Allowed time: 40 minutes -> camera matriciale

Consider a camera of 2040 rows x 2580 columns whose pixel size is 1.8 um. Image of acquiring a scene for analysing objects of 45 cm * 35 cm coming over a belt large 40 cm .

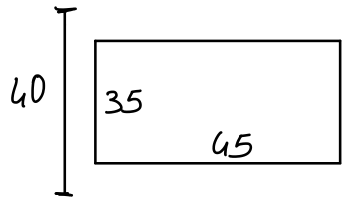
Define the ideal focal length for surely acquiring an entire object, with at least 3 cm of exceeding tolerance in the direction of the motion, when the camera is elevated at 1.5 m from the belt.

Suppose You have available lens with focal length 35 mm, 50 mm and 75 mm: **choose the best one** for working at the distance which best fits 1.8 m, **compute the correct height for positioning the camera**, and **compute the achievable resolution**.

With this set up, **which is the highest speed of the belt** for being sure that we may acquire an entire object, when the camera works at 100 fps?

Which is the size of the smallest detectable defect, if the defect resolution requires at least 10 pixel for being correctly analysed by your software?

(y) $r_y = \frac{2040\,px}{400\,mm} = 5{,}1 \, \frac{px}{mm}$



(x) $r_x = \frac{2580\,px}{450\,mm} = 5{,}7 \, \frac{px}{mm}$

ottimizzo:

lungo y -> $r_y \cdot lung\text{-}x = 5{,}1 \cdot 450 = 2295\ px$

lungo x -> $r_x \cdot lung\text{-}y = 5{,}7 \cdot 400 = 2280\ px$

redundancy $= \frac{(2580 - 2295)}{5{,}1} = 5{,}6\ cm > 3\ cm$ -> oppure si può trovare facendo:

$\frac{2580}{5{,}1} = 50{,}6$

redund. $= 50{,}6 - 45 = 5{,}6$

con $wd = 1{,}5\ m = 1500\ mm$

$f = \frac{wd \cdot s.size}{FOV}$

$s.size = 1{,}8 \cdot 10^{-3} \cdot 2040 = 3{,}67\ mm$

$f = \frac{1500 \cdot 3{,}67}{400\ mm} = 13{,}76 \approx 14\ mm$

$wd = 1800\ mm$ -> $f = \frac{1800 \cdot 3{,}67}{400} = 17\ mm$

=> scegliamo $f = 35\ mm$ e $wd = \frac{35 \cdot 400}{3{,}67} = 3800 = 3{,}8\ m$

frame rate = 100fps $\Rightarrow T = \frac{1}{100} = 0{,}01\ s$

$$V = \frac{\frac{2580}{5{,}1}}{0{,}01} = 50\ \frac{m}{s}$$

$$\frac{10px}{r_g} = \frac{10px}{5{,}1} = 1{,}96\ mm$$

FOR ALL (30 minutes):

Consider the following line scan cameras: **Device “1”:** sensor of **4096 points**, each point of **2.6 micron * 2.6 micron**, able to acquire up to **20.000 lines per second**, price **800 euro**. **Device “2”:** sensor of **2048 points**, each point of **4.2 micron * 4.2 micron**, able to acquire up to **30.000 lines per second**, price **450 euro**.

Define **two setups** for analysing objects having a **surface of 3 m * 15 m** at a resolution of **at least 1 pixel / 500 micron** (both along X and along Y): **setup 1** based on Devices like the “1”, **setup 2,** based on Devices like the “2”.

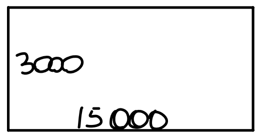
Which is the **preferable setup, in case we wish save money**?

Which is the **preferable setup in case we wish the fastest acquisition period**?

Consider now only the setup 2:

- **How many objects** can be analysed in 1 hour?
- **And at which distance from the object** the camera should be located mounting a lens having focal **length of 50 mm**?
- **Which is the smallest size of a detectable defect**, if your software needs at least **10 pixel * 10 pixel** for a correct processing?

(1) $r_y = \frac{4096}{3000} = 1{,}36 \ \frac{px}{mm}$



$r = \frac{1}{500 \cdot 10^{-3}} = 2 \ \frac{px}{mm}$

Per raggiungere la risoluzione voluta servono 2 device

$\Rightarrow r_y = 2 \cdot 1{,}36 = 2{,}73 \ \frac{px}{mm}$

(2) $r_y = \frac{2048}{3000} = 0{,}68 \ \frac{px}{mm}$

Servono 3 device

$\Rightarrow r_y = 3 \cdot 0{,}68 = 2{,}04 \ \frac{px}{mm}$

Costo 1 = $2 \cdot 800 = 1600$ €

Costo 2 = $3 \cdot 450 = 1350$ € ← migliore

S. size 1 = $2{,}6 \cdot 10^{-3} \cdot 4096 = 10{,}65$ mm

S. size 2 = $4{,}2 \cdot 10^{-3} \cdot 2048 = 8{,}6$ mm ← migliore

$$V_1 = \frac{\ell ps}{r} = \frac{20.000}{2,73} = 7,3 \frac{m}{s}$$

$$V_2 = \frac{30000}{2} = 15 \frac{m}{s}$$ ← migliore

$1h = 3600s \rightarrow s = v \cdot t = 15 \frac{m}{\cancel{s}} \cdot 3600\cancel{s} = 54.000\,m$

$$ogg = \frac{54.000\,m}{15\,m} = 3600\ ogg.$$

se $f = 50mm \Rightarrow wd = \frac{50 \cdot 3000}{8,6} = 17,4\,m$

$$\frac{10\,px}{r_y} = \frac{10}{2,04} = 4,9\,mm$$

Consider the following line scan camera:
Device "1": sensor of **2048 points**, each point of **4.2 micron * 4.2 micron**, able to acquire up to **30.000 lines per second**, price **450 euro**.

and the matricial device:
Device "2": sensor of 2048*2560 points of 2.6 micron * 2.6 micron

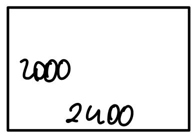
A) Define **two setups** for analysing objects having a **surface of 2.0 m * 2.4 m** at a resolution of **at least 1 pixel / mm** (both along X and along Y) in terms of any additional device needed for the acquisition set up.

B) Define the ideal focal length for both the set up, in case we have to adopt a working distance in the range 2 m – 3 m

Suppose now, that both the devices mounted simultaneously over the same scene.

C) Which is the fastest speed that can act over the object for being correctly acquired by both the set ups?
D) Which is the shortest shutter time of the matricial camera, in case we do not want motion effect greater than 1 pixel?

1 $r_y = \frac{2048}{2000} = 1{,}024 \ \frac{px}{mm}$ ✓



$r = 1 \ \frac{px}{mm}$

2 $r_y = \frac{2048}{2000} = 1{,}024 \ \frac{px}{mm}$ ✓

$r_x = \frac{2560}{2400} = 1{,}06 \ \frac{px}{mm}$ ✓

ottimizzo:

$y \rightarrow 1{,}024 \cdot 2400 = 2457 \ px < 2560 \ px$ va bene

$x \rightarrow 1{,}06 \cdot 2000 = 2120 \ px > 2040 \ px$ non va bene

$\Rightarrow$ scelgo l'ottimizzazione lungo y con $r_y = 1{,}024 \ \frac{px}{mm}$

$S.size \ 1 = 4{,}2 \cdot 10^{-3} \cdot 2048 = 8{,}6 \ mm$

$S.size \ 2 = 2{,}6 \cdot 10^{-3} \cdot 2048 = 5{,}3 \ mm$

B)

$$\begin{cases} wd = 2000mm & f = \dfrac{2000 \cdot 8{,}6}{2000} \\ wd = 3000mm & f = \dfrac{3000 \cdot 8{,}6}{2000} \end{cases}$$

$$\begin{cases} f = \dfrac{2000 \cdot 5{,}3}{2000} \\ f = \dfrac{3000 \cdot 5{,}3}{2000} \end{cases}$$

c) $V_1 = \dfrac{30000}{1{,}024} = 30 \frac{m}{s}$

per quella matricale non ci sono vincoli di velocità, l'importante è che ci sia una velocità adeguata a non avere un'immagine sfocata

D) $\text{shutter time} = \dfrac{\text{speed}}{r \cdot \text{blure}} = \dfrac{30}{1024 \cdot 1} = 0{,}03\ ms$