International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-9 Issue-1, May 2020

Speed Control for DC Encoder Motor and Path Optimization in an Automated Guided Vehicle

Madhuri Chavan, Maya G.

Abstract*: Automated guided vehicle （AGV） has variety of applications in the field of automotive and logistics. For stability of plant AGV should run at a constant speed. The AGV incorporates DC encoder motor which is controlled by Fuzzy controller and PID controller to acquire the constant speed. Response of the system with of fuzzy controller and PID controller is done. . The steady state error and overshoot of the system is reduced by the fuzzy logic controller. Dijkstra's algorithm is applied to find an optimal path. This algorithm finds the shortest path between the source node and destination node.

***Keywords:* Automated Guided Vehicle, Fuzzy controller, shortest path, Dijkstra's algorithm**

I. INTRODUCTION

AGVs are extensively used in industrial applications. AGVs are used in the field of transportation, material handling, warehousing and various engineering applications. In [1] the AGV is incorporated with programmable logic controller (PLC) for the material handling system. Space utilization, increase delivery speed and increase productivity are advantages of AGV. The AGVs have high uniqueness. The design for an AGV is given in [2]

Variation in speed of in AGV causes the instability and it affects the productivity in industries. Therefore there is need for the speed control in AGV. The various controllers used for the speed control are Proportional, Proportional Integral, proportional Integral Derivative controllers. For the speed control in AGV, the speed of the DC encoder motor should be maintained constant. Lead time is increased due to irregular speed and thus productivity of the system decreases. PID controller tuning using the Ziegler-Nichols method is given in [3]. Error is more in the case of PID controller so there is need of controller which reduces the overshoot and steady state error.

Path planning is the basic problem in the AGV, it is the finding the optimal path from source node to destination node. Path planning using navigation function is given in [4].Different algorithms are used to find the optimum path. Dijkstra's algorithm, A-star (A*) algorithm, Tabu search genetic algorithm, are the algorithms used for finding optimal path. Dijkstra's algorithm is based on labelling method and computation is simple comparing to other algorithms.

The paper contains the system configuration which includes the system description and controllers used for the speed control. Then the optimal path calculation algorithm is defined. Last section of the paper contains the simulation result for speed control which gives the comparison of the response of the controllers and optimal path calculation simulation. The simulations are done in MATLAB

Manuscript received on April 02, 2020.
Revised Manuscript received on April 21, 2020.
Manuscript published on May 30, 2020.
* Correspondence Author
Madhuri Chavan*, Dept of Electrical and Electronics Engineering, MESCE Kuttippuram, India. Email: madhuri619madhu@gmail.com
Dr. Maya G., Dept of Electrical and Electronics Engineering, MESCE Kuttippuram, India. Email: haimayag@gmail.com

II. SYSTEM CONFIGURATION

A. Transfer function of the system

Motor is the system and encoder is the feedback element. An encoder which measures the speed of the DC motor. The encoder motor with specification 12V and rated speed is 4500rpm. The motor parameters are provided in Table 1. By using the motor parameters transfer function of the plant (DC motor) is given by Equation. 1

$$G(s) = \frac{10857.14}{s^2 + 175.45s + 685.7} \tag{1}$$

Table- I: DC Encoder motor specifications

Parameters	Symbols	Values
Armature inductance	L	0.35mH
Moment of inertia	J	0.005Kgm^2
Armature resistance	R	0.6Ω
Torque constant	K	0.19Nm/Amp
Damping ratio	B	0.02Nms

B. System Description

Block diagram of the system is shown in Fig.1, in which motor is the system and encoder is the feedback element .Encoder which keeps on calculating the shaft rotation of the motor and which is fed back to the controller and then shaft position is converted into angular velocity. The speed is the set point. Then the controller tries to reduce error in the speed. For the speed control fuzzy logic controller mamdani technique and Z-N method for PID controller tuning is used [5]

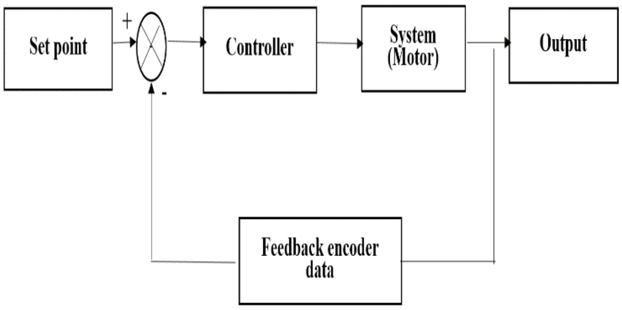

Fig. 1.Block diagram

C. PID Controller

Zeigler Nichols method which is used for the PID Controller tuning. In this method two constants delay time, time constant L and T respectively are calculated from the open loop system simulation. The curve will be S-shaped and tangent is drawn to the curve. The intersection of tangent with time axis gives L and intersection with steady state value gives T.

The gains Kp, Ki and Kd calculated based on the Zeigler-Nichols tuning rule and is consolidated in Table-II

Table-II: PID controller values

controller	Kp	Ti	Td
P	*T*/*L* = 63.02	∞	0
PI	0.9 *T*/*L*= 56.72	*L*/0.3= 0.014	0
PID	1.2*T*/*L*=76.624	2L=0.0088	0.5L=0.0022

D. Fuzzy logic controller

The Fuzzy process is divided into three parts: Fuzzification, inference engine and Defuzzification shown in the Fig.2. The input variables and output variables are defined according to function of controller. Fuzzification converts the motor speed into rhetorical data. Here the inputs are reference speed and speed error.

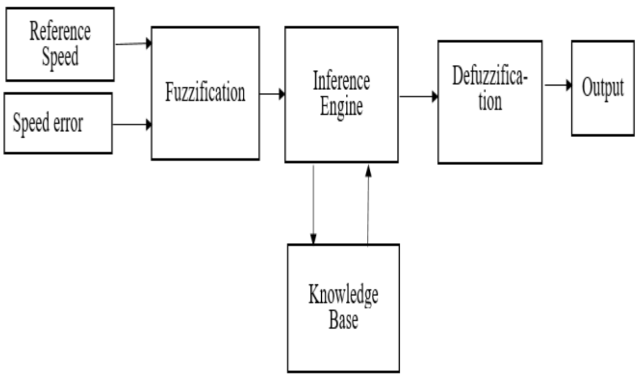

Fig. 2. A general block diagram of Fuzzy logic controller

Fuzzy logic controller which has RPM as input and output is the voltage. Fig. 3 (a) and Fig. 3(b) shows error and change in error of speed which are input membership functions. There are 7 membership functions in input.

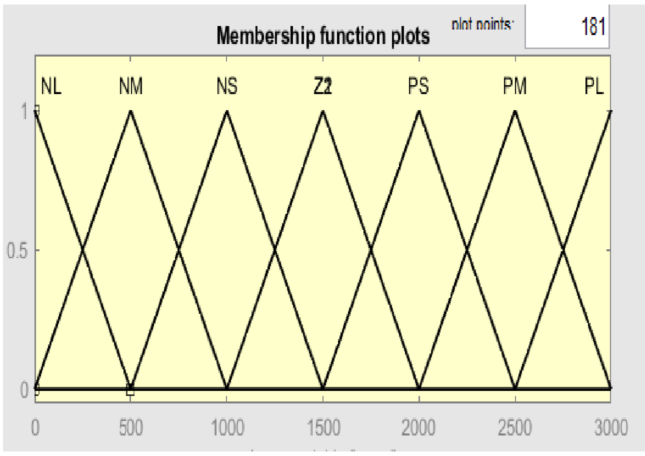

Fig. 3(a). Error

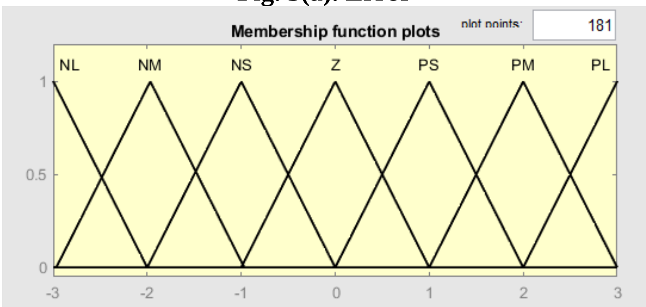

Fig. 3(b). Change in error

The input range of speed is 0 to 3000 rpm. Change in error range kept from -3 to 3.The input membership functions denoted by big negative (BN), medium negative (MN), small negative (SN), zero (ZE), big positive (BP), medium positive (MP), small positive (SP).

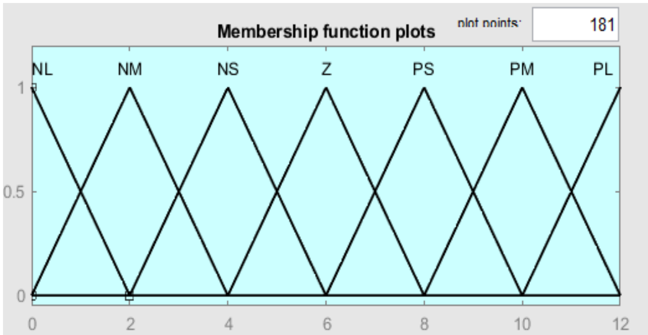

Fig. 4. Output membership function

. The output is voltage in range 0-12V and it is denoted by BN, MN, SN, Z, BP, MP and BP There are 7 membership functions in output shown in Fig.4. There are 49 rules given in Table-III

Table-III: Fuzzy rules

E / CE	BN	MN	SN	ZE	SP	MP	BP
BP	ZE	SP	SP	BP	BP	BP	BP
MP	SN	ZE	SP	MP	BP	BP	BP
SP	MN	SN	ZE	SP	MP	BP	BP
ZE	BN	MN	SN	ZE	SP	MP	BP
SN	BN	BN	MN	SN	ZE	SP	MP

MN	BN	MN	BN	BN	SN	ZE	SP
BN	BN	MN	BN	BN	MN	NS	ZE

The rules defined for the system are if the speed of motor is low than desired speed then output should high. The difference between measured speed and desired speed is positive and the change in error is also positive the output should positive. Output is voltage and which directly proportional to speed.

III. OPTIMUM PATH TRACKING

An optimum path algorithm is designed for AGV. AGV can travel different paths from the given source to destination. Therefore, to make the planned path optimal the routing algorithm must followed by the AGV.

The junctions in the path are known as nodes and radio frequency identification (RFID) tags are placed in each node, distance from one node to another node is called edges. The positioning of AGV using RFID in smart factories is given in [6].

The shortest distance between two nodes is calculated by Dijkstra's algorithm [7]. This algorithm can be used to find the shortest distance from the source node to the destination node. Fig. 5 explains the flowchart of Dijkstra's algorithm. Steps to find optimal path as follows, find the source node from which distance to other node is computed and the destination node and the distance between all the nodes. The distances from each node to other nodes is set to infinity and distance from each node to same node is set to zero. For every neighbor, the distance to the starting node is calculated, and the neighbor's weight is updated. The updated weights are given distance of the parent plus the edge distance. The iteration for the weight updating continue till the destination node is reached.

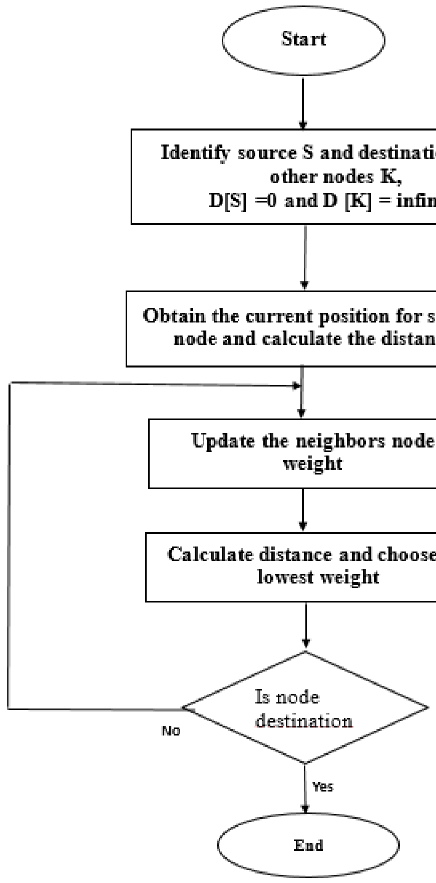

Fig. 5. Flowchart of Dijkstra's algorithm

IV. SIMULATION RESULTS

A. PID controller parameters

Transfer function of the system in equation 1, the system is simulated under open loop condition. The PID parameters Kp, Ki, Kd can be calculated by Ziegler-Nichols tuning algorithm. T and L are calculated to tune Kp, Ki, Kd. From the graph Fig. 6 the values are obtained as T=0.277 sec which is distance from origin to tangent intersection at time axis and L=0.0044 sec which is distance from origin to the tangent intersection at steady state level.

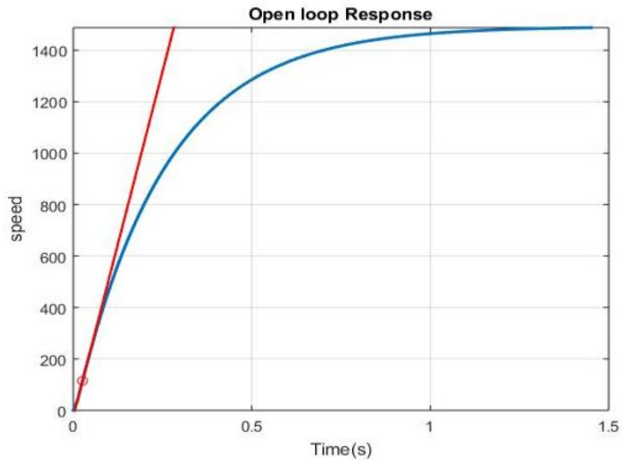

Fig. 6.Zeigler-Nichols Tuning

Retrieval Number: F1133038620 /2020©BEIESP
DOI:10.35940/ijrte.F1133.059120
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

B. System response

The system defined in equation 1 is simulated in Matlab Simulink. The set point is the reference speed given as unit step input. The simulation result obtained for the four responses shown in graph Fig.7. First response is step response the response without controller which has undershoot response. The fuzzy rules in Table-III is used for the simulation of the fuzzy logic controller and Zeigler-Nichols tuning PID Parameters values which obtained from the Table-II.

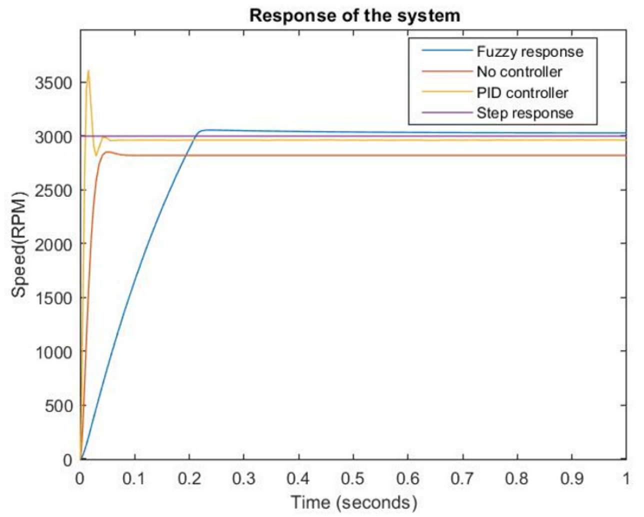

Fig. 7. System response

Comparison of steady state values, steady state error (Ess), Peak time (Tp), Settling time (Ts), Rise time (Tr), Delay time (Td) and Peak overshoot (Mp), are shown in Table-IV. From the table IV it is observed that in case of fuzzy controller overshoot and steady state error is least comparing to PID controller.

Table-IV: Simulated result of the system

Sl. No	Parameters	Without controller	PID controller	Fuzzy controller
1	Ess	10%	2.3%	1.4%
2	Mp	Undershoot	20%	1.9%
3	Tp	0.05	0.011	0.248
4	Ts	0.248	0.2	0.3
5	Tr	0.035	0.004	0.2
6	Td	0.006	0.002	0.037

C. Optimum path determination using Dijkstra's algorithm

For the optimum path calculation the Dijkstra's algorithm is used. Considering the AGV travels in a room with dimension as 100 * 100. The number of nodes are 10.Fig.8shows the optimal path from the 8th node to 2nd node. The shortest path calculated is 54.48

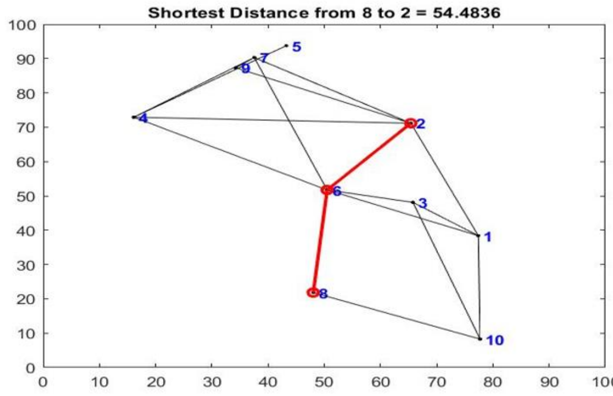

Fig. 8.Optimal path using Dijkstra's algorithm

V. CONCLUSION

The AGVs are extensively used in production units, warehouses and engineering applications. Since their functions differ in each sector, environments where they deployed also vary. Steady state error, Overshoot of the system is lesser for fuzzy controller comparing to PID controller which will reduce lead time of AGV. The system stability is more in case of fuzzy logic controller. Optimal path for AGV is calculated by Dijkstra's algorithm

REFERENCES

1. V Jaiganesh, JD Kumar, J Girijadevi , "Automated guided vehicle with robotic logistics system"- Procedia Engineering, 2014 - Elsevier
2. John Faber Archila , Marcelo Becker, "Mathematical models and design of an AGV (Automated Guided Vehicle)" , IEEE 8th Conference on Industrial Electronics and Applications (ICIEA), 2013
3. P. M. Meshram , Rohit G. Kanojiya, "Tuning of PID controller using Ziegler-Nichols method for speed control of DC motor", IEEE-International Conference On Advances In Engineering, Science And Management, 2012
4. Aniket K. Kar, Narendra K. Dhar,SSFarhad Nawaz, Rashi Chandola, "Automated Guided Vehicle Navigation with Obstacle Avoidance in Normal and Guided Environments", 11th International Conference on Industrial and Information system, 77-82, 2016
5. Priyam Parikh, Saurin Sheth, Dr. Rupesh Vasani, Jigar Kumar Gohil, "Implementating Fuzzy logic controller and PID controller to a DC encoder motor, - A case of an automated guided vehicle", 2nd International conference on materials manufacturing and design engineering, 219-226, 2018
6. Shaoping Lu, Chen Xu, Ray Y. Zhong, "A RFID-enabled positioning system in automated automated guided vehicle for smart factories," Journal of manufacturing systems, volume190 44 2017. 179-190.
7. Dijkstra's, E. W.,A note on two problems in connection with graphs, Numerische Mathematik, , 269-271, 1959

AUTHORS PROFILE

Madhuri Chavanis currently pursuing her master's in Instrumentation and Control Engineering. Completed her B.Tech in Electrical and Electronics Engineering in 2018.

Dr. Maya G. is working as Associate professor in Dept of EEE, MESCE Kuttippuram. She has 12 years of teaching experience. She has completed PhD from NIT Calicut in 2016.She has presented many papers in international conference and published many papers in reputed journals. She is IEEE WIE Member from 2014.