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# **Image Processing**

## **Introduction to Digital Image Processing**

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# Why do we need Image Processing?



## *Table 1. Why do we need Image Processing?*

<b>Why do we need Image Processing?</b>	
<b>It is motivated by the following major applications</b>	
1	Improvement of pictorial information for human perception
2	Image processing for autonomous machine application
3	Efficient storage and transmission



Let us first look at the first major application which is meant for human perception.

***Table 2. Employ methods capable of enhancing pictorial information for human interpretation and analyses***

<b>Employ methods capable of enhancing pictorial information for human interpretation and analyses</b>	
<b>Typical applications:</b>	
1	Noise filtering
2	Content enhancement: <ul style="list-style-type: none"><li>- Contrast enhancement</li><li>- Deblurring</li></ul>
3	Remote sensing



# Noise filtering

- Typical applications of these kinds of techniques are noise filtering.
- In some cases, the images that you get may be very noisy.
- *We* have to filter those images so that the noise present in that image can be removed and the image appears much better.
- In some other kind of applications, we may have to enhance certain characteristics of the image.



# Contrast enhancement

- There are different kinds of applications under this category: one is the **contrast enhancement**.
- Sometimes the image may be very poor contrast and we have to enhance the contrast of that image so that it is better visually.
- In some other cases, the image may be **blurred**. This blurring may occur because of various reasons. May be, the camera setting is not proper or the lens is not focused properly. So, that leads to one kind of blurring.



- The other kind of blurring can be if we take a picture from a moving platform; say for example, from a moving car or from a moving train.
- In that case also you might have absorbed that the image that you get is not a clear image. But it is a blurred image.
- The other kind of application is remote sensing. In remote sensing, the types of images which are used are the aerial images and in most of the cases, the aerial images are taken from a satellite.



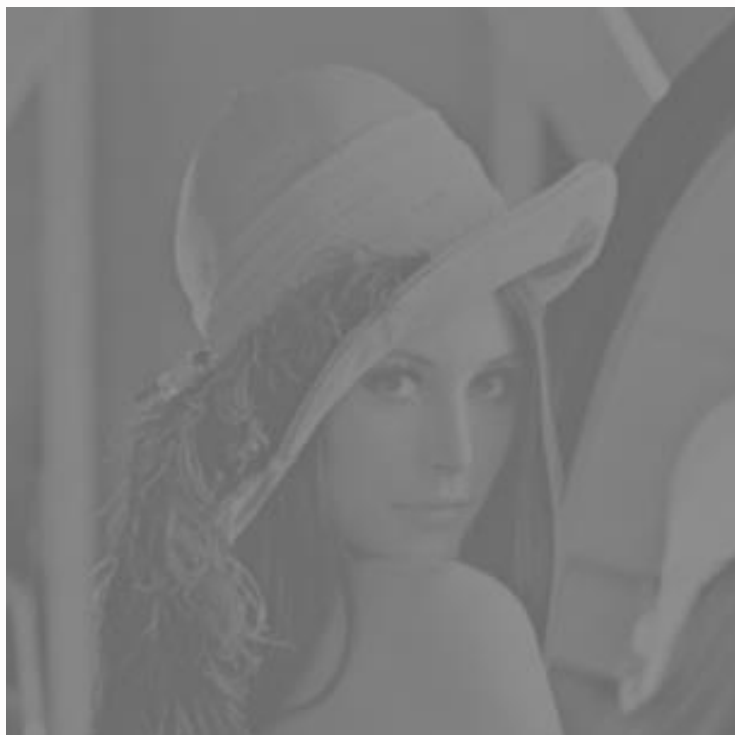
# Image enhancement

- In the second category, for image enhancement;
- you find that again on the left hand side we have an image and on the right hand side, we have the corresponding image which is processed to enhance its contrast.
- If you compare these two images, you find that the low contrast image in this case, there are many details which are not clearly visible.
- So, here after processing, we have got an image which is visually much better than the original low contrast image.





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*Figure 2. Image enhancement.*



# Image Deblurring

- In some of the applications, some cases, the image may be blurred.
- On the top row, the left side, you find an image which is blurred and in this case, the blurring has occurred because of the defocused lens.
- When the image was taken, the lens was not focused properly.
- And, we have talked about another kind of blurring which occurs if you take a picture from a moving platform, may be from a moving train or from a moving car.



Original image



Create a simulated blur in the image

Deblur the image



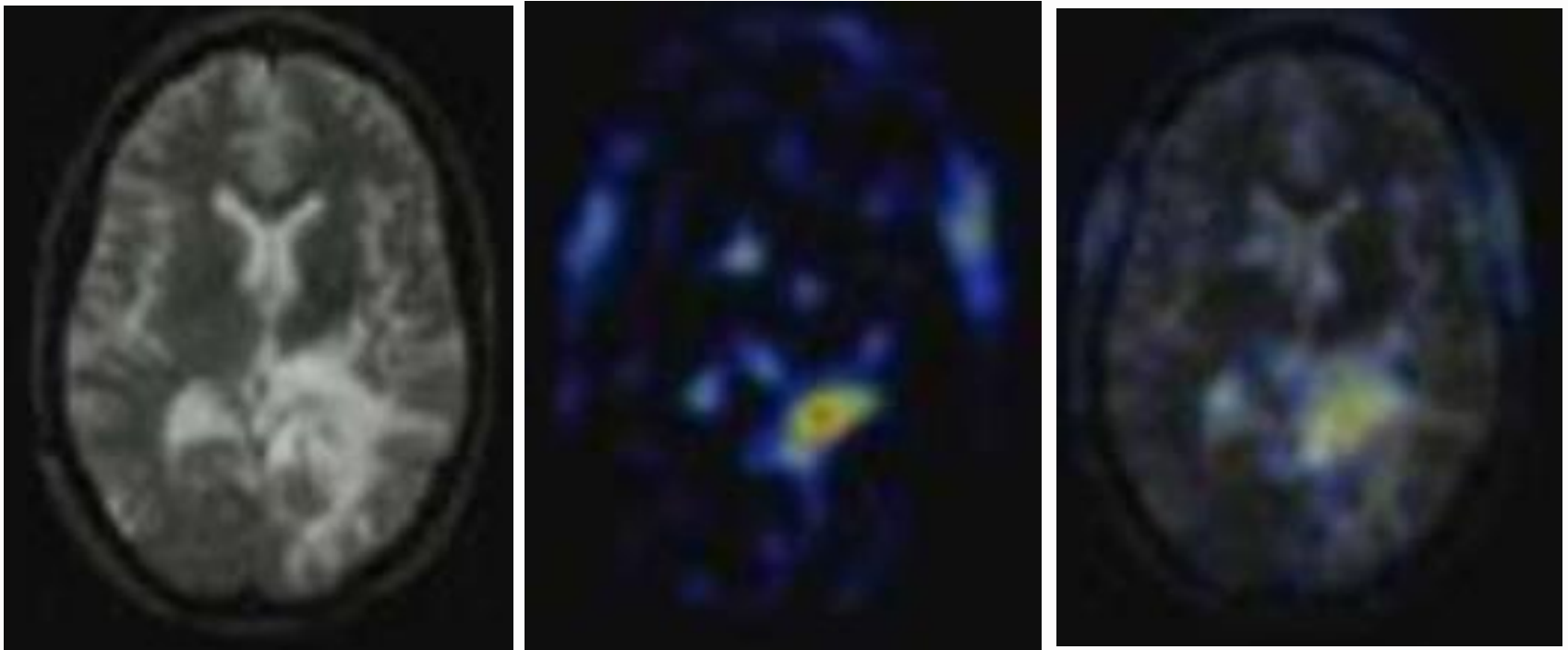
***Figure 3.***  
*Image deblurring.*



# Medical Imaging

- Now, other major application of digital image processing techniques is in the area of medicine.
- I am sure that many of you must have seen the CT scan images where the images of the human brain are formed by using the CT scan machines.
- Here, it shows one slice of a CT scan image and the image is used to determine the location of a tumor.





*Figure 4. Brain tumor.*



- So, you find that the left hand image is the original CT scan image and the middle and the image on the right hand side, there are the processed images.
- Here in the processed image, the region of yellow and red that tell you that the presence of a tumor in the brain.





# Remote sensing

- The image processing techniques are also very important for remote sensing applications.
- So here, this is an image, a satellite image which is taken over the region of Calcutta and you find that many of the information which are present in the image; the blue line, the blue thick line, it shows the river Ganges and there are different color coding used for indicating different regions and when we have a remote sensing image and aerial image of this form which is taken from a satellite, we can study various things.



*Figure 6. Satellite image, Kolkota.*



# Weather forecasting

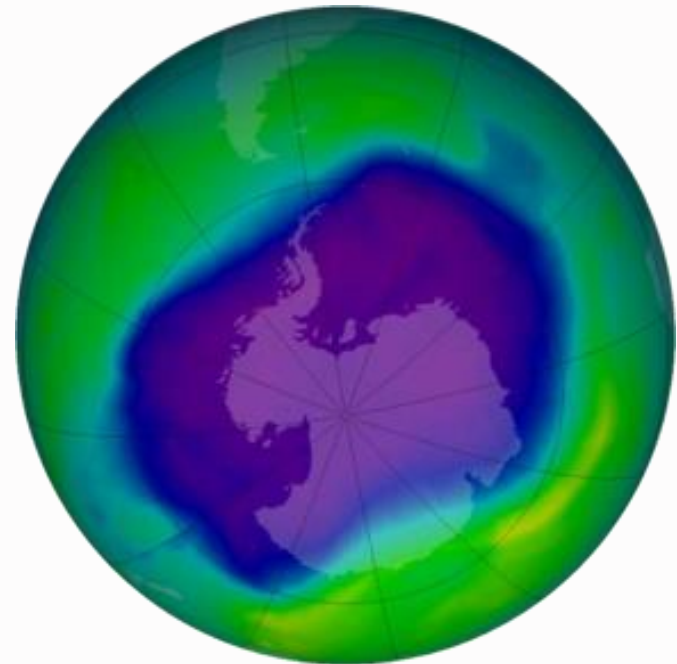
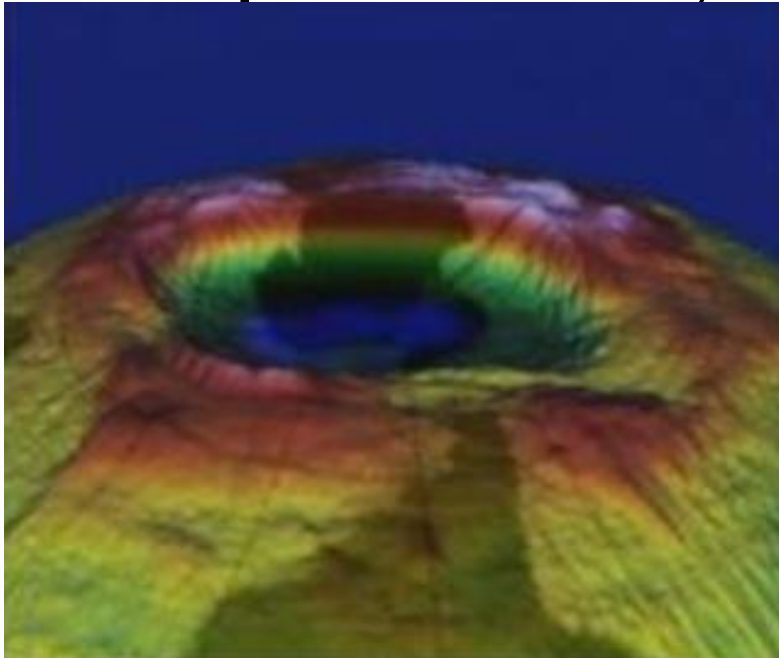
- The image processing techniques is also very important for weather forecasting.
- In that case, on a map some images are overlapped which tells you what the cloud formation in certain regions is.
- That gives you an idea that whether there is going to be some rain, that is going to be some storms and things like that.
- This is an image which shows the formation of hurricane over Dennis which happened in 1990 and through this image, we can find out that what is the extent of this hurricane, what is strength of this hurricane and what are the precautionary measures that can be taken to save live as well as property before.



*Figure 9. Hurricane over Denis, 1990.*



**Atmospheric study.** Image processing techniques are also very useful for atmospheric study.



*Figure 10. Ozone hole.*





**Astronomical studies.** Image processing techniques are also important for astronomical studies. Say for example, in this particular case, it shows the image of a star formation process.



*Figure 11. Star formation.*



# Machine vision applications

- Next we come to the other domain of application of image processing techniques which is the machine vision applications.
- You find that all the earlier applications which we have shown; there the purpose was the visualization, the improvement of the visual quality of the image so that it becomes better for human perception.



***Table 3. Machine Vision applications.***

It is motivated by the following major applications	
1	Improvement of pictorial information for human perception
2	Image processing for autonomous machine application
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# Automated Inspection

- Let us see another application of image processing in machine vision for machine vision purpose.
- Now, before we go to that application, we have shown an image to highlight the importance of boundary information in image processing.
- So here, you find that we have shown the boundary image of an animal. There is no other information available in this image except the boundary contours and you find that if we ask you that can you identify this particular animal and I am sure that all of you will identify this to be a giraffe.



***Figure 13. Importance of boundary information.***



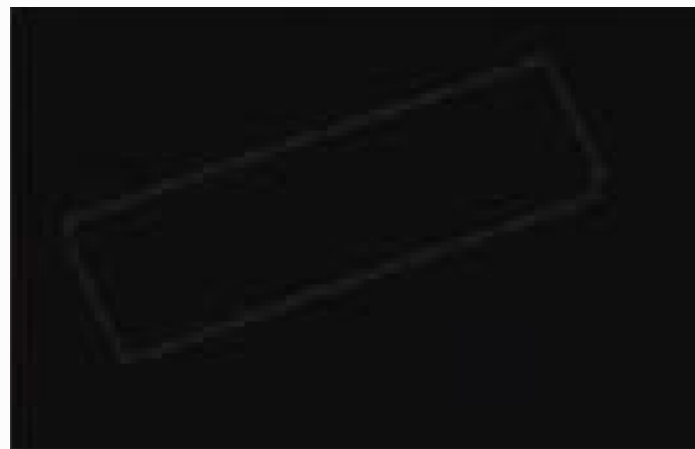
- In many cases or in most of the cases, the boundaries contain most of the information of the objects present in the scene and using this boundary information, we can develop various applications of image processing techniques.
- Here is an application.
- This is an automated inspection process and here the objects that we are interested to inspect are some refractive kits. You find that we have shown 4 different images. The first one is the original image.
- The second one is a threshold image or a segmented image.



- The third image that is the left one on the bottom is a field image. You find that the second image, it is not very smooth. There are a number of black patches over the white region.
- The second one has filled up all those black patches. It shows that what the profile of the object is.
- In the fourth image, you find that it shows the boundary of this object and using this boundary information, we can inspect various properties of this particular object.
- For example, in this particular application there can be 2 different types of defects.

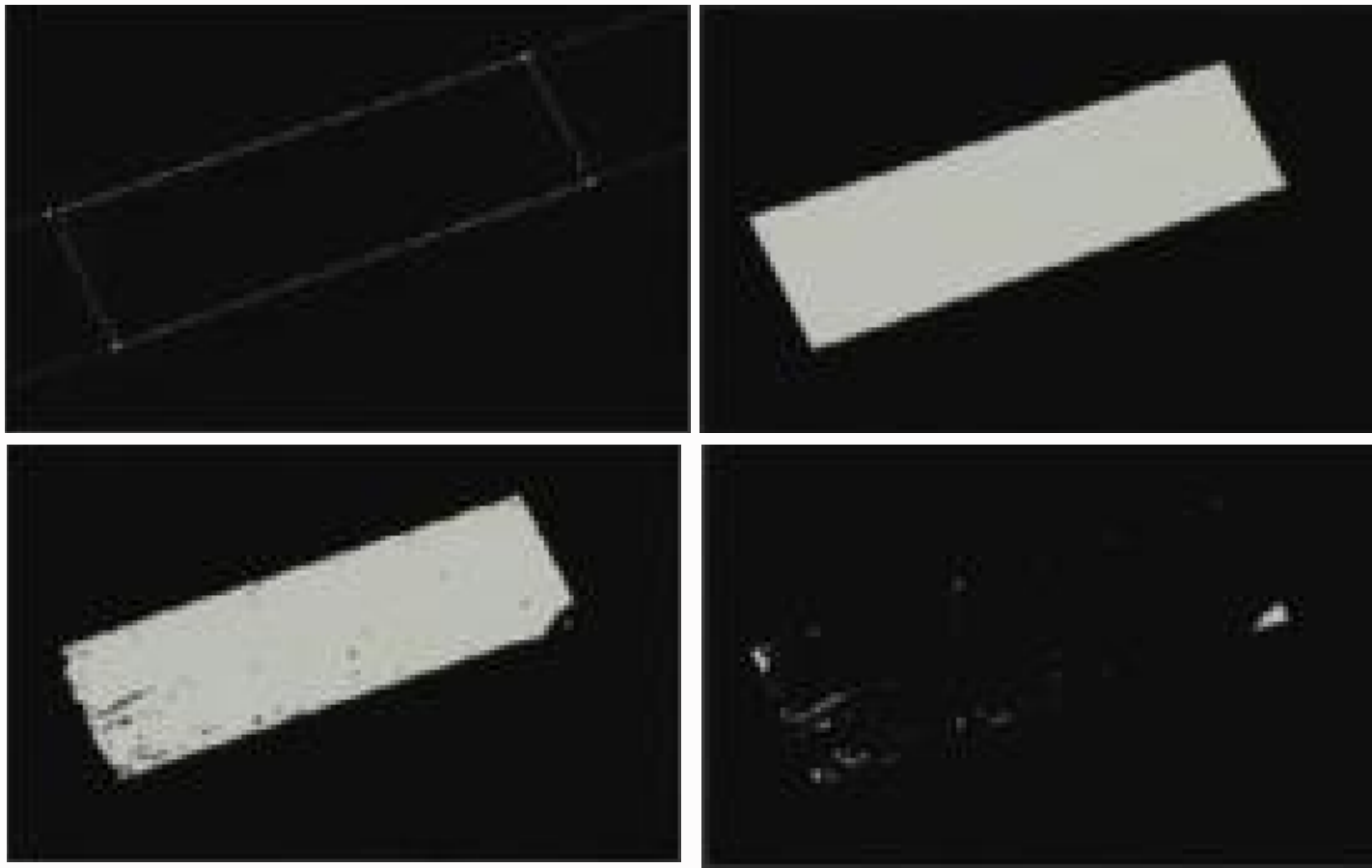


*Figure 14. Automated inspection process of a refractive kit.*





*Figure 15. How these inspections can be made.*





# Video Sequence Processing

*Table 4. Video sequence processing*

Video Sequence Processing	
The major emphasis of image sequence processing is detection of moving parts	
Typical applications:	
1	Detection and tracking of moving target for security surveillance purpose
2	To find out the trajectory of moving targets
3	Monitoring the movements of organ boundaries in medical applications, etc



- Those are the applications which are used for mission vision applications for automating some operation and in most of the cases; it is used for automating the inspection process or automating the assembly process.
- Now, we have another kind of applications by processing the sequence of images which are known as video sequence.
- The video sequence is nothing but the different image frames which are displayed one after another.





# Detection and tracking of moving target

- For example, detection and tracking of moving targets and major application is in security surveillance.
- The other application can be to find the trajectory of a moving target.
- Also, monitoring the movement of organ boundaries in medical applications is very important and all these operations can be done by processing video sequences.
- Let us take one such example.



*Figure 18. Movement detection.*



- Here you find that in the first image, some person is moving against a green background. So, let us see this.
- Here you find that a person is moving against the background.
- Through image processing techniques, we can identify this movement.
- In the second processed sequence, you find that the person is moving which is clearly shown against a black background.
- That means we have been able to separate the background from the moving object.



# Image Compression

*Table 5. Image Compression*

Image Compression	
<b>An image usually contains lot of redundancy that can be exploited to achieve compression:</b> <ul style="list-style-type: none"><li>• Pixel redundancy</li><li>• Coding redundancy</li><li>• Psychovisual redundancy</li></ul>	
Typical applications:	
1	Reduced storage
2	Reduction in bandwidth



- In compression, we want to process the image to reduce the space required to store that image or if you want to transmit the image, we should be able to transmit the image over a low bandwidth channel.
- Now, let us look at this image and let us look at the region that blue circular region; you find that in this particular region, the intensity of the image is more or less uniform.
- That is if I know that the intensity of the image at a particular point, I can predict what is the intensity of it is neighboring point.



- Whenever we talk about an image, the image usually shows 3 kinds of redundancies.
- The first kind of redundancy is called a pixel redundancy which is just shown here.
- The second kind of redundancy is called a coding redundancy and third kind of redundancy is called a psycho visual redundancy.
- These are the 3 kinds of redundancy which are present in an image. Whenever we talk about an image, the image contains 2 types of entities.



- The first one is information content of the image and the second one is the redundancy and these are the 3 different kinds of redundancies.
- The second application is reduction in bandwidth.
- That is if I want to transmit this image over a communication channel or if I want to transmit the video over a communication channel, then the same image or the same video will take much lower bandwidth of the communication channel.



Now, given all these applications, this again shows that what we get after compression.



Original image



1:55



1:156

*Figure 21. Image Compression.*





- The first image is the original image.
- The second one shows the same image but here it is compressed 55 times. If I compare the first image and the second image; I find that the visual quality of the 2 images is almost same at least visually we cannot make much of difference.
- The third image is compressed 156 times; now if you compare this third image with the original image, you find that in the third image there are a number of blocked regions or blocky, these are called blocking artifacts which are clearly visible when you compare it with the original image.



# Image Resolution

- Images make up a very big part of the (web page traffic) data on the Internet.
- This is because an image contains a lot of information compared to text.
- Even a small image sized 200 by 200 (pixels) saved in the bitmap format (using a 24 bits per pixel storage system) can take up  $200 \times 200 \times 24 = 960,000$  bits or  $960,000 / 8 = 120,000$  Bytes = 117.1975 Kilobytes ( $120000 / 1024 = 117.1875$ ).







Same Picture taken at different resolution

***Figure 22. Image Resolution.***



- Below is the image saved in the [BITMAP](#), [GIF](#), [PNG](#) and [JPEG](#) formats.
- The last three are popular web page formats. As can be seen the most efficient format is jpeg at 8KB file size because it is designed to store information on millions of colors that may blend into each other e.g. a photograph or complexly colored image.
- The least efficient is bitmap, and that is why this type of image is not commonly found on web pages (though browsers can display it). Both GIF and PNG are designed to store images that have relatively distinct areas of plain colors.



Bitmap (118KB)	Jpeg (8KB)	Gif (27KB)	Png (25KB)
			

*Figure 23. Image saved in the [bitmap](#), [gif](#), [png](#) and [jpeg](#) formats.*



# Image Representation

- **Introduction.** In computing, all data is logically represented in binary. This is true of images as well as numbers and text. However, an important distinction needs to be made between how image data is displayed and how it is stored. Displaying involves bitmap representation, whereas storing as a file involves many image formats, such as JPEG and PNG.
- **Resolution and DPI.** How image data is displayed? Image data is always displayed on a computer (or digital device) screen as a BITMAP.



- Every image has a resolution which is measured in the number of pixels per row, its width, and the number of pixel rows, its height.
- For example an image with a resolution of 800 by 600 pixels would have 800 pixels in each row and 600 of these rows. How big the image appears on screen, as measured in inches or centimeters are another matter.
- This depends on the dpi or ppi (dots per inch = pixels per inch) of the screen. For example, the dpi of a typical PC monitor is 72dpi; the dpi of an iPad3 is 264 dpi.
- This means the same image will display about 1/3 rd as big on the iPad as it will on the PC.





Normal (resolution: 300x205)



1200% (resolution: 334x282)

***Figure 23. Image at normal zoom (100%) and part of it displayed at 12 times its normal size (1200%).***





# Steps in Digital Image Processing

*Table 8. Steps in Digital Image Processing.*

Steps in Digital Image Processing
<b>Digital Image Processing involves the following main tasks:</b>
<b>Image acquisition:</b> An imaging sensor and the capability to digitize the signal produced by the sensor.
<b>Preprocessing:</b> Enhances the image quality, filtering, contrast enhancement, etc.
<b>Segmentation:</b> Partitions an input image into constituent parts of objects.
<b>Description/Feature Selection:</b> Extracts descriptions of image objects suitable for further computer processing.
<b>Recognition and Interpretation:</b> Assigning a label to the object based on the information provided by its descriptor. <b>Interpretation</b> assigns meaning to a set of labeled objects.
<b>Knowledge Base:</b> Knowledge Base helps for efficient processing as well as inters cooperation.



- After segmentation, the next step is to extract some description of the image objects which are suitable for further computer processing.
- These steps are mainly used for machine vision applications. Then we have to go for recognition.
- Once we get description of the objects; from those descriptions, we have to interpret or recognize what that object is.
- The last step is the knowledge base where the knowledge bases helps for efficient processing as well as inter module cooperation of all the previous processing steps.



*Figure 25. Steps in Digital Image Processing.*

