Autonomous and Mobile Robotics
Class Test no. 2, 2010/2011

Problem 1

Consider a 2R planar manipulator with the first joint at the origin of the plane and links of unit length. Regardless of the initial configuration, we want to bring the tip of the manipulator to the goal point $(1, -1)$ while avoiding collisions with a point obstacle located at $(1, 0)$. To solve this motion planning problem, one can take the following approach:

1. define a suitable set of control points on the manipulator;
2. build an appropriate artificial force field for each control point;
3. control the robot by imposing to its joints the torques resulting from the combined action of the Cartesian force fields.

Compute the complete expression of the torques as a function of the robot configuration.

Problem 2

Consider a fixed-wing UAV flying at a constant altitude with zero pitch angle. In this particular condition, its configuration can be described as $(x \quad y \quad \psi \quad \phi)^T$, where (x, y) are the Cartesian coordinates of the center of gravity, ψ is the yaw angle, and ϕ is the roll angle. The UAV dynamic model is

$$\begin{aligned} \dot{x} &= v \cos \psi \\ \dot{y} &= v \sin \psi \\ \dot{\psi} &= -\frac{g}{v} \tan \phi \\ \dot{\phi} &= u_\phi \end{aligned}$$

where g is the gravity acceleration. The UAV speed v and roll rate u_ϕ are the available control inputs. Assume that the UAV is equipped with a radio sensor that can measure the bearing angle between the UAV main axis and two radio beacons, respectively placed at $P_1 = (x_1, y_1)$ and $P_2 = (x_2, y_2)$. For simplicity, assume that:

- the sensor is exacty located at the center of gravity;
- the beacons are located on the plane of flight;
- the sensor can distinguish between the two landmarks (e.g., by radio frequency);
- the sensor can always see both landmarks.

Build an Extended Kalman Filter for estimating the configuration of the UAV.

[2 hrs 30 mins]