CS 7639 001 Homework 4

Question 1: Optimizing OV07962-E62A module

focal length, f = 2.8 mm
pixel size, t_u = 0.006 mm
Find optimal pitch theta and height h to maximize v for nearby obstacle
Constraints:
v(60m, 165 cm) >= 350 pixels, distant obstacle detection
v(15m, 165 cm) <= 460 pixels, nearby obstacle detection
h >= 0.4m
h <= 0.8m
theta >= 0
theta <= 0.5 radians

Used the projection function equation

$$v(Y,Z) = v_0 + \frac{\alpha\,(Y\sin\theta + (Z-h)\cos\theta)}{Y\cos\theta - (Z-h)\sin\theta}$$

v0 = 240 pixels (480/2)
a(alpha) = f / t_u = 466.7

With the solver in scipy.optimize minimize SLSQP method and initial guess x0 = [0.75, 0.4] - height and camera pitch angle:

- Optimal height (h) = 0.7513 m
- Optimal pitch (theta) = 0.3807 radians (21.81 degrees)
- Distant obstacle, v_near: 434.923 pixels
- Optimal v for nearby obstacle, v_far: 460.000 pixels

Based on these results, max v for nearby is touching exactly at the max constraint boundary, even though optimization result.success and message returned fail and “positive directional derivative for linesearch”. After multiple testing and code modifications, v was always touching around 460. Furthermore, different initial guesses lead to different configurations in the height and theta that satisfy the constraints and results v_near around 460 as well.

Question 2
1. OV07962-E62A module

- a(alpha) = 466.7 (f = 2.8 mm, t_u = 0.006 mm)
- optimal h = 0.7513 m, theta = 0.3807 rad (21.81 degree)
- v_near = 460.000 pixels
- v_far = 434.923 pixels

2. OV07690-R202A module
   - a(alpha) =1600.0 (f = 2.8 mm, t_u = 0.00175 mm)
   - optimal h = 0.7714 m, theta = 0.0783 rad (4.49 degree)
   - v_near = 460.337 pixels # exceeds the v_near <= 460 constraint, precision errors
   - v_far = 389.205 pixels
3. OVM9724-RYDA-ND module
   - a(alpha) =1185.7 (f = 2.8 mm, t_u = 0.0014 mm)
   - optimal h = 0.7683 m, theta = 0.1249 rad (7.16 degree)
   - v_near = 460.193 pixels # exceeds the v_near <= 460 constraint, precision errors
   - v_far = 406.601 pixels

Cost Analysis for all modules

1. OV07962-E62A module
   - Unit price = 7191 / 1000 = $7.191 per module
   - Cost per car (2 modules = $14.38
2. OV07690-R202A module
   - Unit price = 4312 / 1000 = $4.312 per module
   - Cost per car (2 modules = $8.62
3. OVM9724-RYDA-ND module
   - Unit price = 5087 / 1000 = $5.087 per module
   - Cost per car (2 modules = $10.17

Comparing OV07962-E62A module to OV07690-R202A module:

- Cost difference = $14.38 - $8.62 = costs $5.76 more for E62A
- Performance difference = 460.000 - 460.337 = -0.337 pixels (bad performance in v_near)
  434.923 - 389.205 = 45.718 pixels (better performance in v_far
- Is it worth it? = no - costs more and bad performance in v_near but much better in v_far

Comparing OVM9724-RYDA-ND module to OV07690-R202A module:

- Cost difference = $10.17 - $8.62 = costs $1.55 more for RYDA-ND
- Performance difference = 460.193 - 460.337 = -0.144 pixels - bad performance in v_near
  406.601 - 389.205 = 17.396 pixels - better performance in v_far
- Is it worth it? = costs a dollar more and slight worse performance in v_near and slight better performance in v_fear

Based on these results, OV07690-R202A is best due to high v_near performance at 460.337 pixels, cheaper costs at $8.62 per car, and even though it has the lowest v_far performance at 389.205 pixels, it's above the required threshold >= 350 pixels for distant obstacle detection.

The other bundles offer better v_far value but higher cost and not much improvement to v_near (near obstacle).