1 Epipolar geometry

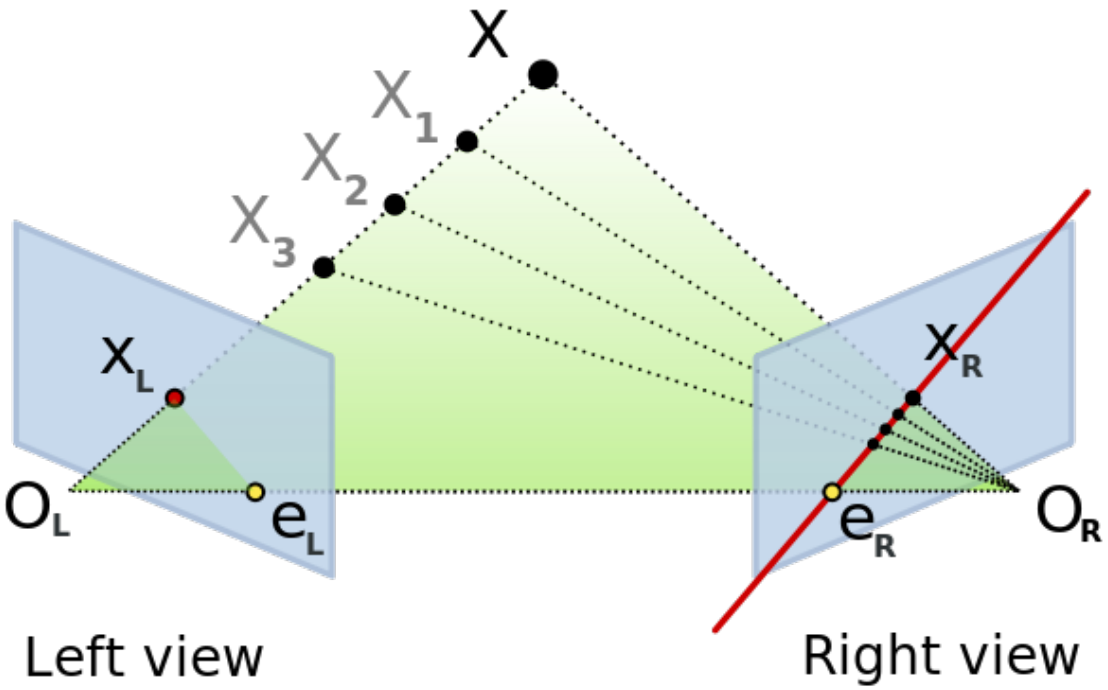

Figure 1: All points $X_1, X_2, \cdots, X_L$ lie on the same epipolar line in the right view

Epipolar geometry is used in stereo vision to limit the searching space when looking for matching points in both images. A point X in 3D space is seen in image A as a point x, which is on the line between camera A's focal point and point X. This line is seen by camera B as a line. This is called an *epipolar line*. Given both the cameras internal and external matrices and a point x_A we can generate an epipolar line corresponding to this point in image B. This constrains the search space to this 1D line.

The points called e_L and e_R in figure 1 are called the *epipolar points* of both images. Epipolar lines rotate around the epipolar point of a given image.

2 Rectification

As we have seen in section 1, we can constrain the search space to a 1D line. However due to the nature computers store images, it would be very convenient if these epipolar lines were parallel to the horizontal scanlines. This is done by a process called *rectification*. This process transforms both images so that the epipolar lines of the images align horizontally. For this, we need a matrix that relates the two cameras. This matrix is called the *fundamental matrix* or *bifocal tensor* and is denoted by the symbol F.

2.1 Fundamental matrix

Given a point x in image A, Fx describes the epipolar line in image B on which the corresponding point x' must lie. This means that F has to satisfy the equation

$$x'^T F x = 0$$

for all corresponding points x and x'. Given enough corresponding points, we can solve this equation linearly. The more points available, the more accurate this fundamental matrix becomes.[1]

2.2 Chessboard points

The corresponding points necessary for generating the fundamental matrix is obtained by making multiple pictures of a chessboard in the environment. The OpenCV toolkit has a builtin function to recognize the corners of a chessboard. In this project we will not elaborate on that subject.

[1] That is, if the corresponding points are accurate as well.