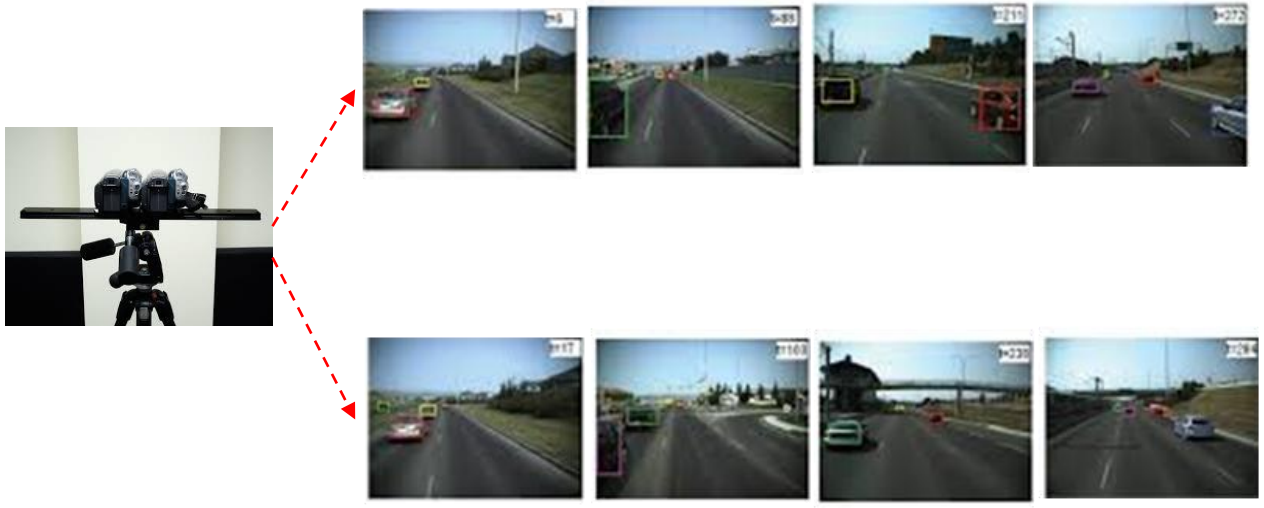
Stereo and Multi-view Sequence Processing

Stereo Sequence



- A stereo sequence is a pair of video streams captured from two cameras placed side by side, usually separated by a small baseline (a few centimeters).
- To simulate human binocular vision — enabling depth perception by comparing the left and right views.
- Disparity : The horizontal difference in the positions of corresponding points in the pair of frames.

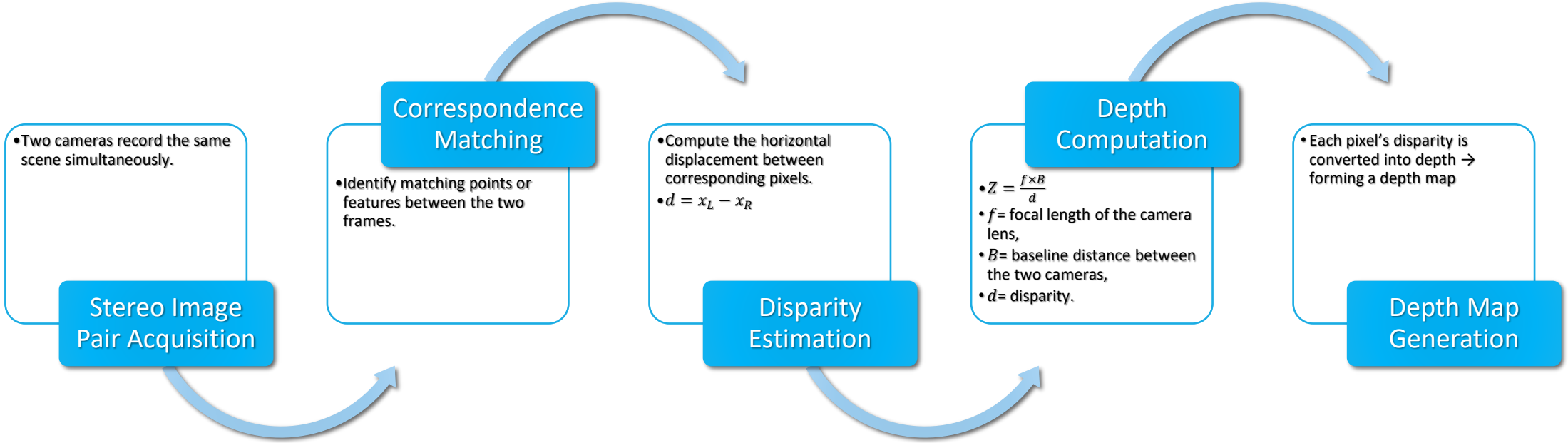
Depth Perception through Stereopsis

Biological Basis:

- In human vision, stereopsis is the ability to perceive depth from the small positional differences (called disparities) between the left and right eye images.
- Each eye views the world from a slightly different angle.
- The brain fuses these two images, matches corresponding points, and interprets the horizontal disparity as depth.
  - Larger disparity → object is closer.
  - Smaller disparity → object is farther away.

Depth Perception through Stereopsis

- Stereo video systems mimic human stereopsis using two or more cameras (e.g., left and right) capturing synchronized video sequences of the same scene from slightly different viewpoints.



Disparity Estimation

- For each pixel in one view (say, the left image), disparity estimation attempts to find the matching pixel in the other view (right image) that represents the same 3D point in the real world.

- Once found, their horizontal offset (disparity) provides depth information using:

$$Z = \frac{f \times B}{d}$$

Objective Function: Disparity Compensated Prediction (DCP)

- To estimate disparity, an objective (cost) function is defined — it measures how well one image can predict the other using disparity compensated prediction (DCP).

$$E(d) = E_{data} + \lambda E_{smooth}$$

- The goal is to find the disparity field $d(x, y)$ that minimizes $E(d)$.

Data Term

Measures matching error between pixels (e.g., intensity or color difference)

- $E_{data} = \sum_{x,y} |I_L(x, y) - I_R(x - d(x, y), y)|$

Smoothness Term

Encourages neighboring pixels to have similar disparity values, assuming surfaces are smooth:

$$E_{smooth} = \sum_{(x,y)} \sum_{(x',y') \in N(x,y)} |d(x, y) - d(x' - y')|$$

Disparity Estimation Methods

1) Block-based Approach
2) 2D- Mesh-based Approach
3) Intra-line Edge Matching Using Dynamic Programming