Statistical Optimal Controller for AGV's to achieve High Index of Performance (IP)

Sangeeta Jana, Malay K. Pandit, Asim K. Jana

Abstract:- ***This paper exhibits a new optimal control two simultaneous processes: velocity and speed control in an embedded controller for an AGV (autonomous guided vehicle) in uncertain situations. This technique has been used to fuse information from internal and external sensors to navigate the AGV in an unmapped environment or in case of uncertainty. Uncertainty, the lack of certainty, A state of having limited knowledge where it is impossible to exactly describe existing state or future outcome, more than one possible outcomes. We have optimized speed and position error that contribute to the motion control problems of an AGV. During the movement of an AGV, whether straight or arc create position and orientation errors. The main concern is to achieve the real time and robustness performance to precisely control the AGV movements. We report here for the first time a novel optimization method based on Markov chain.***

Keywords:- ***Uncertainty, Robust, system index performance, probability of system error.***

1. INTRODUCTION

Embedded real time system with two processes running, the CPU usage time provisioned for each process needs simulation study. In our simulation we consider Markov statistics to get the initial estimates for the scheduled times and later controlling the speed error with PID controller and **robust maintenance** of aggregate probability of error of the system. This is a characteristic describing a model's, test's or system's ability to effectively perform while its variables or assumptions are altered. A robust concept can operate without failure under a variety of conditions. Here we are exhibiting the total system error that is 0.6% **globally robust.**

Manuscript published on 30 April 2012.
***** Correspondence Author (s)

Sangeeta Jana, Assistant Professor, Department of Instrumentation and Control Engineering, Haldia Institute of Technology Haldia, West Bengal, India, mob- +919433312053 (Email: jana_sangeeta@yahoo.co.in).

Dr. Malay K. Pandit, Department of electronics and Communication Engineering Haldia Institute of Technology, Haldia, India, mob:9883035230 (Email: mkp10011@yahoo.com).

Asim K. Jana, Department of electronics and Communication Engineering Haldia Institute of Technology, Haldia, India, mob:9433181550, (Email: asimkjana@gmail.com).

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license http://creativecommons.org/licenses/by-nc-nd/4.0/

2.

3. RELATED WORK

Cazorla et al [1] have studied QOS for embedded systems and Peha[2] suggested some new approaches towards scheduling. J.Liu and E.A.Lee [3] have studied on timed multitasking for real-time embedded software. C.L.Liu and J.W.leyland[4] studied on scheduling algorithms for multiprogramming in a hard real time environment. J.T.Buck.[6] studied on static scheduling and code generation from dynamic dataflow graphs with integer valued control systems. Matschulat et al[7] and Tomoyoshi et al[8] have studied QOS in embedded systems .Atanas Georgive and Peter K.Allen(2004)[9] studied on localization Methods for a Mobile Robot in Urban environments.

4. METHODOLOGY

This research lies in a finite state machine(FSM) based Markov process model for schedulers[5,10] where processes settle to a steady state probability distribution as time evolves. Fig.1, fig.2 and fig3 illustrate convergence of two states one is position and another is velocity we define it as st1 and st2 respectively to steady state with initial state probability distributions πo=[0.50:0.50], [0.40:0.60], [0.30:0.70] respectively considering 100 iterations for each case. Thus the irrespective change of initial considerations of all these cases the two states converge to a steady state value, which justifies our consideration of Markov process.

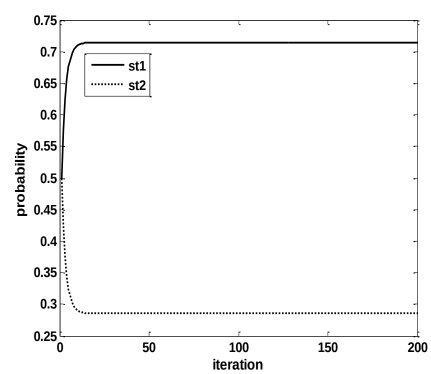

Fig1. Convergence of two states having initial state distribution [0.50:0.50]

© Copyright: All rights reserved.

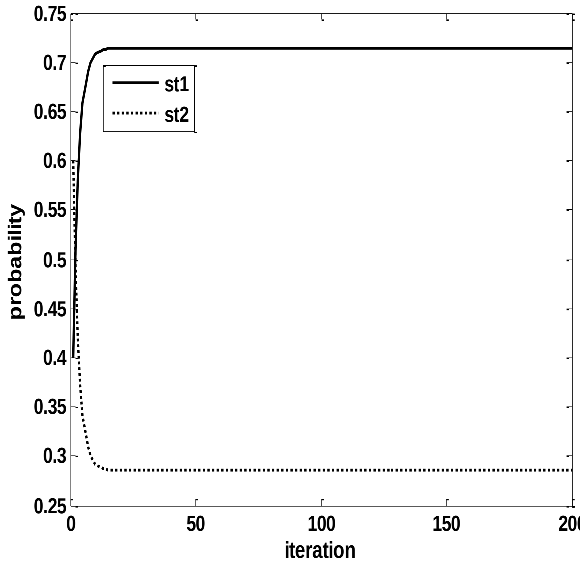

Fig2. Convergence of two states having initial state distribution [0.40:0.60]

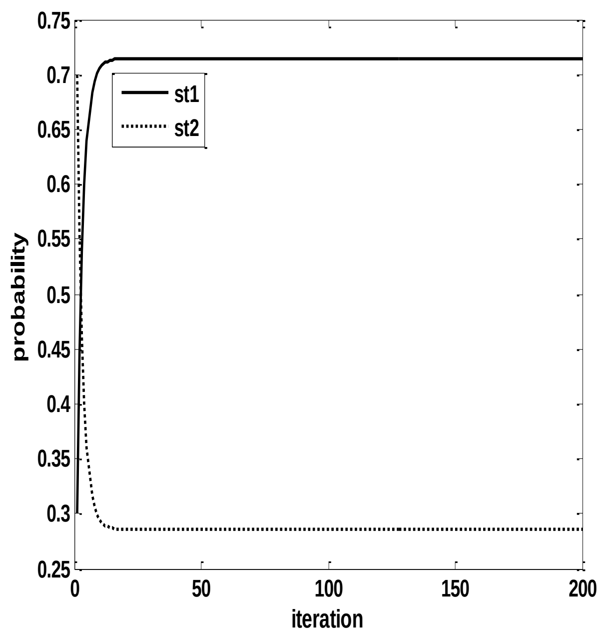

Fig3. Convergence of two states having initial state distribution [0.30:0.70]

4. MODEL AND WORK

4.1 Cruise (speed) control

In Cruise (speed) control system we are basically dealing with two controllers' proportional and integral for handling two errors: one is rise time and another steady state error.

According to our design criteria the car will reach a maximum velocity of 10m/s and able to accelerate up to speed less than 5s that is maintaining rise time error<5s and steady state error<2%.The basic block diagram of this cruise control system is typical unity feedback system that is shown in fig.4.

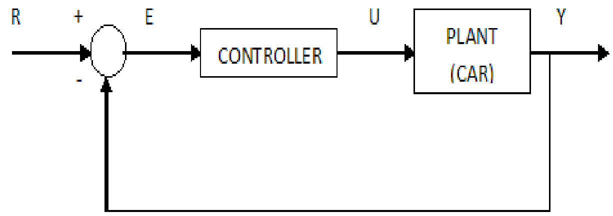

Fig4. Basic Block Diagram of Cruise Control System

The transfer function for this cruise control system

$$Y(s)/U(s)=1/(ms+b) \qquad (1)$$

Where assuming m=1000,b=50,U(s)=10,Y(s)=velocity output.

Initially we are setting Kp i.e proportional control gain 100 and getting the step response of fig.5 shown.

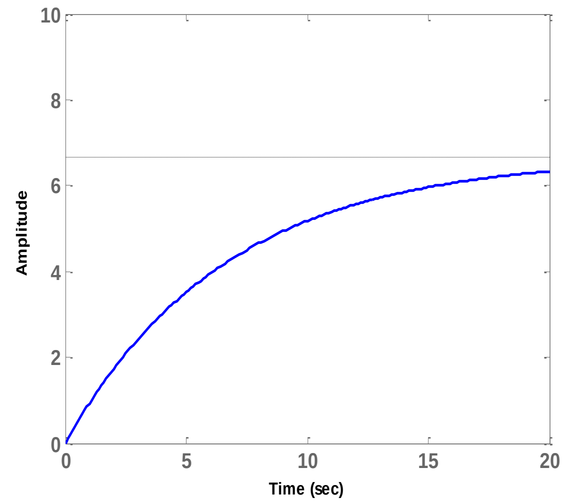

Fig.5. Step response with proportional gain, Kp=100

From plot neither the steady state error nor the rise time satisfies design criteria. Next increasing the Kp value to 10000 and the step response shown in fig.6.

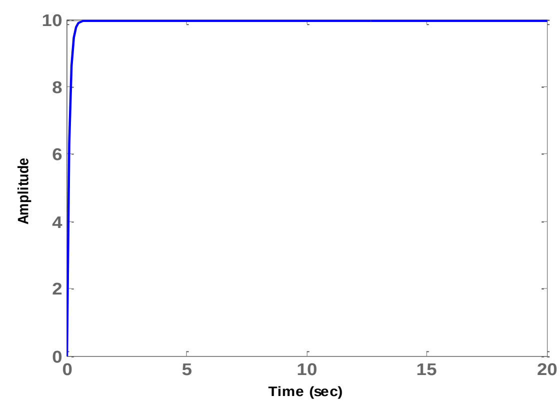

Fig.6. Step response with proportional gain, Kp=10000

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.

Here the steady state error has dropped to zero and the rise time has decreased to less than 0.5 second that is unrealistic.

The solution to this problem is to choose a proportional gain Kp that will give a reasonable rise time and add an integral controller to eliminate the steady state error. Setting Kp value to 600 and Ki (integral gain) to 1 we get the response curve shown in fig.7.

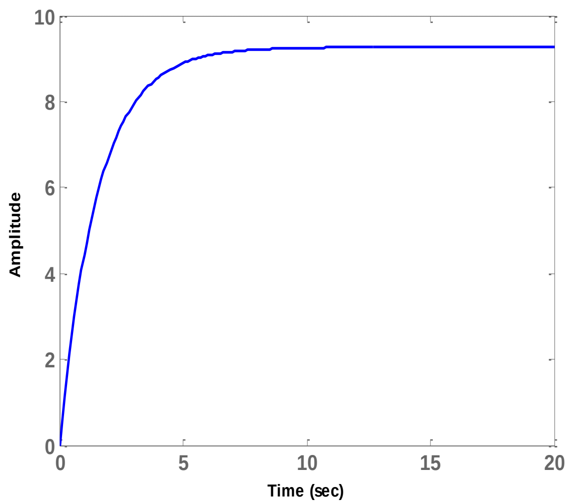

Fig.7. Step response with proportional gain, Kp=600, Ki=1

To eliminate the steady state errors adjust both Kp and Ki value to obtain desired response. Whenever adjusting Ki start with a small value since large Ki can destabilize the response. Setting Kp to 800 and Ki to 40 we are getting the step response shown in fig.8 which meets all design criteria.

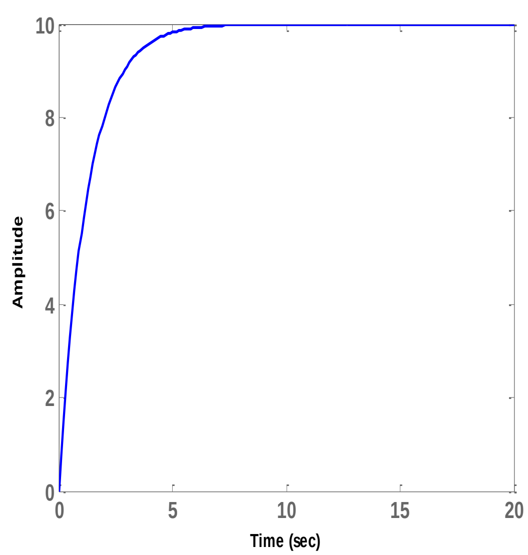

Fig.8. Step response with proportional gain, Kp=800, Ki=40

For that above, unity feedback cruise control system, if we consider with Proportional controller only we can write from the above fig.4

E(s)/R(s)=(ms+b)/ms+(b+Kp) (2)

For the unity step input we can write E(s)=1/(s+((Kp+b)/m))

Therefore e(t)=e-((Kp+b)/m)t

Now Integral square error of the system ISE=$\int_0^\infty e^2(t)dt$ =1/(2(Kp+b)/m).

u(t)=Kp.e(t)=Kp.e-((Kp+b)/m)t

The quadratic performance index of the system J=$\int_0^\infty [e^2(t)+u^2(t)]dt$

After deriving J=m/(2(Kp+b))+((Kp+b)/2m) (3)

The minimum value of J obtained when dJ/dKp=0.This performance index assigns larger weight for error minimization.Finally Kp value comes 900.This value of Kp almost match with the value of Kp that is 800 as shown in fig.8 to get the best step response of our system.

4.2 Position Control

For position control we ave used infrared sensor or using forward looking radar sensor to detect objects moving in front and measure their distances or position.

5. MARKOV STATISTICS

In our model we consider two processes assigned to a single processor. Fig.9 demonstrates the two processes <P1> and <P2> state transition diagram. The directed edges determine CPU's transition or switching from one process to other. The CPU may stay on its present state or switch over to other state, determined by external events. The weights of the corresponding edges are considered as the transition probabilities.

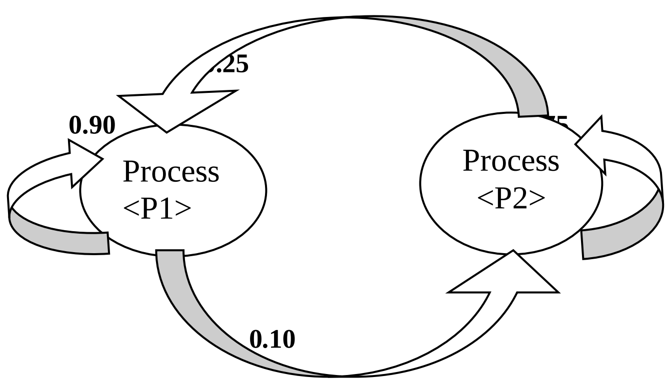

Fig 9: State transition model for two processes

For simulation we consider two matrices P, a state transition matrix for Markov model (here two state model) and E, an error probability matrix. Δ1, Δ2 are the changing parameters. If the state transition matrix P changes by Δ1 and Δ2 the resultant matrix will be Ptun.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.

$$P = \begin{bmatrix} 0.90 & 0.10 \\ 0.25 & 0.75 \end{bmatrix} \quad (1)$$

$$E = \begin{bmatrix} 0.002 & 0.02 \end{bmatrix} \quad (2)$$

$$P_{tun} = \begin{bmatrix} 0.90-\Delta_1 & 0.10+\Delta_1 \\ 0.25+\Delta_2 & 0.75-\Delta_2 \end{bmatrix} \quad (3)$$

The simulation is done by MATLAB version 7.0.We perform simulation for calculating error vector which give error positions in 300000 sequences(iterations) considering random numbers and the state sequence matrix which deals with state transitions. The probability of finding the processor in a given state can be calculated from the state sequence matrix. Similarly error probability can be found from the error vector.

6. RESULTS

We kept the value of tuning parameter Δ1 from -0.02 to +0.05 in step of 0.01 for a given error generation matrix E. Similarly keeping the value of Δ2 from -0.10 to +0.08 in step of 0.01 for a given error generation matrix. Pe,sys (probability of system error) plotted as function of Δ's in fig.10 and fig.11. Pe,sys is robust(stable) if values of Δ1 and Δ2 are kept -0.005 and +0.005 respectively. Although we consider separately a particular combination Δ1 /Δ2 =-/+ 0.005 gives globally robust Pe,sys (probability of system error) and resulting in best system performance.

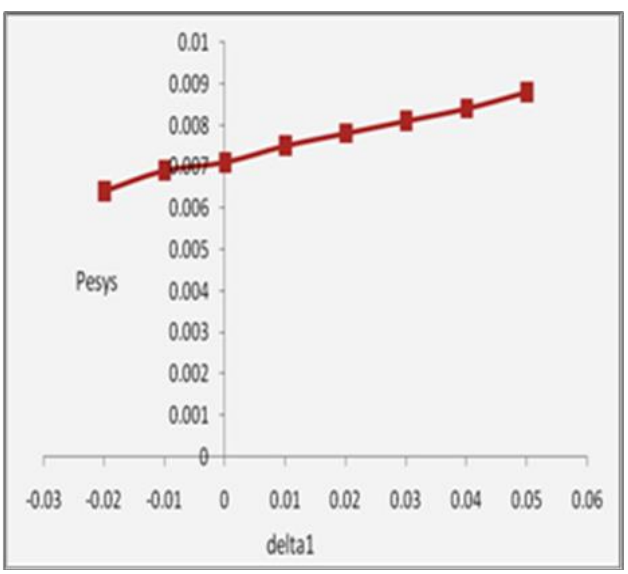

Fig.10. $P_{e,sys}$ Vs Δ_1 (Δ_2=0)

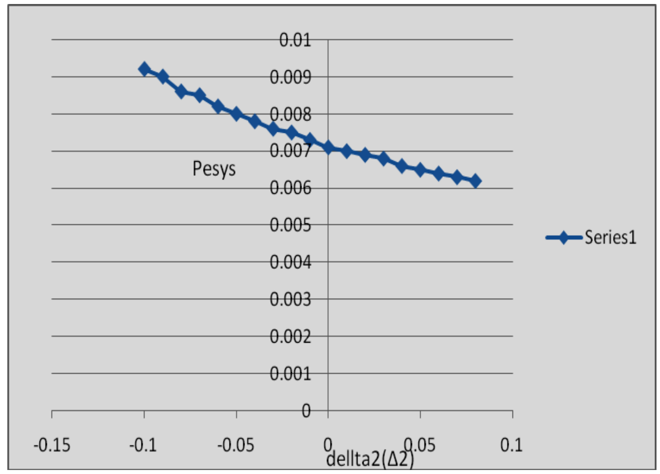

Fig.11. $P_{e,sys}$ Vs Δ_2 (Δ_1=0)

7. CONCLUSSION

Here we have designed a novel scheduler using Markov statistics for use in embedded systems and dealt with speed and position control and maintained high performance index to keep the probability of total system error(Pe,sys) ,globally robust. As processor can not accurately assign a fixed value of Δ .From the above figure it is evident probability of total system error(Pe,sys) is not changing with Δ over a certain range so robust maintenance of Pe,sys is required.

8. ACKNOWLEDGEMENT

We sincerely acknowledge financial support from the TEQUIP, Gov of India (Technical Education Quality Improvement Programme)-Phase 1 grant.

REFERENCES

[1] F.J.Cazorla,Peter M.W.Knijnenburg and E.Fernandez, " QOS for high performance SMT processors in embedded systems", IEEE Micro,July-Aug 2004,pp.24-31.

[2] J.M.Peha and F.A.Tobagi,"Cost based Scheduling and Dropping Algorithms to support Integrated Services", IEEE transactions on Communications, Vol 44, No.2, Feb.1996, pp.192-202.

[3] J.Liu and E.A.Lee, "Timed multitasking for real-time embedded software", IEEE Control system Magazine, pages 65-75, 2003.

[4] C.L.Liu and J.W.leyland, "Scheduling algorithms for multiprogramming in a hard real time environment", Journal of the ACM, 20(1):46-61, 1973.

[5] A.Snaverly, D.M.Tullsen and G.Voelker , "systematic job scheduling with priorities for a simultaneous multithreaded processor" Proc of 9th International Conf on Architectural Support for programming languages and operating systems(ASPLOS-9),ACM Press,2000,pp,234-244.

[6] J.T.Buck," static scheduling and code generation from dynamic dataflow graphs with integer valued control systems". In IEEE Asilomar Conf. on signals, systems, and computers, Pacific Grove,CA, 1994.

[7] Matschulat ,C.A.M.Marcon ,F.Hessel,"A QOS scheduler for real time Embedded systems'',9th Int symposium on Quality Electronic Design(Isqed-2008),March 17-19,2008

[8] S.Tomoyoshi, T.Kosuke,"Table based QOS control for embedded real time systems",

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.

Proc of the ACM SIGPLAN 1999 workshop on languages, compilers, and tools for embedded systems,1999,pp-65-72.
[9] Atanas Georgive and Peter K.Allen(2004), "Localization Methods for a Mobile Robot in Urban environments" IEEE, Transactions on robotics,Vol,20.No.5,October2004,pp851-864.
[10]R.Jain,C.J.Hughes and S.V.Adve,''Soft real time scheduling on simultaneous multithreaded processors", Proc of 23rd real time systems symposium(RTSS-23),IEEE Press,2002,pp.134-135.

AUTHOR PROFILE

Sangeeta Jana is working as Assistant Professor at Haldia Institute of Technology, Haldia, W.B, INDIA. She has received B.Tech, M.Tech Degree in Electronics and Instrumentation Engg and Microelectronics and VLSI Design from CEMK, Kolaghat and NIT, DURGAPUR, W.B, INDIA in 2008 and 2010 respectively, currently pursuing Ph.D at Haldia Institute of Technology under West Bengal University of Technology. Her main research interest includes embedded systems.

Malay K. Pandit received his B.E and M. E degrees in Electronics Engineering from Electronics and Telecom Engg Dept, Jadavpur University, India in 1989 and 1991, respectively. He received his PhD from UK's renowned Cambridge University in 1996. He did his post-doc from the Optoelectronics Research Centre, City University of Hong Kong till 2002 where he pioneered the use of polymers for optical waveguide applications. .He then took a corporate career where he worked in a fibre optic company "FONS (I) Ltd" in the domain of optical networking. Now he is a full Professor in the Electronics Engg Dept and Dean of School of Engineering of the reputed Haldia Institute of Technology where he focuses on embedded systems and grid computing, including their usage in WDM optical networks. He has 45 international publications in this area.Dr. Pandit was awarded the National Scholarship of the Government of India in 1983 and the Nehru Scholarship of the Government of India during his Ph.D. studies

Asim K. Jana is working as Associate Professor at Haldia Institute of Technology, Haldia, W.B, INDIA since 2000. He has received B.Tech, M.Tech Degree in Electronics and Communication Engg and Production Engg from Jadavpur University, W.B, INDIA in 1988 and 1995 respectively, currently pursuing Ph.D at Haldia Institute of Technology under West Bengal University of Technology.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)
© Copyright: All rights reserved.