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NOISE CONTROL FILTRATION OF LATERAL AND YAW DYNAMICS FOR RAILWAY VEHICLE WHEELSET ON TRACK

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ABSTRACT

The noise is the fundamental substandard sign of smooth running of the railway vehicle wheelset over the railroad. This disturbance is created deteriorating environment on deranged railway vehicle speed in any direction of basic degree of freedom. In this paper, Brief applicable mathematic is used framed for necessary modeling. The estimation of perturbations for the movement by wheels and velocity of train in lateral and yaw phases are enumerated. Here dual bucy kalman estimator is implemented to decrease the influence of the noise caused due improper ratio of adhesion level upon track. One estimator reduces the overshoot of noise and other to minimize it at lower level of level of error. Further the behavior of lateral and yaw dynamic analysis is observed by implementation of fuzzy inference system through applicable member functions.

KEYWORDS: *Adhesion, lateral creepage, error estimation, coinicity, creep coefficient, wheel inertia*

INTRODUCTION

The better railway vehicle running performance can be guaranteed by self-governing the lateral and yaw control analysis of rail wheel contact. Many researchers contract with independently control of lateral and Yaw movements of vehicle on rail road. The railway vehicle speed resolute by the vehicle's longitudinal dynamics is measured to be an unreliable limit in vehicle lateral and yaw movement dynamical system[1].

In[2], The spin rate estimation holds on wheelset velocity and lateral motions respectively. The basic yaw speed measurements are accumulated according to their poise value, while the preface filtration of yaw speed is applied in the nonlinear estimator which procures the ultimate yaw speed filteration of railway vehicle.

The researcher Matsumoto et al.[3] suggested the creep individuality on wheel rail interface concuring the measured levels depend upon the linear theory Kalker[4] and demonstrated a small revise on lateral motion of wheelset may guide to alter creepage properties. The yaw and the lateral analysis of bogie body and railway wheelset are responsive towards disparity of conicity by railway wheelset position.

The comeback of the lateral motion of the railway truck is more responsive than vertical response having higher weightage. The spin response of railway truck refers to disappear-able high amplitudes of roll angles than yaw response having low amplitudes. It is obvious that spin motion has higher rate than the yaw movement of railway truck in vehicle dynamics[5]. However vehicle maintenance has been described by authors in[6,17].

A newly wheelset velocity based upon kinematic filteration using Kalman filter concerned to dynamic estimation advances to filter wheel velocity noise setup. To develop estimation algorithms and rail road test result to reveal the effectiveness of the proposed method in an actual world. In an estimation of dynamic analysis worn for activating probable wheel lateral and yaw noise, an appropriate Kalman filter scheme is applied. The Kalman filter's gain matrix is enlisted with forward railway vehicle wheelset speed[6].

The parameters of linearized model used in state space form are utilized by Kalman-Bucy filter. Since the Kalman-Bucy filter is tuned basically through 'Q' matrix which identifies the certainty degree for state model parameters. By setting up the state model factors as highly unsure to the vehicle dynamics then estimator can be used to approximate the creep force associated with lateral and yaw factors[7].

A Fuzzy control scheme solves the dynamic of the lateral control and yaw problem by feed forward technique. Its feedback system works better on the tracking

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error of the model. The feedback rule is assumed to use yaw speed and angular motion about the vertical axis of railway vehicle as stabilizing term in lateral motion control of a railway vehicle[8.9].

In this paper, in second section the lateral and yaw dynamics is modeled by mathematically terms, and third section represents simulation results comprising noise estimation by kalman filter and described by fuzzy member functions. Final section ends by formal conclusion.

DYNAMIC MODELING SYSTEM

The mathematical correlation of lateral and yaw dynamic system with respect to creep is enumerated as under[10,11].

$$y = (V_L + V_R)/2L_g = -(\omega.\Delta r)/2L_g \quad (1)$$

In eq(1) 'y' is lateral motion, V is velocity left/right wheels, ω= angular velocity, r = radius and Lg =gauge length

$\psi = -\left[\frac{V}{(L_g.r_o)}\right] \times \lambda_y$ (2) Where ψ is yaw motion and λ_y as lateral creep and r_o =outer radius

$$\lambda_y = \frac{\dot{y}}{v} - \psi \quad (3)$$

Here $\dot{y}$ is lateral velocity

Thus $\dot{y} = \frac{2f_{22}}{m_w} - \frac{2f_{22}}{m_w.v}$ (4)

applying creep coefficient. Where $f_2 = F_y / \lambda_y$, m_w is mass of wheels

$$\dot{\psi} = -\frac{2L_g\gamma f_{11}}{r_o I_w} - \frac{k_w}{I_w} - \frac{2L_g^2 f_{11}}{vI_w} + \frac{2L_g\gamma f_{11}}{r_o I_w} y_t \quad (5)$$

Where ψ is yaw velocity, I_w is inertia of wheel, k_w is stiffness, γ is conicity and y_t as noise.

SIMULATION RESULTS

The noise of lateral and yaw dynamic system for proposed railway wheelset model is filtered by dual kalman bucy estimator for proficiency and accuracy (Figure-1). The attitude of both motion and velocity of lateral and yaw phenomenon is checked by using various member function of fuzzy logic (Figure-2,3).

Bucy Klaman filter scheme

The multi model is sufficient to filter the states whenever wheel rail interface is altered. Therefore a model based upon estimator is applied to estimate parameters on separate tracking conditions. The span of model based upon estimators depends on these points background of these estimators.

The Figure-4 shows the performance of lateral velocity by two estimators to compute errors of wheelset noise. The estimator-1 shows signals of disturbance in black color at vertical plane from -0.5 m/sec to 0.4 m/sec reduced by estimator-2 after 2.5 sec. after this period estimator-1 noise is minimized -0.3 to 0.2 m/sec on vertical side. Here error is estimated at minor peaks around zero. The error of estimator-1 is traceable at estimator-2 in grey color zone after 2.5 sec and that of estimator-2 in the axis of estimator-1 back grounded by actual signals in black dots.

The Figure-5 shows the performance of lateral movement by two estimations to analyze errors of wheelset noise. The estimator-1 shows signs of disturbance in black color at vertical plane from -0.02 m to 0.015 m reduced by estimator-2 after 2.5 sec. after this period estimator-1, noise is decreased from -0.005 to 0.005 m on vertical side by estimator-2. Here error is estimated at a little bit more in zigzag manner around zero. The error of estimator-1 is visible at estimator-2 grey color zone after 2.5 sec and that of estimator-2 lower peaks in the axis of estimator-1 back grounded by invisible actual signals in black dots[15].

Application of fuzzy member function

In this segment of paper, the dynamics of lateral and yaw in terms of railway wheelset motion and vehicle velocity is expressed by generating applicable member functions of fuzzy logic application. This is simple way to obtain definite interpretation upon imprecise and noisy information. It is also convenient way to map to input sketch upon output sketches[16].

In Figure-6 the yaw motion and speed are compared by the concerned parametric values mentioned in fig-3 to 4. Here their behavior is checked by manipulating in application of Gaussian member function of fuzzy inference system. The fuzzification factor of yaw velocity is greater than fuzzified member for yaw motion according to their own parameter respectively. The Gaussian member function is preferred due to natural design of yaw/ spin dynamics.

In Figure-6, the initial and point of Gaussian member function is between 0.9985 and 0.999 for yaw motion initially on -0.025 and ends at 0.025 rad. While for yaw rate, the initial and point of Gaussian member function is between 0.3 and 0.4 for yaw motion initially on -0.08 and ends at 0.08 rad/sec. The midpoint in both diagrams noise than that of lateral velocity. The disturbance of the lateral speed of wheelset resembles with yaw motion while yaw rate perturbation is controlled mostly by estimator-2 of bucy kalman filter. The applicable selected upon the creep curve. Each filter is tuned to work at specific points. In case of creep curve selected points represent wheelset dynamics in all expected working circumstances. Here only two estimators are operated to demonstrate the proposed idea as for simplicity[12].

The tracking contact condition alters the interference of track from low adhesion level to high adhesion level 2.5 seconds of time during simulation process. To Switch block position prefers the best estimation created by Estimator-1 or Estimator-2 depend upon the minimum absolute error of system. Figure-1 shows the estimated state signals by Estimator-1 and Estimator-2. The Kalman Estimator-1 is tuned for minimum adhesion level point while the kalman estimator-2 is tuned for the maximum adhesion level point[13,14].

Figure-2 shows the minimum error generated by Estimator-1 and filterer -2 for yaw speed. In beginning when railway wheelset is started at minimum adhesion levels an error procured by Estimator-1 is lower than that of used by the Estimator-2. After 2.5 sec the track condition block alters the track condition from lower adhesion to higher adhesion point and it can be proved that the error procured by Estimator-1 becomes greater than the error procured by Estimator-2 of kalman filter. The actual signals denoted by black dots are travelling with disturbance coinciding with generated signals by estimator-1 denoted by black dots smaller before 2.5 sec and slightly more after 2.5 seconds. Here estimator-2 noise denoted by grey dots is scattered more than that of estimator-1 in whole process minor before half of time and greater after it in vertical plane of -0.8 rad/s to 0.6 rad/s within whole period of 5 seconds. Thus noise is

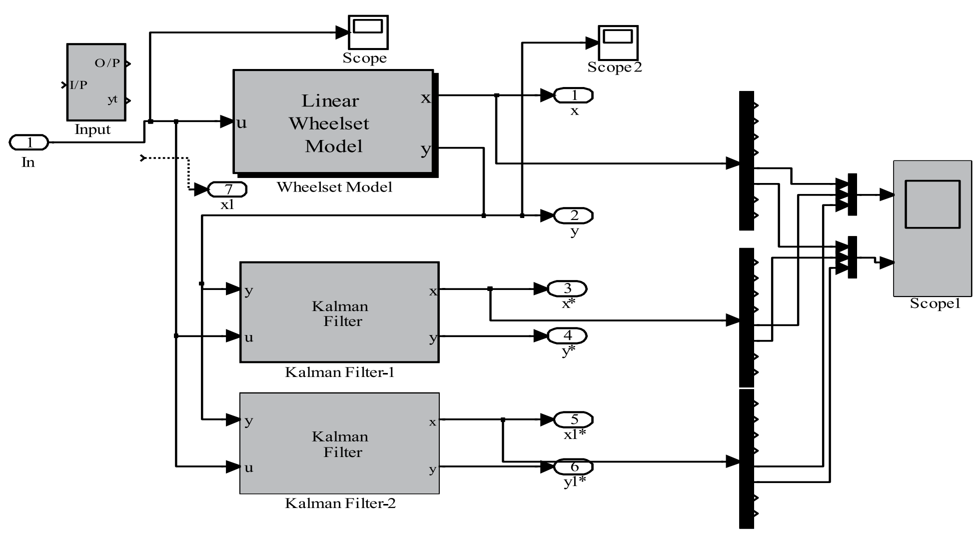

Figure-1 Simulink block of dual kalman filter for wheelset model

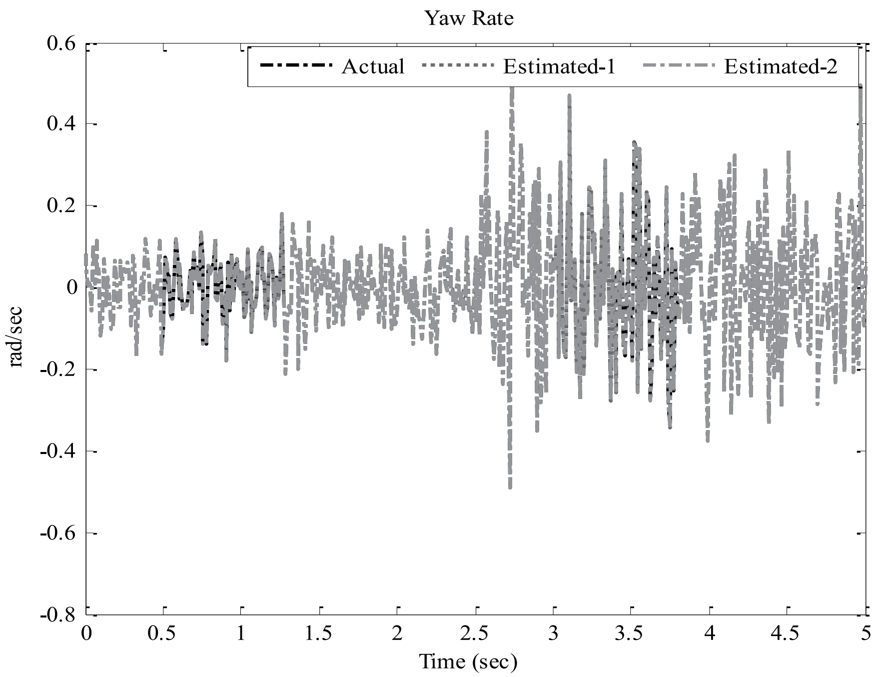

Figure-2 yaw rate error estimation for wheelset noise

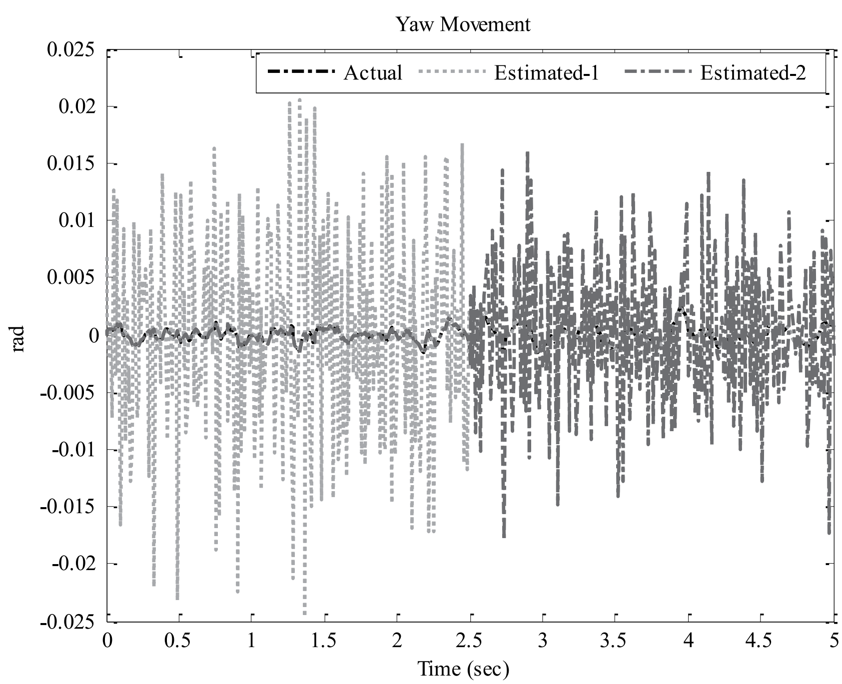

Figure-3 yaw motion error estimation for wheelset disturbance

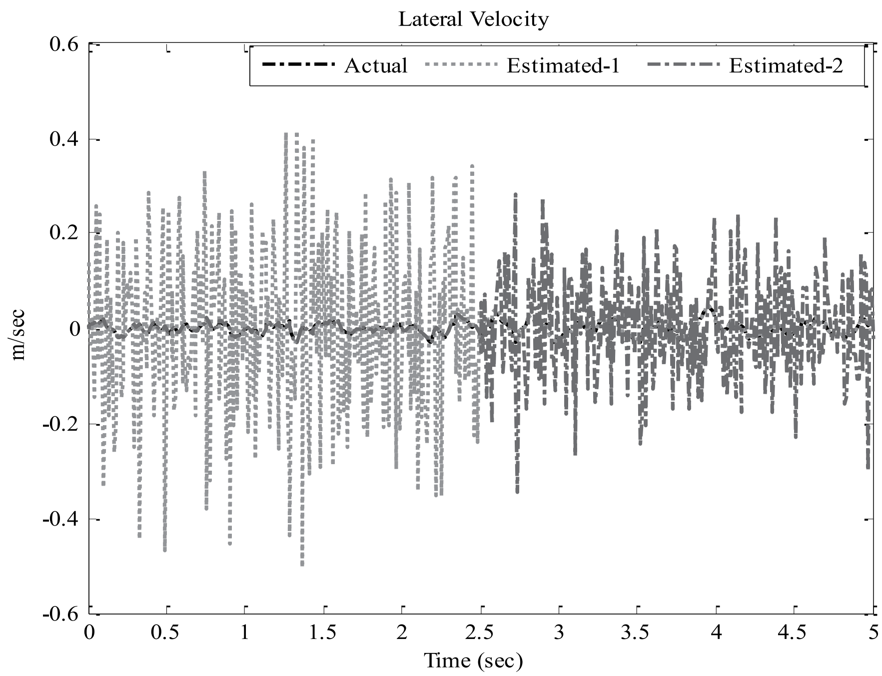

Figure-4 lateral velocity error estimation for wheelset perturbations

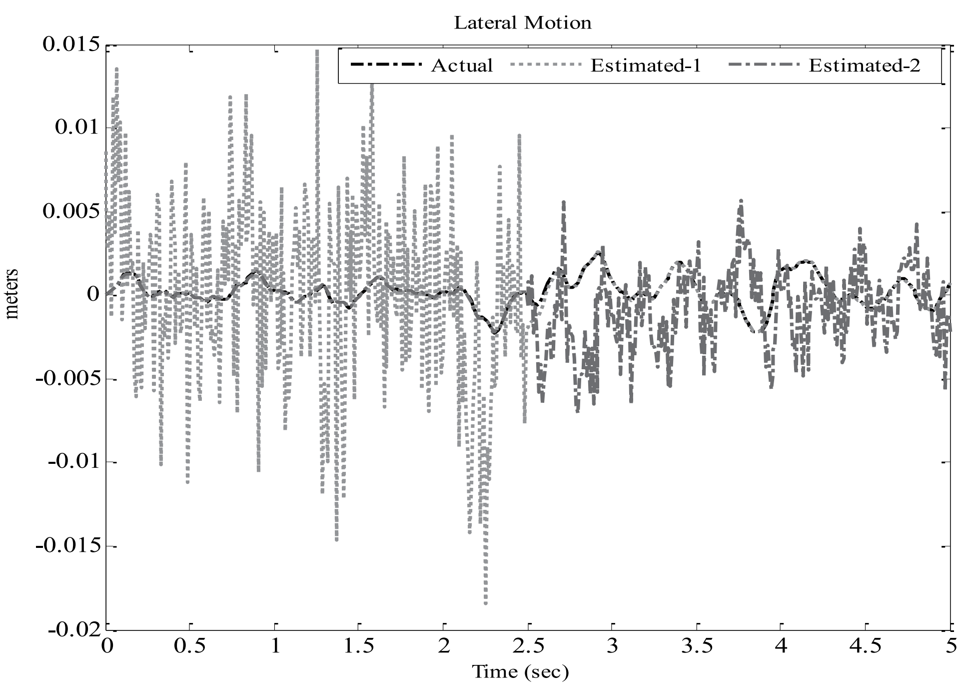

Figure-5 lateral movement for error state estimation of wheelset perturbations

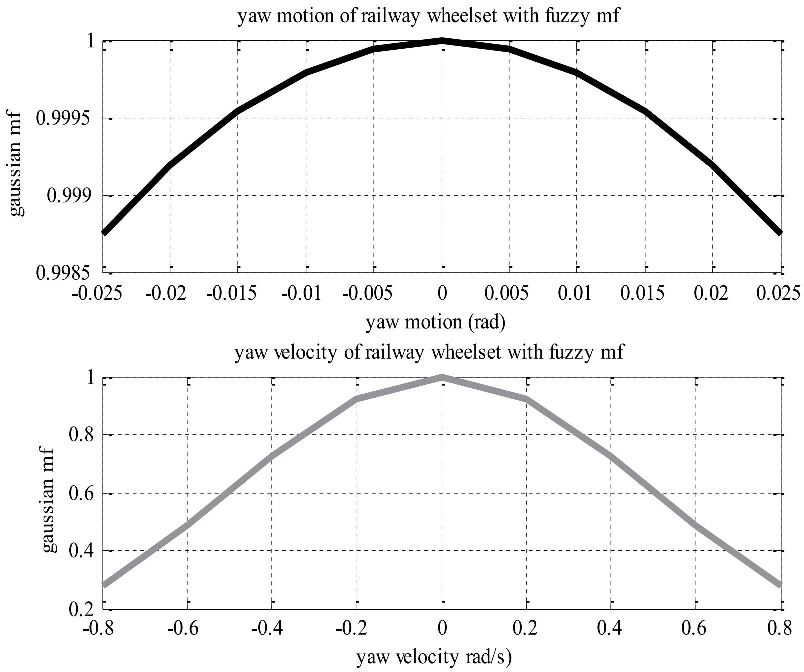

Figure-6 Yaw dynamic behavior by fuzzy member function

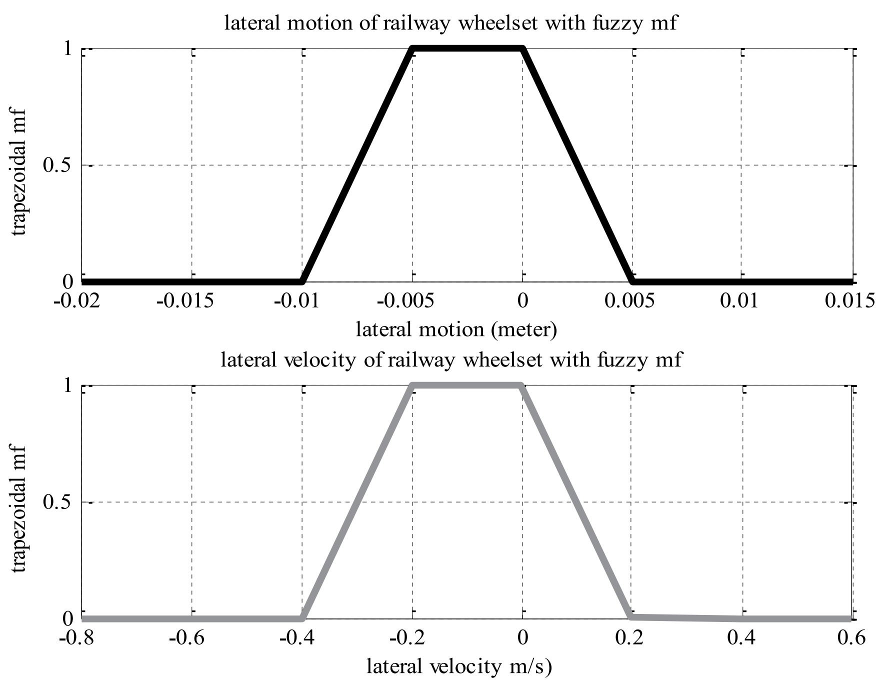

Figure-7 Lateral dynamic behavior by fuzzy member function

decreased surrounding zero in scale.

While in Figure-3 for yaw motion, the caused disturbance is displayed by estimator-1 through error estimation in black color is spaced from -0.025 rad to 0.025 rad on vertical zone within 2.5 seconds. After 2.5 seconds estimator-2 calculates error to decrease the noise in comparison to that of estimator-1 to end in the process of 5 seconds period. Here it is observed that error estimated by estimator-1 is reduced in smaller zigzag around zero in black color at the inner zone of the estimator-2 in grey color, while that of estimator-2 in the plane of estimator-1. The actual signals are running on is zero point.

In figure-7, the lateral dynamic analysis are defuzzified by trapezoidal member function of fuzzy logic system according to their signals prescribed in figure-4 to figure-5 to observe their attitude. Here lateral velocity noise rate is more than that of lateral movement as learned to concerned diagram as well as from this figure-7 by selected trapezoidal points. The horizontal plane refers to their concerned state estimation rates and vertical axis represented by trapezoidal plane. It has having four elements as vector that describes the breaking points member function.

In Figure-7, four elements selected for trapezoidal member function of lateral motion as -0.005 and 0 m for upper portion and for lower portion -0.01 and 0.005 m. While selected four elements for lateral speed as -0.2 and 0 for portion and for lower portion -0.4 and 0.2 m/s.

CONCLUSIONS

The lateral and yaw dynamics for railway vehicle wheelset was enumerated by estimating the generated noise. This noise was then filtered at minimum error by using two estimators of bucy kalman filter. One estimator reduces at some extent while other estimator decreases at eventual space. Whereas member function of fuzzy logic system is used for lateral and yaw dynamic analysis for resembling differentiation and correlation.

From simulation results it can be concluded that yaw rate is mostly dominated by estimator-2 than that of estimator-1 with smaller visible mixed ratio of actual signals. While yaw motion having comparatively greater noise is estimated by estimator-1 and still reduced by estimator-2 after half of consumed time. Thus error ratio is minimized by both estimators at amidst of noise with different opposite estimator colors in smaller zigzag manner followed by actual parameter in back ground.

It can also be concluded from simulation results that lateral rate is also mostly dominated like yaw movement by estimator-2 than that of estimator-1 with smaller visible mixed ratio of actual signals. Whereas lateral movement has very thin noise is estimated by estimator-1 and still reduced by estimator-2 after half of consumed time. Thus error ratio is minimized by both estimators at amidst of noise with different opposite estimator colors in comparatively larger zigzag manner followed by actual parameter in back ground.

This concludes the idea that lateral motion is very low member functions of fuzzy logic are used according to their natural structure of these two degree of freedom that vary by their different assigned values as used for filtering noise.

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