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.

  - **2-level gray scale**
    - White
    - Gray
    - Black

  - **Multi-level gray scale**
    - White
    - Gray
    - Black

  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

- **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.
■ 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.

■ Determining a Measurement Point

\[
\begin{align*}
M &= (M_x, M_y, M_z) \\
V &= (V_x, V_y)
\end{align*}
\]

Actual coordinates are given by \( X = (M_x + V_x), Y = (M_y + V_y), \) and \( Z = M_z \), 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.