l= f (x, y.)

L min ≤ l ≤ L max

L min is to be positive and L max must be finite L min = I min r min L max = I max r max

The interval [L min, L max] is called gray scale. Common practice is to shift this interval numerically to the interval [0, L-l] where l=0 is considered black and l= L-1 is considered white on the gray scale. All intermediate values are shades of gray of gray varying from black to white.

Definition for Pixels and Voxels

Pixel: The pixel -- a word invented from picture element -- is the basic unit of programmable color on a computer display or in a computer image. Pixels are the smallest unit in a digital display.

Voxel: In computer-based modelling or graphic simulation) each of an array of elements of volume that constitute a notional three-dimensional space, especially each of an array of discrete elements into which a representation of a three-dimensional object is divided.

The word voxel originated by analogy to "pixel", with vo representing "volume" (instead of pixel's "picture") and el representing "element"; a similar formation with el for "element" is the word "texel". The term hyper voxel is a generalization of voxel for higher-dimensional spaces.

1.8 Image Sampling and Quantization:

- ➢ To create a digital image, we need to convert the continuous sensed data into digital from. This involves two processes – sampling and quantization. An image may be continuous with respect to the x and y coordinates and also in amplitude. To convert it into digital form we have to sample the function in both coordinates and in amplitudes.

- **Digitalizing the coordinate values is called sampling**
- **Digitalizing the amplitude values is called quantization**
- ➢ There is a continuous the image along the line segment AB. To simple this function, we take equally spaced samples along line AB. The location of each samples is given by a vertical tick back (mark) in the bottom part. The samples are shown as block squares superimposed on function the set of these discrete locations gives the sampled function.

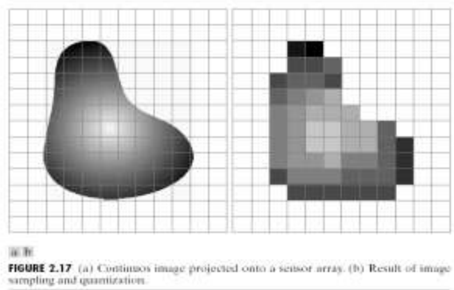

Image sampling: discretize an image in the spatial domain

Spatial resolution / image resolution: pixel size or number of pixels

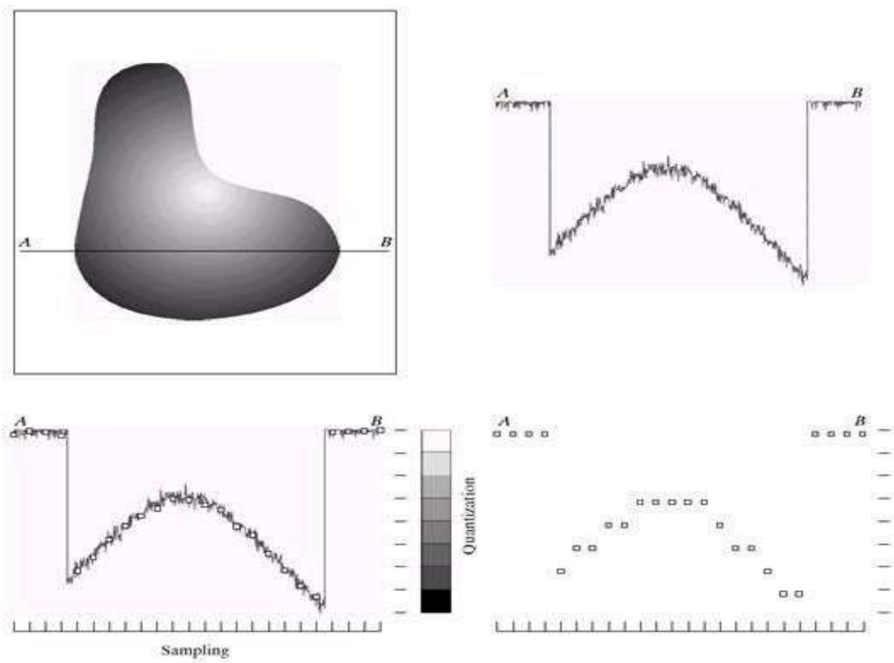

Fig 1.5 Sampling and Quantization

- In order to form a digital, the gray level values must also be converted (quantized) into discrete quantities. So we divide the gray level scale into eight discrete levelsranging from block to white. The vertical tick mark assign the specific value assigned to each of the eight level values.

➢ The continuous gray levels are quantized simply by assigning one of the eight discrete gray levels to each sample. The assignment it made depending on the vertical proximity of a simple to a vertical tick mark.

➢ Starting at the top of the image and covering out this procedure line by line produces a two dimensional digital image.

➢ if a signal is sampled at more than twice its highest frequency component, then it can be reconstructed exactly from its samples.

➢ But, if it is sampled at less than that frequency (called under sampling), then **aliasing** will result.

- This causes frequencies to appear in the sampled signal that were not in the original signal.
- Note that subsampling of a digital image will cause under sampling if the subsampling rate is less than twice the maximum frequency in the digital image.
- **Aliasing** can be prevented if a signal is filtered to eliminate high frequencies so that its highest frequency component will be less than twice the sampling rate.
- Gating function: exists for all space (or time) and has value zero everywhere except for a finite range of space/time. Often used for theoretical analysis of signals. But, a gating signal is mathematically defined and contains unbounded frequencies.
- A signal which is periodic, $x(t) = x(t+T)$ for all t and where T is the period, has a finite maximum frequency component. So it is a band limited signal.
- Sampling at a higher sampling rate (usually twice or more) than necessary to prevent aliasing is called oversampling.

1.9 Zooming and Shrinking of Digital Images:

Zooming may be said oversampling and shirking may be called as under sampling these techniques are applied to a digital image. These are two steps of zooming

i)Creation of new pixel locations

ii) Assignment of gray level to those new locations.

- In order to perform gray –level assignment for any point in the overly, we look for the closest pixel in the original image and assign its gray level to the new pixel in the grid. This method rowan as nearest neighbor interpolation
- **Pixel replication** - Is a special case of nearest neighbor interpolation, it is applicable if we want to increase the size of an image an integer number of times.
- For eg. - To increase the size of image as double. We can duplicate each column. This doubles the size of the image horizontal direction. To increase assignment of each of each vertical direction we can duplicate each row. The gray level assignment of each pixel is determined by the fact that new locations are exact duplicates of old locations.
- **Drawbacks**

  Although nearest neighbor interpolation is fast, it has the undesirable feature that it produces a check board that is not desirable

- **Bilinear interpolation-**Using the four nearest neighbor of a point .let (x,y) denote the coordinate of a point in the zoomed image and let v(x1,y1) denote the gray levels assigned to it .for bilinear interpolation. The assigned gray levels is given by

$$V(x_1,y_1) - ax_1+by_1+cx_1y_1+d$$

Where the four coefficient are determined from the four equation in four unknowns that can be writing using the four nearest neighbor of point (x1,y1).

- **Shrinking** is done in the similar manner .the equivalent process of the pixel replication is row–column deletion .shrinking leads to the problem of aliasing.