Homework 3: Road from Blobs to Faces to Seams!

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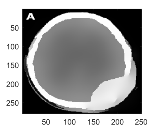
I. Part 1: Anisotropic Diffusion

In this part, we tried to filter the image, 'Brain.jpg', without blurring the edges with anisotropic diffusion (AD).

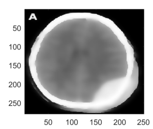
A. Results

The blurring results using anisotropic diffusion with variant 1 and variant 2 are shown in the following figure.

It seems that when using variant 2, the blurring process is done faster than using variant 1 since for it takes 1000 iterations and 100 iterations respectively when using the above two variants, while the other parameters are the same, i.e. $k = 16$ and $\lambda = 0.05$.



(a) Variant 1



(b) Variant 2

Fig. 1: Blurring results

B. Related questions

Question 1: k controls the conduction as a function of gradient. If k is low, small intensity gradients are able to block conduction, so we can see small black blocks in the blurring region, which should not appear in our desire. A larger value may reduce the aforementioned effects, but when it becomes too large, the edges can also be blurred. The results of increasing k from 1 to 20 with step 5 and decreasing it are shown in Figure.2 and Figure.3.

Question 2: λ seems to control the speed of diffusion. If using a larger lambda, the diffusion can be done in fewer iterations. The following figures display the results of increasing and decreasing the value of λ.

Figure.4 displays the result of increasing λ from 0 to 0.1 with step 0.05, and Figure.5 displays the result of decreasing λ from 0.25 to 0.15 with step 0.05.

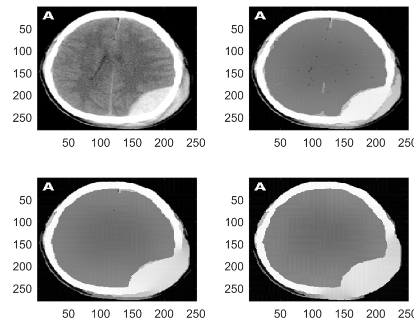


Fig. 2: Results of increasing k

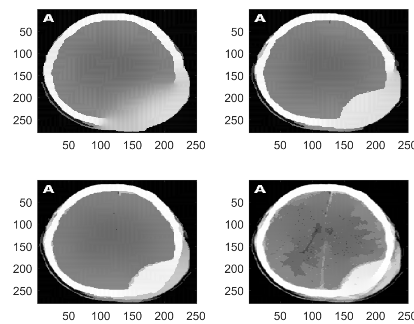


Fig. 3: Results of decreasing k

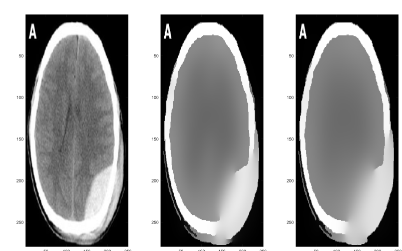


Fig. 4: Results of increasing λ

B. Related questions

Questions related to this part are 3, 4, 5, 6, and 7.

II. Part 2: Face Recognition using Eigen Vectors and Values

This part aims to implement face recognition using eigenfaces.

A. Results

In this part, a recognition rate (RR) of **89.58%** is accomplished on the testing set and a rate of **100%** on the trainning set. The RR is achieved by reducing the 1×10304 image vector into 1×153.

Question 3: When M' increases from 1 to 200, it is obvious that RR increases and then decreases and a highest RR is achieved when $M' = 153$. However, when M' continues increasing from 200 to 500 and more, there's some fluctuation of at first and then RR becomes stable and equals to 87.50%.

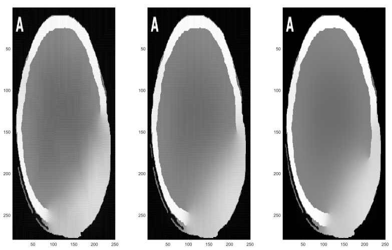


Fig. 5: Results of increasing λ

Question 4: This trend signifies that its not necessary to contain as much dimensions as possible to achieve a high recognition rate, i.e. not all features that we observed in the faces are helpful with recognition. Only with certain number of features that tell most of the differences in our observations or best desicrbe our observations will help the recognition.

Question 5: A drawback of eigen-face recognition is that finding the eigenvectors and eigenvalues are time consuming. Another drawback is that it is very sensitive for lightening conditions and the position of the head.

Question 6: Eigen-face method is not invariant to illumination, rotation, scale or pose. As the method takes the pixel values as comparision for the projection, the accuracy would decrease with varying light intensity. Besides, rotaion, face pose, and scale of an image will also affect the RR greatly. Generally, preprocessing of image is required in order to achieve satisfactory result and there usually has a high correlation between the trainning data and the recognition data, so it should not be a surprise that the accuracy of recognition can be sensitive to the listed factors in the question.

Question 7: Failed case one: From Fig.6 and Fig.7, which displays the training images and testing images of the object, we can see that the the failed testing image (marked in the red frame) has an apparently different face pose comparing with images provided in the training set and other successfully recognized testing images, regardless the difference in facial expression. This failed case also supports our conclusion in question 6 that eigen-face recognition is sensitive to face poses.

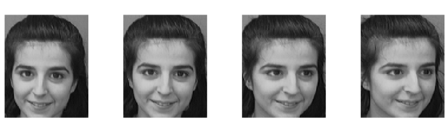


Fig. 6: Training set

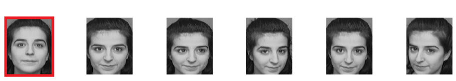


Fig. 7: Testing set

Failed case two: This is a tricky one. Three testing images failed in recognition for this single object. From Fig.9, we can see that the common feature of all three failed images is that they have different face poses from the poses provided in the training set shown in Fig.8, while the other well-recognized images have similar poses with the training images.

Fig. 8: Training set

Fig. 9: Testing set

III. Part 3: Seam Carving

In this part, seam carving algorithm is implemented for content-aware resizing.

A. Results

By implementing dynamic programming in the seam carving algorithm, 100 horizontal seams and 200 vertical seams can be successfully removed in the image. The original image and the seam carved image are shown in Fig. 10.

Fig. 10: Original(top) and the seam carved image (bottom)

We can also use seam carving in one direction and the following figure display the results after carving along only vertical or horizontal direction.

(a) Horizontal (b) Vertical

Fig. 11: More seam carving results

B. Related question

Question 8: An alternative energy function can be the HoG energy function, which is $e1$ (the function we used, i.e. the sum of absolute values of gradients along x and y.)divided by a histogram of gradients measure. The intention of using HoG energy fucntion is to attract a seam to an edge in the picture but to not cross it. This is done by dividing by the max of a histogram of gradients measure to reduce the cost near an edge. But then the cost is multiplied by the e1 energy, so it is high at an edge.

REFERENCES

[1] Pietro Perona and Jitendra Malik. Scale-space and edge detection using anisotropic diffusion.*IEEE Transactions on pattern analysis and machine intelligence,*12(7):629-639, 1990.

[2] Matthew Turk and Alex Pentland. Eigenfaces for recognition. *Journal of cognitive neuroscience*, 3(1):71-86, 1991.

[3] Shai Avidan and Ariel Shamir. Seam carving for content-aware image resizing. *In ACM Transactions on graphics (TOG)*, volume 26, page 10. ACM, 2007.