3. Assignment, Introduction to Robotics WS16/17

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Submission: online until Tuesday, 22. Nov 2016, 11:59 a.m.

Please summarize your results (images and descriptions) in a pdf-document and name it "RO-03-<surnames of the students - group name>.pdf". There should not be any source code in the pdf document.
By the end of this class you will need 50% of points to be allowed to write the final exam.

1. Representations (2 Points):

a) (1 Point) A familiar set of three coordinates that can be used to describe a point in space is cylindrical coordinates. The coordinate \theta gives a direction in the xy plane along which to translate radially by an amount r. Finally, z is given to specify the height above the xy plane. Compute the Cartesian coordinates of the point P_A in terms of the cylindrical coordinates \theta, r, and z.

Now compute the cylindrical coordinates for point P_p = (3,1,2).

b) (1 Point) Another set of three coordinates that can be used to describe a point in space is spherical coordinates. The angles \alpha and \beta can be thought of as describing azimuth and elevation of a ray projecting into space. The third coordinate, r, is the radial distance along that ray to the point being described. Calculate the Cartesian coordinates of the point P_A in terms of the spherical coordinates \alpha, \beta and r.

Now compute the spherical coordinates for point P_p = (3,1,2)

2. Transformations (2 Points):

A frame {B} is located initially coincident with a frame {A}. We rotate {B} about Z_B by \theta degrees, and then we rotate the resulting frame about X by \phi degrees (extrinsic rotation).

a) (1 Point) Give the final rotation matrix that will change the descriptions of vectors from P_B to P_A, provide the calculation steps.

b) (1 Point) Provide the calculation, using the matrix from (a) to represent P_B in frame A.

3. Rotations (6 Points):

Given is the axis-angle rotation vector \Theta = (2, 2, 0) .

a) (1 Point) Calculate the unit vector of the rotation axis k and the angle \theta
b) (2 Points) Derive the rotation matrix R representing the same rotation and show, that your matrix is orthonormal.
c) (1 Point) Derive the quaternion representing the same rotation

Now given a vector P_A = (0, 0, 3)

d) (1 Point) Rotate Vector P_A by \Theta using Rodrigues' formula
e) (1 Point) Now use quaternion q=(0.5 + 0.5j + 1/sqrt(2) k) to rotate vector P_A = (0, 0, 3)

Provide calculation steps for each of the above tasks