Land Vehicle Control Using a Command Filtered Backstepping Approach

Vladimir Djapic[1,2], Jay Farrell[1], and Wenjie Dong[1]

[1] Unmanned Maritime Vehicle (UMV) Lab, SSC-SD, San Diego, CA 92152.

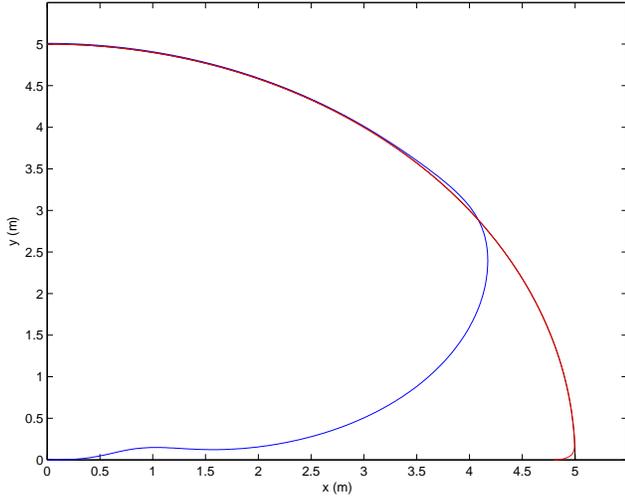[2] Department of Electrical Engineering, University of California at Riverside, Riverside, CA 92521.

Fig. 1. Trajectory of the vehicle on the x-y plane. The actual vehicle trajectory (blue) starts at the origin. The commanded trajectory (black) is a 5.0 m counterclockwise circle starting at $(5, 0)$. The filtered command (red) starts at $(4.8, 0.0)$.
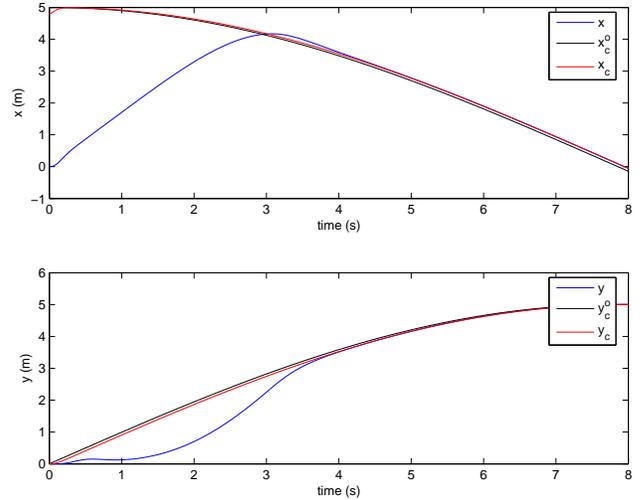

Fig. 2. X and Y Position vs. Time: Blue line is the actual vehicle trajectory, black line is the command, and the red line is filtered command.

VIII. Simulation Results

Figures 1–7 present the results of an 8 second simulated mission, during which the vehicle navigates around a circle with 5.0 meter radius. The vehicle is initially at the center of the circle. The commanded trajectory traverses the circle trajectory in the counter-clockwise direction with speed 1.0 m/s. The control law parameters are as follows: $\omega_n = 20\frac{rad}{s}$, $\zeta = 0.9$, $\bar{u} = 1$, $\bar{k} = 2$, $\alpha = 0.5$, $K_\psi = 2$, $K_u = 10$, and $K_r = 10$ (for definitions of some control parameters, see Appendices I and III).

The 2D position plot is shown Figure 1. The position plot showing x and y position versus time is shown in Figure 2. Rapid convergence to and maintenance of the trajectory is exhibited in Figure 1. During this convergence, the controller is varying the position control gain K_{xy} to maintain physically reasonable values for ψ_c^o and u_c^o. The yaw and yaw backstepping term are shown in Figure 3. Vehicle's horizontal velocity and yaw rate are shown Figure 4. The backstepping terms for u and r controller are shown Figure 5. The position and yaw error plots are shown in Figure 6, while the velocity and yaw rate error plots are shown in Figure 7. Figure 8 plots $V(t)$ versus t, demonstrating that V does exponentially converge to zero. The Simulink simulation is downloadable from the second authors web site.
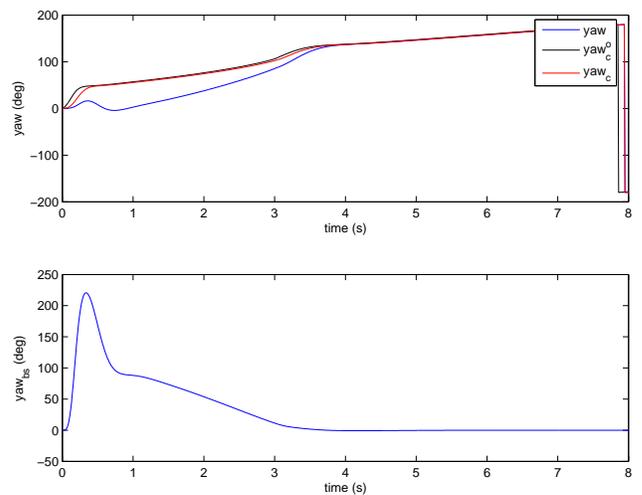

Fig. 3. Yaw and Yaw Backstepping term vs. Time: Blue line is the actual vehicle attitude, black line is the command, and the red line is filtered command.
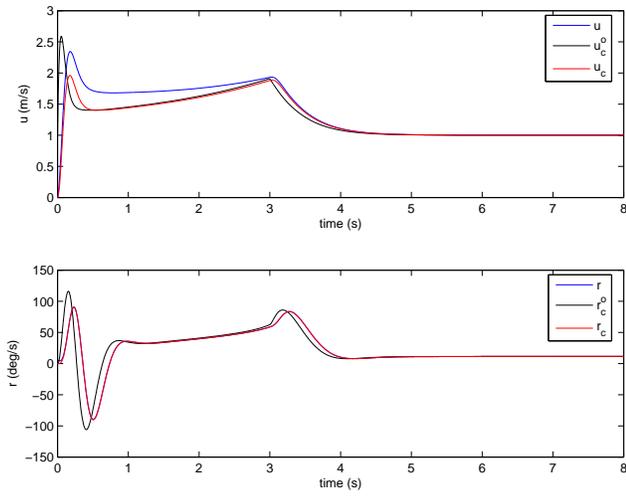
Fig. 4. Velocity and Yaw Rate vs. Time: Blue line is the actual vehicle velocity, black line is the command, and the red line is filtered command.
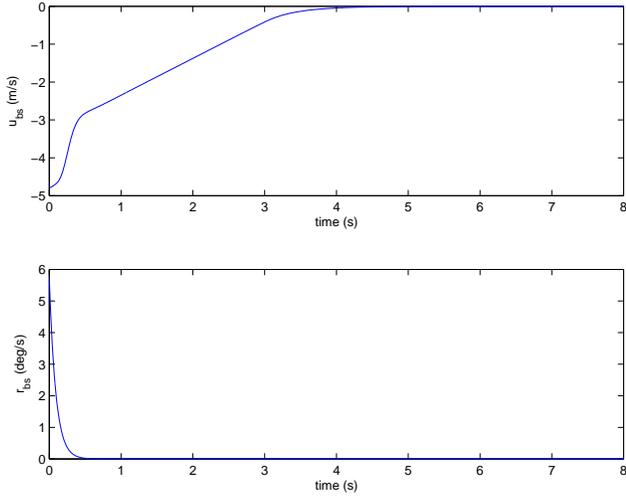
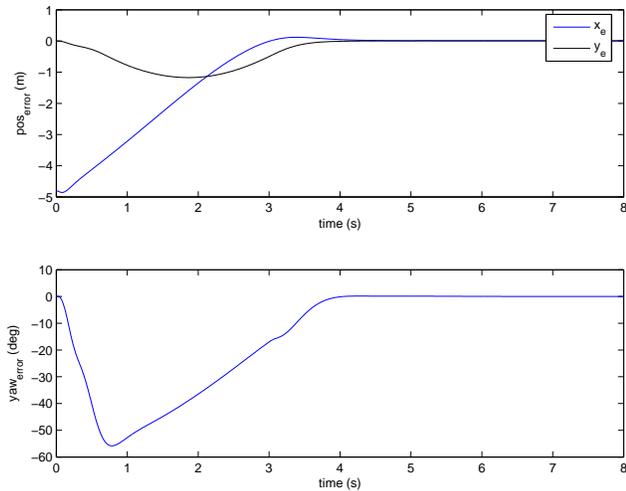

Fig. 5. Velocity and Yaw Rate Backstepping term vs. Time.
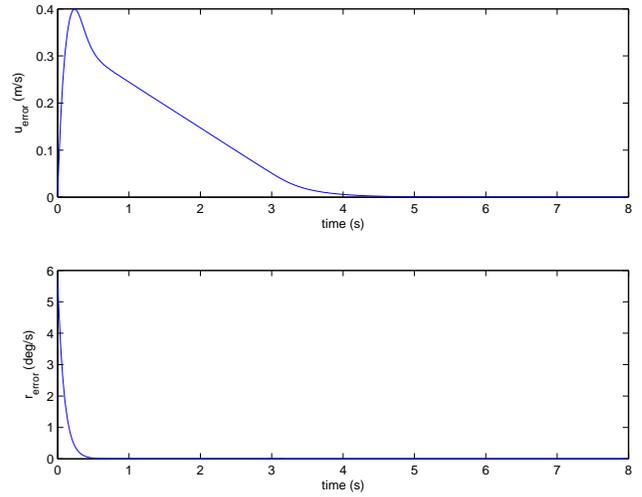

Fig. 6. Position and Yaw error vs. Time.
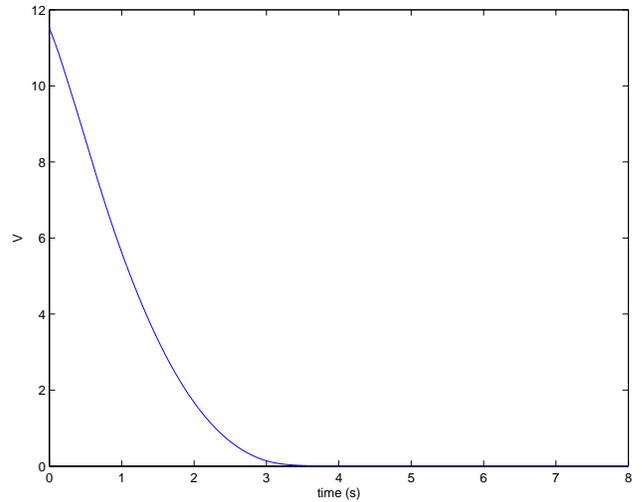

Fig. 7. Velocity and Yaw Rate error vs. Time.

Fig. 8. Lyapunov function V vs. Time.