Design the Autopilot System of using Fuzzy Algoritim

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Abstract

The autopilot system targets decreasing labor, working environment improvement, service safety security and elevation of service efficiency. Ultimate purpose is minimizing number of crew for guarantee economical efficiency of shipping service.

Recently, being achieving research about Course Keeping Control, Track Keeping Control, Roll-Rudder Stabilization, Dynamic Ship Positioning and Automatic Mooring Control etc. which compensate nonlinear characteristic using optimizing control technique. And application research is progressing using real ship on actual field. Relation of Rudder angle which adjusted by Steering Machine and ship-heading angle are non-linear. And, Load Condition of ship acts as non-linear element that influence to Parameter of ship. Also, because the speed of a current and direction of waves, velocity and quantity of wind etc. that is disturbance act in non-linear form, become factor who make service of shipping painfully. Therefore, service system of shipping requires robust control algorithm that can overcome nonlinearity. In this paper, Using Fuzzy algorithm ,Design autopilot system of ship that could overcome the non-linear factor of ship and disturbance and examined result through simulation.

I . Introduction

Ship Automation could classified to Automation of sailing and office automation on inboard. Automation of sailing mean automation of navigation and screw instrument, they need directly to sailing. Technique of sailing Ship Automation is very important to competitive power receiving and order with ship designing and construction. Purpose of Ship Automation is decreasing of labor on inboard, improvement of work environment, assure safety of sailing, and decreasing number of crew member to ultimately assure economical efficiency.

Sailing Ship Automation is linked to number of crew member. So, Number of crew is index of automation technique. In Study about motion of ship, There is Course Keeping Control, Track Keeping Control and Roll-Rudder Stabilization etc. Relation of Rudder angle which adjusted by Steering Machine and ship-heading angle are non-linear. And, Load Condition of ship acts as non-linear element that influence to Parameter of ship. Also, because the speed of a current and direction of waves, velocity and quantity of wind etc. that is disturbance act in non-linear form, become factor who make service of

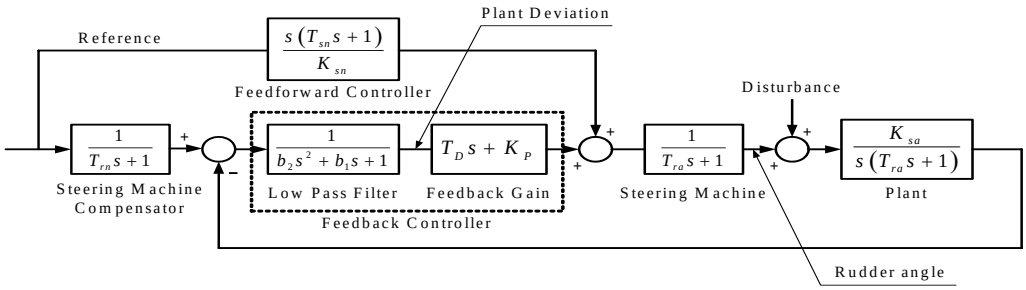


Fig. 2 . System of Ship using PID Controller

shipping painfully. Therefore, service system of shipping requires robust control algorithm that can overcome nonlinearity.

In this paper, Using Fuzzy algorithm ,Design autopilot system of ship that could overcome the non-linear factor of ship and disturbance and examined result through simulation.

Ⅱ. Design of System

Navigation means the method to guide the ship to the other place, it is safe, fast and economy.

Ship on the sailing has the 6-degree motion. This motion is classified translational motion (include Surging at X axis, Swaying at Y axis and Heaving at Z axis) and rotational motion (include Rolling, Pitching and Yawing)

In this paper, we show transfer function about indicator angle of ship and appraise performance using custom PID controller and Fuzzy controller.

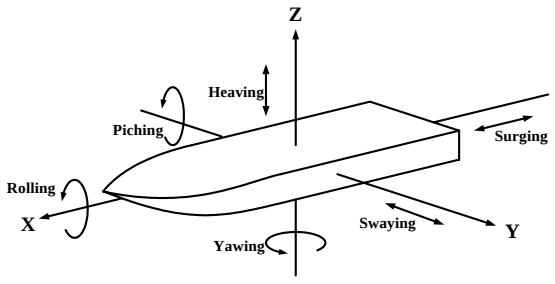


Fig. 1 . 6-degree motion of ship

1. System using PID Controller

The construction of the system using PID controller is shown Fig 2. The feedforward controller set the inverse plant with the nominal parameters. The plant of a ship consists with gyrocompass excluding steering machine. The ship is expressed with a first-oder system. The gyrocompass is expressed with and integrator. Then the transfer function from the reference and the disturbance to the deviation give

$$E_a(s)=\frac{K_{sa}[(U_{\frac{T}{K}a}s^2+U_{\frac{1}{K}a}s)R(s) -(T_m s+1)D_a(s)]}{B_a(s)} \quad (1)$$

$$U_{\frac{T}{K}a}=\frac{T_{sa}}{K_{sa}}-\frac{T_{sn}}{K_{sn}} \quad (2)$$

$$U_{\frac{1}{K}a}=\frac{1}{K_{sa}}-\frac{1}{K_{sn}} \quad (3)$$

$$B_a(s)=C_{TC}(s)(T_{sa}s+1)+K_{sa}C_{FB}(s) \quad (4)$$

$$C_{TC}(s)=s(T_m s+1)(b_2 s^2+b_1 s+1) \quad (5)$$

$$C_{FB}(s)=T_D s+K_P \quad (6)$$

Where, E is the deviation, R is the reference, D is the disturbance, K_s, T_s are a gain and a time constant of the ship parameter, respectively. T_r is a time constant of the steering machine, T_D, K_P are a derivative gain and proportional gain of the feedback gain, respectively, b_2, b_1 both are time constants of the low pass filter.

2. System using Fuzzy Controller

Billow, speed of a current and wind velocity and

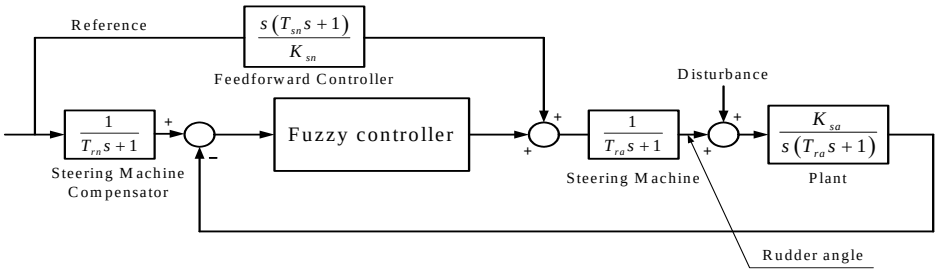
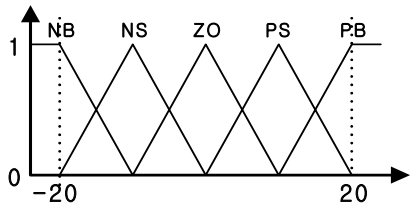


Fig. 3 . System of Ship using Fuzzy Controller

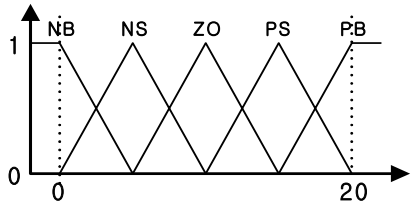
amount of wind that is disturbance element is worked against safety of ship in nonlinear type. So. ship is needed the robust controller. Therefore, this paper is designed the fuzzy controller and apply to ship system. Fig. 3. is block diagram of Fuzzy controller used in this paper. Table. 1. and Fig. 3. is fuzzy rule and membership function that design in this paper.

Table 1. Table of fuzzy rule

ce \ e	NB	NS	ZO	PS	PB
NB	NB	NB	NB	NS	ZO
NS	NB	NS	NS	ZO	PS
ZO	NB	NS	ZO	PS	PB
PS	NS	ZO	PS	PS	PB
PB	ZO	PS	PB	PB	PB



(a) Membership Functions of e, ce



(b) Membership Functions of u

Fig. 4. Membership Functions

Ⅲ. Simulation

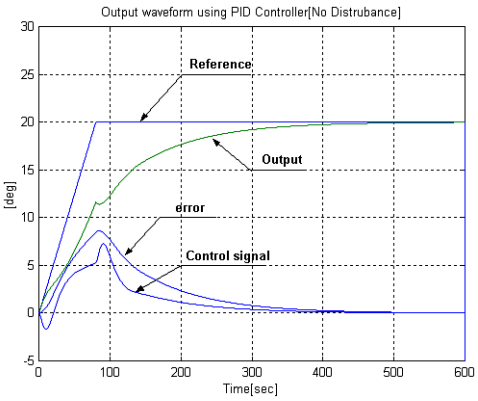
In this paper, we designed PID controller and Fuzzy controller. And applied these to transfer function shown. And appraise performance characteristic.

Table. 2. is coefficient of system and controller used in simulation.

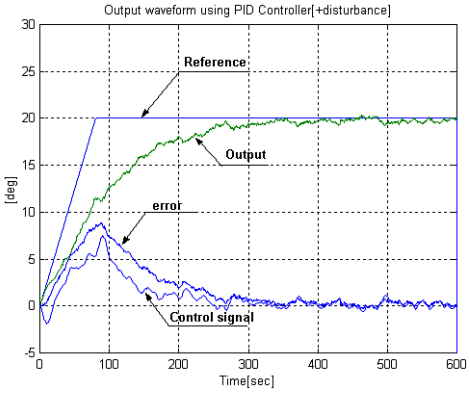
Table. 2. Coefficient of Controller

K_{sn}	0.034 [1/s]
T_{sn}	11.4 [s]
K_P	3.33 [s]
T_D	40.64 [s]
b_2	3.3 [s^2]
b_1	4.1 [s]

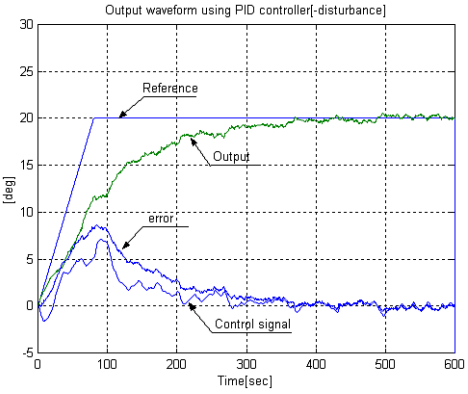
Fig. 5. is Result of simulation about sailing the ship by used PID controller. In navigation of ship, there is various element of disturbance as wind speed and height of billow. This paper used only wind speed as disturbance. Fig. 5. is confirmed safe characteristic of rotation angle. But, In case impress disturbance to going direction. ship is rotated slowly. In case impress disturbance to reverse direction. characteristic of response unstable.



(a) No disturbance



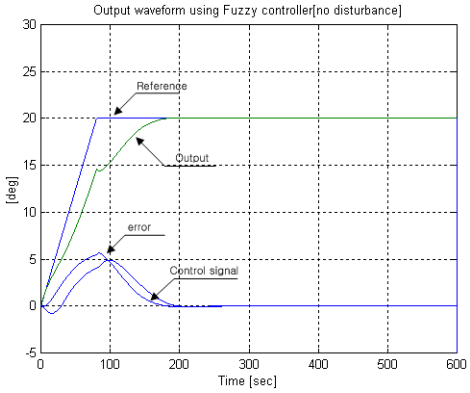
(b) (+) disturbance



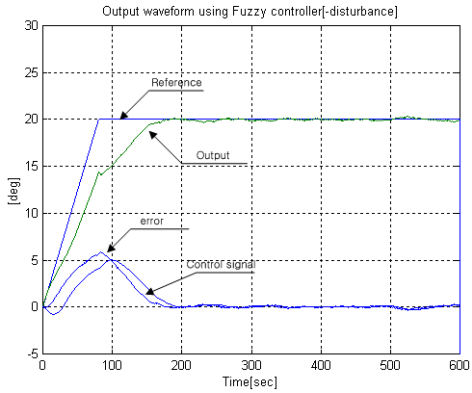
(c) (−) disturbance

Fig. 5. Output waveform using PID Controller

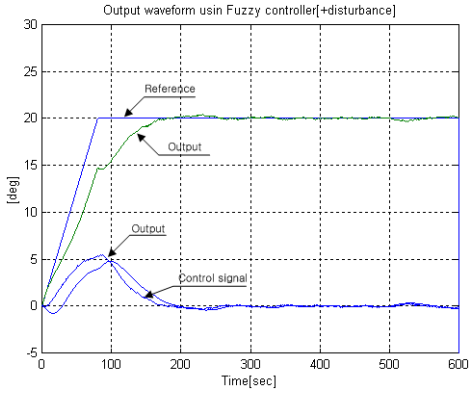
Fig. 6. is Result of simulation about sailing the ship by used fuzzy controller. Like above condition, Fig. 6. (a), (b), (c) is confirmed excellent characteristic of response than PID controller. Specially, Difference is small, when impress the disturbance and not. But, fuzzy controller is shown slow characteristic of response about indicator angle required.



(a) No disturbance



(b) (+) disturbance



(c) (−) disturbance

Fig. 6. Output waveform using Fuzzy Controller

Ⅳ. Conclusion

In this paper, we show transfer function. And, Using PID controller and Fuzzy controller, confirm characteristic of response. As the results, Because Robust property. Fuzzy controller has good characteristic of response than PID controller. But has slow characteristic of response. It maybe is cause membership function and rule. There is impossible to position control without tracking control

Therefore, research task at future is studying tracking control with course keeping control.

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