ASSIGNMENT

Question 1: Bandwidth Requirement for an Autonomous Vehicle Camera System

To estimate the **bandwidth required**, we consider the parameters:

- **Resolution**: 1920×1200.
- **Bits per pixel (bpp)**: Typically 24 bits (3 bytes) for RGB color.
- **Frames per second (fps)**: 52.7 fps.

Calculation:

1. Total pixels per frame:
   $1920 \times 1200 = 2{,}304{,}000$ pixels
2. Bytes per frame:
   $2{,}304{,}000 \times 3$ bytes$=6{,}912{,}000$ bytes.
3. Bandwidth (bytes per second):
   $6{,}912{,}000 \times 52.7 = 364{,}406{,}400$ bytes/second.

   This is approximately **364 MB/s** for one camera.

For a system with **8 cameras** (typical for Tesla or Waymo): 364 MB/s×8=2.91 GB/s.

This estimate assumes no compression. If compression (e.g., H.264 or H.265) is used, the bandwidth is reduced significantly.

Question 2: Pixel Size and Coverage at Various Distances

Parameters:

- **Sensor size**: 2/32/32/3" sensor diagonal (11 mm).
- **Resolution**: 1920×12001920 \times 12001920×1200 pixels.
- **Focal lengths**: 6 mm, 3.7 mm, and 25 mm.

Step 1: Calculate Field of View (FOV)

The field of view can be computed using the focal length and the sensor dimensions.

Parameters:

- **Sensor width**: 8.8 mm
- **Sensor height**: 6.6 mm
- **Resolution**: 1920×1200
- **Distances**: 20 m,100 m
- **Pedestrian dimensions**: 40 cm (width),180 cm (height)
- **Focal lengths**: 6 mm,3.7 mm,25 mm

Step 1: Field of View (FOV)

The horizontal FOV is calculated using the formula:

FOV (horizontal) = 2 * arctan(sensor width / 2 * focal length)

For each focal length:

6 mm focal length:

FOV = 2 * arctan(8.82 / 6)≈74.07

3.7 mm focal length:

FOV = 2 * arctan(8.82 / 3.7)≈102.58

25 mm focal length:

FOV = 2 * arctan(8.82 / 25)≈19.68

tep 2: Scene Width

The scene width (or height) at a given distance is calculated using:

Scene width = 2 * distance * tan(FOV / 2)

6 mm focal length at 20 m:

Scene width = 2 * 20 * tan(74.07 / 2)≈29.33 m

At 100 m:

Scene width = 2 * 100 * tan(74.07 / 2)≈146.67 m

3.7 mm focal length at 20 m:

Scene width=2 * 20 * tan(102.58 / 2)≈47.57 m

At 100 m:

Scene width=2 * 100 * tan(102.58 / 2)≈237.84 m

25 mm focal length at 20 m:

Scene width = 2 * 20 * tan(19.68 / 2)≈7.04 m

At 100 m:

Scene width = 2 * 100 * tan(19.68 / 2)≈35.2 m

Step 3: Pixel Size

The pixel size is calculated as:

Pixel size=Scene width / Resolution width

6 mm focal length at 20 m:

Pixel size = 29.33 / 1920≈0.01528 m/pixel

At 100 m:

Pixel size = 146.67 / 1920≈0.07639 m/pixel

3.7 mm focal length at 20 m:

Pixel size = 47.57 / 1920≈0.02478 m/pixel

At 100 m:

Pixel size = 237.84 / 1920≈0.12387 m/pixel

25 mm focal length at 20 m:

Pixel size = 7.04 / 1920≈0.00367 m/pixel

At 100 m:

Pixel size = 35.2 / 1920≈0.01833 m/pixel

Step 4: Pedestrian Dimensions in Pixels

Pedestrian dimensions (pixels)=Physical dimensions / Pixel size

6 mm focal length:

1. At 20 m:

   Pixel size (width)=0.01528m/pixel,Pixel size (height)=0.01833m/pixel.

   Width (pixels)=0.40.01528≈26.18 pixels,

   Height (pixels)=1.80.01528≈117.83 pixels.

2. At 100 m:

   Pixel size (width)=0.07639m/pixel,Pixel size (height)=0.09167m/pixel.

   Width (pixels)=0.40.07639≈5.24 pixels,

   Height (pixels)=1.80.07639≈23.57 pixels.

3.7 mm focal length:

1. At 20 m:
   Pixel size (width)=0.02478 m/pixel,

   Pixel size (height)=0.02973 m/pixel.

   Width (pixels)=0.40.02478≈16.15 pixels.

   Height (pixels)=1.80.02973≈60.55 pixels.

2. At 100 m:
   Pixel size (width)=0.12387 m/pixel,

   Pixel size (height)=0.14865 m/pixel.

Width (pixels)=0.40.12387≈3.23 pixels.

Height (pixels)=1.80.14865≈12.11 pixels.

25 mm focal length:

1. At 20 m:
   Pixel size (width)=0.00367 m/pixel,

   Pixel size (height)=0.00440 m/pixel.

   Width (pixels)=0.40.00367≈109.09 pixels.

   Height (pixels)=1.80.00440≈409.09 pixels.

2. At 100 m:
   Pixel size (width)=0.01833 m/pixel,

   Pixel size (height)=0.02200 m/pixel.

   Width (pixels)=0.40.01833≈21.82 pixels.

   Height (pixels)=1.80.02200≈81.82 pixels.

This analysis provides an overview of the bandwidth requirements for autonomous vehicle camera systems and detailed calculations regarding pixel sizes and pedestrian representation at various distances using different focal lengths.