­­To determine the qualities of the Moth Eye surfaces, a program was written to process and evaluate a set of sample images

In the method ***readAndProcess(imLoc, display=display\_default)*** images are read and pre-processed. In this work, pre-processing comprises BGR to RGB conversion, RGB to grayscale conversion and smoothing the image using a median filter. Filters are applied to improve matching, so sharpen and blur to get better contrast and gradient.

The methods ***getCircles(locs, rgb\_testim, ori\_im, display=display\_default)*** using Normed Cross correlation of the Hough transform are used to find circles in the images. The normed cross correaltion method using a template determined uniquel from each sample image to be searched for using a sliding template method. Alternatively circles are drawn on the original image on the basis of Hough circle method.

The houghCircle method requires two parameters based on the image quality and the max proposed radius of the circles. The max and min radii are chosen based on scale of image so the small dark wedges between circles are not included. The estimate the diameter of each detected circle from the previous step in terms of pixel and micrometres is found. The array of determined circles was recast as unit16 because of the low resolution of the images. The method was found to detect the space between pixel as decimals, so it was recast as an integer to correctly give the pixel locations. The input of this function includes the circles, and the output of this method is the diameter of each circle, both in terms of pixels and micrometres. It was realised that the first line of the array included the deleted circles, so the first row which is zero since calculating Euclidean distance and assigned to iterate to determine the distances. A unique circle is determined with the condition when the inter-circle separation is less than 1.5 x pixel diameter. The algorithm checks the distance between two circles and if the circle is on edge, or has non nearby, then there it is an invalid result. Thus, points that do not satisfy this condition are replaced with a zero element and remake the array to store only the unique circles.

An estimate for the percentage of circles that are covered in the transformed grayscale image if found. Taking a grayscale distribution shows where the threshold must be. In this way the threshold is chosen around 65. When binarized, the values below the threshold are converted to 0, black. Consequently, the histogram of black and white shows frequency as number of black or white pixels. Also, some circles are necessary to be deleted as some circles were multiply counted. The ratio of white circles with respect to the black circles is found to estimate the coverage of the surface with circles. On this basis of circle value percentage, if the result is above a threshold of 70%, the image is returned as ‘good’, otherwise, it is ‘bad’.

From the results of the earlier methods it was thus simple to determine various meaningful statistics of the images. The surface reflection and average separation of circles is calculated from the determined from the results of earlier methods. The input of this method is the number of Hough circles, the mean diameter of the circles in pixels, and the length of Hough circles at the beginning. This method returns the average sphere separation in terms of pixels and micrometres. The size of the uncovered regions is then computed using the RGB image, grayscale image, and the mean diameter of the circles as the input. This method returns the sorted contour list.

In the method ***numDoubleLayers(dist, circles, rgb, mean\_Diameter, circleDiameters, display=display\_default)*** the number of double layers is calculated. This method takes array of distances, Hough circles, transformed RGB image, diameter of Hough circles in pixels, and the mean diameter. A double layer is counted when sphere separation is less than sphere diameter. So, if there is overlapping the distance of a given circles will be less than the diameter of the other compared circle.

Lastly, the dominant packing coordination shape is estimate using a method of evaluating the number of circles that are adjacent to any given circle. Several methods were trailed until it was found to be easiest by using a dictionary of possible shape with coordination values designating the number of vertices of the shape. If the given circle had a number of unique adjacent circles equal to a specific number of vertices, then the count for that shape was increased. For example, two adjacent circles to a given circle ill result in a triangular packing. (figure)