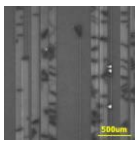
Part 2 – Machine vision lighting

- Aims of machine vision lighting
- Types of machine vision lighting and applications
- Spectral content of vision illumination source
- Lighting for multispectral and hyperspectral imaging
- Factors affecting lighting selection
- Factors affecting consistency of lighting
- *Activity 6* : Identify machine vision lighting types
- *Activity 7* : Match lighting type with image
- *Activity 8 (Practical)* : Effect of lighting type on object features
- *Activity 9* : Determine pulse width required in strobe lighting
- *Activity 10* : Select lighting based on scene characteristics
- *Activity 11a (Practical)* : Determine consistency of lighting
- *Activity 11b (Practical)* : Determine uniformity of lighting

Why is lighting important in machine vision system?

http://www.keyence.com/

http://www.qualitymag.com/



www.ee-mat.com

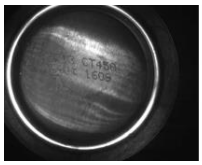
Write down as many reasons as you can

Examples of bad and good machine vision lighting

Bad

Good

www.ni.com

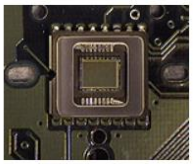


Bad?

Good?

www.ni.com

Bad



Good

www.edmundoptics.com

Bad

Good

www.ni.com

Bad?

White Light

Infrared Light

Good?

www.automate.org

Bad

Good

www.advancedillumination.com

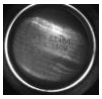
2.1 Aims of machine vision lighting

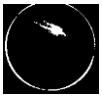
- To provide the scene with sufficient illumination that meets the following three criteria:

(1) Maximize contrast on features of interest

(2) Minimize contrast elsewhere

(3) Provide a measure of robustness

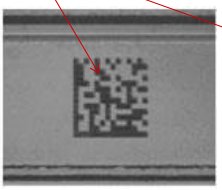


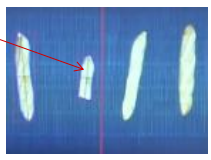


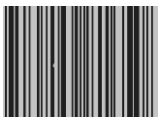
Features of interest

$$\text{Weber contrast} = \frac{|I - I_b|}{I_b}$$

$$\text{Michelson contrast} = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$







LEARNING POINT 1

Name the three criteria that machine vision lighting must meet?

Quiz1

Which one of these images has the best contrast?

Calculate the contrast of the feature (QR code) in each case if the average grayscale value of the feature is 10.

A

Mean grayscale value = 151

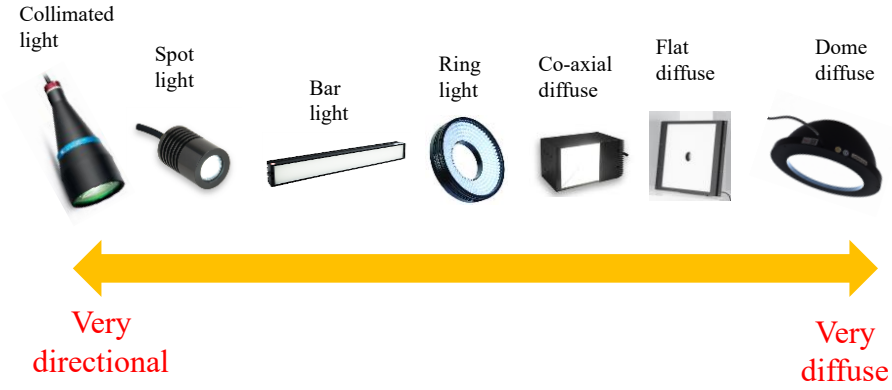
B

Mean grayscale value = 240

C

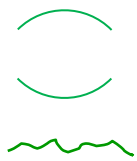
Mean grayscale value = 205

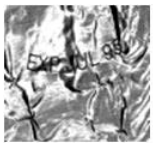
- Range of common machine vision lightings



(a) Front lighting

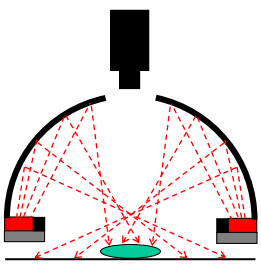
- Omni-directional illumination (diffuse front lighting/full bright field): Dome diffuse





https://www.keyence.com/

https://www.keyence.com/

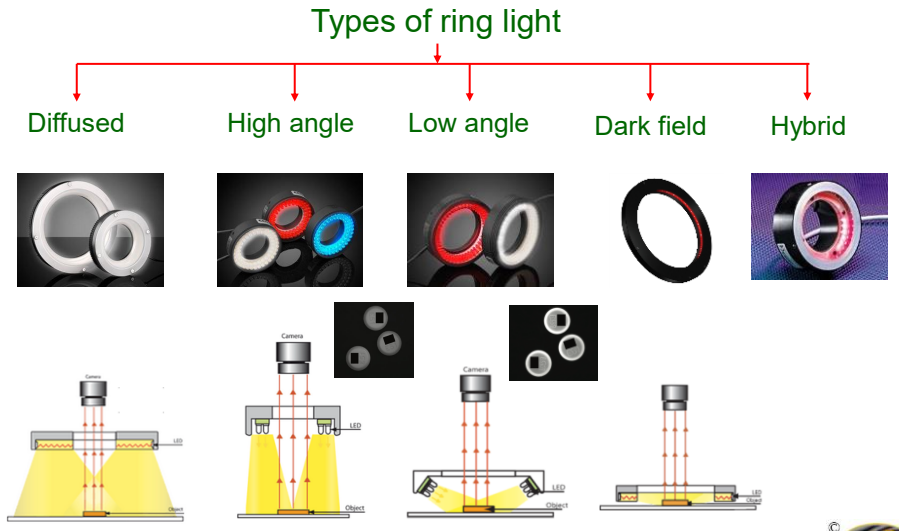


Advantages:

Disadvantages:

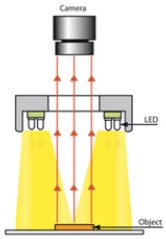
(a) Front lighting

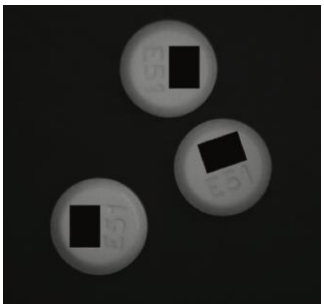
- Omni-directional illumination (diffuse front lighting/full bright field): Ring light



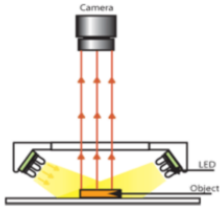
vitalvisiontechnology.com

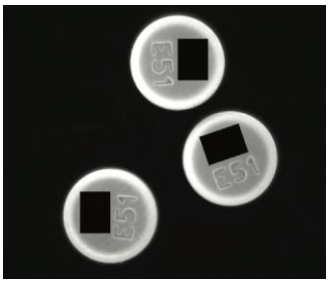
High angle





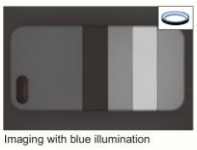
Low angle

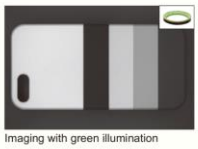


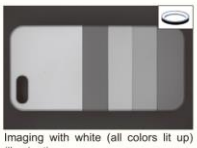


(a) Front lighting

- Omni-directional illumination (diffuse front lighting/full bright field): Ring light
  - Diffuse ring light

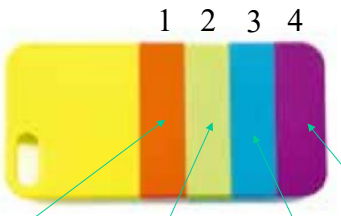






- Uniform high intensity diffuse light source
- Illumination for text recognition (OCR) and color examination

Let' try



R=235, G=106, B=4

R=155, G=20, B=136

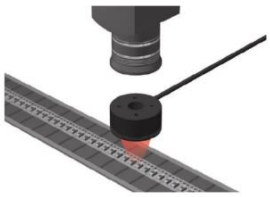
R=208, G=225, B=122

R=2, G=164, B=210

Which stripe will appear (i) the brightest, (ii) the darkest, when the phone casing is illuminated using each of the following colored lights

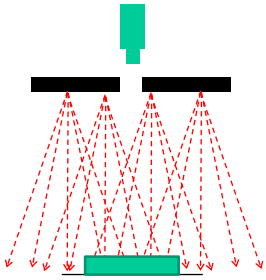
(a) Red
(b) Green
(c) Blue

- High angle ring light



Direct lighting for uniform intensity → Ideal for brightfield illumination

www.edmundoptics.com



www.edmundoptics.com

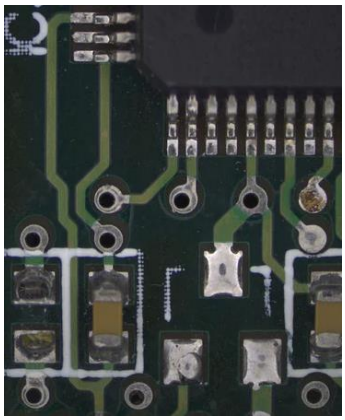
Quiz 3a

What lighting types are used in this application?

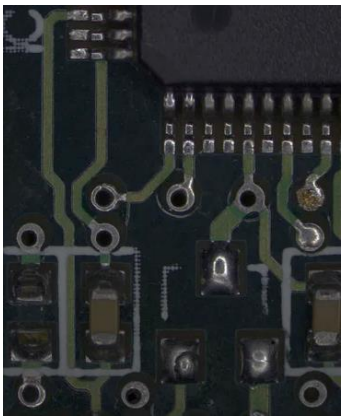
metrology.news

Quiz 4

Guess what lighting was used - ring light or flat diffuse?



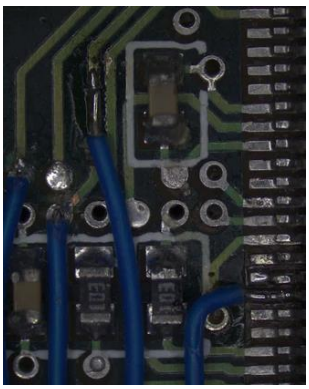
A



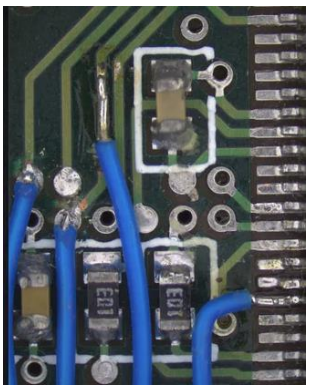
B

Quiz 5

Guess what lighting was used - ring light or flat diffuse?



A

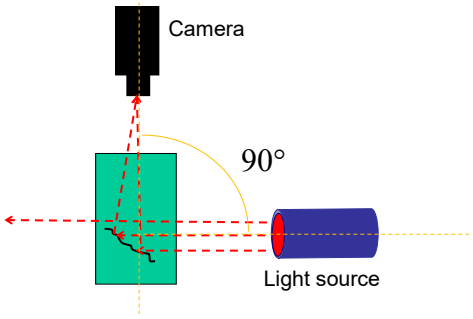


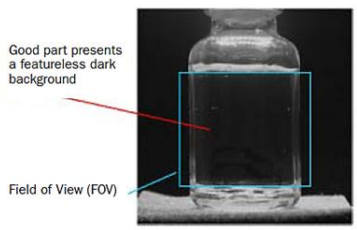
B

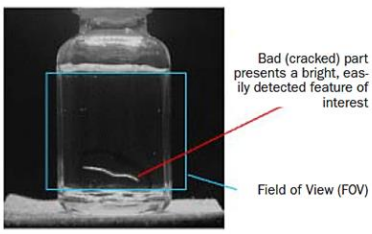
LEARNING POINT 2

Name the four common types of omni-direction (diffuse) front lighting

(b) Dark field lighting using orthogonal light projection:

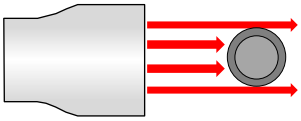




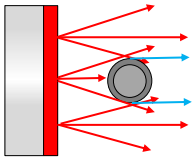


(b) Back lighting

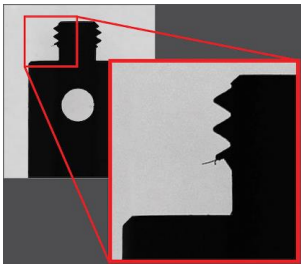
- Telecentric illumination

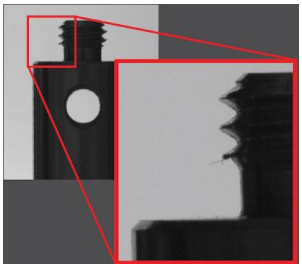


Telecentric backlight



Standard backlight





Quiz 7 (Demo)

Problem:
Figure opposite shows the image of a cylindrical object captured using diffused backlighting where there is heavy diffusion of light along the edges.

Challenge:
Suggest way(s) to reduce the amount of light diffused at the edges without changing the lighting

Activity 8 (Practical) - Effect of lighting type on object features

Learning outcome:
To analyze the effect of lighting type on the object features

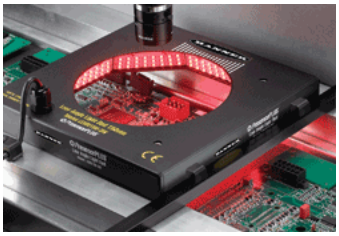
Challenge:
Figure 1 shows a 5 sen coin having surface contamination. You are required to capture the image of the coin using three different lighting types: (i) ring light (normal and low position), (ii) low angle bar light and (iii) back light. (Hint: Use 35 lens with 5 mm extension tube at working distance of about 150 mm)

Figure 1

Examine the images captured and state what feature(s) can be extracted from each image. Hence, suggest, with proper justification, the best lighting method to:

(a) detect surface contamination
(b) measure the diameter of the coin
(c) read the character '5' on the surface of the coin

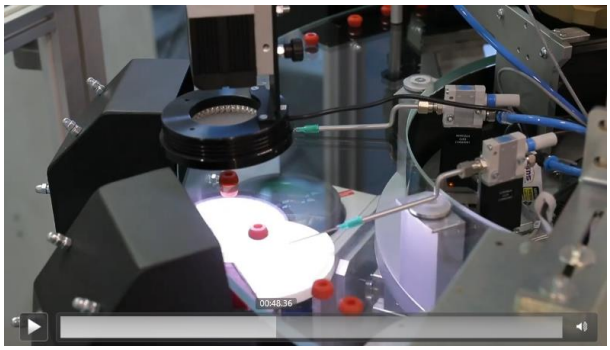
(e) Strobe lighting



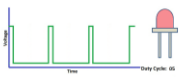
http://www.keyence.com/

What are disadvantages of using continuously ON lighting?

(e) Strobe lighting

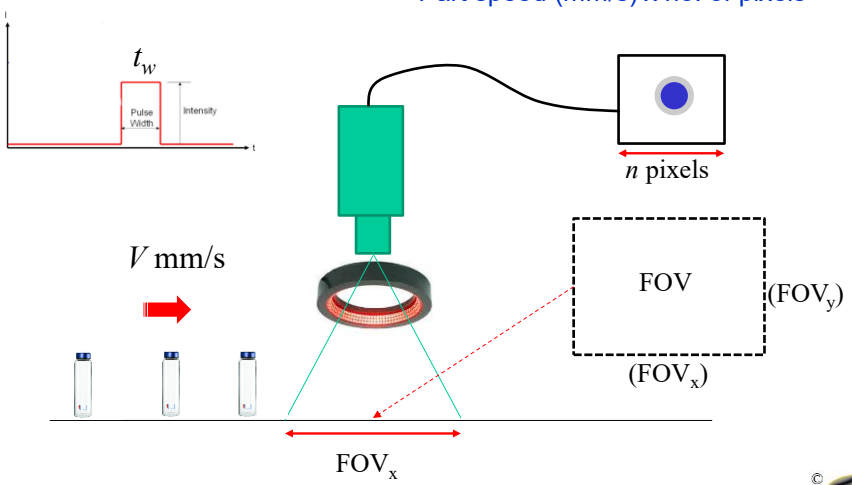


(e) Strobe lighting



- Used for rapidly moving parts

Min. strobe pulse width (s), t_w = $\frac{\text{Field of view (FOV}_x\text{) (mm)}}{\text{Part speed (mm/s) x no. of pixels}}$



Activity 9 – Determine pulse width in strobe lighting

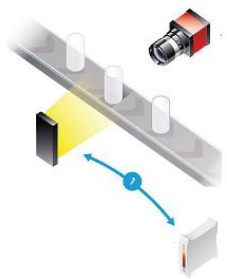
An object moving at 100 m/min is to be captured using a CCD camera have specification shown. The field-of view is 200 mm by 160 mm. Determine the pulse width required.

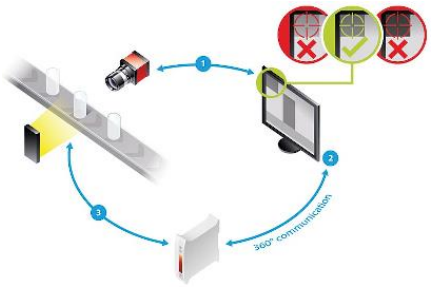
BU132M

Model Name	BU132M
Imager	CMOS image sensor
Number of effective pixels (H) x (V)	1280 x 1024
Scanning area (H) x (V) [mm]	6.78mm x 5.43mm (1/1.8 type)
Pixel size (H) x (V) [µm]	5.3µm x 5.3µm
Scan method	Progressive
Electronic shutter method	Global shutter

2.5 Factors affecting consistency of lighting

- Age of light source
- Ambient light
- Stability of power supply – depends on current control device
- Temperature of light → use temperature sensor, optical sensor or image feedback:

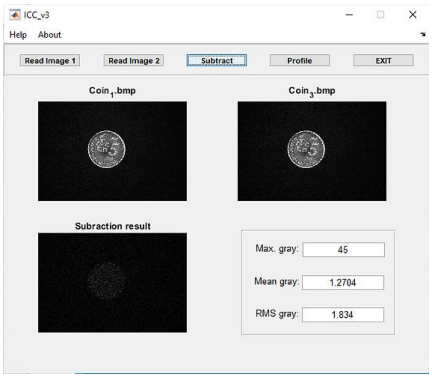




www.qualitymag.com

Activity 11a – Determine consistency of lighting

Capture several images at random using the system provided. Select suitable lighting for your application. Then, subtract the subsequent image from the first image. Is your lighting stable?



Activity 11b – Determine uniformity of lighting

Capture the image of a white background (such as an A4 paper) under the following lighting conditions:

a) Normal position ring light
b) Low position ring light
c) Normal position ring light and side bar light
d) Side bar light only
e) Backlight only

Which of these do you think will produce (i) the most uniform lighting, and (ii) the least uniform lighting? Confirm using the Lighting Uniformity Checker GUI provided.