International Journal of Smart Electrical Engineering, Vol.6, No.2,Spring2017
pp. 61:65
ISSN: 2251-9246
EISSN: 2345-6221

Optimising AGV Colonies' Efficiency by Fuzzy Simulation

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Abstract

This is an adoptive design of ant colony system and has been generalized to automated guided vehicles AGV transport system, predetermined targets replacement results has been evaluated simulating four AGV in Mat lab by Particle Algorithm and fuzzification and simulating the operative environment with regard to constant velocity and different results has been compared to each other by changing robots' location and replacement of obstacles in the environment and using laser guidance system. Optimizing considered sensor's arrays led to more efficient and faster feedback. Regarding improvements mentioned, AGVs passing the obstacles with ease, choosing the shortest distance to the target and are flexible enough in case of one of the AGVs failure. 1- The AGV that has worked less than the others (from distance perspective), 2- the AGV which has been the closest to the failed AGV and 3- the AGV that has replaced fewer load. In fact, the system was able to operate more efficiently than when using an AGV.

Keywords: AGV Colony, Fuzzy Simulation, AGV Colony's Efficiency
Article history: Received 23-JUL-2017; Revised 11-SEP-2017; Accepted 12-OCT-2017.

1. Introduction

Nowadays wide range of industry is operated within automation and robotic systems. Among automated transport systems, AGV systems are of great importance by means of being economical, better production control, flexibility in capacity and direction, health and environment advantageous and also performing process test and montage while transporting. AGVs first appear in 1950's for transporting materials inside a production unit in the industrialized countries and from then AGVs have been employed for different purposes with different guiding systems in the industry. [1]

In 1998, Kortenkamp et al, studied control in AGVs and proposed a new electromechanical model for them. Later in 1999, Novick et al simulated a sample AGV based on laser sensors and by the use fuzzy system. The main challenges in an AGV is time, cost, guiding the AGV and avoiding the obstacles. There are papers on controlling an AGV with fuzzy methods. The importance of this paper is in minimising the mission's time, revival of economic value and promotion of behavioural science of AGVs which is inspired by ant colony behaviour. [2]

2. Preliminaries

A) Automated Guided Vehicle Definition

American material transport institute has defined AGV as follow:

A vehicle which is equipped with automatic guiding whether electromagnetic or optical and is capable of following the guided direction and might be utilized by the system for planning the vehicle, stops, and determining the transport rate or any other task.

Overall, AGV is a vehicle which can move in predetermined and specific direction automatically without human interference. [3]

B) Problem Definition

This paper aims to study the efficiency and task division (in case of one of AGVs failure) in AGVs colony which includes three conveyors and one collector. AGVs' velocity is considered constant and with regard to the fixed times which they unload at specific time and also their operating environment, simulation is conducted in Mat Lab and its validity has been checked.

Multipurpose environment with multiple obstacles and traverse directions has been applied for the simulation. [4] After defining initial provisions, result has been extracted. A reliable design based on actual needs is of highest importance. Simulation validity increases as a result of coincidence of design with actual system. At the end, AGVs move in the Mat Lab environment. Presumption for robots' movements:

- Robot moves to the desirable point and get to direction laser sensor commanded. In this method robot can choose any path to the target, but the path must be one of the shortest while has the least time and it mustn't hit any obstacle.
- Robot move along a desirable path which has specific start and end. [5]

C) Design

In this design with regard to constant velocity for each AGV, in case of failure of one of the AGVs, others besides replacing their own load make up the failed AGV to save time and increase efficiency. This issue proves the drawbacks of designs in efficient simulations of AGVs colony. The velocity of each AGV is set to 12 m/s and the sample space to 400*400 square meters. [6,7]

Wheeling mechanism chosen to be wheel and chain for higher flexibility and balance throughout the path. [8]

Table.1 represents the wheels' dimension for each AGV:

Table.1.
AVG Wheel specifications

Item	*AGV1*	*AGV2*	*AGV3*	*AGV4*
Movement System Type	4 Wheel	Wheel & Chain	Wheel & Chain	4 Wheel
Wheel Diameter	22.7 cm	32 cm	18 cm	26.1 cm

3. Fuzzy Rules

As shown in Figure 1, three sensors have been applied on the robot and they have a triangular arrangement. This type is the most common arrangement on robots among sensors.

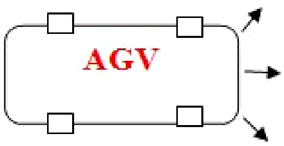

Fig. 1. Lidar Sensor arrangement

Fuzzification includes determining input and out parameters and variables and developing fuzzy rules. Inputs consist of laser sensor outputs, denoted by L1, L2, and L3. Output is considered as the robot movement based on angle deviation throughout the path to the target. This rules lead to 125 rules but as far as much of them end up with the same results, 17 rules have been applied eventually. Table 2 demonstrates these fuzzy rules for robots' movements. [9-13]

In case robot sense an obstacle at the start time, considered the distance and angle to the target tries to turn around the obstacle based on the defined rules. Robot movement includes changing in both angle and location. Figure below indicates the robot's replacement in differential movement.

Table.2.
Fuzzy rules of motion

	L3	*L2*	*L1*	*S*	*Θ*
1	So Far	So Far	So Far	Constant	-------
2	So Far	Far	So Far	Constant	-------
3	So Far	Medium	So Far	Constant	-------
4	So Far	Close	So Far	Constant	Medium
5	So Far	So Close	So Far	Constant	Steep
6	Close	So Close	So Close	Constant	Steep
7	Close	Medium	Medium	Constant	Medium
8	Close	Far	Medium	Constant	Slight
9	Close	So Far	Close	Constant	Medium
10	Close	So Far	So Close	Constant	Slight
11	Close	Medium	So Far	Constant	Medium
12	So Close	So Close	So Close	Constant	Steep
13	So Close	Medium	So Close	Constant	Steep
14	So Close	Far	So Close	Constant	Steep
15	So Close	So Far	So Close	Constant	Steep
16	So Close	So Close	Close	Constant	Steep
17	So Close	So Close	Medium	Constant	Steep

4. MATLAB Fuzzy Simulation

As shown in Figure 2, five statuses have been considered for sensor no.1 which has been located in the edge of the robot and sensor recognition interval is within 100-centimetres radius that is scaled from 1 to 10. [14, 15, 16] Table 3 shows the different intervals for every status.

Other sensors are defined and valued same as sensor no.1. Furthermore, Figure 3 shows the membership function for angle deviation output where intervals defined for angle deviation is demonstrated in Table 4.

Impact coefficient values are shown in vertical column and are used to weight each point.

Commands are given based on these weights and their comparison.

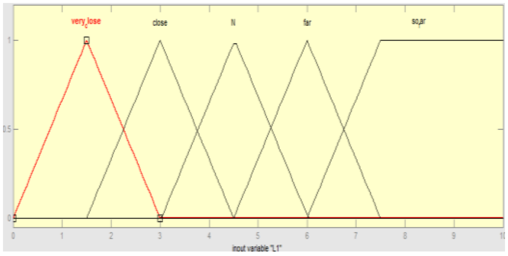

Fig. 2. The membership function for laser sensor(L1)

Table.3.
Intervals defined for laser sensor (L1)

Fuzzy Term	***So Close***	***Close***	***Medium***	***Far***	***So Far***
Distance	0-30	15-45	30-60	45-75	60-∞

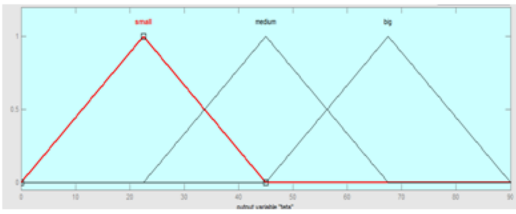

Fig. 3. The membership function for angle deviation

Table.4.
Intervals defined for angle deviation

Fuzzy Term	***Slight***	***Medium***	***Steep***
Value	0-45	5.5-22.67	5-42.90

5. Simulating Movement

Robots' movement simulation was conducted for four different scenarios by calling the fuzzy function since fuzzy rules; robots' definitive functions, obstacles, and the rest have been applied.

A) First Movement scenario

As shown in Figure 4, each 4 robots are active and operating in this scenario (AGVs no. 1, 2, and 3 are conveyor and AGV no. 4 is collective which is located in load output) and are running for 2 minutes under examination. Load input in each three terminals is six loads per minute. Distances from AGV no.4 for the first, second, and third input is 200, 250, and 70 metres sequentially. Loading and unloading time is 3 seconds for each.

Table 5 indicates that in the first scenario every three AGVs delivered their load to AGV no. 4 in 2 minutes according to constant velocity. Number of loads replaced and the loads left are also mentioned.

B) Second Movement Scenario

Figure 5 demonstrating a scenario in which robot no.1 fails in the midway and stops but two other robots are operating. Number of loads replaced and loads left are shown in Table 6.

C) Third Movement Scenario

Figure 6 shows the third scenario in which robot no.2 fails in the midway and stops but robots no. 1 and 3 are still operating. Numbers of loads replaced and left are mentioned in Table 7.

D) Forth Movement Scenario

In this scenario robot no.3 fails somewhere in the path and robots no. 1 and 2 are still operating, Figure 7 is an indication of this scenario. Table 8 also shows the number of loads replaced and left.

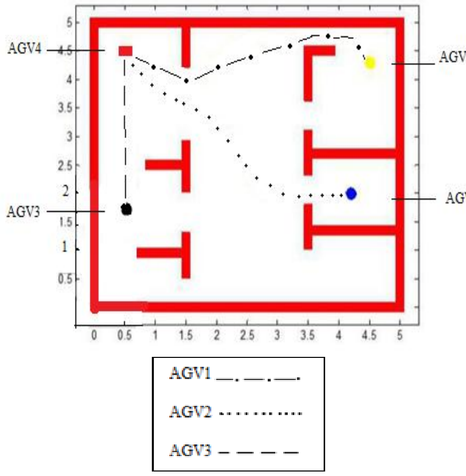

Fig. 4. First movement scenario

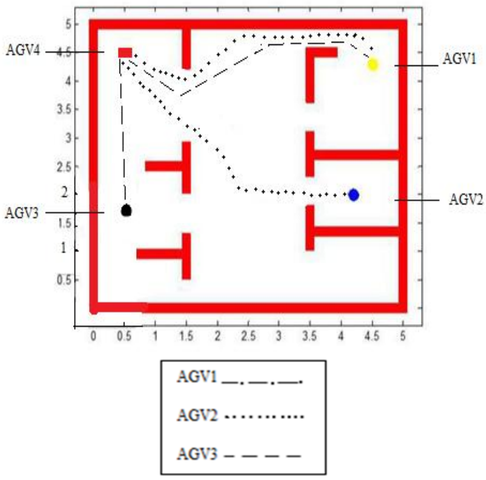

Fig. 5. Second movement scenario

 ISSN: 2251-9246
EISSN: 2345-6221

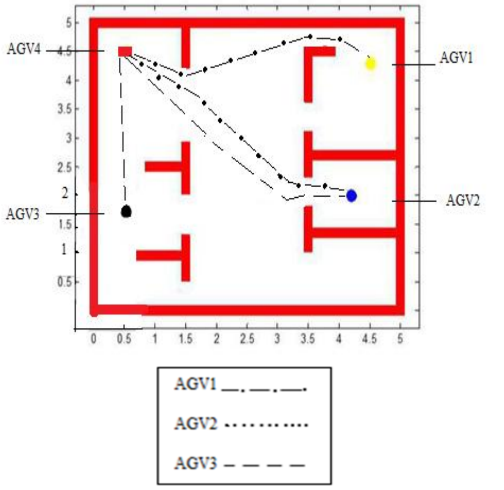

Fig. 6. Forth Movement Scenario

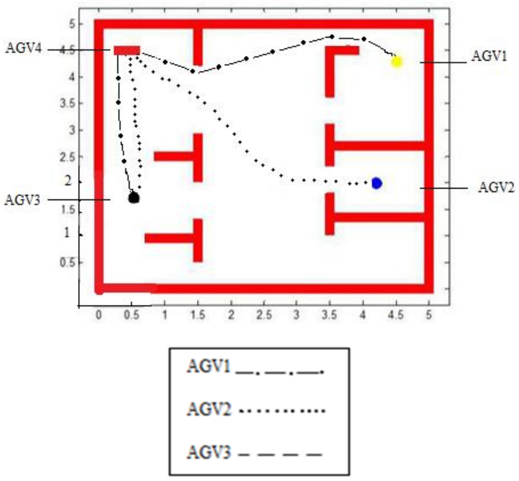

Fig. 7. Third Movement Scenario

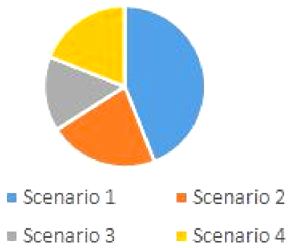

Fig. 8. Replacement loads

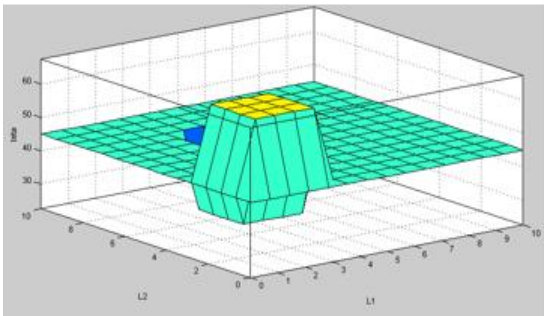

Fig. 9. Output page

Table.5.
First mmovement scenario

Average Time of Round Trip	***AGV1***	***AGV2***	***AGV3***
Loads Replaced	3	3	6
Loads Left	9	9	6

Table.6.
Second movement scenario

Average Time of Round Trip	***AGV1***	***AGV2***	***AGV3***
Loads Replaced	1+1	0	1+3
Loads Left	11	10	9

Table.7.
Third Movement Scenario

Average Time of Round Trip	***AGV1***	***AGV2***	***AGV3***
Loads Replaced	0	1+1	2+2
Loads Left	9	11	10

Table.8.
Forth Movement Scenario

Average Time of Round Trip	***AGV1***	***AGV2***	***AGV3***
Loads Replaced	1+2	1+2	0
Loads Left	10	10	10

6. Conclusion

Figure 8 shows the proportion of loads replaced to total load in the system that denotes in spite of load increase, system efficiency is high and acceptable. After applying fuzzy rules and defining input parameters and by the use of fuzzy function, results extracted that are mentioned in figure 9.

Figure 9. illustrates take sensor L1, L2, and L3 into account and based on fuzzy algorithm the best efficiency is approximately 40%, and in proportion to base treatment system is operating 60% more optimised by fuzzy operations. The flat part is the base treatment (without fuzzification) of system and upper part shows the system's flexibility with fuzzification in comparison with baseline (beneath part) which worked out well by using accessible variables (angle). The black part of image indicates the constant system's response during the system's decision making time which means, in median level, distance recognition by fuzzy system sensors response no different in comparison with baseline. [17, 18]

7. Discussion

Using AGVs Colonies prevent load transport dropping in some locations and periods of time. Despite the increase of system load, system maintained its efficiency. However, system faces difficulties in case one of the robots fails to operate in base treatment because there is no supportive robot. Moreover, using classic controllers for controlling AGVs needs to know all the forces and momentums that results in complicated calculations and experiments but using fuzzy controller for guiding and control leads to system sustainability and efficiency and also saves time.

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