A VISUAL SERVOING APPROACH FOR AUTONOMOUS DOORWAY PASSING

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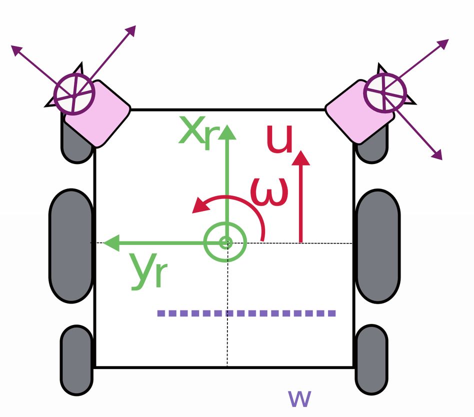
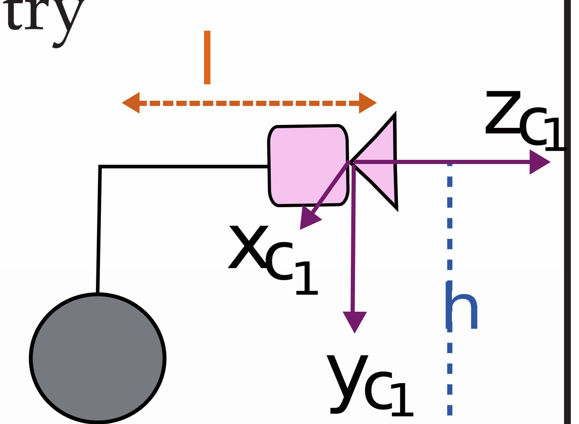
Abstract

Doorways make wheelchair navigation difficult and hazardous for users. A low-cost **monocular vision** based autonomous framework for the task is introduced. **A Lyapunov-based control scheme** is employed to generate a trajectory based on line features representing doorposts. A constraint taken into account that that the robot able to position regardless of its initial position. *First step in semi-autonomous navigation systems with human in the loop.*

Robotic Wheelchair

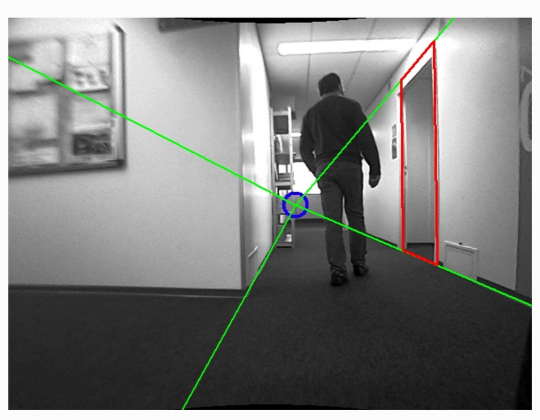
Non-holonomous unicycle
Translational velocity u and Rotational velocity ω.
Robot Operating System
2 Cameras + Odometry





Control variable - Restricted to rotational velocity ω for motion exigency.

Dedicated door detection and tracking framework



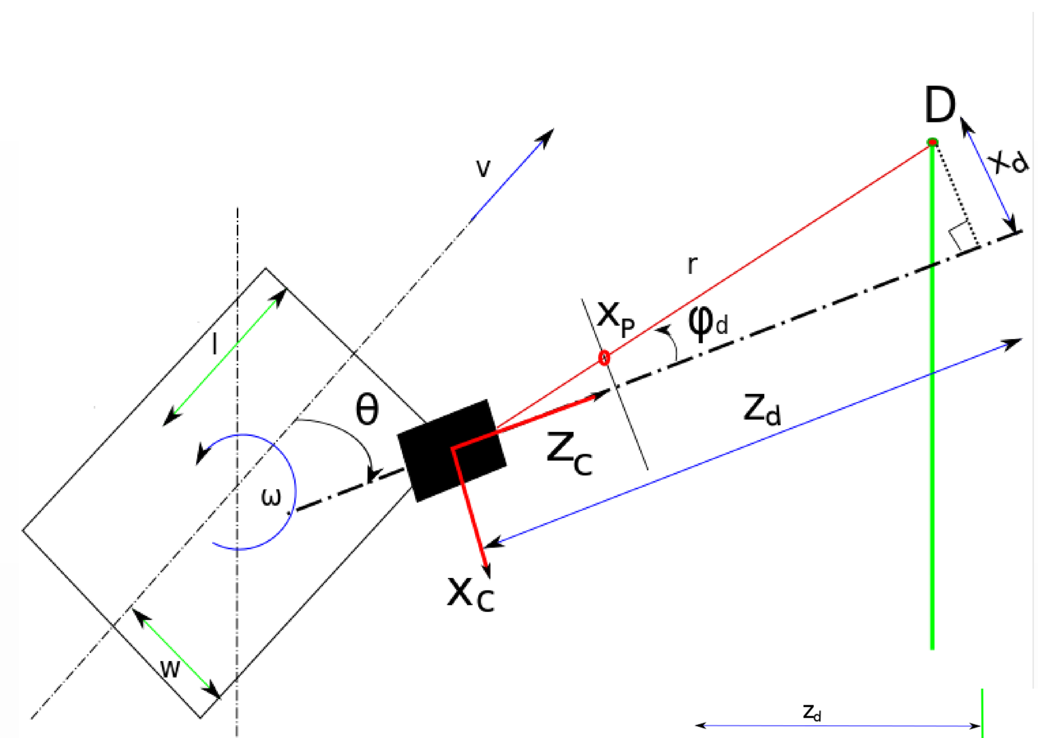
Visual Servoing

Foot of the doorpost $D = (x_d, h, z_d)^T$

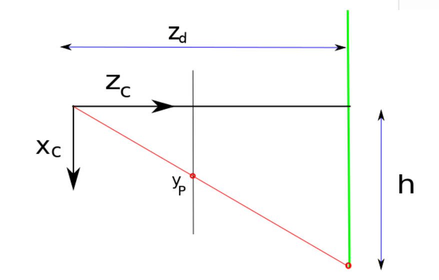
$r = \sqrt{x_d^2 + z_d^2}$, and $\boldsymbol{\phi_d = \arctan\left(\frac{x_d}{z_d}\right)}$, .

Projection D **in image** (x_P, y_P)

$$\boldsymbol{r = \frac{h}{y_P.\cos(\phi_d)}}.$$

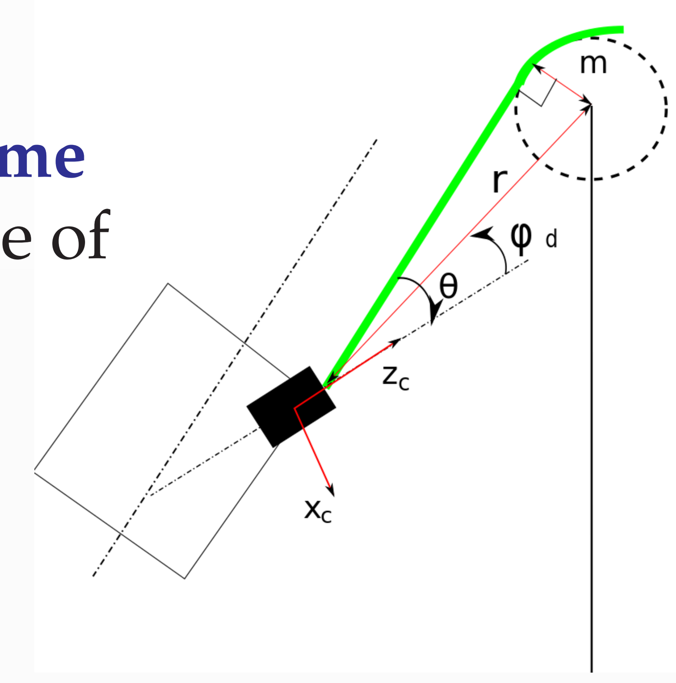


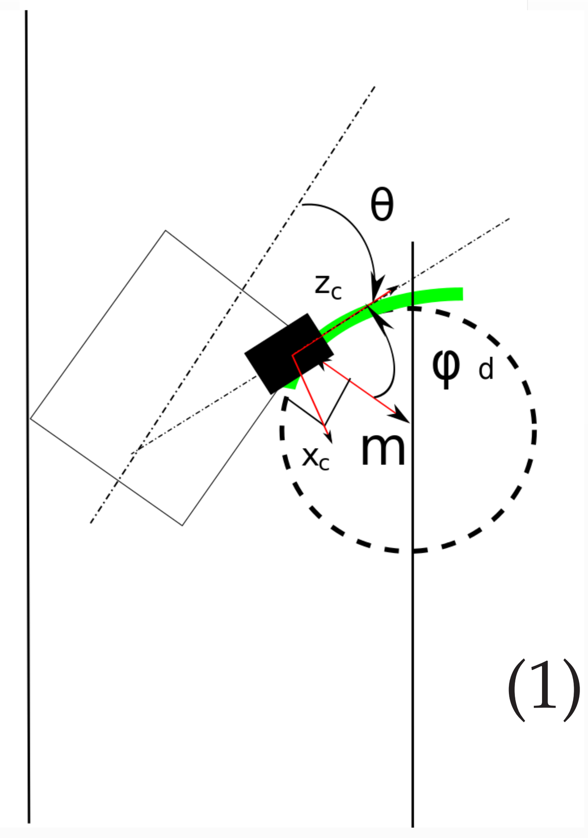
Position of line features representing the doorpost.
A desired value ϕ_d^* to be achieved by ϕ_d for task completion



$$\boldsymbol{\phi_d^* = \theta - \arcsin\left(\frac{m}{r}\right)} \quad \text{if} \quad \boldsymbol{r > m}$$
$$\boldsymbol{\phi_d^* = \theta - \frac{\pi}{2}} \quad \text{if} \quad \boldsymbol{r \leq m.}$$

A novel Lyapunov-based control scheme assuring global asymptotic convergence of the visual feature ϕ_d to ϕ_d^* is designed.



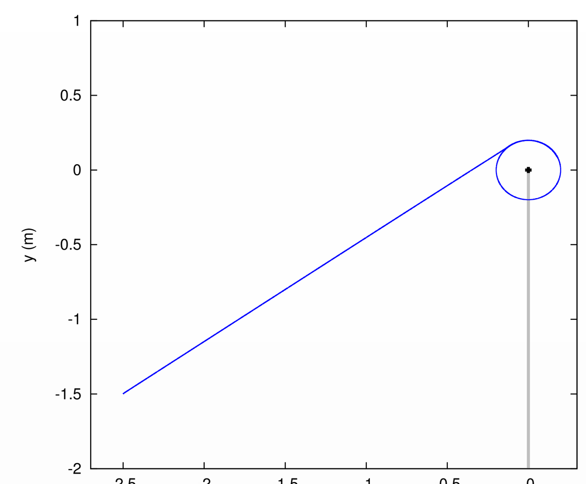


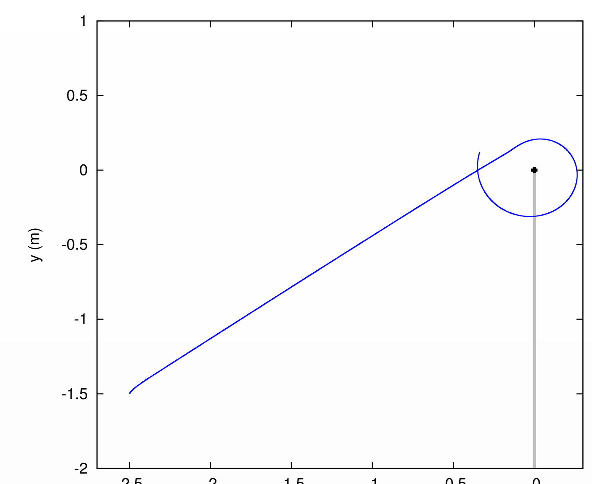
$$\boldsymbol{\omega = \frac{-k(\phi_d - \phi_d^*) - A(r, \phi_d)u}{1 + B(r, \phi_d)}}, \qquad (1)$$

$A(r, \phi_d)$ and $B(r, \phi_d)$ respectively are functions of r and ϕ_d.
Control law switch when $r = m$ changing forms of A & B

Results

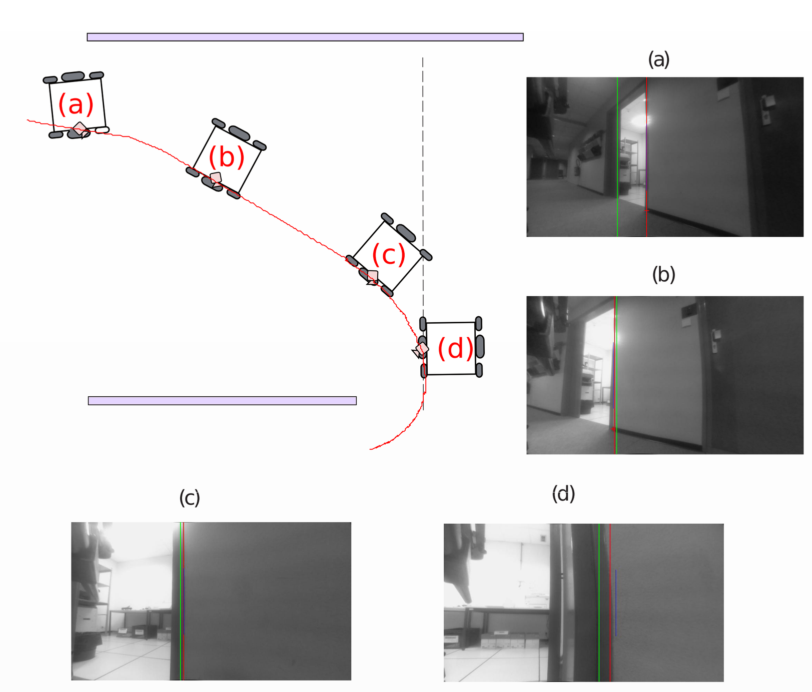
SIMULATIONS



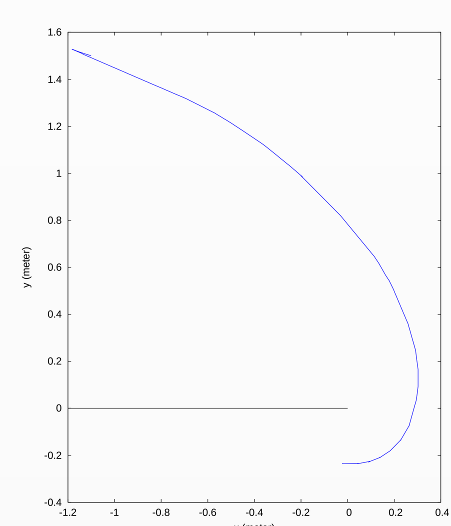


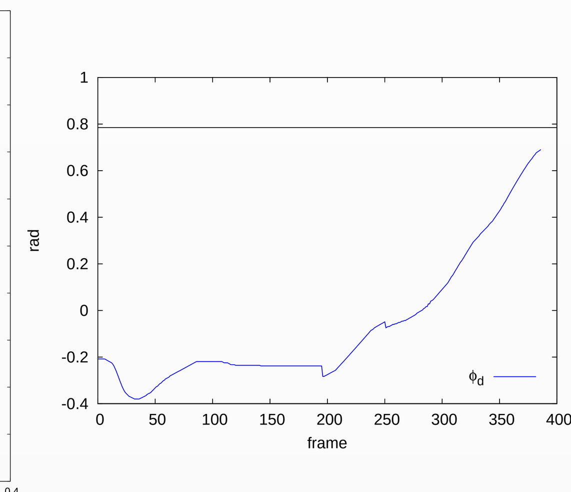
The simulated trajectory of the wheelchair with respect to the doorpost for 2 cases.

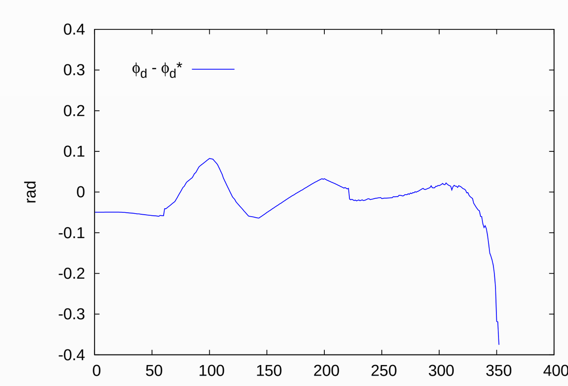
Reconstructed trajectory

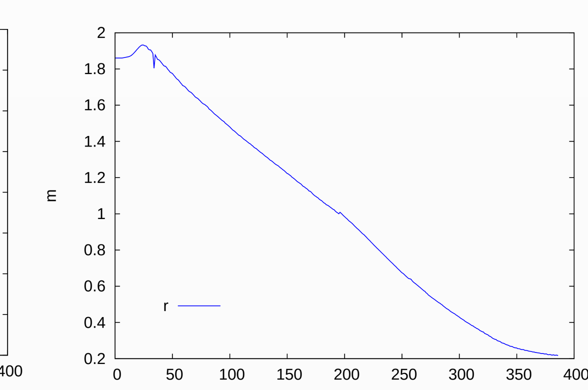


EXPERIMENTS ON THE ROBOT









Real World Experiment - Trajectory, ϕ_d, $\phi_d - \phi_d^*$ and the depth r.

Conclusions

A Lyapunov-based visual control scheme is designed for autonomous doorway passage. Results show the convergence of the control law as well as the *feasibility of the system as a first step in designing a semi-autonomous systems.*

References

[1] F. Pasteau, M. Babel, and R. Sekkal, Corridor following wheelchair by visual servoing, in *IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, IROS 2013*, Tokyo, Japan, 2013

[2] F. Chaumette and S. Hutchinson, Visual servo control, part i: Basic approaches, in *IEEE Robotics and Automation Magazine, vol. 13,*, December 2006.