GGE6303_Computer Vision
Lab1
Student: Niloofar Ghanbari
Student ID: 3744141

Question1:

Graphics programmer - 3d reconstruction

This job needs approximately three years of experience in software engineering and a bachelor's degree in computer science or equivalent experience. The candidate would be familiar with Problem-solving and optimization experience. Additionally have an experience with computer vision algorithms, computer graphics pipelines, and native mobile app development.

Computer Vision Developer

In this position, it is very important to be creative, especially in coding, problem-solving, and be able to plan and develop, and deliver end-to-end machine learning systems. The person who applies for the job must have 1 to 2 experience in designing AI applications using Python, with a strong grasp of computer vision, and software engineering standard methodologies such as code reusability. Experience in machine learning algorithms, including unsupervised, supervised, and reinforcement learning, and a variety of neural network models are needed. The programming language like python, Deep learning frameworks (such as TensorFlow, Keras, and Pytorch), Python libraries (such as Numpy, Panda, Scikit Learn, and OpenCV), and Cloud computing platforms (such as AWS, and Azure) play a key role in this position.

Animation R&D Programmer: Computer Vision and ML

The candidate should have a computer science degree if not he/she can have equivalent industry experience. The programming language skill that is needed in this title of the job is Python. For applying it is important to have experience in the image, video, or mesh processing and computer vision techniques, photogrammetry, and surface reconstruction, machine learning/deep learning (ML/DL) approaches. Also, the candidate is able to communicate with programmers, technical artists, animators, and riggers and share complex technical information.

question 4: 480 x 640 (rows, columns) (y, x)

$\underbrace{\text{rows}}_{\text{Height}}$, $\underbrace{\text{columns}}_{\text{width}}$

$\underbrace{\text{2D Coordinates to 1D Coordinates}}$

$i = x + y * \text{width}$

- $(x,y) = (38, 52) \longrightarrow i = 38 + 52 \times 640 = \boxed{33{,}318}$
- $(x,y) = (592, 241) \longrightarrow i = 592 + 241 \times 640 = \boxed{154.832}$
- $(x,y) = (33, 0) \longrightarrow i = 33 + 0 \times 640 = \boxed{33}$

$\underbrace{\text{1D index to 2D Coordinates}}$

y = numpy.floor(i/width)

x = i % width

- i = 8092 → y = numpy.floor(8092/640) = $\boxed{12}$
  → x = 8092 % 640 = $\boxed{412}$

- i = 24061 → y = numpy.floor(24061/640) = $\boxed{37}$
  → x = 24061 % 640 = $\boxed{381}$

- i = 38190 → y = numpy.floor(38190/640) = $\boxed{59}$
  → x = 38190 % 640 = $\boxed{430}$

question 5.a :

$$\begin{bmatrix} 176 & 94 & 201 & 219 \\ 37 & 161 & 16 & 88 \\ 71 & 129 & 177 & 81 \\ 41 & 198 & 107 & 19 \end{bmatrix}$$

4

width (column) $\rightarrow x$

4 Height (row) $\downarrow Y$

$$\begin{matrix} (0,0) & (0,1) & (0,2) & (0,3) \\ (1,0) & (1,1) & (1,2) & (1,3) \\ (2,0) & (2,1) & (2,2) & (2,3) \\ (3,0) & (3,1) & (3,2) & (3,3) \end{matrix}$$

$[Y, x]$

- Flip (height - 1 - Y , x)

$$\longrightarrow \begin{bmatrix} (3,0) & (3,1) & (3,2) & (3,3) \\ (2,0) & (2,1) & (2,2) & (2,3) \\ (1,0) & (1,1) & (1,2) & (1,3) \\ (0,0) & (0,1) & (0,2) & (0,3) \end{bmatrix}$$

$$\begin{bmatrix} 41 & 198 & 107 & 19 \\ 71 & 129 & 177 & 81 \\ 37 & 161 & 16 & 88 \\ 176 & 94 & 201 & 219 \end{bmatrix}$$

Flip-array

- Flop (Y , width - 1 - x)

$$\longrightarrow \begin{bmatrix} (0,3) & (0,2) & (0,1) & (0,0) \\ (1,3) & (1,2) & (1,1) & (1,0) \\ (2,3) & (2,2) & (2,1) & (2,0) \\ (3,3) & (3,2) & (3,1) & (3,0) \end{bmatrix}$$

$$\begin{bmatrix} 219 & 201 & 94 & 176 \\ 88 & 16 & 161 & 37 \\ 81 & 177 & 129 & 71 \\ 19 & 107 & 198 & 41 \end{bmatrix}$$

Flop-array

- invert (subtracting each pixel from 255)

$$\begin{bmatrix} 176 & 94 & 201 & 219 \\ 37 & 161 & 16 & 88 \\ 71 & 129 & 177 & 81 \\ 41 & 198 & 107 & 19 \end{bmatrix} \xrightarrow[\text{(each pixel}-255]{\text{invert}} \begin{bmatrix} 79 & 161 & 54 & 36 \\ 218 & 94 & 239 & 167 \\ 184 & 126 & 78 & 174 \\ 214 & 57 & 148 & 236 \end{bmatrix}$$

- rotate

$$(\underset{\text{original height}}{Y}\ \ \underset{\text{original width}}{x}) \longrightarrow (\overbrace{\text{new-height}}^{y'}\ \ \overbrace{\text{new-width}}^{x'})$$

$$\begin{cases} y' = x \\ x' = \text{height} - 1 - y \end{cases}$$

$$\begin{bmatrix} 176 & 94 & 201 & 219 \\ 37 & 161 & 16 & 88 \\ 71 & 129 & 177 & 81 \\ 41 & 198 & 107 & 19 \end{bmatrix} \longrightarrow \begin{array}{l} \xrightarrow{\hspace{6em}} x \\ \begin{matrix} (0,0) & (0,1) & (0,2) & (0,3) \\ (1,0) & (1,1) & (1,2) & (1,3) \\ (2,0) & (2,1) & (2,2) & (2,3) \\ (3,0) & (3,1) & (3,2) & (3,3) \end{matrix} \\ \downarrow Y \end{array}$$

rotate $\longrightarrow$

$$\begin{array}{l} \xrightarrow{\hspace{6em}} x' \\ \begin{matrix} (3,0) & (3,1) & (3,2) & (3,3) \\ (2,0) & (2,1) & (2,2) & (2,3) \\ (1,0) & (1,1) & (1,2) & (1,3) \\ (0,0) & (0,1) & (0,2) & (0,3) \end{matrix} \\ \downarrow y' \end{array} \qquad \begin{bmatrix} 41 & 198 & 107 & 19 \\ 71 & 129 & 177 & 81 \\ 37 & 161 & 16 & 88 \\ 176 & 94 & 201 & 219 \end{bmatrix}$$

- 90°-clockwise-array-question 6. a :

4-bit Image $\begin{bmatrix} 5 & 8 & 3 & 7 \\ 1 & 3 & 3 & 9 \\ 6 & 8 & 2 & 7 \\ 4 & 1 & 0 & 9 \end{bmatrix}$

$\downarrow$

$2^4 - 1 = 15$

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
In Image	1	2	1	3	1	1	1	2	2	2	0	0	0	0	0	0

$h = [1 \; 2 \; 1 \; 3 \; 1 \; 1 \; 1 \; 2 \; 2 \; 2 \; 0 \; 0 \; 0 \; 0 \; 0 \; 0]$

$\bar{h} = \left[\frac{1}{16} \; \frac{2}{16} \; \frac{1}{16} \; \frac{3}{16} \; \frac{1}{16} \; \frac{1}{16} \; \frac{1}{16} \; \frac{2}{16} \; \frac{2}{16} \; \frac{2}{16} \; \frac{0}{16} \; \frac{0}{16} \; \frac{0}{16} \; \frac{0}{16} \; \frac{0}{16} \; \frac{0}{16}\right]$

16 pixel

$\bar{h} = [0.0625 \; 0.125 \; 0.0625 \; 0.1875 \; 0.0625 \; 0.0625 \; 0.0625 \; 0.125 \; 0.125 \; 0.125$
$0 \; 0 \; 0 \; 0 \; 0 \; 0]$

$\bar{C} = [0.0625 \quad 0.0625 + 0.125 \quad 0.0625 + 0.125 + 0.0625 \quad \ldots]$

$\bar{C} = [0.0625 \; 0.1875 \; 0.25 \; 0.4375 \; 0.5 \; 0.5625 \; 0.625 \; 0.75$
$0.875 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1 \; 1]$

question 7.a :

- Double-difference Image $\longrightarrow I' = |I_t - I_{t-1}| > \tau$ And $|I_{t+1} - I_t| > \tau$

$$|I_1 - I_2| = \begin{bmatrix} 18 & 168 & 94 & 97 \\ 120 & 97 & 78 & 198 \\ 83 & 70 & 208 & 17 \\ 238 & 208 & 189 & 68 \end{bmatrix} - \begin{bmatrix} 21 & 168 & 92 & 71 \\ 122 & 71 & 191 & 227 \\ 83 & 212 & 16 & 187 \\ 240 & 216 & 188 & 68 \end{bmatrix} = \begin{bmatrix} 3 & 0 & 2 & 26 \\ 2 & 26 & 113 & 29 \\ 0 & 142 & 192 & 170 \\ 2 & 8 & 1 & 0 \end{bmatrix}$$

if $> T=40 \rightarrow 1$, $< T=40 \rightarrow 0$

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix}^*$$

$$|I_2 - I_3| = \begin{bmatrix} 21 & 168 & 92 & 71 \\ 122 & 71 & 191 & 227 \\ 83 & 212 & 16 & 187 \\ 240 & 216 & 188 & 68 \end{bmatrix} - \begin{bmatrix} 20 & 171 & 92 & 70 \\ 76 & 193 & 39 & 255 \\ 207 & 20 & 20 & 194 \\ 241 & 210 & 190 & 73 \end{bmatrix} = \begin{bmatrix} 1 & 3 & 0 & 1 \\ 46 & 122 & 152 & 28 \\ 126 & 192 & 4 & 7 \\ 1 & 6 & 2 & 5 \end{bmatrix}$$

if $> T=40 \rightarrow 1$, $< T=40 \rightarrow 0$

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 \\ 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}^{**}$$

Change pixels $\rightarrow \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$

- Triple-difference Image $\longrightarrow I' = (|I_{t-1} - I_t|) + |I_{t+1} - I_t| - |I_{t-1} - I_{t+1}| > \tau$

As we calculate in Double-difference :

$$|I_1 - I_2| = \begin{bmatrix} 3 & 0 & 2 & 26 \\ 2 & 26 & 113 & 29 \\ 0 & 142 & 192 & 170 \\ 2 & 8 & 1 & 0 \end{bmatrix} \qquad |I_2 - I_3| = \begin{bmatrix} 1 & 3 & 0 & 1 \\ 46 & 122 & 152 & 28 \\ 126 & 192 & 4 & 7 \\ 1 & 6 & 2 & 5 \end{bmatrix}$$

know we calculate $|I_1 - I_3|$:

$$|I_1 - I_3| = \begin{bmatrix} 2 & 3 & 2 & 3 \\ 56 & 96 & 39 & 57 \\ 126 & 50 & 188 & 177 \\ 3 & 2 & 1 & 5 \end{bmatrix}$$

$$\longrightarrow |I_1 - I_2| + |I_2 - I_3| - |I_1 - I_3| = \begin{bmatrix} 2 & 0 & 0 & 24 \\ 8 & 52 & 226 & 0 \\ 0 & 284 & 8 & 0 \\ 0 & 12 & 2 & 0 \end{bmatrix}$$

$$\text{if} \begin{cases} > T = 40 \rightarrow 1 \\ < T = 40 \rightarrow 0 \end{cases} \longrightarrow \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

change pixels

question 8 :

$-\ I_A \text{ OVER } I_B \qquad \overbrace{I_A \wedge M_A + I_B \wedge M_B \wedge \neg M_A}^{\text{New Image}(I')} \qquad \overbrace{M_A + M_B}^{M'}$

$$\neg M_A = \begin{bmatrix} 0 & 0 & 255 \\ 0 & 0 & 255 \\ 255 & 255 & 255 \end{bmatrix}$$

$$I_B \wedge M_B \wedge \neg M_A = \begin{bmatrix} X & X & X \\ X & X & 184 \\ X & 119 & 162 \end{bmatrix}^{*}$$

$$M_B \wedge \neg M_A = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 255 \\ 0 & 255 & 255 \end{bmatrix}$$

$$I_A \wedge M_A = \begin{bmatrix} 132 & 231 & X \\ 237 & 105 & X \\ X & X & X \end{bmatrix}^{**}$$

$$I' = * + ** \longrightarrow I' = \begin{bmatrix} 132 & 231 & X \\ 237 & 105 & 184 \\ X & 119 & 162 \end{bmatrix}$$

$$M' = M_A + M_B = \begin{bmatrix} 255 & 255 & 0 \\ 255 & 255 & 255 \\ 0 & 255 & 255 \end{bmatrix}$$

$$I_A \text{ OVER } I_B = \begin{bmatrix} 132 & 231 & X \\ 237 & 105 & 184 \\ X & 119 & 162 \end{bmatrix}$$

$$- I_A \text{ IN } I_B \qquad I' = I_A \qquad m' = m_A \wedge m_B$$

$$I' = \begin{bmatrix} 132 & 231 & 227 \\ 237 & 105 & 238 \\ 193 & 59 & 128 \end{bmatrix} \qquad m' = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 255 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$I_A \text{ IN } I_B = \begin{bmatrix} X & X & X \\ X & 105 & X \\ X & X & X \end{bmatrix}$$

$$- I_A \text{ ATOP } I_B \qquad I' = I_A \wedge m_A + I_B \wedge \neg m_A \qquad m' = m_B$$

$$\neg m_A = \begin{bmatrix} 0 & 0 & 255 \\ 0 & 0 & 255 \\ 255 & 255 & 255 \end{bmatrix} \rightarrow I_B \wedge \neg m_A = \begin{bmatrix} X & X & 116 \\ X & X & 184 \\ 36 & 119 & 162 \end{bmatrix}$$

$$I_A \wedge m_A = \begin{bmatrix} 132 & 231 & 0 \\ 237 & 105 & 0 \\ 0 & 0 & 0 \end{bmatrix} \xrightarrow{+} I' = \begin{bmatrix} 132 & 231 & 116 \\ 237 & 105 & 184 \\ 36 & 119 & 162 \end{bmatrix}^{*}$$

$$m' = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 255 & 255 \\ 0 & 255 & 255 \end{bmatrix}^{**}$$

$$I_A \text{ ATOP } I_B = \begin{bmatrix} X & X & X \\ X & 105 & 184 \\ X & 119 & 162 \end{bmatrix}$$

question 9.a :

$$\hat{I}(x,y) = \bar{\alpha}_x \bar{\alpha}_y I_{00} + \alpha_x \bar{\alpha}_y I_{10} + \bar{\alpha}_x \alpha_y I_{01} + \alpha_x \alpha_y I_{11}$$

$$I = \begin{bmatrix} 232 & 177 & 82 & 7 \\ 241 & 18 & 152 & 140 \\ 156 & 221 & 67 & 3 \end{bmatrix}$$

$P(0.1, 0.7)$

$$\begin{cases} x_0 = \text{floor}(x) = 0 \rightarrow \alpha_x = x - x_0 = 0.1 - 0 = 0.1 \\ y_0 = \text{floor}(y) = 0 \rightarrow \alpha_y = y - y_0 = 0.7 - 0 = 0.7 \end{cases}$$

$$\begin{cases} \bar{\alpha}_x = 1 - \alpha_x = 1 - 0.1 = 0.9 \\ \bar{\alpha}_y = 1 - \alpha_y = 1 - 0.7 = 0.3 \end{cases}$$

$$\hat{I}(0.1, 0.7) = (0.9)(0.3)(232) + (0.1)(0.3)(177) + (0.9)(0.7)(241)$$
$$+ (0.1)(1.7)(18) = \boxed{221.04}$$

$P(1.2, 0.5)$

$$\begin{cases} \bar{\alpha}_x = 1 - 0.2 = 0.8 \\ \bar{\alpha}_y = 1 - 0.5 = 0.5 \end{cases} \qquad \begin{cases} x_0 = 1 \rightarrow \alpha_x = 0.2 \\ y_0 = 1 \rightarrow \alpha_y = 0.5 \end{cases}$$

$$\hat{I}(1.2, 0.5) = (0.8)(0.5)(177) + (0.2)(0.5)(82) + (0.8)(0.5)(18)$$
$$+ (0.2)(0.5)(152) = \boxed{101.4}$$

$P(1.3, 1.6)$

$$\begin{cases} \bar{\alpha}_x = 1 - 0.3 = 0.7 \\ \bar{\alpha}_y = 1 - 0.6 = 0.4 \end{cases} \qquad \begin{cases} x_0 = 1 \rightarrow \alpha_x = 1.3 - 1 = 0.3 \\ y_0 = 1 \rightarrow \alpha_y = 1.6 - 1 = 0.6 \end{cases}$$

$$\hat{I}_{(1.3, 1.6)} = (0.7)(0.4)(18) + (0.3)(0.4)(152) + (0.7)(0.6)(221) + (0.3)(0.6)(67)$$

$$= \boxed{128.16}$$

$P(2.8, 1.7)$

$$\begin{cases} \bar{\alpha}_x = 1 - 0.8 = 0.2 \\ \bar{\alpha}_y = 1 - 0.7 = 0.3 \end{cases} \qquad \begin{cases} x_0 = 2 \rightarrow \alpha_x = 2.8 - 2 = 0.8 \\ y_0 = 1 \rightarrow \alpha_y = 1.7 - 1 = 0.7 \end{cases}$$

$$\hat{I}_{(2.8, 1.7)} = (0.2)(0.3)(152) + (0.8)(0.3)(140) + (0.2)(0.7)(67)$$

$$+ (0.8)(0.7)(3) = \boxed{53.78}$$