

USV Modeling

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Abstract

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I. INTRODUCTION

II. BACKGROUND

[Sonnenburg and Woolsey, 2013] examines model for USV with steerable outboard motor (vectored thrust) where sideslip is a major concern. Uses notation from [Fossen, 1994]

III. MANEUVERING MODEL

In this section we follow the notation and process detailed in [Fossen, 2011]. The horizontal-plane maneuvering model captures is formulated using state vector $\boldsymbol{\nu} = [u, v, r]^T$ where the velocities u , v and r are in the surge, sway and yaw directions respectively. The velocities are considered to be relative to an irrotational constant ocean current.

$$\mathbf{M}_{RB}\dot{\boldsymbol{\nu}} + \mathbf{M}_A\dot{\boldsymbol{\nu}}_r + \mathbf{C}_{RB}(\boldsymbol{\nu})\boldsymbol{\nu} + \mathbf{C}_A(\boldsymbol{\nu}_r)\boldsymbol{\nu}_r + \mathbf{D}(\boldsymbol{\nu}_r)\boldsymbol{\nu}_r = \boldsymbol{\tau} + \boldsymbol{\tau}_{wind} + \boldsymbol{\tau}_{waver} \quad (1)$$

where $\boldsymbol{\nu}_r$ is the velocity vector relative to an irrotational water current $\boldsymbol{\nu}_c$, i.e., $\boldsymbol{\nu} = \boldsymbol{\nu}_r + \boldsymbol{\nu}_c$. The rigid body kinetics are represented by the rigid body mass \mathbf{M}_{RB}

$$\mathbf{M}_{RB} = \begin{bmatrix} m & 0 & 0 \\ 0 & m & mx_g \\ 0 & mx_g & I_z \end{bmatrix}, \quad (2)$$

where m is the mass of the vehicle, I_z is the moment of inertia about the body-centered z-axis and x_g is distance, along the x-axis, from the origin of the body-centered frame to the center of gravity of the vessel, and by the rigid body Coriolis-centripetal matrix,

$$\mathbf{C}_{RB}(\boldsymbol{\nu}) = \begin{bmatrix} 0 & 0 & -m(x_g r + v) \\ 0 & 0 & mu \\ m(x_g r + v) & -mu & 0 \end{bmatrix}. \quad (3)$$

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Noting that $\mathbf{C}_{RB}(\boldsymbol{\nu})$ is skew-symmetric, i.e., $\mathbf{C}_{RB}(\boldsymbol{\nu}) = -\mathbf{C}_{RB}^T(\boldsymbol{\nu})$. The hydrodynamic effects are represented by the added mass matrix

$$\mathbf{M}_A = \begin{bmatrix} -X_{\dot{u}} & 0 & 0 \\ 0 & -Y_{\dot{v}} & -Y_{\dot{r}} \\ 0 & -Y_{\dot{r}} & -N_{\dot{r}} \end{bmatrix}. \quad (4)$$

and the Coriolis-centripetal matrix for the added mass

$$\mathbf{C}_A(\boldsymbol{\nu}_r) = \begin{bmatrix} 0 & 0 & Y_{\dot{v}}v_r + Y_{\dot{r}}r \\ 0 & 0 & -X_{\dot{u}}u_r \\ -Y_{\dot{v}}v_r - Y_{\dot{r}}r & X_{\dot{u}}u_r & 0 \end{bmatrix}. \quad (5)$$

IV. ACKNOWLEDGMENTS

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