

Underwater Remotely Operated Vehicle Control System Architecture

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Abstract

Underwater Remotely Operated Vehicle (ROV) control system architecture, work Class II - underwater inspection is demonstrated. The object is programmed on MATLAB simulink. The nonlinear modeled plants were processed by approximation way. Author planned a controller of an underwater ROV object. PID controller is used modeled plant. Tuning PID tool is used MATLAB for choose underwater ROV controller. Researchers tested an underwater ROV for system and solving problems an underwater ROV architecture.

Keywords: *Underwater, Remotely, Vehicle Control*

INTRODUCTION

Point [1], build ROV control system interesting discussion future technology. ROV has many set program to help stabilize a ship's state so that through course sequence. Many control theory established of the system. Traditional Controls, Future Model Controls, Variation PID Controls [2], Evaluation Linearity, Adaptive Fuzzy Controls techniques mentioned above. Therefore, an accurate model is preferred. However, enough of the request. That expected of sustainable, the traditional unmeaning.

Remotely Operated Vehicle control designs are very complicated. The main question, (1) uncertainty of the environment which exhibits noise to maintain & parameter models, (2) parametric random additional, volatile hydrodynamic, linear, mass [3]

Many method in architecture systems requirement [4]. Much previous work previously focuses primarily on the specific one-motion control. The author designs 6 DOF underwater vehicle control system by other ROV work for inspection. Factory testing are demonstrated.

METHODOLOGY

Theoretical foundations architecture are presented. A discussion of MATLAB programming and running is also demonstrated.

2.1 Formula of ROV

ROV models are giving formula of motion, with previous state, can be numerically have the data of vehicle. Data are shown in Table 1. Figure 1 show reference, which are detailed explanation.

Table 1. Six degrees of freedom.

DOF	Forces & Moment	Linear and Angular Velocities	Position and Euler Angles
Surge	X	u	x
Sway	Y	v	y
Heave	Z	w	z
Roll	K	p	ϕ
Pitch	M	q	θ
Yaw	N	r	ψ

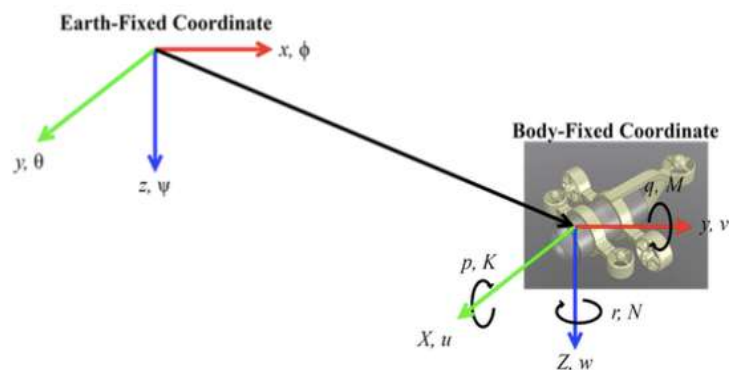


Figure 1. Coordinate systems.

Standar marine use [5], formula of speed is demonstrated in Eq. (1). linear velocities in the direction of wave, wobble, & lift shown in detailed. Eq. (2) show other freedom. The other are demonstrated in Eq. (3).

$$\nu = [\nu_1 \quad \nu_2]^T = [u \quad v \quad w \quad p \quad q \quad r]^T \quad (1)$$

$$\eta = [\eta_1 \quad \eta_2]^T = [x \quad y \quad z \quad \phi \quad \theta \quad \psi]^T \quad (2)$$

$$\tau = [\tau_1 \quad \tau_2]^T = [\tau_x \quad \tau_y \quad \tau_z \quad \tau_\phi \quad \tau_\theta \quad \tau_\psi]^T. \quad (3)$$

Using Newton's approximation, the motion of a rigid body in Eq. (4), which MUROV $R6 \times 6$ weight inertial then CUROV (ν) $R6 \times 6$ is the other motion.

$$M_{UROV}(\dot{\nu}) + C_{UROV}(\nu)\nu = \tau. \quad (4)$$

$$M_{UROV}(\dot{\nu}) + C_{UROV}(\nu) + D(\nu)\nu + g(\eta) = \tau \quad (5)$$

$$\dot{\eta} = J(\eta_2)\nu. \quad (6)$$

The ROV's hydrodynamic model, as presented in Eqs. (5) and (6), considers how constant terms like world constant and added body weight combine with dynamic forces like $g(\eta)$ buoyancy and gravity, CUROV Coriolis, and $J(\eta_2)$ Euler moments to determine the ROV's motion. This nonlinear model, expressed in matrix form, provides a mathematically rigorous description of the ROV's behavior. [6].

2.2 Controller Design

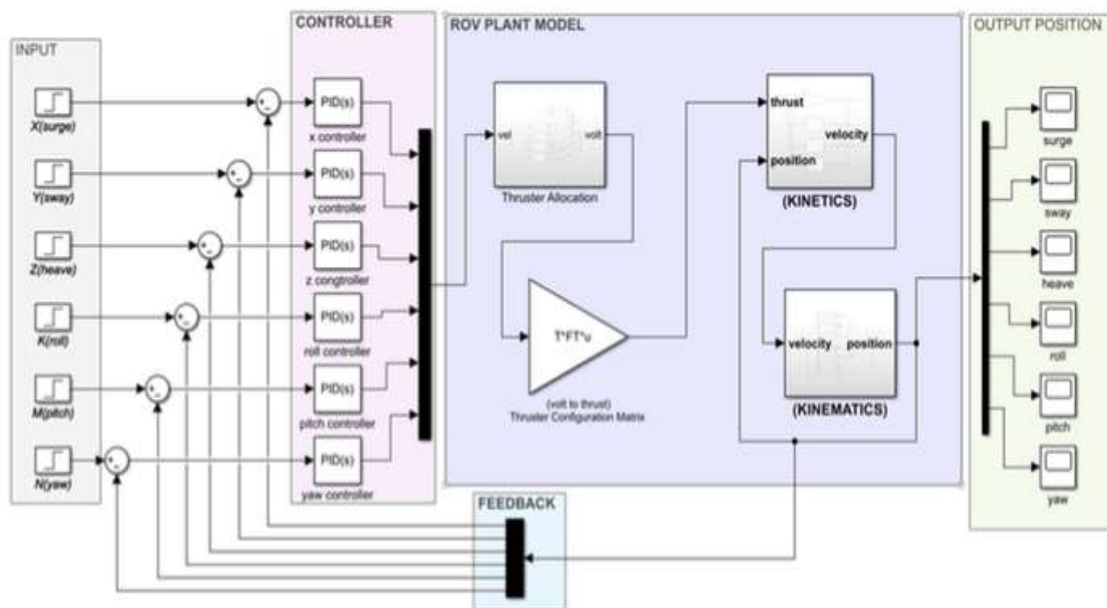


Figure 2. Simulink program

Figure 2 present simulink program of ROV. System with controllers that location of ROV. The traditional used tuning the ROV can improve controller, object first processes. Initialization was carried out by MATLAB.

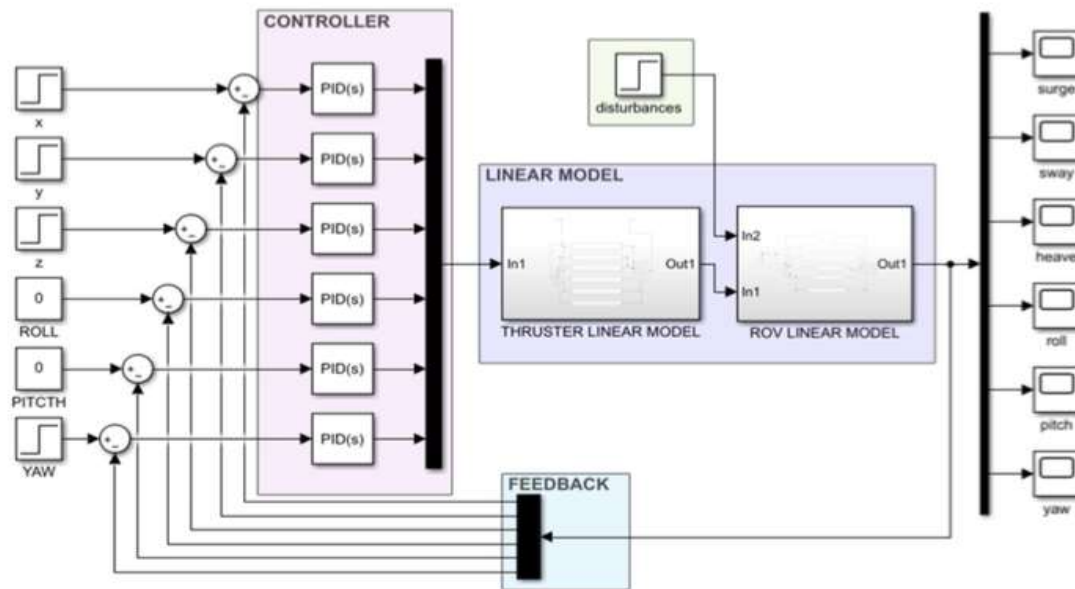


Figure 3. Control Strategy using the Linearized Model

Figure 3 present modern controller. The linear plant replaces in setup. The noise linear represent various noise that may experience.

Table 2. PID Controller Gains.

Gain	Roll	Pitch	Yaw	x	y	z
k_p	0	0	4.39	9.88×10^5	1.18×10^6	1.12×10^5
k_i	7.61×10^4	3.16×10^5	1.03×10^{-2}	9.36×10^3	1.12×10^4	1.06×10^4
k_d	0	0	4.15×10^2	6.29×10^5	7.51×10^6	7.15×10^6

Table 2 present advantages new strategy. Controller model is a discontinue controller which operates sampling rate of 0.1 ms. Benefit controller is presented individually. response must a up time of 2 seconds, a completion time of 5 seconds, a set error of 5%, and an overshoot of 30% [7].

RESULTS AND DISCUSSION

Unit step is checked with another controller disabled. Scope present the output of particular move. Table 3 present running program. Two degrees controller have not final performance that the simulation have not experience overshoot, which is stable initial value. That personal work in their way, then examine controller all round.

Table 3. Controller Step Response Simulation.

Parameter	Roll	Pitch	Yaw	x	y	z
Rise Time (s)	243	63.2	3.66	36.5	34.8	32.2
Peak Amplitude	N/A	N/A	1.23	1.02	1.16	1.12
Peak Time (s)	N/A	N/A	7.4	125	110	106
Overshoot (%)	N/A	N/A	22.5	2	16	11.7
Settling Time (ms)	431	120	24	243	257	269

Without any actuator is unstable. Simulations are carried out at many unit step controller, Table 4 present a error rate of test performed on system. For angle parameter, step point is 89.9° to +90.1° in 5° increments. For simulation of linear motion, the set point is Range of depths from 10 m to 90 m increments.

Table 4. Average Settling Time Error

Parameter	% Error
Roll Angle	1.60
Pitch Angle	1.01
Yaw Angle	1.98
x Movement	0.80
y Movement	1.11
z Movement	2.00

CONCLUSION

The paper showed a robotic object. These include propulsive, mechanic presented by a complex system of equations using in matrix. This model is modeled using Simulink blocks. Various ROV vehicle's degrees of controls. Object is linearized implement the classic strategy to architecture controller. Choose a linear architecture of every motion. The traditional controller is selected here. Controller unit responses are determined independently. Every controller have good response. In exchange for the speed of high motion, a 22.5% peak was determined on controller. Every actuator present a precipitation small 5% of error. An robotic is following a better controller result simultanly. This indicates robotic have a certain route in the determined noise. System running results achieve best performance of ROV.

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