## **Camera Calibration and 3D Reconstruction (calib3d Module)**

The calib3d module in OpenCV is mainly used when we need to understand how a camera sees the world and to correct the distortions that happen in images. It also deals with 3D vision tasks like measuring distances, reconstructing objects in 3D, and estimating positions.

### **1. Camera Models**

Every camera has certain settings and properties that decide how it sees the world. In OpenCV, these are usually split into two main things:

* Intrinsic parameters - These are inside the camera, like focal length, the center point of the image, and how much the lens distorts the image.
* Extrinsic parameters - These are about where the camera is placed in the real world and which way it’s pointing.

All this info is stored in something called a camera matrix.

### **2. Undistortion**

Many cameras, especially wide-angle or cheap ones, make straight lines look curved. This is called distortion.

With calibration, we can find out how the lens distorts the image, and then OpenCV can adjust that effect so the picture looks normal.

Example cases:

* The straight road is looking straight only and not turny anywhere.
* Making sure a scanned document looks flat and not bent.

### **3. Stereo Vision**

When two cameras are placed side by side, it becomes possible to figure out how far away objects are, similar to how human eyes work. The calib3d module processes images from both cameras, finds the differences between them, and creates something called a disparity map, which basically represents the depth of the scene.

Uses:

* Robots figuring out where obstacles are.
* Drones measuring distances.
* Making 3D photos or videos.

### **4. Pose Estimation**

Pose estimation is figuring out where an object is and how it’s rotated in space. If it already knows some points in real life and can match them to points in a picture, OpenCV can calculate the object’s position and angle.

Uses:

* Augmented reality (placing fake objects in real places).
* Tracking sports movements.