Why Image processing? The images give us a lot of information but some initial preprocessing is required as they might include some noise.
The quality of the image is basically resolution. It is of two type:

1) Spatial resolution (smallest visible detail)
2) Grey level resolution(smallest visible change in grey level)

Image enhancement can be done using two methods: Spatial domain methods and Frequency domain methods.

To improve the results Image stacking was used, where multiple images are captured and then stacked together, then either median average or sigma clipped average is used to give the resulting image. This reduces noise and improves quality of image by 40 times but all these highly depends upon the camera used and various external factors.

Image Segmentation is the process of partitioning images into multiple segments based on common characteristics. The basic type of segmentation is done using edge detection techniques to obtain all the abrupt changes in pixel values. The pixels are clustered so that these can be assigned to a group. The clustering can be done using the simple K-Means Clustering technique or any other accordingly.

Semantic Segmentation:
It is basically partitioning an image into parts or in simple words assigning labels. This labelling is done by finding the argmax of the feature score. The pixel labels for training images must be known beforehand, these labels become part of the feature map. We divide the image into patches. Large patches lead to high computation and small patches lead to poor segmentation due to information loss. To produce a segmentation map from these patches downsampling is followed by upsampling also called Encoder/Decoder structure.

Instance Segmentation:
When we separate the instances of the same class then it comes under instance segmentation.

The image segmentation approaches can be classified into two types: 1) Discontinuity detection based approach: It implements edge detection as it detects the sudden changes in the pixel values and links formed due to boundaries. 2) Similarity detection based approach: In this, image is segmented based on the similarity.The techniques that fall under this category are: thresholding techniques, region growing techniques and region splitting and merging.

Three Segmentation methods:

1) Threshold based image segmentation:
    Types:
    1) Global -> single threshold for the entire image therefore requires distinct intensity pixels. Types: otsu, optimal, histogram, iterative, maximum correlation, clustering and multi thresholding.
        Histogram based thresholding tries to find out if there is a peak in the intensity value that can be used as threshold, if there are multiple peaks then selecting threshold is difficult.

Iterative method takes average intensity as initial threshold and then iteratively updates this threshold for k iterations similar to 1D k means clustering but here results highly depend upon the initial t and mean is calculated every time.
Otsu method does not find threshold manually, it exhaustively searches for correct threshold using histograms but the drawback is it assumes histogram to be bimodal.
Maximum correlation is identical to otsu (explain otsu).
Multithresholding overcomes the drawback of global thresholding by using multiple thresholds.
Clustering based-> fuzzy c means : it allows a pixel to be part of more than one group and using this we try to reach a local optimal solution after iterations. -> K means : k-1 thresholds are taken to create k segments.

2) Local -> If the gradient effect is small in the image then the image can be divided into sub images and then choose a threshold for each sub image based on properties of image like mean.
3) Adaptive -> mean based , gaussian based, chow and kaneko approach : uses 7x7 sub images and threshold for each assuming that small sub images are uniform.

2) Region based image segmentation:
    1) Region growing: it selects seed pixels manually for each region to be segmented. Now a candidate pixel is compared with seed pixel and neighbouring pixels if they are in that region. If its similarity value crosses the threshold it is assigned that region. Good for colour image segmentation.
    2) Region splitting and merging: Initially the image is considered as a single region and then divided until the similarity btw the sub region is more. Region merging is done for these subregions as single splitting is meaningless. Steps: divide the whole image into quadrants till variance is large, then merge any quadrants that are similar enough, Repeat this.
3) Artificial Neural Network Based Segmentation:
    1) Mask rcnn: build on top of faster rcnn, so with bbox and labels it also returns object mask. Used coco dataset.
    2) U-Net architecture: Firsty maxpool downsampling to encode the input image into feature representations at multiple different levels is done and then the goal is to semantically project the discriminative features (lower resolution) learnt by the encoder onto the pixel space (higher resolution) to get a dense classification.

Comparison:
1. Histogram based thresolding involves manual intervention and threshold needs to be found out using threshold and therefore cannot be used in real time.

2. Otsu method works well for some images and give poor results for certain types of images. The results from Otsu have too much of noise in the form of the background being detected as foreground. The main advantage is the simplicity of calculation of the threshold. Since it is a global algorithm it is well suited only for the images with equal intensities. The method does not work well with variable illumination This might not give a good result for the images with lots of variation in the intensities of pixels.

3. The drawback of adaptive thresholding is that it is computational expensive and, therefore, is not appropriate for real-time applications.

4. We can see that the result is better that those obtained by thresolding on this image but may not be the same case for other. Also,this algorithm presents several advantages over other color image segmentation algorithms. Region growing approach is simple. The border of regions found by region growing are perfectly thin and connected. The algorithm is also very stable with respect to noise. Limitation is that, it requires a seed point, which generally means manual interaction. Thus, each region to be segmented, a seed point is needed.

5. The disadvantage is that that learning may slow down in the middle layers of deeper models. This is due to gradients becoming diluted further away from the output of a network, where the error is computed, resulting in slower learning for far-removed weights. The advantages of U-Net models are probably worth the risk, though, and choosing the right activation functions and regularization parameters can probably mitigate adverse effects caused by vanishing gradients in the middle layers of U-Net models.

6. We see that mask R-CNN works very well in image segmentation. But requires pre knowledge to predict anything i.e. it requires dataset to train it. It is an extension of Faster R-CNN, therefore it is better as compared U-Net model.

There is no single method which can be considered good for all type of images or all methods equally good for a particular type of image. Depending upon the type image we need to select the type of algorithm for Image Segmentation.