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Development of Sliding Mode Fuzzy Controller for Advanced Navigation System

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ABSTRACT: Considering the robustness of sliding mode controllers against structured and unstructured uncertainties, and also exogenous inputs, the process of design and implementation of a sliding mode controller is proposed based on a linearized and non linearized model of the navigation system. Here, a knowledge-based Mamdani-type fuzzy Sliding Mode Controller (FSMC) is proposed to decrease the chattering effects intelligently, which in turn could obtain the high accuracy tracking performance of the SMC. Following proving the stability of the proposed SMCs based on direct Lyapunov's method, the performance of the proposed controller based on low cost MEMS based accelerometer and gyroscope is compared with that of the extended Kalman filter based IMU through simulation and real experiments with the IMU (Inertial Measurement Unit). To achieve better control performance, fuzzy adaptive sliding mode control is proposed in which the control gains are tuned according to fuzzy rules, and an adaptation law is used to guarantee that the control gains can compensate for model uncertainties of the navigation System.

KEYWORDS: Sliding mode controllers, Kalman Filter, IMU (Inertial Measurement Unit), Mamdani-type fuzzy Sliding Mode Controller (FSMC)

I. INTRODUCTION

Advancement in low cost micro electromechanical inertial sensors have opened new vistas in futuristic highly accurate navigation system that finds application in autonomous vehicles/devices and robots that are able to self navigate in spite of poor or no GPS signal in hazardous environments like mines, underwater, difficult terrains. However, these inertial sensors suffer from errors that increase unbounded and need to be augmented by estimators such as Kalman filters. The real time implementation of Kalman filter poses several problems such as a kalman filter suppresses the effect of inertial sensor noise using GPS derived position and velocity as updates but within a limited band of frequency and time period. A Kalman filter works only under certain predefined model and conventional input data that suit these models but are not easily attainable using MEMS based inertial sensors.

A fuzzy adaptive sliding mode control (FASMC) scheme is used to solve the trajectory tracking problem. Sliding mode control (SMC) provides an effective approach for controlling the systems with nonlinearities, uncertainties, and bounded external disturbances because such control results from a sliding mode on a predefined hyper plane of the state space. However, the undesirable chattering phenomenon is often caused by switching the discontinuous control law from one to another. To attenuate chattering, we introduce fuzzy set theory into SMC to construct the fuzzy sliding mode control (FSMC) for tuning the control gains. In the FSMC system, the control gains continuously vary with the sliding surface according to the fuzzy rules, which effectively attenuates SMC chattering. In addition, an adaptation law is used to guarantee that the gains can compensate for the model uncertainties of the autonomous vehicles.

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II.LITERATURE SURVEY

Study of Sliding mode controller was done in reference 1. Chattering Problem was there as draw back here. So, combination of sliding mode control and Fuzzy control can be used to eliminate this problem . Here, there is no Mathematical Proof for stability, more number of Rules makes system complex Study of FSMC was done. It can overcome Disadvantage of other two methods. Latest Research in FSMC related to navigation Present Research in FSMC and Drawbacks are discussed.

III. PROPOSED ALGORITHM

To design a new, better and reliable navigation system which can work even in the absence of GPS and to substantially increase the time interval over which INS works. To design and develop a high accuracy MEMS based INS and GPS integrating system using FSMC based algorithms not currently available as commercial off the shelf product suitable for navigation applications (theory & simulation). Comparison of performance of proposed FSMC with conventional EKF by simulation. To improve stability and eliminate chattering by FASMC Development of new control law by fusing SMC and fuzzy control for navigation Application. Validation of new control law by MATLAB/SIMULINK simulation. Developed algorithm will be implemented in real-time applications using Embedded C++ on Processor. Integration of MEMS based INS system Fuzzy sliding mode controller with developed algorithm.

The trajectory tracking of an autonomous system is a complex process depending on a variety of parameters which includes Co-ordinates of the system(centre of volume(CV),centre of gravity(CG)),Position of the plane, Orientation of the plane .Tracking error-mainly depends on velocities, control gains(ki),control inputs and other disturbances. There are various methods of reducing the tracking error i.e. by applying fuzzy-based tuning method to error-based fuzzy sliding mode controller for adjusting the sliding surface gain. Since the sliding surface gain is adjusted by “gradient descent optimization method”. Fuzzy-based tuning gradient descent optimal error-based fuzzy sliding mode controller is Stable .model-free controller which eliminates the chattering phenomenon without the use of the boundary layer function. Still the tolerance of tracking error can be reduced to avoid intervention of parameter uncertainties and external disturbances. Adaptive law is used in conjunction with sliding mode fuzzy control.

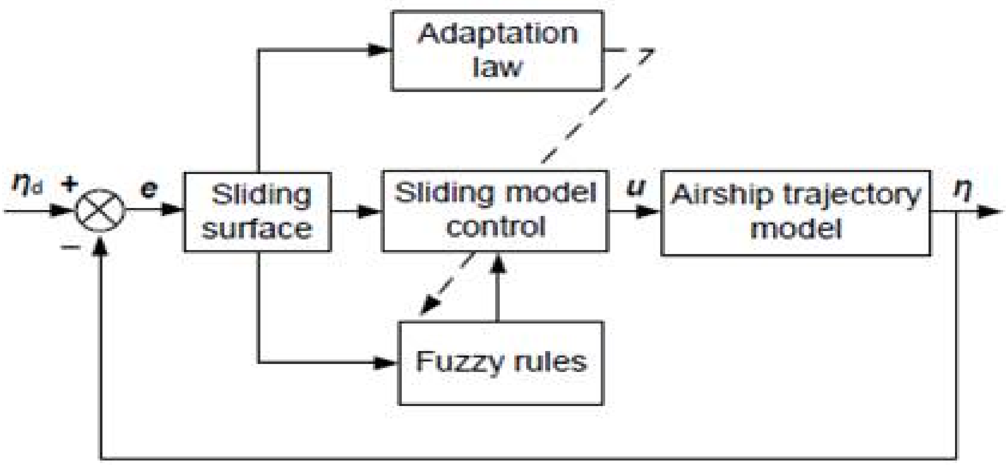

Fig.1 The system block diagram of the fuzzy adaptive sliding mode control (FASMC) scheme

Mathematical modeling of navigation equations. Development of new Fuzzy adaptive sliding mode Controller Law. Designing a new sensor fusion technique using FSMC. Verification of simulation results with Theoretical values. Development of C++ code on Embedded platform. Development of Prototype with Intel Atom Processor using MATLAB C Encoder / MATLAB HDL Encoder.

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IV. EXPERIMENT AND RESULT

With the rapid progress of navigation technologies, the advanced control system plays a key role in the development of the autonomous navigation. Nonlinear dynamics, model uncertainties, and external disturbances contribute to the difficulty in manoeuvring an autonomous vehicle to track a time-varying reference trajectory. Therefore, trajectory tracking control remains a key technical challenge for the autonomous vehicles.GPS & MEMS based INS integration is a complex process and includes Quality and type of inertial sensors, Validity of Error models, Estimation algorithm, Operational aspects. Most extensively used technique for data fusion is based on Kalman filtering methodology and depends on the quality of inertial sensor data which suffers from drawbacks like chattering. So, in order to overcome this, we are designing a prototype which navigates a MEMS based INS device to an FSMC system in which the model uncertainties can be compensated and used for real time applications. In case of GPS signal outages, INS assists the proper motion control of an autonomous vehicles. But, INS will work for world's standard time of 45 seconds. If there is no GPS signal available and when INS working time is greater then vehicle trajectory becomes uncertain. Our main aim is to enlarge the time interval over which INS works.
Classical sliding mode control (SMC), sliding mode fuzzy control (SMFC), and adaptive sliding mode fuzzy control (ASMFC) are implemented in Matlab/Simulink environment. In thesis controllers changing updating factor performance, tracking performance, error, and robustness are compared.

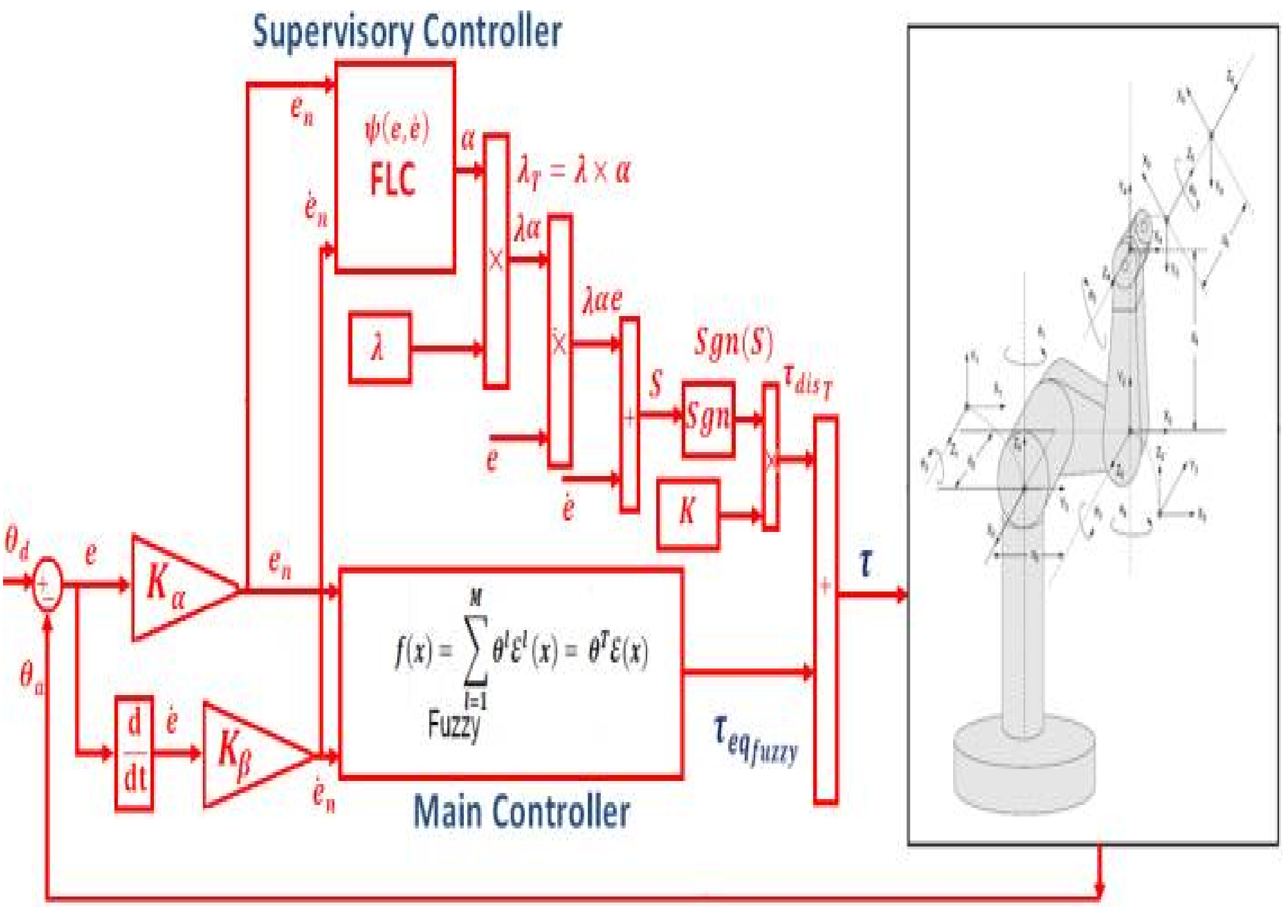

Fig.2: Fuzzy based tuning gradient descent optimal fuzzy sliding mode controller

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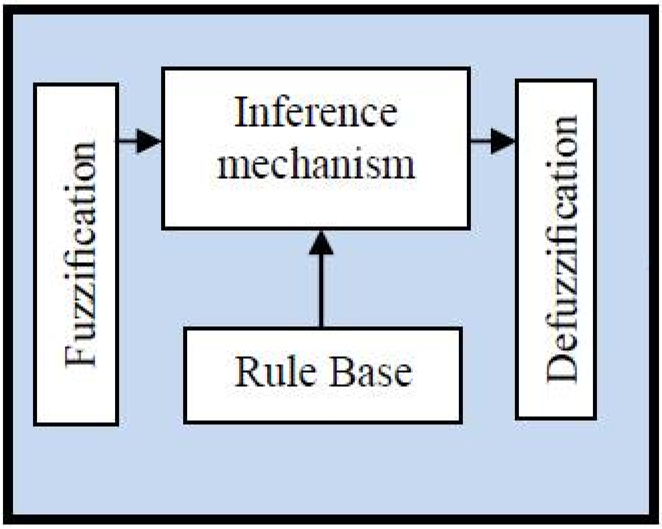

Fig.3.Fuzzy Controller Part

In this,fuzzification was done through rule base by inference mechanism.The fuzzy rule can be applied to get the feasible results.The fuzzified code was again sent to defuzzification for futher processing.

V.CONCLUSION

Firstly, the sliding mode control and its applications were thoroughly studied to understand the exact importance of it in assessing the system non-linear ties and uncertainties varying with time. Secondly, the sliding mode control is combined with fuzzy logic controller for both sliding mode controller and fuzzy sliding mode controller applications the system performance is sensitive to the sliding surface slope coefficient (λ).For instance, if large value of λ is chosen, the response is very fast the system is unstable and conversely, if small value of λ is considered the response of system is very slow but system is stable. Therefore to have a good response, computing the best value sliding surface slope coefficient is very important.

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BIOGRAPHY

I completed my M.Tech in Electrical Power Engineering with an aggregate of 84.4% at ***Srinivasa Institute of Technology & Management Studies*** affiliated to Jawaharlal Nehru Technological University (JNTU).

Educational Qualification	Board/ University	College / School Name	Year of Passing	%Marks
SSC	Board of Secondary Education	RayalSeema Public School	1999-2000	81.5
Intermediate	Board of Intermediate Education	Kora Junior college	2000-2002	86.1
B.Tech (EEE)	JNTU	Srinivasa Institute of Technology & Management Studies	2003-2007	72.7

EXPERIENCE SUMMARY:

Organisation	***Srinivasa Institute of Technology & Management Studies,chittoor***
Duration	***2.5Years (28th Dec 2007 to 15th May 2010)***
Designation	***Assistant Professor***

Organisation	***Oxford college of Engineering,Bangalore***
Duration	***2Years (28th Jan 2012 to till date)***
Designation	***Assistant Professor***

ACADEMIC PROJECT:

TITLE **:** TUNING OF PID CONTROLLER PARAMETERS THROUGH GA
SOFTWARE **:** MATLAB
INVOLVEMENT **:** DESIGNING,CODING & ANALYSIS

This project assists with designing a PID controller for nonlinear systems such as time delay systems, unstable systems and the controller parameters were tuned online using Genetic Algorithm. The tuning of PID controller is more effective with improved system performance. A comparative study of Genetic Algorithm and classical Ziegler-Nichols tuning method were made and optimal response is obtained using Genetic Algorithm for different dynamic systems. In future studies, the genetic based PID Controller can be implemented for specific applications such as speed control of Electric motor drives, Position control of Pneumatic valves, Level control in the boilers etc,.

ACADEMIC EXCELLENCE:

Stands as one of three toppers in all educational courses studied.

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Got cent percent results in various subjects taught.

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