Step 1

The imread matlab function is used to load the image.

Step 2

In order to convert the image to grayscale, the function rgb2gray is used. The function works by eliminating saturation and hue information from the image whilst retaining its luminance. The image is now represented as a 2d array, with intensity values ranging between 0 and 255.

Step 3

Method

A Median Filter has been used to remove salt and pepper noise within the image. As displayed in figure 1, the filter has worked well to remove the outlier pixels whilst retaining overall image quality. The filter determines each output value based on the pixels neighborhood. It computes the median value from the neighborhood list (including the input value), subsequently changing the input pixel with the median value. Ahmed. (2015). [**http://www.sersc.org/journals/IJSIP/vol8\_no10/34.pdf**](http://www.sersc.org/journals/IJSIP/vol8_no10/34.pdf) **344**

Elmustafa S . Ali Ahmed. (2015). Median Filter Performance Based o n Different Window Sizes f or Salt and Pepper Noise Removal in Gray and RGB Images. *nternational Journal of Signal Processing, Image Processing and Pattern Recognition*. 8 (1), 343-352.

Padding

Zero padding has been used. The median filter therefore has full coverage of the image including it corners and sides. Alternatively the image could be cropped. However this would reduce PPI losing image detail.

Filter Comparison

When testing a mean filter, output displays grey specks in similar positions to the salt and pepper noise. This is due to the linear nature of the filter being more sensitive to the 0 and 255 outliers **(Quote).** Pixels true to the original image are being influenced by outlier pixels in their neighborhood. With its trait of selecting the middle value within a pixels neighborhood a median filter is less sensitive to these outliers and therefore in this case a better choice for noise removal than the mean filter. Laganière (2011).

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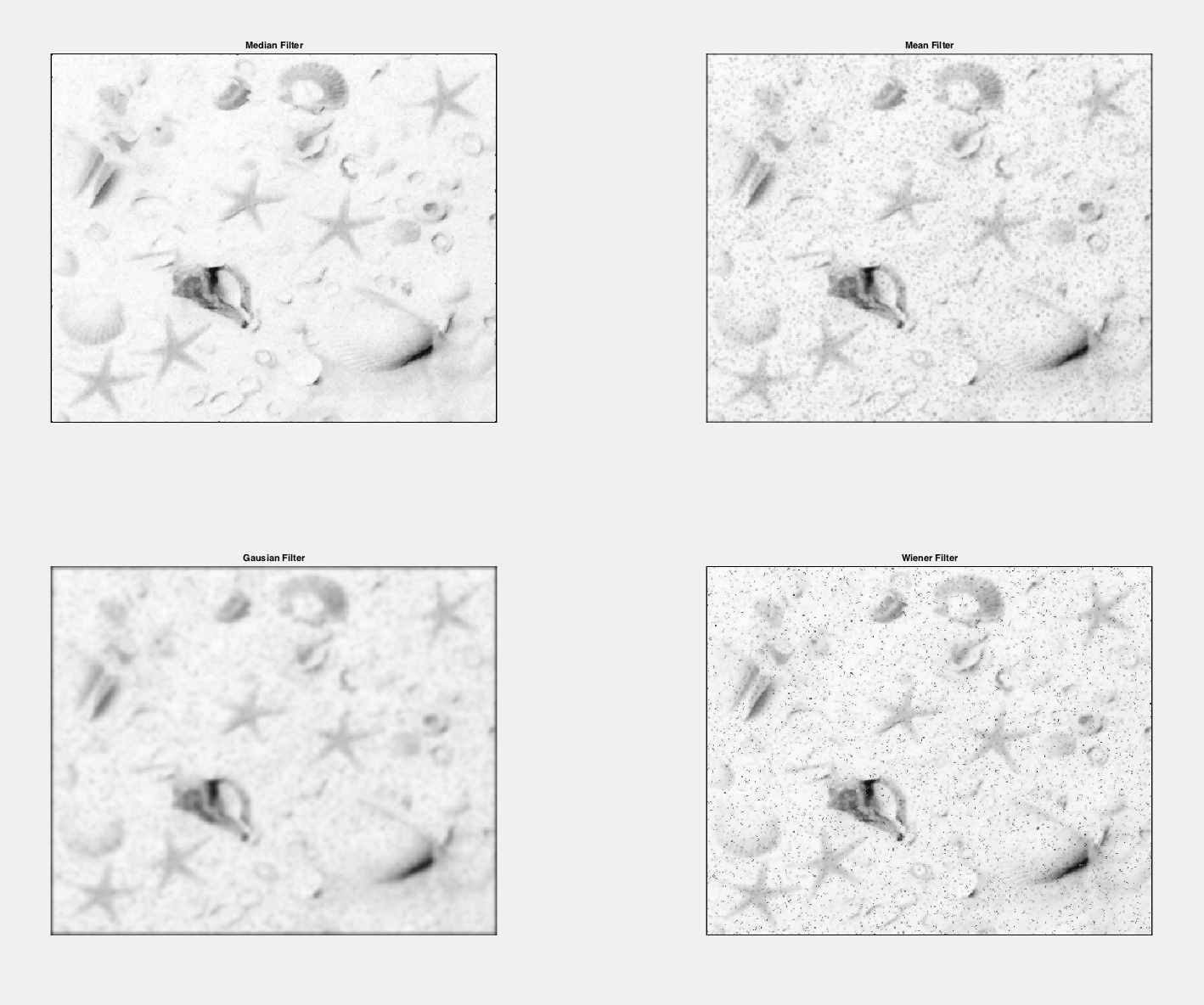
Robert Laganière (2011). *OpenCV 2 Computer Vision Application Programming Cookbook*. Birmingham: Packt Publishing Ltd. 148.

A Gaussian filter seems to remove the salt and pepper noise however does not preserve edges of the image as well as the median filter. In terms of speed the linear trait of the Gaussian algorithm is likely to be faster than median filter's non-linear sorting process. However maintenance of detail is crucial in later stages i.e. identifying the starfishes. As a result detail over speed is an accepted trade off. Bradski (2008).

Gary Bradski (2008). *Learning OpenCV*. California: O’Reilly Media. 127.

A Wiener filter has been used to determine if the tailoring of local image variance removes more noise than a median filter. It seems when defining a 3 by 3 neighborhood, the filter doesn’t blur the edges of objects within the image however it has only removed a small amount of salt and pepper noise.

In evaluating a pixel using a 5 by 5 neighborhood noise is taken away, however this is at the cost of losing further detain within the image. As displayed in figure 1, a 3 by 3 neighborhood completely takes away the salt and pepper noise whilst also retaining image detail. If there was a higher amount of noise within the image, using a 5 by 5 neighborhood may have been applicable.



Step 4

As it can be seen from the original image histogram, intensity values are grouped around the higher end of the graph. This shows that the image has low contrast. Increasing the contrast of the image will increased detail of its objects. In order to increase contrast intensity values have to be stretched. In order to stretch the values histogram equalisation has been implemented as an enhancement.

The method outputs the images intensity levels by approximation of their probability of occurrence. As displayed in figure 1, the original image has histogram components, which are localised to high intensity values. This stretches these intensity values, increasing contrast and therefore detail of light objects within the image. Each starfish is made darker, which will aid in segmenting them from the image. **186 oreily open cv**

Original intensity levels of the image are narrowly localised around the higher end of the intensity spectrum. Contrast stretching has subtly expanded the narrow range making the pixel intensities slightly darker. This has slightly increased the contrast of the image and subtly increased detail of objects (including the starfish). However, as shown in figure 23 contrast stretching does not expand the range of intensities as much as histogram equalisation. Therefore in wanting to bring out the most detail in the image, histogram equalisation is the better option.

Gamma correction has also been tested as an enhancement. Gamma correction works using the power law where an input value is raised to a given power and then outputted as a non-linear value. When specifying a power of 0.5 (Gamma compression), brighter intensity levels increased. This did not increase the contrast of the starfishes, but does make background detail lighter, which would be useful in when thresholding (segmenting the starfish). When specifying a power of 1.5, darker intensity levels increased. This inversely increased the contrast of the starfishes as well as background regions. This particular result was similar to the output of histogram equalisation. Histogram equalisation however seems like the best enhancement to use, this because it makes the edges of each starfish darker which defines them more than any form of gamma correction.

Task 5

The Otsu method has been considered. The method works by splitting the image intensity values into two regions. The variance of both regions is then calculated which indicates the compactness of both distributions. Adding both variance result returns the threshold for the image. Gonzalez (2009).

Rafael C. Gonzalez (2009). *Digital Image Processing*. 2nd ed. United States of America: Gatesmark . 561.

Because the image has been equalised pixel intensities are not group together and not bi model in histogram structure. As a result the threshold seems too high at the value of 0.7. This enables undesirable detail as foreground pixels. This has resulted in white details forming around or connecting to the starfishes, as well as to other non-relevant shells.

Instead of the Otsu method a simple threshold number has been trialled and tested. The value 0.31 seems like the best threshold to use. Unlike when the Otsu method it disallows sand artefacts becoming foreground pixels which in turn reduces the number of undesired artefacts whilst leaving each starfish in place.

The in built Matlab function im2Bw is used to segment the image into classes. It works by evaluating every pixel within the image against a threshold ‘t’. If a given pixel value is above t then the value is mark as '1' (forground) else the pixel is marked as 0 (background).

Task 6

The high intensity probability of background pixels within the image leads to histogram equalisation increasing the detail of background artefacts, which do not belong to the pixels of interest.

Morphological processing inhibits a set of non-linear operations, which can be used to remove undesired regions within the binary image. Opening has been utilised. Opening comprises of two operations, erosion and dilation. Both operations create a new binary image where a structuring element ‘Kernel’ determines whether a pixel has a zero or non-zero value. Each morphological kernel has a pixel arrangement, which specifies the evaluative region of the input image. For example the square shaped kernel in figure 8 will consider a complete 3 by 3 neighbour of a pixel, whilst the kernel in figure 9 will only consider its corresponding pixels ‘plus shaped’.

Erosion superimposes the structuring element se on top of the binary image where the origin of se is placed at every computed pixel in the input image. If the structuring elements meet non-zero neighbourhood pixel from evaluated the given pixel stays the same, otherwise the pixel is converted to 0. Laganière (2011) A disk shaped kernel with a size 5 x 5 (2 pixels each side of the evaluating pixel) is used to erode the image. As displayed in figure 10 this eliminates small background artefacts whilst still retaining general shape of each starfish. When using a when using a square shaped kernel, unwanted shapes in the image are reduced to a smaller size however edges of the stars seem to lose a higher amount of detail, this is because of the square structure evaluates more pixels than the disk arrangement than the disk arrangement.

Robert Laganière (2011). *OpenCV 2 Computer Vision Application Programming Cookbook*. Birmingham: Packt Publishing Ltd. 118.

In using a larger size 7 x 7 disk kernel more unwanted detail is removed from the binary image. However this is at the cost of further reducing the shape of each starfish (figure). The subsequent process of dilation would recover this shape, however a higher kernel size would also be required. This would increase the size of other artefacts as a well as the pixels of interest. As a result a 5 x 5 disk size seems like the best compromise between removal of artefacts and maintenance of starfish shape.

Dilation works in an opposite manner to the erosion process. If one or more pixels in the structuring process correspond with a pixel in the binary images neighbourhood, the evaluated pixel is changes to 1, otherwise the pixel is already one and another pixel is evaluated. Using a square kernel arrangement with a size of 4 x 4 increases the size of each starfish without compromising shape.

When using a disk arrangement with a size of higher 5x5, the shape of each starfish do not enlarge as much as using a 4 x 4 square arrangement. This is due to the shape of the disk-structuring element, which does not evaluate all surrounding neighbourhood pixels. In using a 5 x 5 kernel size with a square kernel, the starfishes bloat whilst increasing the size of the unwanted artefacts. Whilst using a smaller size 3 x 3 kernel, the starfishes have sharp edges, which are otherwise smoothed out when using a 4 x 4 size.

When implementing a closing operation (dilation and erosion), this maintains more wanted artefacts than the *chosen* opening method. This is a result of the small background pixels being enlarged first, then not being taken away due to the erosive kernel not being large enough to remove the artefacts. A “” size kernel which removes the unwanted pixels also deforms the pixels of interest (starfish). As a result the closing operation is not utilised in the binary image.

Task 7

To estimate the area and perimeter of all objects within the binary image the function ‘regionprops’ is used. The function identifies the area and perimeter of all foreground pixels within the image. The metric “4\*pi\*area/perimeter^2” indicates the roundness of a given object. The MATLAB function BWLabel is used to identity each region within the image. An new matrix name ‘out’ is created to hold the pixels of interest.

Using a ‘for’ loop, every region within the array is evaluated. An ‘if’ statement then identifies if the given region has a roundness metric between 0.2 and 0.3. This seems like the best threshold in order to identify the pixels of interest in the binary image. If the statement passes the given object the region of pixels the region is marked with a circle, and the region number is stored within an array ‘outCol’.

Subsequently, another loop loops through outCol and finds the whole region using the ‘bwlabel’ function. It then adds the region to the ‘out’ matrix.

Using an adaptive method, the image is split up into 50 by 50 neighbourhoods an individual mean is computed and set as the threshold for each. This has resulted in just the shells and starfish being in the foreground and the majority of sand artefacts being placed in the background. This is because….