Prof. Dr. G. Schöner, Institut für Neuroinformatik gregor.schoener@rub.de

Autonomous robotics

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Exercise 3 Attractor Dynamics for vehicle motion

Read the paper by Bicho, Mallet, Schöner (2008): Using Attractor Dynamics to Control Autonomous Vehicle Motion. In: *Proceedings of the 24th Annual Conference of the IEEE Industrial Electronics Society* (IECON98), p. 1176-1182, Aachen, Germany (reprint available on web page). This covers much of the contents of lecture 3.

1 Obstacle dynamics Eqs. 1, 2, 3 of the paper

You have analyzed Eq. (1) in last week's exercise. Now we'll focus on how the terms depend on sensory information in the "sub-symbolic" approach.

1. Make a plot of Eq. (2): $\lambda(d)$, where d is the distance measured by a sensor. Explain the geometrical meaning of the two parameters, β_1 and β_2 and mark the plot to highlight that meaning.

2. Give a geometrical justification for Eq. (3). [Hint: Draw the vehicle, its detection range, $\Delta\Theta$, an obstacle that covers the entire detection range at the measured distance, d, and the robot at that distance. Interpet the $R/(R+d)$ as the tangent of an angle (R short for R_{robot}).]

3. Plot Eq. (3) numerically by giving reasonable values to the parameters (e.g. $\Delta\Theta = 60\,\text{deg}$, $R = 0.2$ meters, and $d >= R$).

4. Plot two force-lets of Eq. (1) that are separated by $1.25 * \Delta\Theta$ into the same plot together with their sums. Make that plot for a short distance (e.g. $d = 2R$) and a large distance (e.g. $d = 8R$) (assume that same distance applies for both force-lets). Interpret the difference you see between these two cases.

2 Invariance

The robot is faced with single obstacle at distance $d = 5R$. Assume the obstacle's size is such that is covers exactly the angular range, $\Delta\theta = 60\,\text{deg}$ of the distance sensors. Assume also, that the sensor returns the true distance to that obstacle, irresprective of how much of the sensor's angular range is covered by the obstacle.

Now imagine the obstacle being moved around the robot on a circle at a constant distance from the robot. For any given sensor, it may lie outside the angular detection cone for some positions of the obstacle, and inside the cone for other positions.

1. Make a bird's eyes view of the situation and introduce notation as in the paper, so that you mathematically characterize when the obstacle falls into a particular sensor's cone of detection. [Important: represent the angle to the obstacle relative to a fixed world axis, the same world axis relative to which you measure heading direction... or else everything becomes too complicated.]

2. Remind yourself what the repulsion force-let looks like when the object is in the cone of detection of an indidvidual sensor and when it is outside. Simplify the model by only taking the linear part into account. What is the heading direction from which the sum of two neighboring force-lets repel when the obstacle falls into the cones of detection of these two neighboring sensors?

3. Make a plot of the direction of repulsion as a function of the angle at which the obstacle is located as it circles around the robot. Compare that direction of repulsion to the true direction in which the obstacle lies.

4. Now think about the same setting, but with the obstacle staying put and the vehicle rotating on the spot. Make a plot of the direction of repulsion as a function of the orientation of the vehicle. Interpret this plot in light of the issue of "invariance" mentioned in the lecture.

3 Puzzler

Does the obstacle forcel-let (Equ (1)) of the front sensor contribute to obstacle avoidance?