STEREO IMAGING

In computer and human vision, the term Stereo means the recovery of a 3-D scene from its multiple view images.

Stereo techniques are local and robust. They are used to extract depth information.

Main stereo methods include:

- Photometric Stereo
  - Shape from shading

- Geometric Stereo
  - Shape from motion
    - Single moving camera in a static scene gives multiple images.
  - Triangulation based stereo
    - Two cameras are used which provide two separate views of an object.

Humans also use triangulation to extract depth information's of a scene.
STEREO IMAGING
(cont. 1)

Triangulation or Stereo Imaging

- Consider one world point \( w \) in the scene and two cameras assuming:
  - Cameras are identical having same focal length \( \lambda \).
  - Coordinate systems of both cameras are perfectly aligned, differing only in the location of their origins.
  - The distance between the centres of the camera lenses (the baseline \( B \)) is known.

- Shape from Stereo Objective

Find the coordinates \( (X, Y, Z) \) of the point \( w \) having image points \( (x_1, y_1) \) and \( (x_2, y_2) \) from the two images of scene obtained by the two cameras.
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The camera and world co-ordinate systems are brought into coincidence.

The $xy$-$plane$ of both images is aligned with the $XY$-$plane$ of the world co-ordinate system.

The $Z$ co-ordinate of $w$ is same for both camera co-ordinate systems.

Let us bring first camera into coincidence with the world co-ordinate system.

$$X_1 = \left(\frac{x_1}{\lambda}\right)(\lambda - Z_1) \quad [1]$$

Then bring the second camera into coincidence with the world co-ordinate system, but keep the same relative arrangement of cameras.

$$X_2 = \left(\frac{x_2}{\lambda}\right)(\lambda - Z_2) \quad [2]$$
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(cont. 3)

The \( Z \) co-ordinate is same for both camera co-ordinate systems and \( B \) is the separation between cameras, Therefore

\[
X_2 = X_1 + B
\]
\[
Z_2 = Z_1 = Z
\]

Substituting them in 1st and 2nd equations and solving for \( Z \)

\[
X_1 = \frac{x_1}{\lambda}(\lambda - Z)
\]
\[
X_1 + B = \frac{x_2}{\lambda}(\lambda - Z)
\]

\[
Z = \lambda - \frac{\lambda B}{x_2 - x_1}
\]

It indicates that if the difference between the corresponding image co-ordinates \( x_2 \) and \( x_1 \) can be determined calculating \( Z \) co-ordinate of \( \mathbf{w} \) is a simple matter.
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(cont. 4)

● The Correspondence Problem

Pair up the image points in two images such that each point in a pair is the image of same point in scene.

☞ The establishment of correspondence may require that an entire image be searched for every point in the other image.

● Extensive search problem is avoided due to the epipolar constraint.

● Epipolar plane
   A plane through the baseline is termed an epipolar plane

● Epipolar line
   An epipolar plane intersect two image planes along straight lines called epipolar lines.

● Epipoles
   The intersection points of baseline and the epipolar lines are epipoles.
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(cont. 5)

● Epipolar constraint

For a given point in one image, its corresponding point in the other image is constrained to lie on the straight line_

which is the projection of the line through the given image point and its centre of projection.

Epipolar constraint reduces the search space from two-dimensional to one-dimension

● Epipolar geometry of normal image pair

If image planes are identical and parallel to baseline, the epipolar lines are also parallel to baseline and the search space for \((x_2, y_2)\) for a given \((x_1, y_1)\) point will be the line represented by

\[
y = y_1
\]