

1. Explain (write and/or draw) the following machine vision related terms, max. about 5 lines per item (1 point per item, max 5 points)
  - a. Spatial resolution
  - b. Camera exposure or integration time
  - c. Camera field-of-view (FOV)
  - d. Back (background) illumination
  - e. Depth-of-field of imaging system (= camera + optics) / Blob tool
  
2. Chocolate boxes (dark in color) are on a continuously moving fast (100 mm/s) and transparent conveyor belt that is 200 mm wide. The size of the box is 100 x 100 mm and it can be in any orientation and in any position on the conveyor belt. A white label (50 x 50 mm) containing some black text can be in any position and orientation on the upper surface of the box. There is a simple trigger sensor that senses the presence of the box with  $\pm 5$  mm repeatability. Answer and **give reasons** for the following items (2 points per item, max 10 points):
  - a. What kind of illumination you would recommend to this system. Why?
  - b. Determine the needed field-of-view size and imaging geometry (meaning the location of the camera(s) and light source(s) relative to the part)
  - c. Assume that the smallest text feature has 1x1 mm dimensions. Select a camera resolution that is suitable for this task: 640x480, 752x480, 1280x1024, 1600x1200, 2048x1536 pixels. Should the camera be "progressive scan" (or "global shutter") or "interlaced scan" (or "rolling shutter")? Why?
  - d. Size of a pixel on camera detector is 5.2 x 5.2  $\mu\text{m}$ . If we want to use a  $f = 25$  mm optics, how far from the conveyor belt should we attach the camera?
  - e. Shortly describe the basic structure of the program making the measurements.

Some (maybe) useful equations

$$m = \frac{h'}{h} = \frac{s'}{s} \quad \frac{1}{f} = \frac{1}{s} + \frac{1}{s'} \quad \frac{f}{z} = \frac{r'}{r} \quad \frac{x'}{x} = \frac{y'}{y} = \frac{r'}{r} \quad f = h_d \frac{D}{h_{FOV}} \quad f = w_d \frac{D}{w_{FOV}}$$

$$M_{ij} = \sum_{x=1}^N \sum_{y=1}^M x^i y^j f(x, y) \quad X = \frac{M_{10}}{M_{00}} \quad Y = \frac{M_{01}}{M_{00}}$$

Please use separate paper for the next 2 questions.

3. Explain the most significant differences between Machine Vision and Camera Based Co-ordinate measuring machines (CCD-CMM).
  
4. What do the next two definitions and terms mean; LS and MZ?. Do also make small drawings to illustrate the differences and meaning.