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Tracking Control System For Autonomous Underwater Vehicle Using Mrac Technique

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ABSTRACT : To design the tracking controller for autonomous under water vehicle system using MRAC technique. It also detailed about Modeling and simulation of the dynamic coupling between manipulated system and autonomous under water vehicle. The proposed algorithm may be use to estimate the unknown non linearity online and to compensate for the rest of the system dynamics. Adaptive control system help to find unknown parameter, because under water has high linearity. We cannot able to find the linearity in accurate way so we are using Model reference adaptive control (MRAC) to manipulate the non-linearity. The effectiveness and robustness of the control using Matlabsimulation.

KEYWORDS*:*Manipulated system, MRAC, Trajectory position, Vehicle position.

I.INTRODUCTION

An underwater vehicle is a mobile robot designed for aquatic work environments. Remote control is usually carried out through copper or fiber optic cables. A human operator sits in a shore-based station, boat or submarine bubble while watching a display that shows what the robot sees..The operator can also maneuver the robot. Sophisticated underwater incorporate telepresent to give the operator a sense of being in the place of the machine . A simple underwater called the flying eyeball has been in military and scientific use for decades. The spherical vehicle lacks robot arms but it is highly maneuverable. It is equipped with onboard cameras, lamps and thrusters. A launcher containing the robot and its communications cable is dropped from a boat. When the launcher gets to the desired depth, it releases the robot, which is connected to the launcher by a tether. The tether and the drop cable transmit commands to the robot and convey data back to the operator.

Human-Piloted method causes many problem while driving , trajectory tracking , force control and time delay in the human control machine. These some of few mention difficulties can be solve by using autonomous under water vehicle. For developing a system mathematical model of the AUVMS is needed. Matlab will helps to found Modellling and simulation of the AUVMS. The use of autonomous AUVMS to perform complex underwater manipulation tasks such as closing of valves, cutting, drilling, sampling and in the field of scientific research and ocean system engineering which gives rise in challenging control problems involving nonlinear, coupled and high dimensional systems.

Remotely operate vehicles (ROVs) help to manipulate with one or two manipulators. The Autonomous underwater vehicles (AUVMs) do not have any and are limited to survey-type application. AUVMs is totally different from the manufactory or landbased manipulators, it is highly extract to control underwater manipulator system due to some issue like highly nonlinear, time-variant, uncertainties in hydrodynamic effects and disturbances by ocean, Due to the motion changes its center of gravity and buoyancy.

This paper shows about Model Reference Adaptive control (MRAC) for AUWVMs, Which helps to update the unknown parameters according to the adaptive control system. The output of the system compared to a desired response from reference model. The control parameters are updated based on its error. The goal is for the parameters to converge to ideal values that cause the plant response to match the response of the model reference model.

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II.AUTONOMOUS UNDERWATER MANIPULATOR CONTROL SYSTEM

To cause motion of the links each joint of manipulator are powered and driven by actuator that applies force or torque. A control system provides the actuator commands that move the manipulator to achieve the specified end and effector motion. "Control set-points" generated from the trajectory planner based on their commands. The actual joint and end-effector positions and their measured using sensor and feedback to the controller to correct the error. The extended kalmans filter will help to control the error and maximize the valve according to the consider output

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III. MANIPULATOR DYNAMIC MODEL

Autonomous underwater manipulated system planar manipulator mounting on the vehicle. The coupled effect between manipulator and vehicle is neglected . The angle of manipulated vehicle is shown in the fig 1.

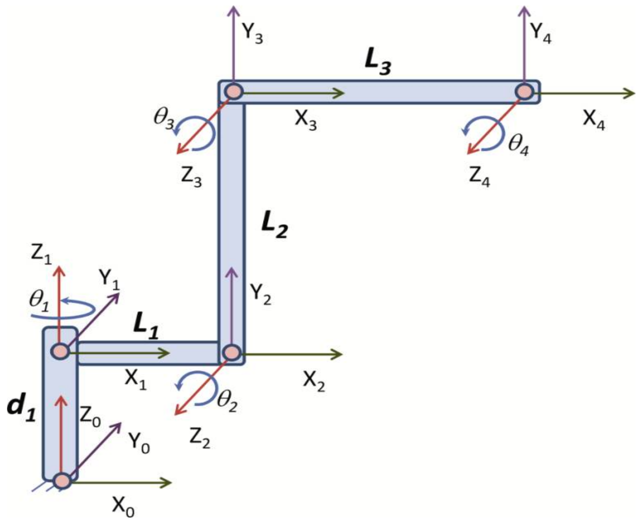

Fig.1. Dynamic system and position of AUVMS

a. Land-based manipulator

$$m(q)\ddot{q} + c(q,\ddot{q})\dot{q} + f_g(q) = u$$

where q is the n x 1 joint angle vector, M(q) is the n x n inertia matrix, C(q,) is the n x n coriolis and centripetal matrix, is the gravity factor and u is the input torque. [2]

b. Underwater Manipulation

Hydrostatics

In static analysis of underwater bodies, both the gravitational force acting on the body mass and buoyancy force must be considered.

IV. DYNAMIC MATHEMATICAL MODEL OF AUVMS

In this work dynamic modeling of AUVWMS is derived using Newton-Euler formulation scheme. The dynamic equation of motions of AUWVMS can be expressed as followed

$$M_v(\eta)\ddot{\eta} + C_v(\eta,\dot{\eta})\dot{\eta} + D_v(\eta,\dot{\eta})\eta + g_v(\eta) + F_v(\mu,\dot{\mu},\ddot{\mu},\eta,\dot{\eta}) = \mathcal{T}_v + W_v$$
$$M_R(\mu)\ddot{\mu} + C_R(\mu,\dot{\mu})\dot{\mu} + D_R(\mu,\dot{\mu})\dot{\mu} + g_R(\mu) + F_v(\mu,\dot{\mu},\eta,\dot{\eta},\ddot{\eta}) = \mathcal{T}_R + w_R$$

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Where $\eta = [xyz\phi\psi\theta]^T$
$\dot{\eta}$= vector of linear and angular velocity of AUWVMS
$\ddot{\eta}$=vector of linear and angular accelerations of the AUWVMS
$M_v(\eta)\ddot{\eta}$= Vector of inertial forces and moments
$C_v(\eta,\dot{\eta})\dot{\eta}$=coriolis and centripetal effect of the vehicle
$D_v(\eta,\dot{\eta})\dot{\eta}$=vector damping effects of the vehicle
$g_v(\eta)$ =restoring effects of the vehicle
τ_v=input vector of thruster , control plane forces and moments.
$M_R(\mu)\ddot{\mu}$=Vector of inertial forces and moments of the manipulated
$C_R(\mu,\dot{\mu})\dot{\mu}$= vector of coriolis and centripetal effects of the manipulator
$D_R(\mu,\dot{\mu})\ddot{\mu}$= vector of dampling effects of the manipulator
τ_R=vector manipulator system
The suffixes "V" and "R" denote the vehicle manipulator system

V. TRACKING CONTROL SCHEME OF THE AUVMS

This research will helps to develop the real time, model-based and adaptive on board nonlinear motion controller for a AUVMs which help to control the manipulated system. This controller can face the problem like associated with parameters variations like buoyancy variations , model uncertainties , disturbances and noises. Model –based adaptive and robust nonlinear controller can be developed in real time controller as first step. Due to the parameter updated scheme system dynamic is observe through the adaptive controller
.

VI. STRUCTUREOFREFERENCEMODEL

Asecondordersystemisapplied frequently for reference model.Theparametersusedarechosenproperly accordingtothedesiredbehaviorthatwewantthesystemreact. A basic second order referencemodel isgiven as:

$$G(s) = \frac{\omega_n^2}{s^2 + 2\eta\omega_n s + \omega_n^2}$$

where$\eta\omega_n$iscalledattenuation,$\omega_n$istheundampednaturalfrequencyandη representsthedampingratio ofthe system.Thebehavior ofthe systemdepends ontherelativevaluesof the$\omega_n$andη.,thevalueofη isset1 in the project,whilethevalueof$\omega_n$canbecomputedwhensettling timeissetto3seconds.Whenη =1,thesystemissaidtobecriticallydamped.Acriticallydampedsystem convergestozerofasterthananyotherwithoutoscillating.Byassigningthisvalue,thereferencemodeltransfer[2]:

$$G_m(s) = \frac{1.78}{s^2 + 2.66s + 1.78}$$

State–Space can be represented instead transfer function.Whenthetransfer functionisconvertedintostate-space,thevalueofmatrix A_n, $B_n$and $C_n$are equalto

$$A_n = \begin{bmatrix} 0 & 1 \\ -1.78 & -2.66 \end{bmatrix}$$
$$B_n = \begin{bmatrix} 0 \\ 1.78 \end{bmatrix}$$
$$c_n = [1 \quad 0]$$

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VII. POSITION OF AUVMs

They have six position which help to move the vehicle,according to manipulated direction.When its moves under the water many non-linearity affect the vehicle. To prevent from that non-linearity EKF has been use to minimize the error of the output

	Name	Forces/Moments	Linear/Angular	Velocities	Position& Euler Angles
1	Surge	(x -axis motion)	X	u	χ
2	Heave	(y -axis motion)	Y	v	γ
3	Sway	(z-axis motion)	Z	W	z
4	Roll	(rotation about x)	K	P	ϕ
5	Yaw	(rotation about y)	M	Q	θ
6	Pitch	(rotation about z)	N	R	ψ

Tab.1.1 position of AUVMs

VIII. DESIGN OF ADAPTIVE CONTROL

State variables and characterizes the behavior of the manipulator state has compare by nonlinear function. This features helps to controller any type of dynamic model. Non linear function of the corresponding state variables should be composed in a closed loop system. This is most used in convertional control laws Leads to a close-loop control system arranged by linear differential equation but exit of control system which is state variable is non-linear. Design parameters is proposed and described in the proposition 1 and performance analysis section is observed (EKF) assisted adaptive control which is capable of fulfilling the tracking control objective with proper selection. This control schemes I to create a close loop controller with system parameters that can be updated to change response of the system through parameter estimate system[1]. The reference model output of the system is compared to a desired response.

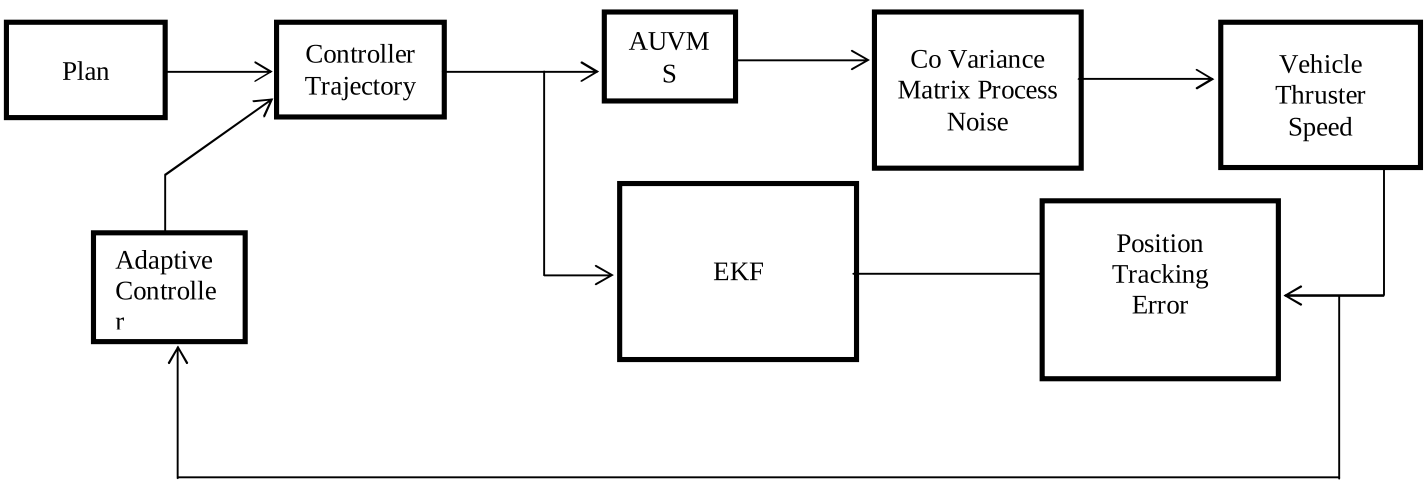

Fig. 2 Block diagram of the proposed control scheme for AUVMS

IX. DESCRIPTION OF THE TASKS

The tasks that has been consider for simulation. The task is that the vehicle is commanded to track a given Matlab trajectory with the manipulator (at rest or home position), initial 20s its accelerates and move the vehicle forward in the speed of 1m/s and for the final 20s , the vehicle decelerates to zero speed. Trajectory position is consider according to sway velocity and out, heave up and down. The Vehicle is 0.25 m/s when it is in sway velocity and heave motion. The position has been chosen to zero when the vehicle and manipulator initial velocity, the initial desired and actual position and orientation . The sensor noise in the positions and orientations measurement are shown in performance analysis.

X. RESULT AND DISCUSSIONS

Matlab simulation result are show and discussed to investigate the effectiveness and shows the observer state errors of the manipulator position based on EKF scheme. The MRAC Technique will help to identify the error in non-linearity but it will affected by the error when the non-linearity are high so EKF has been use to detector error. It will help to reduce the error due to the high non-linearity accurate. Each figure shown out the variation happens when the vehicle moves inside the water.Fig.3 shows the vehicle position tracking error of the PID ideal position when the vehicle in the starting position.

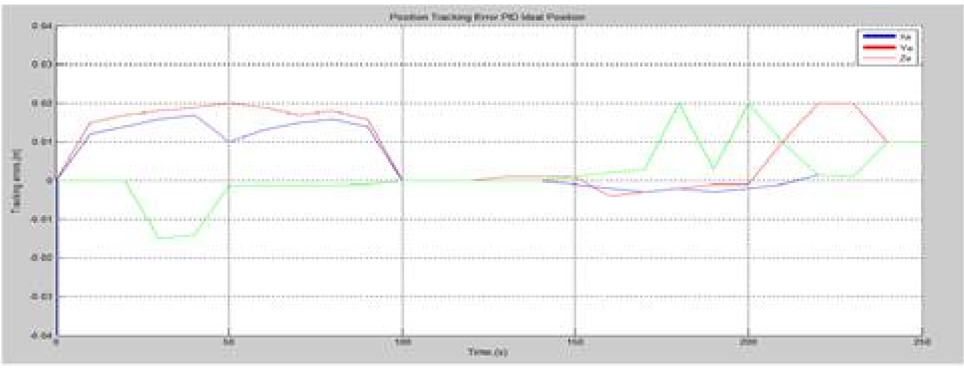

Fig. 3 position tracking error of the PID ideal position

shows the vehicle position tracking error of the PID ideal position when the vehicle in the starting position. Ithelp to move the vehicle inside the water this is the starting stage of the vehicle when it moves.

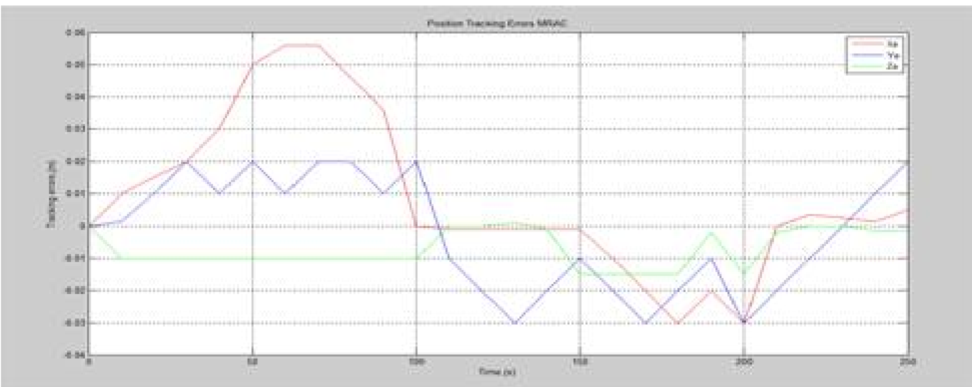

Fig . 4 Position tracking error MRAC

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shows the Position tracking error with the help of MRAC. Non-linearity are high inside the water so when vehicle moves inside the water it ill affect by the non-linearity. To control that error we are using MRAC. This will help to track the position error inside the water.

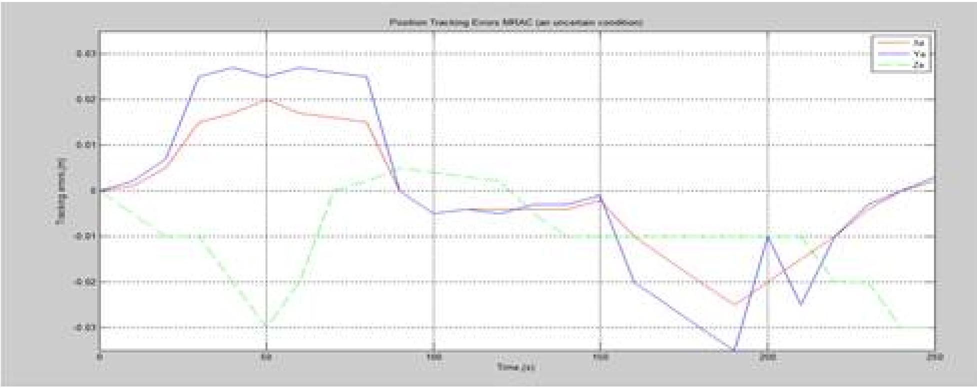

Fig . 5 Position tracking error MRAC (an uncertain condition)

This figure tell about Position tracking error with MRAC when the position is in an uncertain condition . Sometimes the decisions you make will involve a lot of uncertainty and you may not get accurate place so to control tat we are using MRAC .

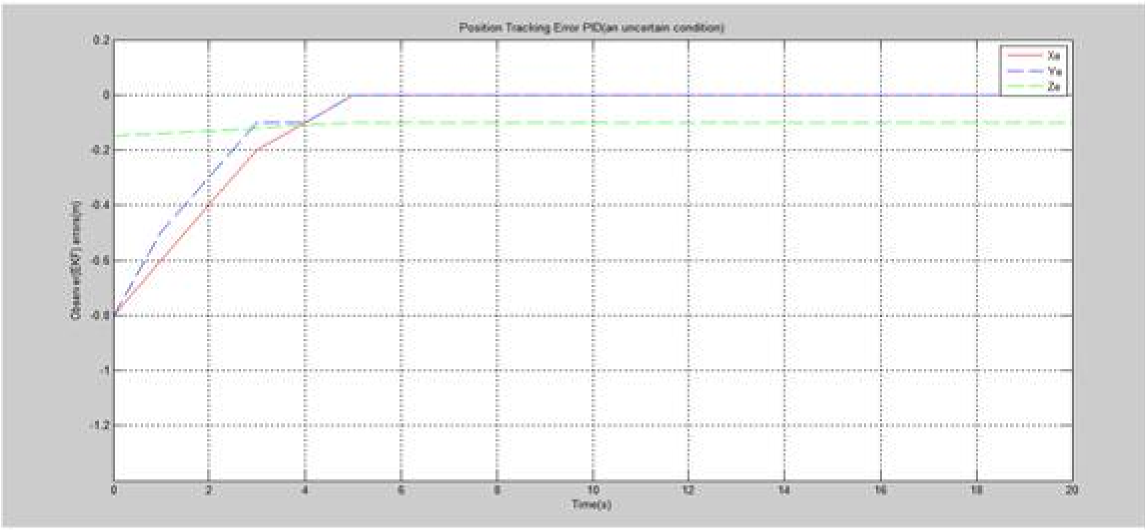

Fig .6 Position tracking error PID (an uncertain condition)

Fig.shown detail about the Position tracking error with the help of PID when the position of the AUWMS is an uncertain condition. Position of AUVMS may be vary so control that we are using PID control .

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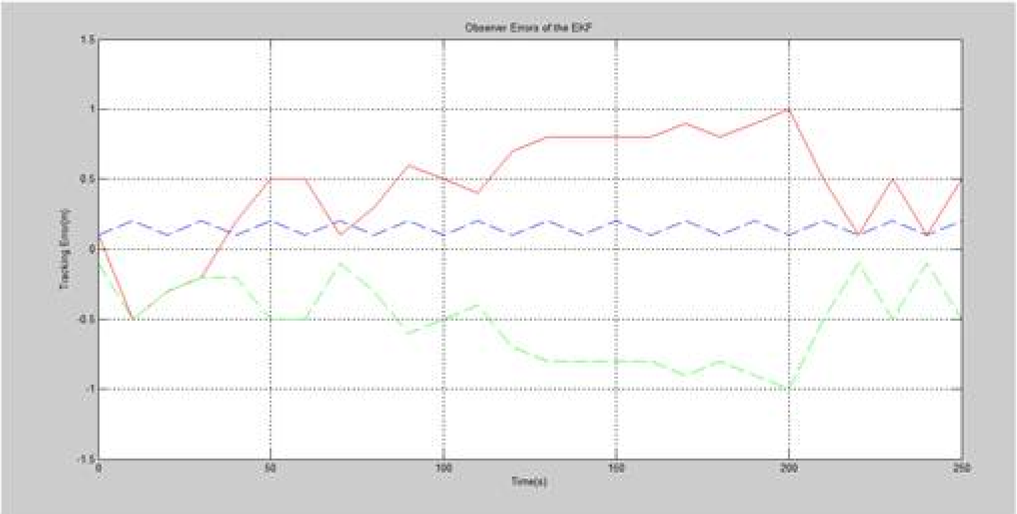

Fig . 7 Observe Errors of the EKF

This fig. will help to Observe Errors of the extended kalman filter (EKF). IF we use MRAC also the non-linearity are high inside the water we wont get accurate value inside the water what we extract aiming . EKF will help to give as the nearest value what we want.

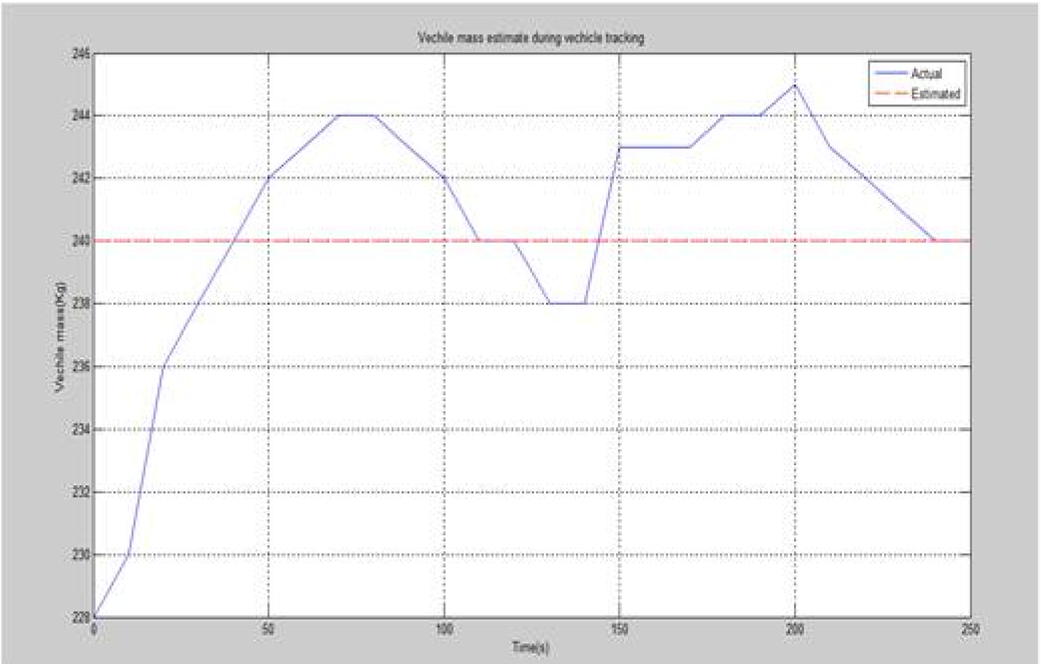

Fig .8 Vehicle mass estimation during vehicle tracking

Figtells detailed Vehicle mass estimation during vehicle is in the tracking position. This will help to track the vehicle where the vehicle is accurately moving.

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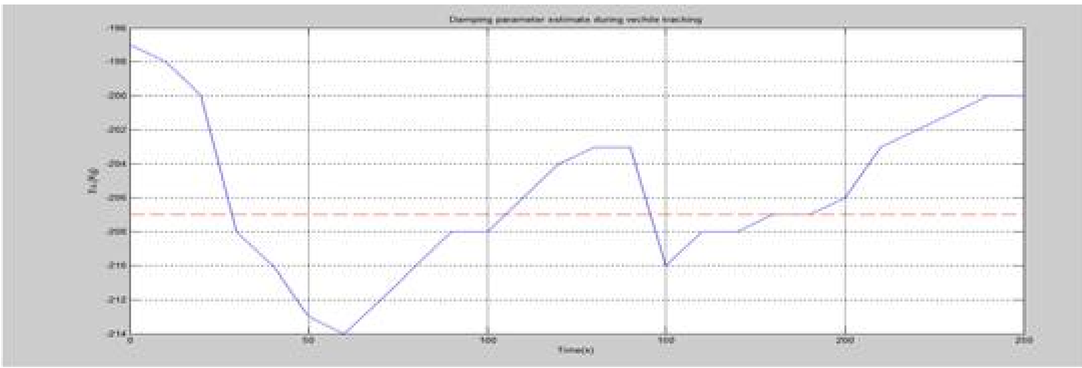

Fig .9 Damping parameter estimate during vehicle tracking

Fig. help to find Damping parameter estimate during vehicle tracking.Damping Parameter is an influence within or upon an oscillatory system that has the effect of reducing, restricting or preventing its oscillations. while the vehicle is in tracking.

XI. CONCLUSION

This work is proposed a model reference adaptive control approach for an AUVMS to perform underwater intervention tasks incorporating desired trajectory information. Matlab simulations were carried out to verify and demonstrate the effectiveness of the proposed scheme. In particular, the performance of the model reference adaptive controller is compared with that of the conventional PID controller for the given AUVMS operation . The obtained results confirm the effectiveness and robustness of the proposed scheme in terms of tracking errors and control effort in the presence of external disturbances and parameter uncertainties. This research provides a generalized framework for modeling and controlling of an AUVMS considering the dynamic coupling between the vehicle and the manipulator, which is crucial for achieving underwater manipulation tasks for a variety of scientific, industrial, and military missions using unmanned underwater vehicles. The future enhancement will show us about the accurate trajectory position of the vehicle and about the sensor of the vehicle.

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