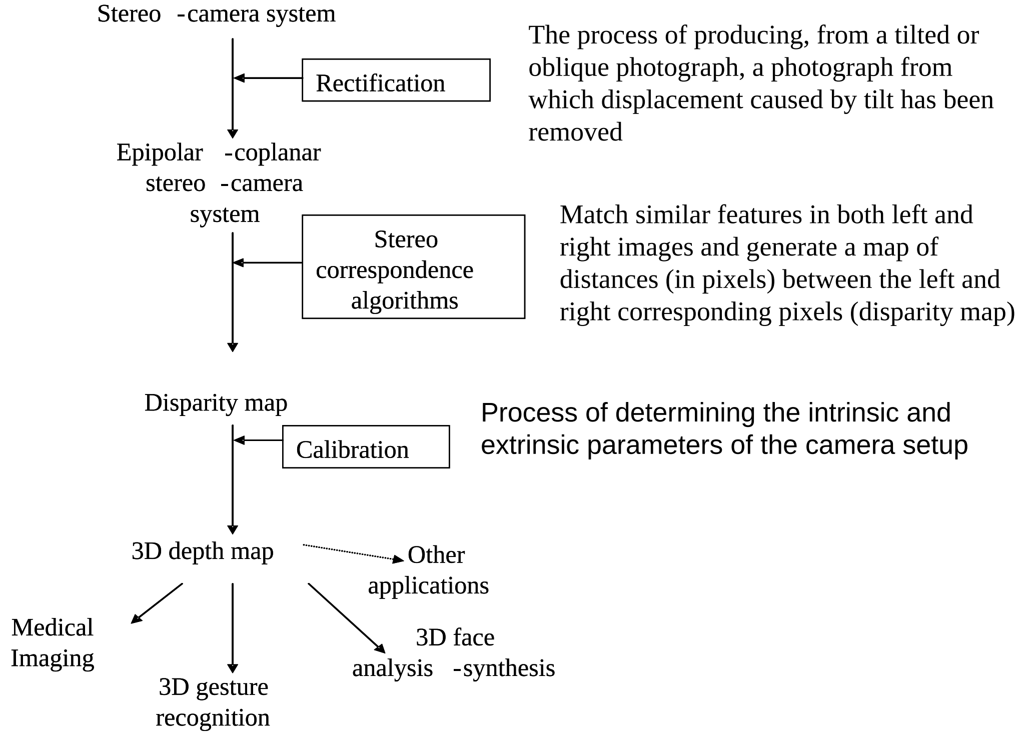
Build a 3D face using stereo Vision



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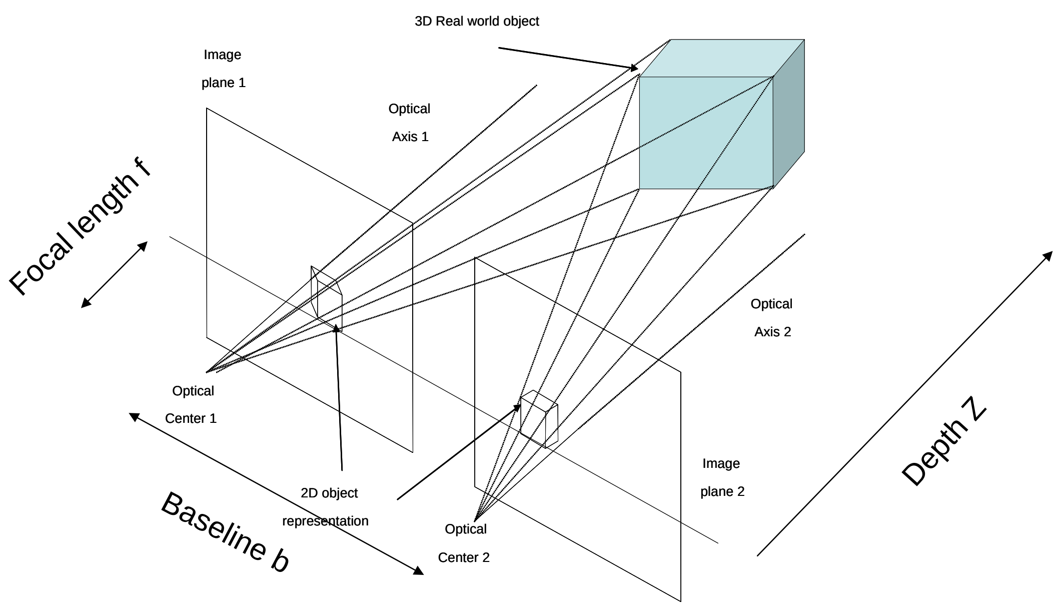
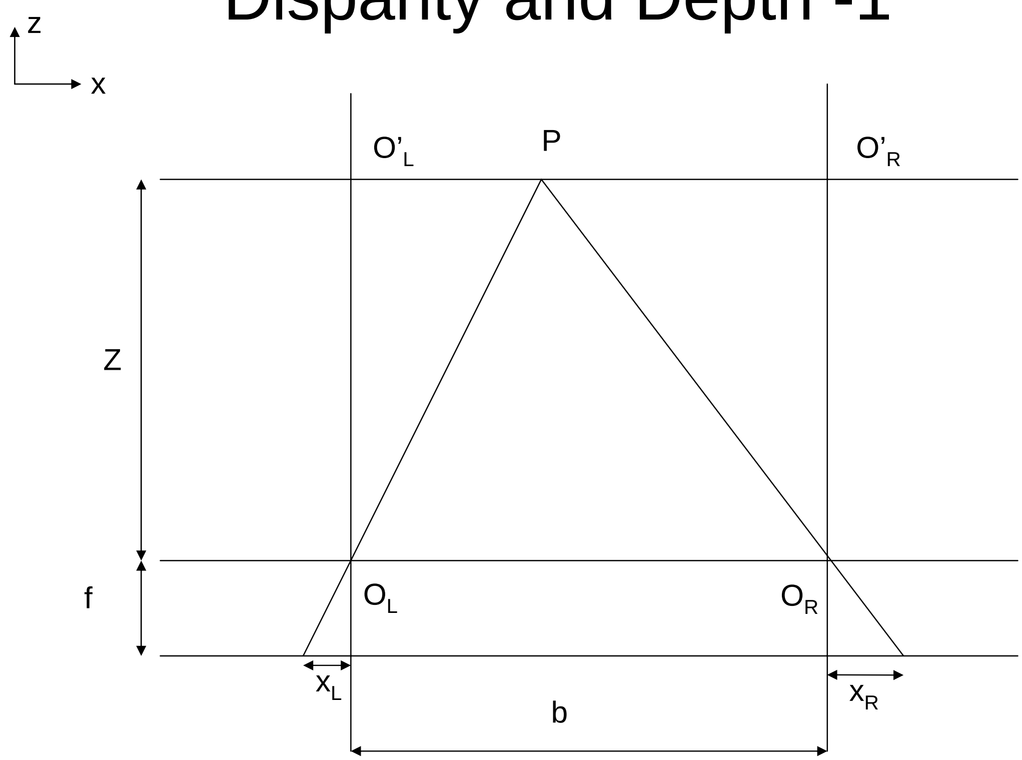
1. Acquisition of data
   1. Interactive stereo using manual clicking
   2. Binocular stereo algorithms
2. Processing of data (disparity map)
   1. Manual registration of points disparities
      1. Sparse disparity map
      2. Interpolation to generate a dense disparity map
   2. Automatic registration
      1. dense disparity map
3. 3D face
   1. Creation of the 3D depth map
   2. Delaunays Triangulation
   3. Mapping of the texture
4. Animated 3D face (optional)
   1. Registration of the 3D face (from 3.2) to the 3D generic face model
   2. Mapping of the texture

Stereo System display



Disparity and Depth -1



Disparity and Depth-2

The similar triangles theorem (Thales) links the distances on the camera sensors (x_l and x_r) to the distances O'_LP, O'_RP and f

$$x_L = \frac{f \times O'_L P}{Z} \qquad x_R = \frac{f \times O'_R P}{Z}$$

Note that, x_l and x_r are usually given in pixel position on the images but may be converted to a distance by multiplying by p, the physical width of a pixel on the sensor. The disparity dP of point P is defined as the difference in position on the left and the right images:

Disparity and Depth-3

$$d_P = x_L - x_R$$
$$= \frac{f}{Z}\left(\overline{O'_L P} - \overline{O'_R P}\right)$$
$$= \frac{f}{Z}\left(\overline{O'_L P} + \overline{P O'_R}\right)$$
$$= \frac{f}{Z}\overline{O'_L O'_R} = \frac{f}{Z} b$$

where
Z = distance along the camera Z axis (meters)
f = focal length (meters)
B = baseline (in metres)
d = disparity (in pixels)

Once Z is determined,
X and Y can be computed using projective geometry:

X = uZ/f
Y = vZ/f

where u and v are the centered pixel location in the 2D image.
$u = x_c - x$
$v = y_c - y$

Disparity and Depth-4

If the object is placed at an infinite distance:

This shows that an object at infinity appears at the same place on both image planes. Practically, the camera resolution (i.e. pixel width p) will give the minimum measurable disparity, i.e. the maximum depth.

If the disparity tends toward an infinite distance:

For a finite sensor width, the depth cannot reach 0. The minimal value of the depth is given by:

$$Z_{\min} = \frac{b \times f}{n \times p}$$