II-B. The aim of this experiment to see if the found corners are going to be laying in the same color space as the original image hence, for the playing card we should get a spike of green pixels around the cluster of red pixels. Referring, to figure 30 we can see that the histograms overlay over each other for the mid intensities, and they is some deviation in the lower intensities. Deviation in the lower intensities of the image is expected as in some transformed images we're introducing more black pixels into the image because of the method we're using to rotate the image as seen 25, 26, 27, and 28. Therefore, as we can see the produced histograms in figure 30 support the invariance of the harris corner detection.

Furthermore, this is further consolidated through the calculated distances between the transformed image, and the original image. As we can see in figure 24 the distances found in each transformed image is the same. Given, the introduction of greater quantity of black pixels due to the manner of rotation of the image we would expect the histograms to be a fixed distance away from each other which, is demonstrated through figure 24. Therefore, as demonstrated the harris corner detection rotationally invariant as shown through the diamond card.

IV. TASK TWO: IMAGE FEATURES

an example on how to reference other sections V

A. part ii

V. TASK THREE

VI. TASK FOUR

REFERENCES

- [1] Dr. S. An. 2020. Machine Perception Lecture 03 [PowerPoint slides] Available: https://learn-ap-southeast-2-prod-fleet01-xythos.s3.ap-southeast-2.amazonaws.com/5dc3e34515a0e/4348643?response-cache-control=private%2C%20max-age%3D21600&response-content-disposition=inline%3B%20filename%3DUTF-8%27%27lecture03_feature_detection.pdf&response-content-type=application%2Fpdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Date=20200927T060000Z&X-Amz-

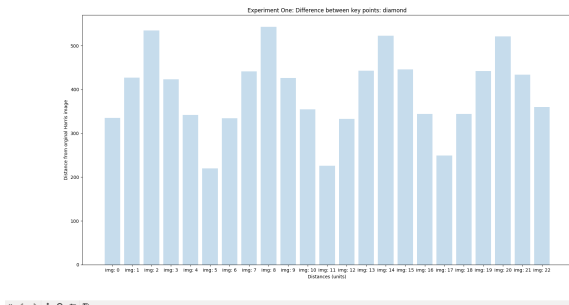


Fig. 1: Difference of keypoints found relative to first image: Harris, Rotated, Diamond

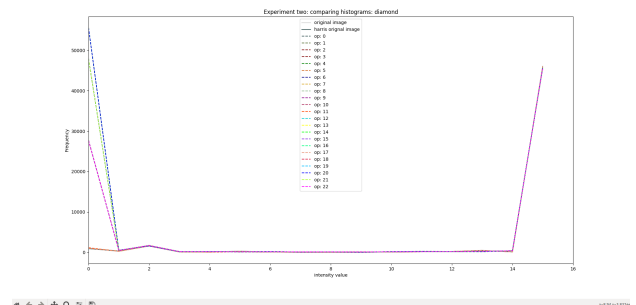


Fig. 2: Comparison of histograms for each transformed image: Harris, Roateted, Diamond

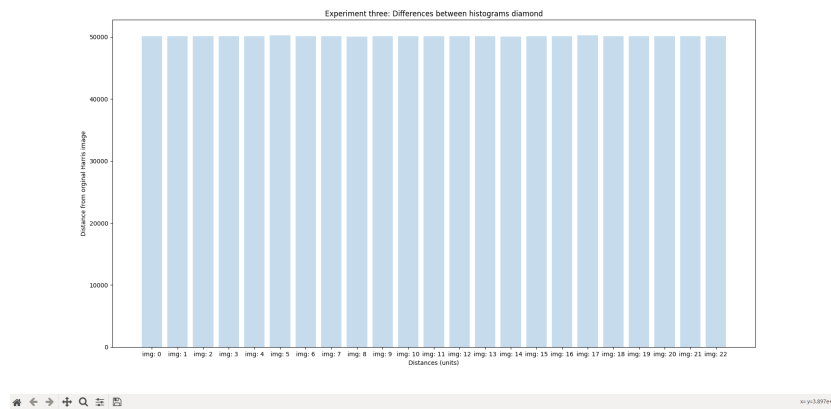


Fig. 3: Difference of distances between histograms relative to original: Harris, Rotated, Diamond

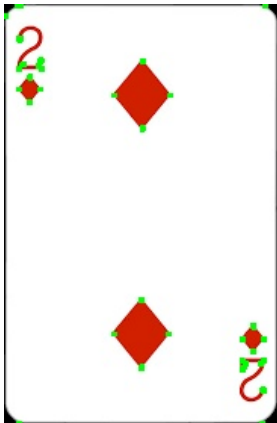


Fig. 4: Diamond harris rotated original produced image

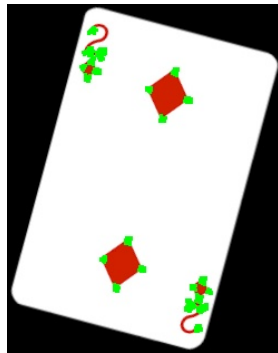


Fig. 5: Diamond harris image 1 rotated produced image

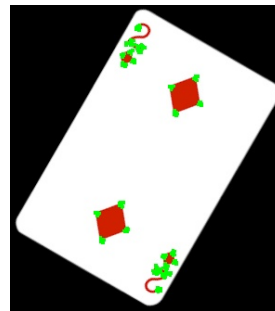


Fig. 6: Diamond harris image 2 rotated produced image

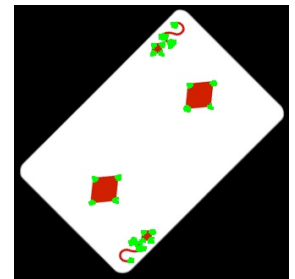


Fig. 7: Diamond harris image 3 rotated produced image

A set of 24 experimental images were produced. Only four displayed in report as displaying all 24 doesn't add great benefit to the reader. To re-view all 24 experimental images please implement the algorithms found in the appendixes.

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[2] A. Mordvinsteve and K. Abid. "Harris Corner detec-

tion". OpenCV-Python Tutorials. https://opencv-python-tutroals.readthedocs.io/en/latest/py_tutorials/py_feature2d/py_features_harris/py_feature2d.html (retrieved Sept. 27, 2020).

[3] . OpenCV. "Introduction to SIFT (Scale-Invariant Feature Transform)". OpenCV-Open source Computer vision.

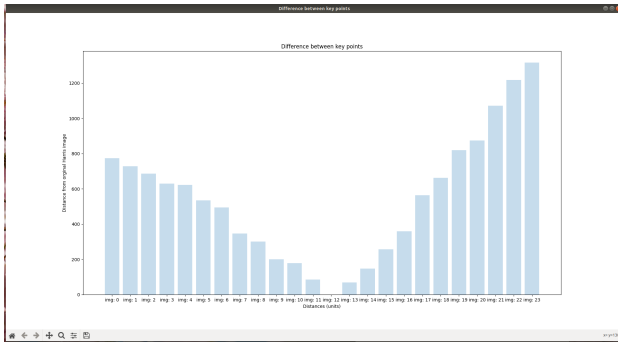


Fig. 8: Difference of keypoints found relative to first image: Harris, Rotated, Diamond

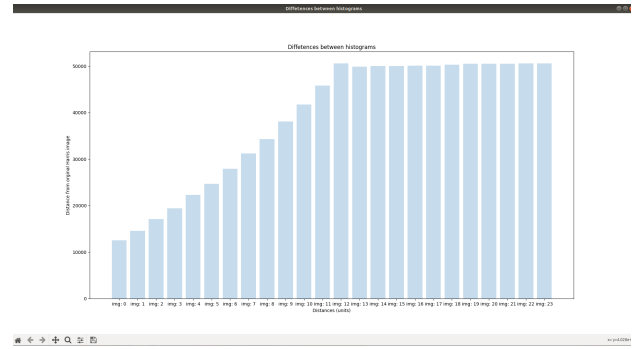


Fig. 9: Difference between the distances of histograms

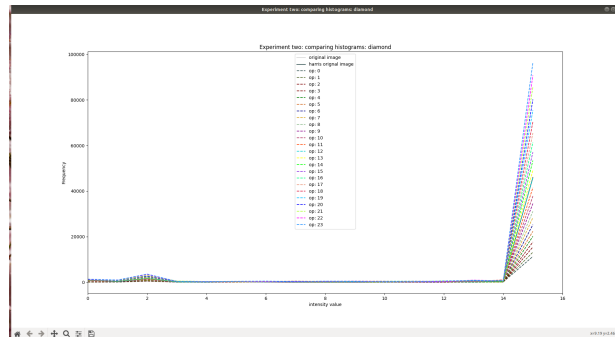


Fig. 10: All produced histograms: Harris, Scaled, Diamond

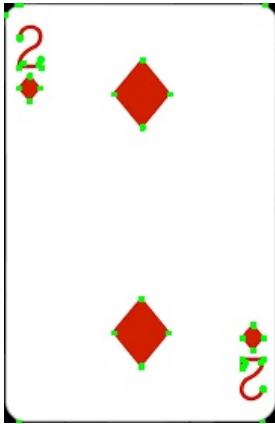


Fig. 11: Harris scaled original produced image: Harris, Scaled, Diamond

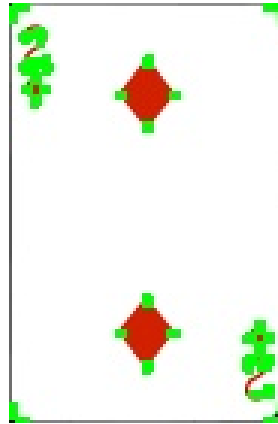


Fig. 12: Diamond arris image 1 scaled produced image

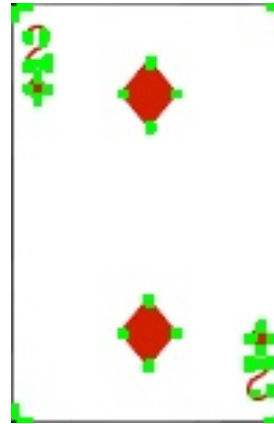


Fig. 13: Diamond harris image 2 scaled produced image

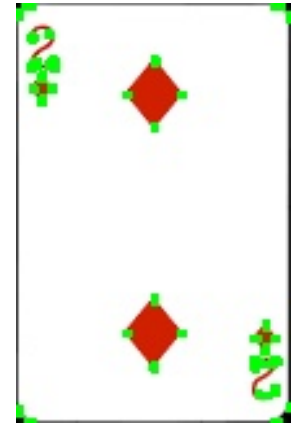


Fig. 14: Diamond harris image 3 scaled produced image

A set of 24 experimental images were produced. Only four displayed in report as displaying all 24 doesn't add great benefit to the reader. To re-view all 24 experimental images please implement the algorithms found in the appendixes.

https://docs.opencv.org/3.4/da/df5/tutorial_py_sift_intro.html

APPENDIX

APPENDIX A

TASK 1 CODE PRINT OUT

APPENDIX B

TASK 2 CODE PRINT OUT

- [4] . C. Harris and M. Stephens. 1988. A Combined Corner And Edge Detector. Plessey Research Roke Manor, UK. [Online]. Available: <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.434.4816&rep=rep1&type=pdf>

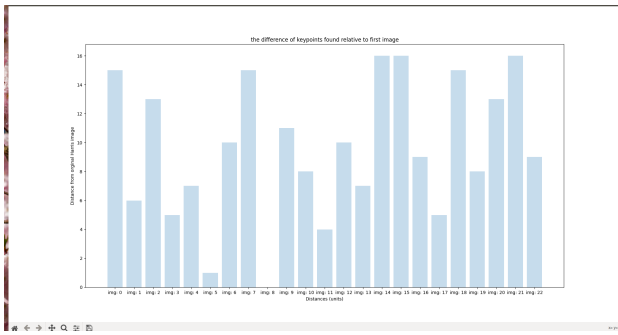


Fig. 15: Difference of keypoints found relative to first image: SIFT, Rotated, Diamond

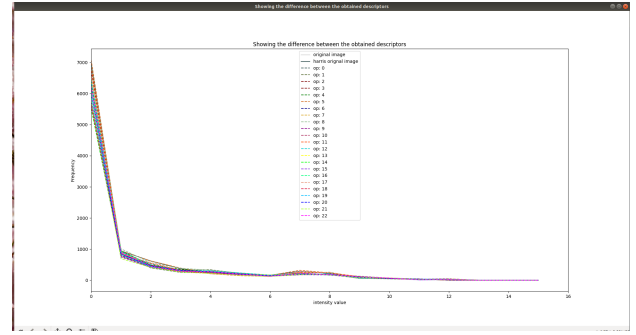
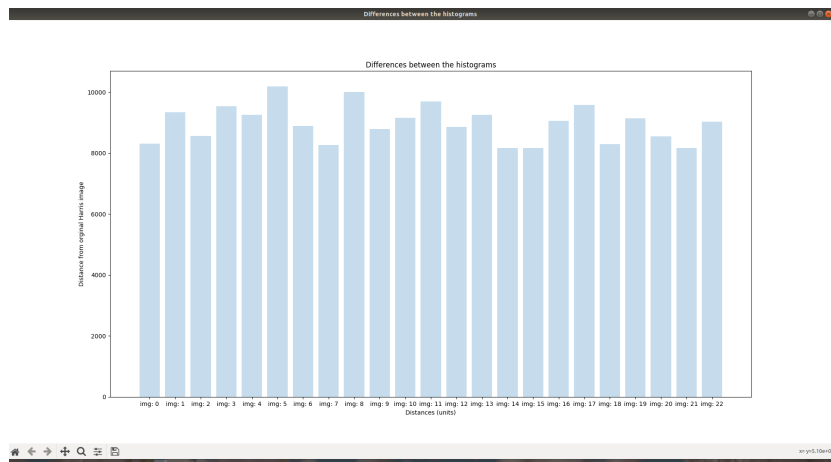


Fig. 16: Comparison of histograms for each transformed image: SIFT, Roateted, Diamond



diffrences between histograms.png
Fig. 17: Difference of distances between histograms relative to original: SIFT, Rotated, Diamond

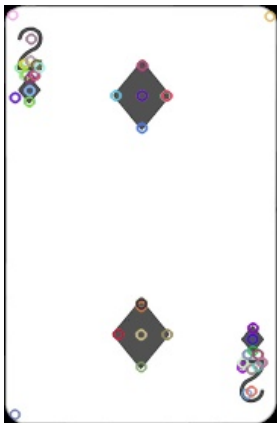


Fig. 18: Diamond SIFT rotated original produced image

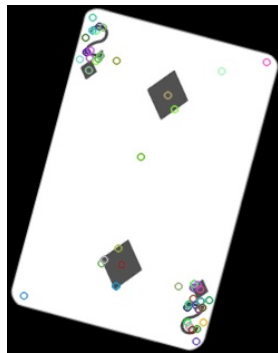


Fig. 19: Diamond SIFT image 1 rotated produced image

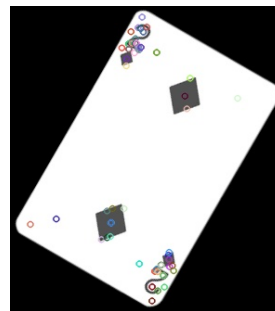


Fig. 20: Diamond SIFT image 2 rotated produced image

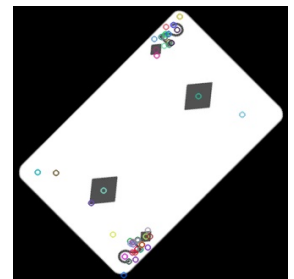


Fig. 21: Diamond SIFT image 3 rotated produced image

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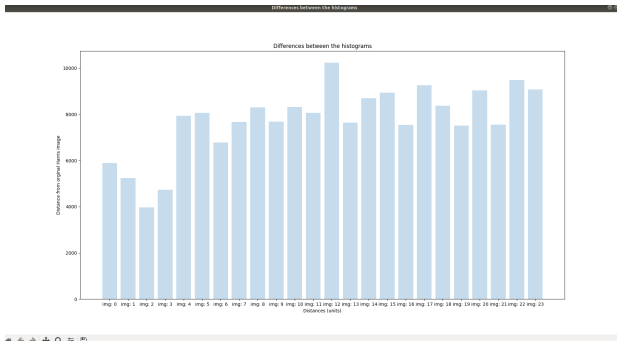


Fig. 22: Difference of keypoints found relative to first image: SIFT, Scaled, Diamond

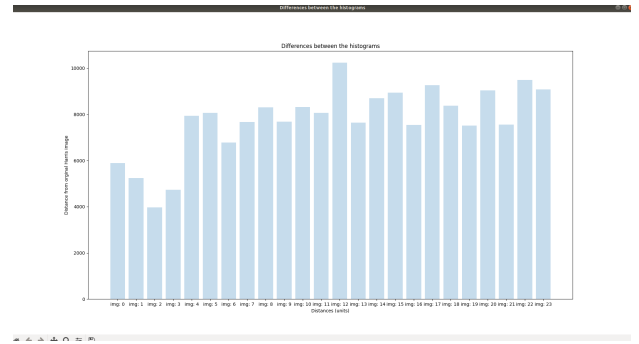


Fig. 23: Difference between the distances of histograms

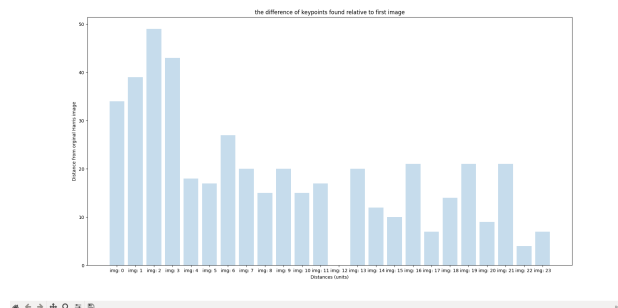


Fig. 24: All produced histograms: SIFT, Scaled, Diamond

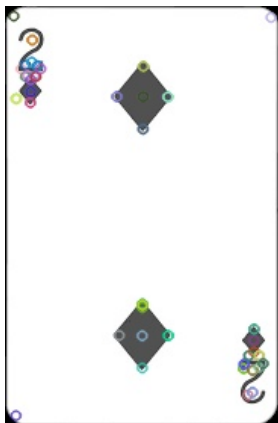


Fig. 25: Harris scaled original produced image: Harris, Scaled, Diamond

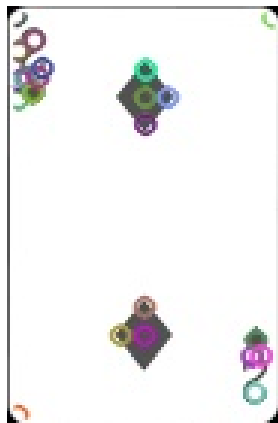


Fig. 26: Diamond SIFT image 1 scaled produced image

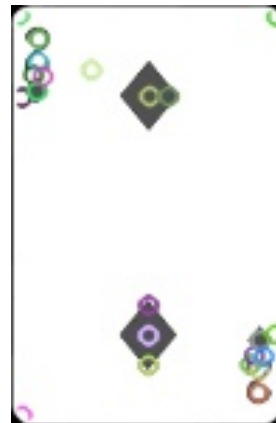


Fig. 27: Diamond SIFT image 2 scaled produced image

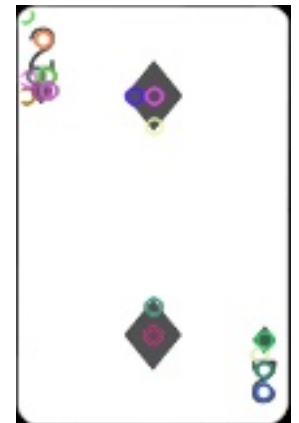


Fig. 28: Diamond SIFT image 3 scaled produced image

A set of 24 experimental images were produced. Only four displayed in report as displaying all 24 doesn't add great benefit to the reader. To re-view all 24 experimental images please implement the algorithms found in the appendixes.

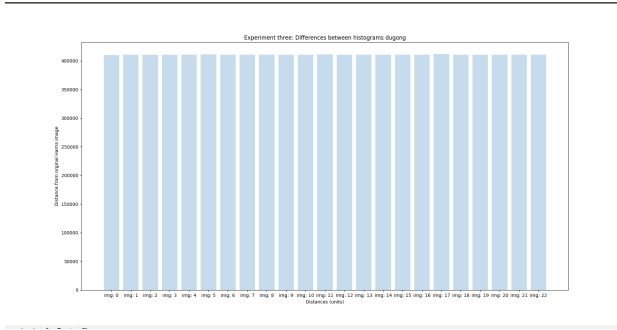


Fig. 29: Difference of keypoints found relative to first image: Harris, Rotated, Diamond

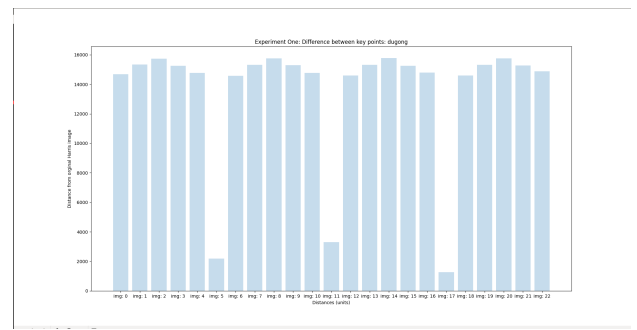


Fig. 30: Comparison of histograms for each transformed image: Harris, Roateted, Diamond

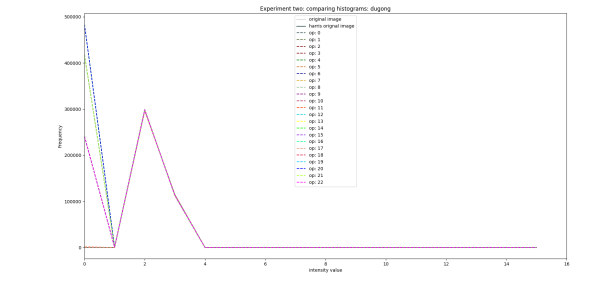


Fig. 31: Difference of distances between histograms relative to original: Harris, Rotated, Diamond



Fig. 32: Diamond harris rotated original produced image

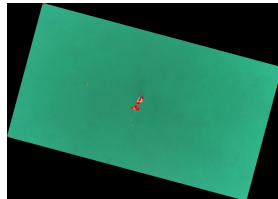


Fig. 33: Diamond harris image 1 rotated produced image

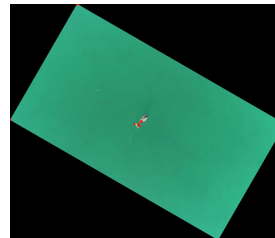


Fig. 34: Diamond harris image 2 rotated produced image

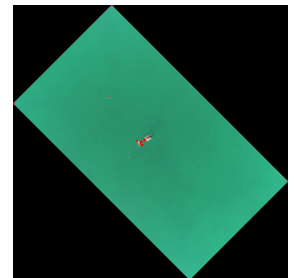


Fig. 35: Diamond harris image 3 rotated produced image

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between keypoints found.png

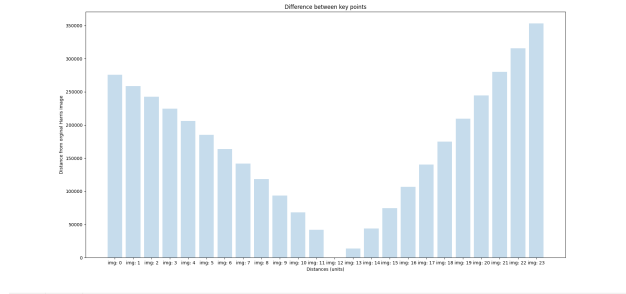


Fig. 36: Difference of keypoints found relative to first image: Harris, Rotated, Diamond

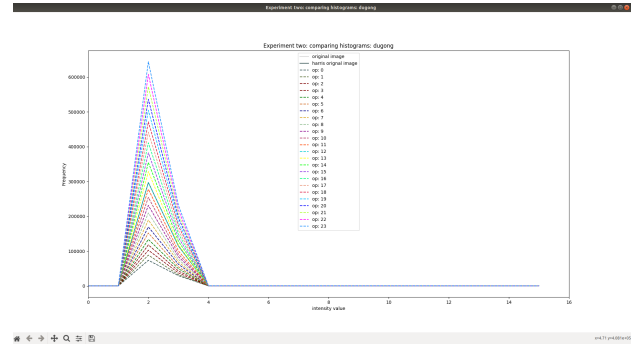


Fig. 37: Comparison of histograms for each transformed image: Harris, Roateted, Diamond

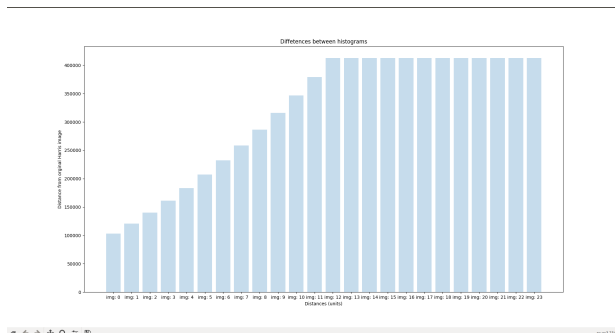


Fig. 38: Difference of keypoints found relative to first image: Harris, Rotated, Diamond



Fig. 39: Diamond harris scaled original produced image



Fig. 40: Diamond harris image 1 scaled produced image

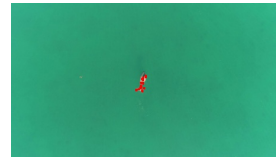


Fig. 41: Diamond harris image 2 scaled produced image



Fig. 42: Diamond harris image 3 scaled produced image

A set of 24 experimental images were produced. Only four displayed in report as displaying all 24 doesn't add great benefit to the reader. To re-view all 24 experimental images please implement the algorithms found in the appendixes.