

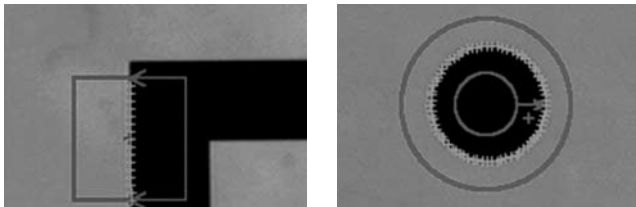
# Vision Measuring Machines

## Vision Measurement

Vision measuring machines mainly provide the following processing capabilities.

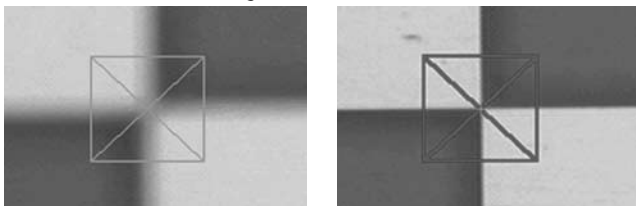
### Edge detection

Detecting/measuring the edge in the XY plane



### Auto focusing

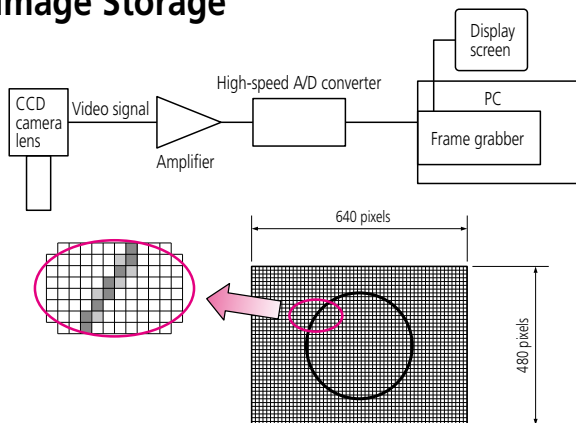
Focusing and Z measurement



### Pattern recognition

Alignment, positioning, and checking a feature

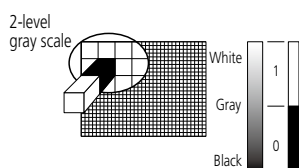
## Image Storage



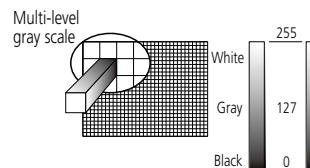
An image is comprised of a regular array of pixels. This is just like a picture on fine plotting paper with each square solid-filled differently.

## Gray Scale

A PC stores an image after internally converting it to numeric values. A numeric value is assigned to each pixel of an image. Image quality varies depending on how many levels of gray scale are defined by the numeric values. The PC provides two types of gray scale: two-level and multi-level. The pixels in an image are usually displayed as 256-level gray scale.



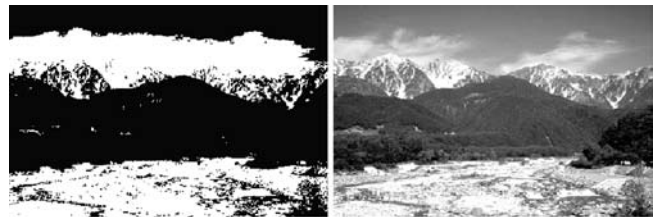
Pixels in an image brighter than a given level are displayed as white and all other pixels are displayed as black.



Each pixel is displayed as one of 256 levels between black and white. This allows high-fidelity images to be displayed.

## Difference in Image Quality

Difference between 2-level and 256-level gray-scale images



Sample image displayed in 2-level gray scale

Sample image displayed in 256-level gray scale

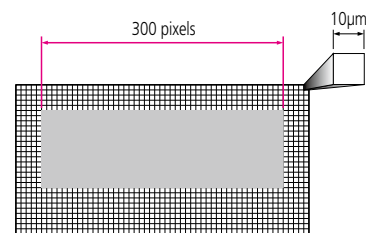
## Variation in Image Depending on Threshold Level



These three pictures are the same image displayed as 2-level gray scale at different slice levels (threshold levels). In a 2-level gray-scale image, different images are provided as shown above due to a difference in slice level. Therefore, the 2-level gray scale is not used for high-precision vision measurement since numeric values will change depending on the threshold level that is set.

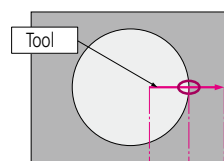
## Dimensional Measurement

An image consists of pixels. If the number of pixels in a section to be measured is counted and is multiplied by the size of a pixel, then the section can be converted to a numeric value in length. For example, assume that the total number of pixels in the lateral size of a square workpiece is 300 pixels as shown in the figure below. If a pixel size is 10µm under imaging magnification, the total length of the workpiece is given by 10µm x 300 pixels = 3000µm = 3mm.



## Edge Detection

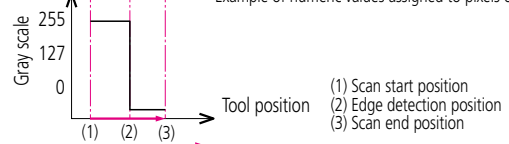
How to actually detect a workpiece edge in an image is described using the following monochrome picture as an example. Edge detection is performed within a given domain. A symbol which visually defines this domain is referred to as a tool. Multiple tools are provided to suit various workpiece geometries or measurement data.



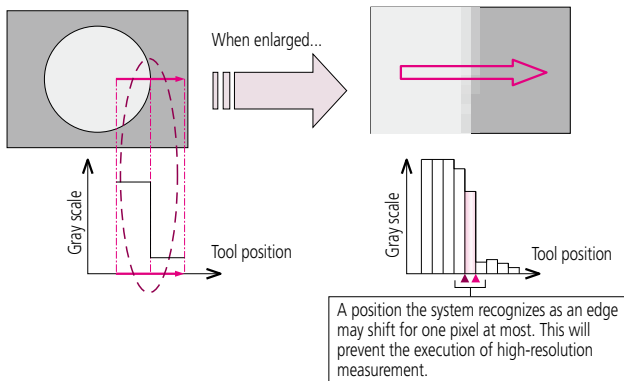
The edge detection system scans within the tool area as shown in the figure at left and detects the boundary between light and shade.

244	241	220	193	97	76	67	52	53	53
243	242	220	195	94	73	66	54	53	55
244	246	220	195	94	75	64	56	51	50

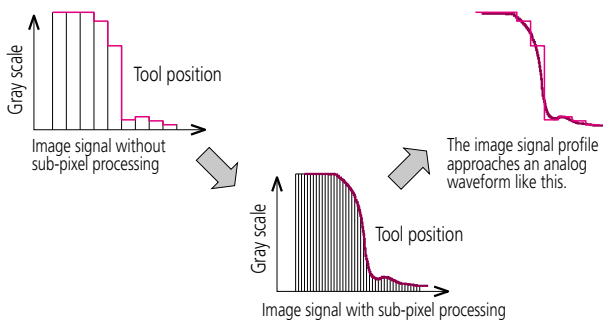
Example of numeric values assigned to pixels on the tool



## High-resolution Measurement

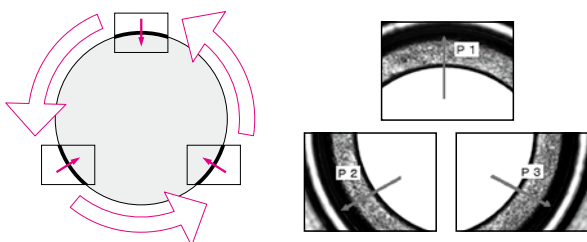


As the image processing for increasing the resolution of edge detection, sub-pixel processing is used. Edge is detected by determining interpolation curve from adjacent pixel data as shown below. As a result, it allows measurement with resolution higher than 1 pixel.

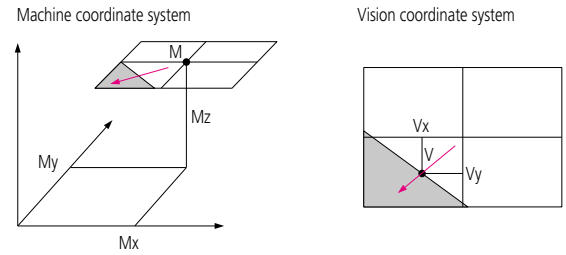


## Measurement along Multiple Portions of an Image

Large features that cannot be contained on one screen have to be measured by precisely controlling the position of the CCD sensor and stage so as to locate each reference point within individual images. By this means the system can measure even a large circle, as shown below, by detecting the edge while moving the stage across various parts of the periphery.



## Determining a Measurement Point



Measuring machine stage position  
 $M = (Mx, My, Mz)$

Detected edge position (from the center of vision)  
 $V = (Vx, Vy)$

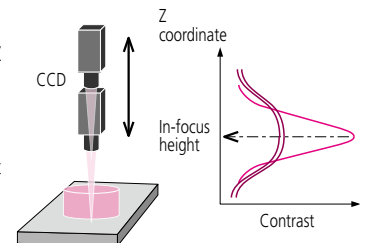
Actual coordinates are given by  $X = (Mx + Vx)$ ,  $Y = (My + Vy)$ , and  $Z = Mz$ , respectively.

Since measurement is performed while individual measured positions are stored, the system can measure dimensions that cannot be included in one screen, without problems.

## Principle of Auto Focusing

The system can perform XY-plane measurement, but cannot perform height measurement only from the CCD camera image. The system is commonly provided with the Auto Focus (AF) mechanism for height measurement. The following explains the AF mechanism that uses a common image, although some systems may use an AF laser.

The system analyzes an image while moving the CCD up and down in the Z axis. In the analysis of image contrast, an image in sharp focus will show a peak contrast and one out of focus will show a low contrast. Therefore, the height at which the image contrast peaks is the just in-focus height.



## Variation in Contrast Depending on the Focus Condition

Edge contrast is low due to out-of-focus edges.

Edge contrast is high due to sharp, in-focus edges.

