EL7021 Robotics & Autonomous Systems

Assignment 1: Sensors

2010, Semester 2

1. Two cameras, each with focal length $f = 0.06$ m, are mounted as a parallel baseline stereo pair. The baseline separation of the cameras is $b = 0.2$ m. Each camera's image plane is a square pixel array of 256×256 pixels with side length $= 0.02$ m.

   (a) For an object displaced $z = 3.2$ m from the baseline joining the camera lenses, calculate the disparity.

   (b) An object produces its images at pixel numbers $x_l = 100$, $x_r = 120$ and $y_l = y_r = 200$, with respect to pixel coordinate origins located at the lower left corners of each image. With respect to a global origin located half way between the two lenses, calculate the global coordinates of the object.

   (c) If the y and z coordinates remain constant, how much in the positive x direction must the object be moved so that it can just no longer be seen in the left camera image?

   (d) For an object with $x = y = 0$, what value of z would give the highest accuracy range measurement?

2. An active triangulation system has a laser which can be rotated about an axis perpendicular to the line joining it with an imaging sensor. The laser is displaced $b = 0.1$ m from the centre of the imaging sensor and the imaging sensor has a lens with focal length $f = 0.02$ m. An object is located at coordinates (1.0, 6.0) with respect to an origin at the centre of the imaging sensor's lens, and lies within the plane of the scanning laser.

   (a) Calculate the image coordinate u (w.r.t. the same origin as the object) and the angle θ at which the laser must point w.r.t. the line joining the laser's point of rotation and the centre of the imaging sensor's lens.

   (b) The imaging sensor has a resolution of 0.01 mm. The object is displaced a distance of +0.1 m in the z direction. Can the sensor detect this change?

   (c) With the object initially at coordinates (1.0, 6.0) an angular change in the laser's rotation of 2^o is measured. Calculate the approximate change in the z coordinate of the object which must have occured.

3. An AMCW LADAR operates with a modulating frequency of 5MHz. Its receiver electronics adds zero mean shot noise to the received signal, with variance $0.01V^2$.

   (a) Calculate the maximum working range of the LADAR.

   (b) If the receiver electronics can only measure a minimum phase shift of 1^o, calculate the range resolution of the LADAR.

   (c) If the received signal strength recorded from a target at a range of 4 m is 1.4 V, calculate the range variance.

   (d) If the noise in the range estimate is assumed to follow a Gaussian distribution, within which band of range values will the actual target lie with a probability of 95%?