The knowledge base of the machine vision lens

In order to select the correct machine vision lens, it’s important to know the basic parameter of the machine vision lens.

Contrast: Delivering light contrast to the sensor.

Resolution: Delivering object detail to the sensor, it influences the image quality.

Depth of Field: The Depth of Field refers to the area within the field of view which is in focus. A large depth of field means that a large percentage of the field of view is in focus, from objects close to the lens often to infinity. A shallow depth of field has only a small section of the field of view in focus. The depth of field is influenced by several factors. A wide angle lens generally has a larger depth of field than a telephoto lens, and a higher F stop setting typically has a larger depth of field than a lower setting. With auto iris lenses, the automatic adjustment of the aperture also means constant variation of depth of field. The small depth of field is most apparent at night when the lens iris diaphragm is fully open and the depth of field is at its minimum. Objects that were in focus during the day may become out of focus at night.

Field of View: Area imaged by a lens.

Focal Length: The focal length of the lens is measured in mm and directly relates to the angle of view that will be achieved. Short focal lengths provide wide angles of view and long focal lengths become telephoto, with narrow angles of view. A "normal" angle of view is similar to what we see with our own eye, and has a relative focal length equal to the pick up device. According to the focal length, the lens could be divided the fixed focal length lens and vari-focal lens.

F-STOP: The lens usually has two measurements of F-Stop or Aperture, the maximum Aperture (minimum F-Stop) when the lens iris diaphragm is fully open, and the minimum aperture (maximum F-Stop) just before the iris completely closes. The F-Stop has a number of effects upon the final image. A low minimum F-Stop will mean the lens can pass more light in dark conditions (often called a Fast Lens), allowing the camera to produce a better image at night. A maximum F-Stop may be necessary where there is a very high level of light or reflection, as this will prevent the camera from "whiting out" or over exposing, and thereby help maintain a constant video level. Some Auto-Iris

Lenses are supplied with Neutral Density spot filters, to increase the maximum F-Stop. The F-Stop also directly affects the depth of field.

Working Distance: Distance between the lens face and the object.

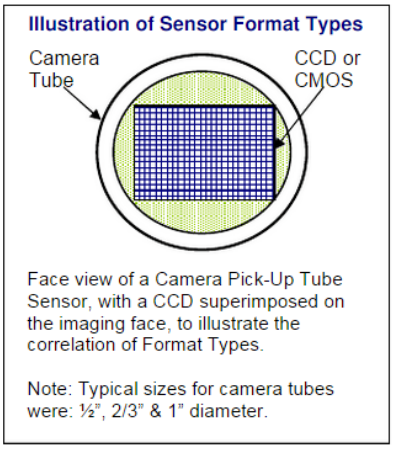
Distortion: The many aberrations that modify your otherwise perfect image.

AUTO (AI) or MANUAL IRIS (MI): Generally we tend to use auto iris lenses externally where there are variations in the lighting levels. Manual iris lenses are used normally for internal applications where the light level remains constant. However, with the introduction of electronic iris cameras it is now possible to use manual iris lenses in varying light conditions and the camera will electronically compensate the shutter speeds. There are several considerations to this option though: the setting of the F-Stop becomes critical; if the iris is opened fully to allow the camera to work at night, the depth of field or focus (DOF) will be very small and it may be more difficult to achieve sharp focus even during the day. The camera can maintain normal video levels, but it cannot affect the depth of field. If the iris is closed to increase the depth of field, the low light sensitivity performance of the camera will be reduced.

Format: The size of the camera's imaging device (CCD) also affects the angle of view, with the smaller devices creating narrower angles of view when used on the same lens. The format of the lens, however, is irrelevant to the angle of view, it merely needs to project an image which will cover the device, i.e.: the same format of the camera or larger. This also means that 1/3" cameras can utilize the entire range of lenses from 1/3" to 1", with a 1/3" 8mm lens giving the same angle as a 2/3" 8mm lens. The latter combination also provides increased resolution and picture quality as only the centre of the lens is being utilized, where the optics can be ground more accurately.

Common Image Sensor Sizes: In the table below, left; “Format Type" refers to the commonly used type designation for CCD & CMOS etc sensors; The inch format size is a hangover from the previous era of Vacuum Pick-Up Tube Sensors and does not easily calculate to the actual CCD size –actual CCD size – as illustrated in the diagram below, right. "Aspect Ratio" refers to the ratio of Width to Height, "Dia." refers to the diameter of the tube size (this is simply the Type converted to millimetres), "Diagonal / Width / Height" are the dimensions of the sensors image producing area.

			CCD Sensor sizes (mm)		
Format Type	Aspect Ratio	Ø Dia. (mm)	Diagonal mm	Width mm	Height mm
1/4"	4:3	7.056	5.000	3.600	2.700
1/3.6"	4:3	7.056	5.000	4.000	3.000
1/3.2"	4:3	7.938	5.680	4.536	3.416
1/3"	4:3	8.467	6.000	4.800	3.600
1/2.7"	4:3	9.407	6.721	5.371	4.035
1/2.5"	4:3	10.160	7.182	5.760	4.290
1/2"	4:3	12.700	8.000	6.400	4.800
1/1.8"	4:3	14.111	8.933	8.5	6.8
1/1.7"	4:3	14.941	9.500	7.600	5.700
2/3"	4:3	16.933	11.000	8.800	6.600
1"	4:3	25.400	16.000	12.800	9.600
4/3"	4:3	33.867	22.500	18.000	13.500
1.8"	3:2	45.720	28.400	23.700	15.700
35mm Film	3:2	n/a	43.300	36.000	24.000



C or CS mount: Most CCTV Cameras and Lenses are generally CS-Mount. With CS-Mount Cameras, both types of Lenses can be used, but the C-Mount Lens requires a 5mm spacer ring to be fitted between the camera and lens - to achieve a focused image. Machine Vision Cameras are still mainly C-Mount, with a few exceptions being CS-Mount or even the Larger F-Mount. It is not possible to use CS-Mount Lenses on C-Mount cameras. The Back-Focus Distance (the distance from the front of the Cameras Sensor or image plain to the end of the Lens Mount) is 17.525mm for C-Mount and 12.5mm for CS-Mount. Some Cameras have a Lens Mount which can be mechanically adjusted to fine tune the Back-Focus Distance. This fine tuning ability is particularly important for Fixed-Focus (usually Wide-Angle) Lenses and Zoom Lenses – where it is essential to keep par-focus through the zoom range.

F mount: Machine Vision Cameras, with larger format sensors (usually bigger than 1"), particularly Line-Scan Cameras, require a larger format Lens than the 1" C-Mount.

M12 mount (D-mount) or M13 mount: Most compact and Board (PCB) Cameras with smaller sensors (1/3" & ¼"), usually have an optional M12 Mount. This uses the common 12mm diameter x 0.5mm pitch thread Mini Board Lenses; which are sometimes referred to as D-Mount (not to be confused with the larger D-Mount Cinema-Photography Lenses).
The M13-Mount Lens is less common, having a 13mm diameter x 1mm pitch thread. These lower cost compact Board Lenses offer comparable quality to the more expensive Larger Format (C & F Mount etc) - on VGA & XGA resolutions. They are not usually fitted with an iris diaphragm or focus mechanism. (The usual method to obtain sharp focus is to physically screw the lens in or out of its camera mount). These Lenses are generally 1/3"format and thus only suitable for cameras with 1/3" or ¼" sensors. It is also possible to use the M12 or M13-Mount Lenses on C or CS-Mount Cameras (with 1/3" & ¼"

sensors), by using a suitable adaptor. As the cameras become smaller,there are also other Mounts used e.g. M10, M9 etc.

VIDEO DRIVE (VD) or DIRECT DRIVE (DD) : With Auto-Iris lenses it is necessary to control the operation of the iris to maintain perfect picture levels. Video driven lenses contain amplifier circuitry to convert the video signal from the camera into iris motor control. With Direct Drive lenses, the camera must contain the amplifier circuitry, and the lens now only contains the galvanometric iris motor (making it less expensive). The deciding factor depends on the auto iris output of the camera. Most now have both types,except Machine Vision Cameras, which generally do not have any drives.