

Table 1: Positional error: Average error is computed for the last 300 nodes, i.e. for the last 0.6s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008s with a real-time control frequency of 125 Hz. Using  $\beta = 1.0$ .  
Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	5-rotated	10-rotated	20-rotated
x	0.05	-1	$9.655 \cdot 10^{-01}$	$2.747 \cdot 10^{-03}$	<b><math>5.039 \cdot 10^{-04}</math></b>
x	0.05	+1	$1.556 \cdot 10^{-01}$	$6.701 \cdot 10^{-03}$	<b><math>4.380 \cdot 10^{-03}</math></b>
x	0.10	-1	$7.463 \cdot 10^{-01}$	<b><math>6.879 \cdot 10^{-03}</math></b>	$7.065 \cdot 10^{-03}$
x	0.10	+1	$6.953 \cdot 10^{-01}$	$2.635 \cdot 10^{-02}$	<b><math>7.760 \cdot 10^{-03}</math></b>
x	0.15	-1	$1.304 \cdot 10^{+00}$	$1.637 \cdot 10^{-02}$	<b><math>3.100 \cdot 10^{-03}</math></b>
x	0.15	+1	$7.994 \cdot 10^{-01}$	$2.051 \cdot 10^{-02}$	<b><math>4.160 \cdot 10^{-04}</math></b>
y	0.05	-1	$9.085 \cdot 10^{-01}$	$7.931 \cdot 10^{-03}$	<b><math>5.408 \cdot 10^{-04}</math></b>
y	0.05	+1	$7.291 \cdot 10^{-01}$	$9.160 \cdot 10^{-03}$	<b><math>1.339 \cdot 10^{-03}</math></b>
y	0.10	-1	$1.397 \cdot 10^{-01}$	$3.340 \cdot 10^{-03}$	<b><math>9.523 \cdot 10^{-04}</math></b>
y	0.10	+1	$8.774 \cdot 10^{-01}$	$1.343 \cdot 10^{-02}$	<b><math>1.523 \cdot 10^{-03}</math></b>
y	0.15	-1	$7.818 \cdot 10^{-01}$	$7.713 \cdot 10^{-02}$	<b><math>7.734 \cdot 10^{-04}</math></b>
y	0.15	+1	$2.600 \cdot 10^{-01}$	$5.699 \cdot 10^{-03}$	<b><math>2.741 \cdot 10^{-03}</math></b>
z	0.05	-1	$3.400 \cdot 10^{-03}$	$2.355 \cdot 10^{-03}$	<b><math>8.931 \cdot 10^{-04}</math></b>
z	0.05	+1	$1.066 \cdot 10^{+00}$	$4.147 \cdot 10^{-03}$	<b><math>1.733 \cdot 10^{-03}</math></b>
z	0.10	-1	$1.026 \cdot 10^{+00}$	$8.625 \cdot 10^{-01}$	<b><math>1.121 \cdot 10^{-03}</math></b>
z	0.10	+1	$1.399 \cdot 10^{+00}$	$4.433 \cdot 10^{-03}$	<b><math>1.679 \cdot 10^{-03}</math></b>
z	0.15	-1	$9.817 \cdot 10^{-01}$	$2.438 \cdot 10^{-02}$	<b><math>4.462 \cdot 10^{-04}</math></b>
z	0.15	+1	$9.533 \cdot 10^{-01}$	$6.319 \cdot 10^{-03}$	<b><math>5.024 \cdot 10^{-04}</math></b>

Table 2: Positional error: Average error is computed for the last 300 nodes, i.e. for the last 0.6s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008s with a real-time control frequency of 125 Hz. Using  $\beta = 1.2$ .  
Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	5-rotated	10-rotated	20-rotated
x	0.05	-1	$7.177 \cdot 10^{-01}$	$2.436 \cdot 10^{-03}$	<b><math>7.460 \cdot 10^{-04}</math></b>
x	0.05	+1	$8.194 \cdot 10^{-01}$	$4.181 \cdot 10^{-03}$	<b><math>1.132 \cdot 10^{-03}</math></b>
x	0.10	-1	$1.034 \cdot 10^{+00}$	$4.596 \cdot 10^{-03}$	<b><math>2.512 \cdot 10^{-03}</math></b>
x	0.10	+1	$7.250 \cdot 10^{-01}$	$7.123 \cdot 10^{-01}$	<b><math>3.497 \cdot 10^{-03}</math></b>
x	0.15	-1	$3.828 \cdot 10^{-02}$	<b><math>2.061 \cdot 10^{-03}</math></b>	$3.748 \cdot 10^{-03}$
x	0.15	+1	$8.797 \cdot 10^{-01}$	<b><math>1.855 \cdot 10^{-03}</math></b>	$2.612 \cdot 10^{-03}$
y	0.05	-1	$7.131 \cdot 10^{-01}$	$2.321 \cdot 10^{-03}$	<b><math>1.655 \cdot 10^{-03}</math></b>
y	0.05	+1	$1.110 \cdot 10^{+00}$	$1.432 \cdot 10^{-03}$	<b><math>4.821 \cdot 10^{-04}</math></b>
y	0.10	-1	$8.915 \cdot 10^{-01}$	$2.205 \cdot 10^{-03}$	<b><math>8.017 \cdot 10^{-04}</math></b>
y	0.10	+1	$8.973 \cdot 10^{-01}$	$3.986 \cdot 10^{-03}$	<b><math>1.042 \cdot 10^{-03}</math></b>
y	0.15	-1	$9.166 \cdot 10^{-01}$	$6.206 \cdot 10^{-01}$	<b><math>5.027 \cdot 10^{-04}</math></b>
y	0.15	+1	$7.723 \cdot 10^{-01}$	$6.031 \cdot 10^{-03}$	<b><math>3.184 \cdot 10^{-04}</math></b>
z	0.05	-1	$7.760 \cdot 10^{-01}$	$4.792 \cdot 10^{-03}$	<b><math>2.529 \cdot 10^{-04}</math></b>
z	0.05	+1	$7.151 \cdot 10^{-01}$	$3.510 \cdot 10^{-03}$	<b><math>7.402 \cdot 10^{-04}</math></b>
z	0.10	-1	$8.494 \cdot 10^{-01}$	$5.716 \cdot 10^{-03}$	<b><math>3.604 \cdot 10^{-03}</math></b>
z	0.10	+1	$9.422 \cdot 10^{-01}$	$4.403 \cdot 10^{-03}$	<b><math>1.430 \cdot 10^{-03}</math></b>
z	0.15	-1	$7.573 \cdot 10^{-01}$	$9.834 \cdot 10^{-03}$	<b><math>3.471 \cdot 10^{-03}</math></b>
z	0.15	+1	$7.960 \cdot 10^{-01}$	$7.205 \cdot 10^{-03}$	<b><math>3.125 \cdot 10^{-03}</math></b>

Table 3: Positional error: Average error is computed for the last 300 nodes, i.e. for the last 0.6 s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008 s with a real-time control frequency of 125 Hz. Using  $\beta = 1.4$ . Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	5-rotated	10-rotated	20-rotated
x	0.05	-1	$6.103 \cdot 10^{-01}$	$2.544 \cdot 10^{-03}$	<b><math>1.117 \cdot 10^{-03}</math></b>
x	0.05	+1	$8.169 \cdot 10^{-01}$	$3.426 \cdot 10^{-03}$	<b><math>2.371 \cdot 10^{-03}</math></b>
x	0.10	-1	$2.280 \cdot 10^{-02}$	<b><math>2.645 \cdot 10^{-03}</math></b>	$4.181 \cdot 10^{-03}$
x	0.10	+1	$6.521 \cdot 10^{-01}$	$1.137 \cdot 10^{+00}$	<b><math>2.870 \cdot 10^{-03}</math></b>
x	0.15	-1	$7.712 \cdot 10^{-01}$	$6.348 \cdot 10^{-03}$	<b><math>2.740 \cdot 10^{-03}</math></b>
x	0.15	+1	$8.921 \cdot 10^{-01}$	$3.128 \cdot 10^{-03}$	<b><math>2.981 \cdot 10^{-03}</math></b>
y	0.05	-1	$9.114 \cdot 10^{-01}$	$3.324 \cdot 10^{-03}$	<b><math>2.170 \cdot 10^{-04}</math></b>
y	0.05	+1	$9.143 \cdot 10^{-01}$	$2.254 \cdot 10^{-03}$	<b><math>3.662 \cdot 10^{-04}</math></b>
y	0.10	-1	$8.895 \cdot 10^{-01}$	$5.751 \cdot 10^{-03}$	<b><math>3.931 \cdot 10^{-04}</math></b>
y	0.10	+1	$8.230 \cdot 10^{-01}$	$2.894 \cdot 10^{-03}$	<b><math>3.607 \cdot 10^{-04}</math></b>
y	0.15	-1	$7.583 \cdot 10^{-01}$	$1.035 \cdot 10^{+00}$	<b><math>1.834 \cdot 10^{-03}</math></b>
y	0.15	+1	$1.459 \cdot 10^{+00}$	$1.517 \cdot 10^{-03}$	<b><math>2.488 \cdot 10^{-04}</math></b>
z	0.05	-1	$8.681 \cdot 10^{-01}$	$6.548 \cdot 10^{-03}$	<b><math>2.174 \cdot 10^{-04}</math></b>
z	0.05	+1	$1.053 \cdot 10^{+00}$	$6.842 \cdot 10^{-03}$	<b><math>3.812 \cdot 10^{-03}</math></b>
z	0.10	-1	$6.629 \cdot 10^{-01}$	$8.238 \cdot 10^{-03}$	<b><math>2.786 \cdot 10^{-03}</math></b>
z	0.10	+1	$7.947 \cdot 10^{-01}$	$2.510 \cdot 10^{-03}$	<b><math>5.063 \cdot 10^{-04}</math></b>
z	0.15	-1	$8.602 \cdot 10^{-01}$	$1.031 \cdot 10^{-02}$	<b><math>1.371 \cdot 10^{-03}</math></b>
z	0.15	+1	$8.231 \cdot 10^{-01}$	$1.319 \cdot 10^{-03}$	<b><math>2.360 \cdot 10^{-04}</math></b>

Table 4: Rotational error: Average error is computed for the last 300 nodes, i.e. for the last 0.6 s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008 s with a real-time control frequency of 125 Hz. Using  $\beta = 1.0$ . Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	5-rotated	10-rotated	20-rotated
x	0.05	-1	$8.117 \cdot 10^{+01}$	$1.042 \cdot 10^{-02}$	<b><math>4.146 \cdot 10^{-03}</math></b>
x	0.05	+1	$1.073 \cdot 10^{+01}$	<b><math>1.791 \cdot 10^{-02}</math></b>	$2.296 \cdot 10^{-02}$
x	0.10	-1	$8.463 \cdot 10^{+01}$	<b><math>2.404 \cdot 10^{-02}</math></b>	$4.303 \cdot 10^{-02}$
x	0.10	+1	$9.826 \cdot 10^{+01}$	$6.793 \cdot 10^{-02}$	<b><math>4.298 \cdot 10^{-02}</math></b>
x	0.15	-1	$9.034 \cdot 10^{+01}$	$5.159 \cdot 10^{-02}$	<b><math>2.105 \cdot 10^{-02}</math></b>
x	0.15	+1	$8.967 \cdot 10^{+01}$	$5.562 \cdot 10^{-02}$	<b><math>8.481 \cdot 10^{-03}</math></b>
y	0.05	-1	$8.179 \cdot 10^{+01}$	$1.883 \cdot 10^{-02}$	<b><math>4.121 \cdot 10^{-03}</math></b>
y	0.05	+1	$9.971 \cdot 10^{+01}$	$2.845 \cdot 10^{-02}$	<b><math>5.859 \cdot 10^{-03}</math></b>
y	0.10	-1	$3.525 \cdot 10^{-01}$	$9.685 \cdot 10^{-03}$	<b><math>7.942 \cdot 10^{-03}</math></b>
y	0.10	+1	$1.040 \cdot 10^{+02}$	$4.003 \cdot 10^{-02}$	<b><math>6.913 \cdot 10^{-03}</math></b>
y	0.15	-1	$9.218 \cdot 10^{+01}$	$2.032 \cdot 10^{-01}$	<b><math>4.978 \cdot 10^{-03}</math></b>
y	0.15	+1	$5.823 \cdot 10^{-01}$	$1.594 \cdot 10^{-02}$	<b><math>1.446 \cdot 10^{-02}</math></b>
z	0.05	-1	$3.662 \cdot 10^{-02}$	$1.092 \cdot 10^{-02}$	<b><math>3.241 \cdot 10^{-03}</math></b>
z	0.05	+1	$9.741 \cdot 10^{+01}$	$1.308 \cdot 10^{-02}$	<b><math>8.225 \cdot 10^{-03}</math></b>
z	0.10	-1	$9.540 \cdot 10^{+01}$	$9.082 \cdot 10^{+01}$	<b><math>8.174 \cdot 10^{-03}</math></b>
z	0.10	+1	$8.928 \cdot 10^{+01}$	$1.489 \cdot 10^{-02}$	<b><math>8.288 \cdot 10^{-03}</math></b>
z	0.15	-1	$9.817 \cdot 10^{+01}$	$7.379 \cdot 10^{-02}$	<b><math>2.674 \cdot 10^{-03}</math></b>
z	0.15	+1	$1.091 \cdot 10^{+02}$	$1.179 \cdot 10^{-01}$	<b><math>8.190 \cdot 10^{-03}</math></b>

Table 5: Rotational error: Average error is computed for the last 300 nodes, i.e. for the last 0.6 s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008 s with a real-time control frequency of 125 Hz. Using  $\beta = 1.2$ . Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	5-rotated	10-rotated	20-rotated
x	0.05	-1	$8.687 \cdot 10^{+01}$	$8.792 \cdot 10^{-03}$	<b><math>5.570 \cdot 10^{-03}</math></b>
x	0.05	+1	$8.381 \cdot 10^{+01}$	$1.170 \cdot 10^{-02}$	<b><math>9.102 \cdot 10^{-03}</math></b>
x	0.10	-1	$9.270 \cdot 10^{+01}$	<b><math>1.524 \cdot 10^{-02}</math></b>	$1.698 \cdot 10^{-02}$
x	0.10	+1	$9.493 \cdot 10^{+01}$	$9.179 \cdot 10^{+01}$	<b><math>2.229 \cdot 10^{-02}</math></b>
x	0.15	-1	$1.024 \cdot 10^{-01}$	<b><math>1.035 \cdot 10^{-02}</math></b>	$2.599 \cdot 10^{-02}$
x	0.15	+1	$9.470 \cdot 10^{+01}$	<b><math>1.190 \cdot 10^{-02}</math></b>	$1.639 \cdot 10^{-02}$
y	0.05	-1	$7.841 \cdot 10^{+01}$	<b><math>8.451 \cdot 10^{-03}</math></b>	$9.446 \cdot 10^{-03}$
y	0.05	+1	$8.571 \cdot 10^{+01}$	$7.226 \cdot 10^{-03}$	<b><math>1.179 \cdot 10^{-03}</math></b>
y	0.10	-1	$9.826 \cdot 10^{+01}$	<b><math>5.636 \cdot 10^{-03}</math></b>	$6.607 \cdot 10^{-03}$
y	0.10	+1	$9.440 \cdot 10^{+01}$	$1.352 \cdot 10^{-02}$	<b><math>3.898 \cdot 10^{-03}</math></b>
y	0.15	-1	$9.423 \cdot 10^{+01}$	$9.130 \cdot 10^{+01}$	<b><math>5.120 \cdot 10^{-03}</math></b>
y	0.15	+1	$8.918 \cdot 10^{+01}$	$1.458 \cdot 10^{-01}$	<b><math>1.143 \cdot 10^{-03}</math></b>
z	0.05	-1	$1.057 \cdot 10^{+02}$	$6.323 \cdot 10^{-02}$	<b><math>2.100 \cdot 10^{-04}</math></b>
z	0.05	+1	$9.971 \cdot 10^{+01}$	$1.410 \cdot 10^{-02}$	<b><math>3.342 \cdot 10^{-03}</math></b>
z	0.10	-1	$9.293 \cdot 10^{+01}$	$3.154 \cdot 10^{-02}$	<b><math>1.753 \cdot 10^{-02}</math></b>
z	0.10	+1	$7.318 \cdot 10^{+01}$	$1.481 \cdot 10^{-02}$	<b><math>6.300 \cdot 10^{-03}</math></b>
z	0.15	-1	$1.057 \cdot 10^{+02}$	$2.810 \cdot 10^{-02}$	<b><math>1.678 \cdot 10^{-02}</math></b>
z	0.15	+1	$8.659 \cdot 10^{+01}$	$2.441 \cdot 10^{-02}$	<b><math>1.529 \cdot 10^{-02}</math></b>

Table 6: Rotational error: Average error is computed for the last 300 nodes, i.e. for the last 0.6 s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008 s with a real-time control frequency of 125 Hz. Using  $\beta = 1.4$ . Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	5-rotated	10-rotated	20-rotated
x	0.05	-1	$8.956 \cdot 10^{+01}$	<b><math>7.817 \cdot 10^{-03}</math></b>	$8.354 \cdot 10^{-03}$
x	0.05	+1	$9.328 \cdot 10^{+01}$	<b><math>1.007 \cdot 10^{-02}</math></b>	$1.425 \cdot 10^{-02}$
x	0.10	-1	$8.194 \cdot 10^{-02}$	<b><math>9.760 \cdot 10^{-03}</math></b>	$2.575 \cdot 10^{-02}$
x	0.10	+1	$8.231 \cdot 10^{+01}$	$8.804 \cdot 10^{+01}$	<b><math>1.680 \cdot 10^{-02}</math></b>
x	0.15	-1	$8.643 \cdot 10^{+01}$	$2.107 \cdot 10^{-02}$	<b><math>1.971 \cdot 10^{-02}</math></b>
x	0.15	+1	$8.857 \cdot 10^{+01}$	<b><math>1.017 \cdot 10^{-02}</math></b>	$1.863 \cdot 10^{-02}$
y	0.05	-1	$9.785 \cdot 10^{+01}$	$8.778 \cdot 10^{-03}$	<b><math>1.509 \cdot 10^{-03}</math></b>
y	0.05	+1	$7.681 \cdot 10^{+01}$	$7.439 \cdot 10^{-03}$	<b><math>4.179 \cdot 10^{-04}</math></b>
y	0.10	-1	$1.028 \cdot 10^{+02}$	$1.425 \cdot 10^{-02}$	<b><math>1.691 \cdot 10^{-03}</math></b>
y	0.10	+1	$9.577 \cdot 10^{+01}$	$8.266 \cdot 10^{-03}$	<b><math>1.285 \cdot 10^{-03}</math></b>
y	0.15	-1	$8.103 \cdot 10^{+01}$	$1.019 \cdot 10^{+02}$	<b><math>9.920 \cdot 10^{-03}</math></b>
y	0.15	+1	$9.368 \cdot 10^{+01}$	$6.721 \cdot 10^{-03}$	<b><math>1.639 \cdot 10^{-03}</math></b>
z	0.05	-1	$8.303 \cdot 10^{+01}$	$2.268 \cdot 10^{-01}$	<b><math>2.422 \cdot 10^{-03}</math></b>
z	0.05	+1	$9.326 \cdot 10^{+01}$	<b><math>1.778 \cdot 10^{-02}</math></b>	$1.935 \cdot 10^{-02}$
z	0.10	-1	$8.262 \cdot 10^{+01}$	$2.234 \cdot 10^{-02}$	<b><math>1.315 \cdot 10^{-02}</math></b>
z	0.10	+1	$8.463 \cdot 10^{+01}$	$1.008 \cdot 10^{-02}$	<b><math>4.885 \cdot 10^{-03}</math></b>
z	0.15	-1	$9.609 \cdot 10^{+01}$	$2.969 \cdot 10^{-02}$	<b><math>9.820 \cdot 10^{-03}</math></b>
z	0.15	+1	$8.463 \cdot 10^{+01}$	$3.631 \cdot 10^{-03}$	<b><math>2.108 \cdot 10^{-03}</math></b>

Table 7: Computational time: Average error is computed for the last 300 nodes, i.e. for the last 0.6s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008 s with a real-time control frequency of 125 Hz. Using  $\beta = 1.0$ . Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	mpc-5-rotated	mpc-10-rotated	mpc-20-rotated
x	0.05	-1	<b>2.080</b> · 10 <sup>+00</sup>	5.121 · 10 <sup>+00</sup>	6.011 · 10 <sup>+00</sup>
x	0.05	+1	<b>2.340</b> · 10 <sup>+00</sup>	4.618 · 10 <sup>+00</sup>	1.328 · 10 <sup>+01</sup>
x	0.10	-1	<b>2.317</b> · 10 <sup>+00</sup>	5.000 · 10 <sup>+00</sup>	1.376 · 10 <sup>+01</sup>
x	0.10	+1	<b>2.238</b> · 10 <sup>+00</sup>	3.882 · 10 <sup>+00</sup>	1.384 · 10 <sup>+01</sup>
x	0.15	-1	<b>2.128</b> · 10 <sup>+00</sup>	5.359 · 10 <sup>+00</sup>	1.018 · 10 <sup>+01</sup>
x	0.15	+1	<b>1.804</b> · 10 <sup>+00</sup>	4.263 · 10 <sup>+00</sup>	7.045 · 10 <sup>+00</sup>
y	0.05	-1	<b>2.234</b> · 10 <sup>+00</sup>	5.254 · 10 <sup>+00</sup>	6.361 · 10 <sup>+00</sup>
y	0.05	+1	<b>2.353</b> · 10 <sup>+00</sup>	4.481 · 10 <sup>+00</sup>	7.900 · 10 <sup>+00</sup>
y	0.10	-1	<b>2.702</b> · 10 <sup>+00</sup>	3.894 · 10 <sup>+00</sup>	7.868 · 10 <sup>+00</sup>
y	0.10	+1	<b>3.348</b> · 10 <sup>+00</sup>	6.480 · 10 <sup>+00</sup>	7.532 · 10 <sup>+00</sup>
y	0.15	-1	<b>2.088</b> · 10 <sup>+00</sup>	5.583 · 10 <sup>+00</sup>	7.256 · 10 <sup>+00</sup>
y	0.15	+1	<b>2.061</b> · 10 <sup>+00</sup>	6.533 · 10 <sup>+00</sup>	9.164 · 10 <sup>+00</sup>
z	0.05	-1	<b>1.616</b> · 10 <sup>+00</sup>	3.652 · 10 <sup>+00</sup>	6.278 · 10 <sup>+00</sup>
z	0.05	+1	<b>1.900</b> · 10 <sup>+00</sup>	5.449 · 10 <sup>+00</sup>	9.167 · 10 <sup>+00</sup>
z	0.10	-1	<b>2.042</b> · 10 <sup>+00</sup>	5.336 · 10 <sup>+00</sup>	8.706 · 10 <sup>+00</sup>
z	0.10	+1	<b>1.452</b> · 10 <sup>+00</sup>	5.071 · 10 <sup>+00</sup>	9.423 · 10 <sup>+00</sup>
z	0.15	-1	<b>2.062</b> · 10 <sup>+00</sup>	5.392 · 10 <sup>+00</sup>	1.185 · 10 <sup>+01</sup>
z	0.15	+1	<b>2.247</b> · 10 <sup>+00</sup>	6.047 · 10 <sup>+00</sup>	7.994 · 10 <sup>+00</sup>

Table 8: Computational time: Average error is computed for the last 300 nodes, i.e. for the last 0.6s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008 s with a real-time control frequency of 125 Hz. Using  $\beta = 1.2$ . Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	mpc-5-rotated	mpc-10-rotated	mpc-20-rotated
x	0.05	-1	<b>2.824</b> · 10 <sup>+00</sup>	4.477 · 10 <sup>+00</sup>	7.237 · 10 <sup>+00</sup>
x	0.05	+1	<b>1.962</b> · 10 <sup>+00</sup>	5.067 · 10 <sup>+00</sup>	8.797 · 10 <sup>+00</sup>
x	0.10	-1	<b>2.241</b> · 10 <sup>+00</sup>	3.351 · 10 <sup>+00</sup>	1.173 · 10 <sup>+01</sup>
x	0.10	+1	<b>2.313</b> · 10 <sup>+00</sup>	4.690 · 10 <sup>+00</sup>	1.405 · 10 <sup>+01</sup>
x	0.15	-1	<b>1.765</b> · 10 <sup>+00</sup>	4.574 · 10 <sup>+00</sup>	1.002 · 10 <sup>+01</sup>
x	0.15	+1	<b>1.782</b> · 10 <sup>+00</sup>	3.609 · 10 <sup>+00</sup>	9.842 · 10 <sup>+00</sup>
y	0.05	-1	<b>2.034</b> · 10 <sup>+00</sup>	4.613 · 10 <sup>+00</sup>	1.034 · 10 <sup>+01</sup>
y	0.05	+1	<b>2.068</b> · 10 <sup>+00</sup>	3.800 · 10 <sup>+00</sup>	5.256 · 10 <sup>+00</sup>
y	0.10	-1	<b>2.352</b> · 10 <sup>+00</sup>	3.975 · 10 <sup>+00</sup>	5.889 · 10 <sup>+00</sup>
y	0.10	+1	<b>2.156</b> · 10 <sup>+00</sup>	3.482 · 10 <sup>+00</sup>	5.444 · 10 <sup>+00</sup>
y	0.15	-1	<b>2.297</b> · 10 <sup>+00</sup>	5.385 · 10 <sup>+00</sup>	7.708 · 10 <sup>+00</sup>
y	0.15	+1	<b>1.846</b> · 10 <sup>+00</sup>	4.085 · 10 <sup>+00</sup>	2.258 · 10 <sup>+00</sup>
z	0.05	-1	<b>1.660</b> · 10 <sup>+00</sup>	5.634 · 10 <sup>+00</sup>	8.901 · 10 <sup>+00</sup>
z	0.05	+1	<b>1.814</b> · 10 <sup>+00</sup>	5.194 · 10 <sup>+00</sup>	1.085 · 10 <sup>+01</sup>
z	0.10	-1	<b>1.994</b> · 10 <sup>+00</sup>	5.205 · 10 <sup>+00</sup>	1.249 · 10 <sup>+01</sup>
z	0.10	+1	<b>1.856</b> · 10 <sup>+00</sup>	5.594 · 10 <sup>+00</sup>	1.052 · 10 <sup>+01</sup>
z	0.15	-1	<b>1.965</b> · 10 <sup>+00</sup>	6.853 · 10 <sup>+00</sup>	1.167 · 10 <sup>+01</sup>
z	0.15	+1	<b>2.482</b> · 10 <sup>+00</sup>	4.447 · 10 <sup>+00</sup>	8.156 · 10 <sup>+00</sup>

Table 9: Computational time: Average error is computed for the last 300 nodes, i.e. for the last 0.6s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008s with a real-time control frequency of 125 Hz. Using  $\beta = 1.4$ . Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	mpc-5-rotated	mpc-10-rotated	mpc-20-rotated
x	0.05	-1	<b>1.377</b> · 10 <sup>+00</sup>	5.429 · 10 <sup>+00</sup>	7.748 · 10 <sup>+00</sup>
x	0.05	+1	<b>1.758</b> · 10 <sup>+00</sup>	4.347 · 10 <sup>+00</sup>	1.166 · 10 <sup>+01</sup>
x	0.10	-1	<b>1.831</b> · 10 <sup>+00</sup>	3.823 · 10 <sup>+00</sup>	1.174 · 10 <sup>+01</sup>
x	0.10	+1	<b>1.672</b> · 10 <sup>+00</sup>	4.081 · 10 <sup>+00</sup>	1.158 · 10 <sup>+01</sup>
x	0.15	-1	<b>1.962</b> · 10 <sup>+00</sup>	4.337 · 10 <sup>+00</sup>	1.039 · 10 <sup>+01</sup>
x	0.15	+1	<b>1.866</b> · 10 <sup>+00</sup>	3.238 · 10 <sup>+00</sup>	9.545 · 10 <sup>+00</sup>
y	0.05	-1	<b>2.251</b> · 10 <sup>+00</sup>	3.418 · 10 <sup>+00</sup>	6.805 · 10 <sup>+00</sup>
y	0.05	+1	<b>1.888</b> · 10 <sup>+00</sup>	2.886 · 10 <sup>+00</sup>	5.031 · 10 <sup>+00</sup>
y	0.10	-1	<b>2.576</b> · 10 <sup>+00</sup>	3.469 · 10 <sup>+00</sup>	6.497 · 10 <sup>+00</sup>
y	0.10	+1	<b>1.973</b> · 10 <sup>+00</sup>	3.266 · 10 <sup>+00</sup>	3.116 · 10 <sup>+00</sup>
y	0.15	-1	2.485 · 10 <sup>+00</sup>	<b>1.742</b> · 10 <sup>+00</sup>	7.826 · 10 <sup>+00</sup>
y	0.15	+1	<b>1.868</b> · 10 <sup>+00</sup>	3.403 · 10 <sup>+00</sup>	3.531 · 10 <sup>+00</sup>
z	0.05	-1	<b>1.591</b> · 10 <sup>+00</sup>	4.538 · 10 <sup>+00</sup>	6.413 · 10 <sup>+00</sup>
z	0.05	+1	<b>2.082</b> · 10 <sup>+00</sup>	6.133 · 10 <sup>+00</sup>	1.364 · 10 <sup>+01</sup>
z	0.10	-1	<b>1.967</b> · 10 <sup>+00</sup>	6.249 · 10 <sup>+00</sup>	1.102 · 10 <sup>+01</sup>
z	0.10	+1	<b>2.181</b> · 10 <sup>+00</sup>	4.656 · 10 <sup>+00</sup>	7.429 · 10 <sup>+00</sup>
z	0.15	-1	<b>2.438</b> · 10 <sup>+00</sup>	4.606 · 10 <sup>+00</sup>	1.058 · 10 <sup>+01</sup>
z	0.15	+1	<b>2.099</b> · 10 <sup>+00</sup>	3.089 · 10 <sup>+00</sup>	5.973 · 10 <sup>+00</sup>

Table 10: Solver configuration: We used a factor of 4 for the integration time, i.e. the integration constant is 0.008s with a real-time control frequency of 125 Hz. Using  $\beta = 1.0$ . Bold types of minimum values are considered experiment (i.e. row) wise.

penalty	rotated
mpc_u_pen	1.000 · 10 <sup>-02</sup>
mpc_x_pen	7.000 · 10 <sup>+04</sup>
mpc_rot_pen	1.000 · 10 <sup>+05</sup>
mpc_state_bound_pen	0.000 · 10 <sup>+00</sup>
mpc_state_pen	0.000 · 10 <sup>+00</sup>
mpc_q_pen	5.000 · 10 <sup>-03</sup>
mpc_v_pen	3.000 · 10 <sup>-02</sup>

Table 11: Positional error (DDP): Average error is computed for the last 300 nodes, i.e. for the last 0.6 s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008 s with a real-time control frequency of 125 Hz. Using  $\beta = 1.4$ . Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	rotated
x	0.05	-1	$6.953 \cdot 10^{-04}$
x	0.05	+1	$7.326 \cdot 10^{-04}$
x	0.10	-1	$6.534 \cdot 10^{-04}$
x	0.10	+1	$7.165 \cdot 10^{-04}$
x	0.15	-1	$7.048 \cdot 10^{-04}$
x	0.15	+1	$8.183 \cdot 10^{-04}$
y	0.05	-1	$4.722 \cdot 10^{-04}$
y	0.05	+1	$7.929 \cdot 10^{-04}$
y	0.10	-1	$5.670 \cdot 10^{-04}$
y	0.10	+1	$1.051 \cdot 10^{-03}$
y	0.15	-1	$2.582 \cdot 10^{-04}$
y	0.15	+1	$1.162 \cdot 10^{-03}$
z	0.05	-1	$6.538 \cdot 10^{-04}$
z	0.05	+1	$5.701 \cdot 10^{-04}$
z	0.10	-1	$7.382 \cdot 10^{-04}$
z	0.10	+1	$5.777 \cdot 10^{-04}$
z	0.15	-1	$7.896 \cdot 10^{-04}$
z	0.15	+1	$5.671 \cdot 10^{-04}$

Table 12: Rotational error (DDP): Average error is computed for the last 300 nodes, i.e. for the last 0.6 s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008 s with a real-time control frequency of 125 Hz. Using  $\beta = 1.4$ . Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	rotated
x	0.05	-1	$7.238 \cdot 10^{-02}$
x	0.05	+1	$8.037 \cdot 10^{-02}$
x	0.10	-1	$7.491 \cdot 10^{-02}$
x	0.10	+1	$8.669 \cdot 10^{-02}$
x	0.15	-1	$7.959 \cdot 10^{-02}$
x	0.15	+1	$8.444 \cdot 10^{-02}$
y	0.05	-1	$4.876 \cdot 10^{-02}$
y	0.05	+1	$9.231 \cdot 10^{-02}$
y	0.10	-1	$2.927 \cdot 10^{-02}$
y	0.10	+1	$1.107 \cdot 10^{-01}$
y	0.15	-1	$3.107 \cdot 10^{-02}$
y	0.15	+1	$1.346 \cdot 10^{-01}$
z	0.05	-1	$7.908 \cdot 10^{-02}$
z	0.05	+1	$6.586 \cdot 10^{-02}$
z	0.10	-1	$8.823 \cdot 10^{-02}$
z	0.10	+1	$6.133 \cdot 10^{-02}$
z	0.15	-1	$9.309 \cdot 10^{-02}$
z	0.15	+1	$5.907 \cdot 10^{-02}$

Table 13: Computational time (DDP): Average error is computed for the last 300 nodes, i.e. for the last 0.6 s of the trajectory. We used a factor of 4 for the integration time, i.e. the integration constant is 0.008 s with a real-time control frequency of 125 Hz. Using  $\beta = 1.4$ . Bold types of minimum values are considered experiment (i.e. row) wise.

direction	radius	orientation	ddp-rotated
x	0.05	-1	$7.300 \cdot 10^{-01}$
x	0.05	+1	$6.980 \cdot 10^{-01}$
x	0.10	-1	$9.704 \cdot 10^{-01}$
x	0.10	+1	$9.591 \cdot 10^{-01}$
x	0.15	-1	$9.703 \cdot 10^{-01}$
x	0.15	+1	$9.650 \cdot 10^{-01}$
y	0.05	-1	$6.718 \cdot 10^{-01}$
y	0.05	+1	$6.705 \cdot 10^{-01}$
y	0.10	-1	$6.761 \cdot 10^{-01}$
y	0.10	+1	$6.753 \cdot 10^{-01}$
y	0.15	-1	$9.567 \cdot 10^{-01}$
y	0.15	+1	$9.610 \cdot 10^{-01}$
z	0.05	-1	$6.721 \cdot 10^{-01}$
z	0.05	+1	$6.704 \cdot 10^{-01}$
z	0.10	-1	$9.604 \cdot 10^{-01}$
z	0.10	+1	$9.607 \cdot 10^{-01}$
z	0.15	-1	$9.601 \cdot 10^{-01}$
z	0.15	+1	$9.624 \cdot 10^{-01}$

Table 14: Solver configuration (DDP): We used a factor of 4 for the integration time, i.e. the integration constant is 0.008 s with a real-time control frequency of 125 Hz. Using  $\beta = 1.4$ . Bold types of minimum values are considered experiment (i.e. row) wise.

penalty	rotated
ddp_u_pen	$1.000 \cdot 10^{-02}$
ddp_x_pen	$1.000 \cdot 10^{+03}$
ddp_rot_pen	$0.000 \cdot 10^{+00}$
ddp_state_bound_pen	$0.000 \cdot 10^{+00}$
ddp_state_pen	$0.000 \cdot 10^{+00}$
ddp_q_pen	$0.000 \cdot 10^{+00}$
ddp_v_pen	$5.000 \cdot 10^{-01}$