Continuous State Space Q-Learning for control of Nonlinear Systems

ten Hagen, S.H.G.

Citation for published version (APA):
Appendix B

The Mobile Robot

B.1 The robot

The robot we used in the experiments is a Nomad Super Scout II, see figure B.1. This is a mobile robot with a two wheel differential drive at its geometric center. The drive motors of both wheels are independent and the width of the robot is 41 cm. The maximum speed is 1 m/s at an acceleration of 2 m/s².

The robot has a MC68332 processor board for the low level processes. These include sending the control commands to the drive motors, but also keeping track of the position and orientation of the robot by means of odometry. All other software runs on a second board equipped with a Pentium II 233Mhz processor.

Figure B.1. The Nomad Super Scout II
B.2 The model of the robot

The mobile robot has three degrees of freedom. These define the robot’s position $x$ and $y$ in the world and the robot’s orientation $\phi$. The speeds of the left and right wheel $v_l$ and $v_r$ are the control actions that make the robot move.

Because the geometric center of the robot is right between the wheels, the control actions can also be indicated by a traversal speed $v_t$ and rotational speed $\omega$. The traversal speed is given by:

$$v_t = \frac{1}{2}(v_l + v_r) \quad (B.1)$$

The rotational speed is given by:

$$\omega = \frac{1}{W}(v_r - v_l) \quad (B.2)$$

where $W$ indicates the width of the robot (41 cm).

The change of position and orientation is given by:

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\phi} \end{bmatrix} = \begin{bmatrix} \sin(\phi)v_t \\ \cos(\phi)v_t \\ \omega \end{bmatrix} \quad (B.3)$$

We can notice here that the change of the orientation is independent of the position, but the change of position depends on the orientation. We also have to note that (B.3) is a simplified model of the robot, since it does not take into account the acceleration.

By taking the integral over a fixed sample time interval $T$, the discrete time state transition can be derived:

$$\begin{align*}
    x_{k+1} &= x_k + \frac{v_t}{\omega} (\sin(\phi_k + T\omega) - \sin(\phi_k)) \\
    y_{k+1} &= y_k + \frac{v_t}{\omega} (\cos(\phi_k) - \cos(\phi_k + T\omega)) \\
    \phi_{k+1} &= \phi_k + \omega T 
\end{align*} \quad (B.4)-(B.6)$$

This hold for any $\omega \neq 0$. If $\omega = 0$, the orientation does not change and $x_{k+1} = x_k + T\sin\phi_k$ and $y_{k+1} = y_k + T\cos\phi_k$. 