가상 AGV를 이용한 물류자동화 시뮬레이션 개발

Development of a material handling automation simulation using a virtual AGV

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Abstract - In this paper, we studied about AGVs modeling and material handling automation simulation using a virtual AGV. The proposed virtual AGV model that operates independently each other is based on a real AGV. Continuous straight-line and workstation model using vector drawing method that could easily, rapidly work system modeling are suggested. Centralized traffic control, which could collision avoidance in intersection and should not stop AGV as possible, and algorithm for detour routing which performs when another AGV is working in pre-routed path are proposed. The traffic control and the algorithm have been proved efficiently by simulation.

Key Words :AGV System, Material Handling Automation, Modeling and Simulation

1. Introduction

The first AGV system was built and introduced in 1953. It was a modified tow tractor that was used to pull a trailer and follow an overhead wire in a grocery warehouse. the late 50's and early 60's towing AGVs were in operation in many types of factories and warehouses. In 1973, Volvo in Kalmar, Sweden set out to develop non-synchronous assembly equipment as an alternative to the conventional conveyor assembly line. In the 1970's the principal guidance technology was to induce an electronic frequency through a wire that was buried in the floor. As electronics and microprocessors advanced, so did AGV applications. As the vehicles became more intelligent, the path became less sophisticated. Today there are several hundred systems using AGVin operation which were produced by a number of manufacturers. AGVS is the system integrating various systems necessary to use an AGV.[1,4]

In this paper, a manufactory system model for the AGVS is proposed. It used a simulation of the AGVS for navigation and traffic management[2,5]. The AGV guide paths are modeled with continuous straight-lines and they are generated on off-line. The network model for its guide paths is composed of workstations and continuous straight-lines. Using the network model, optimal path plan and optimal selection AGV are developed by the A* algorithm[3]. The zone blocking was suggested to improve the efficiency of the system when passing a crossroads and a roundabout route plan was carried out again to shorten the processing time of an AGV in case an active path is included in a routing plan.

The modeling is done on a computer for simulating AGVS. Simulation is the modeling of a system or process to gain a better understanding of the performance of that system or process in operation.

2. Architecture of AGVS

Fig. 1 shows the proposed architecture of AGVS which is composed of a command manger, process manager, data manager and AGV manager.

2.1 The AGV Manager

The AGV manager operates AGVs and handles the moving instruction associated with the AGV control. A task corresponds to the instruction to convey a sequence of goods, and a moving instruction corresponds to the instruction to go along the path to convey goods and the instruction to load and unload goods on an AGV. For a time, the task is stored in a buffer and the task waits to be performed. When a task is completed, the next instruction is performed sequentially. The AGV manager selects a path based on established criteria. These criteria may be the shortest distance or the path with the least

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traffic at the present time. The path is converted into the sequential moving instruction, and transferred to an AGV. An AGV with the moving instruction operates independently and the AGV are managed by an AGV manager till the task is finished. To ensure against one AGV entering an already occupied zone or intersection of a guide path and to provide for orderly and efficient routing in general, the location of each vehicle is monitored and decisions are made based on this knowledge. The AGV manager is performed in on-line.

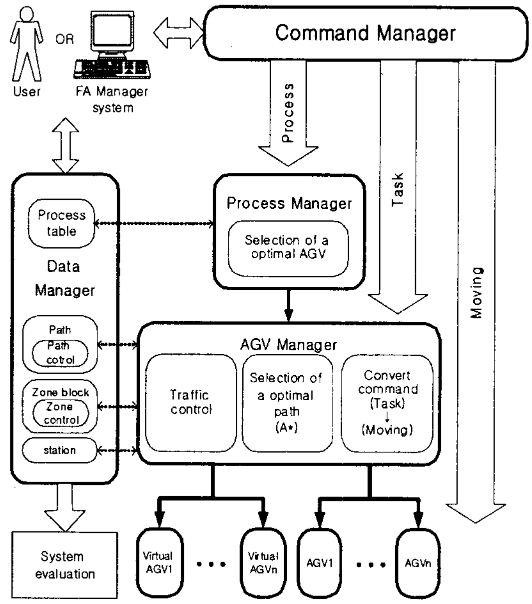

Fig. 1 Architerture of AGVS

2.2 The Process Manager

Operation requests happen on FA management system, occur optionally by a user, or take place by a button or a sensor in a work place. An input operation request instruction is stored in a buffer for a time, processed sequentially, and transferred to an AGV manager in the form of sequential task by referring to an process table if an optimal AGV processing operation request instruction fastest is determined[6]. The task can be planned in advance and registered at the process table of a data manager. The process manager selects a AGV based on a performance time using the A* algorithm. The performance time is evaluated from the equation.

$$T_p = T_{arrival} + T_{remain} + \alpha \cdot W \quad (1)$$

where, T_p is a estimation time for AGV to perform the order.

$T_{arrival}$ is a time that AGV arrive at the ordered workstation.

T_{remain} is a estimation time for AGV to finish a current work.

α is a weight constant.

W is a AGV operation times.

The process manager selects an optimal AGV that have the least performance time. A weight constant α and W are used to keep the working ratio of all AGVs similar.

When one AGV enters an already occupied zone or intersection of a guide path, traffic can occur. It causes a decrease in system productivity and efficiency. We propose two methods to solve this problem. The first method is a roundabout path plan that detours a path in which other AGVs stops to work, or a congested path. The AGVS always checks on next path if other AGV is presently working when all AGVs enter a path.

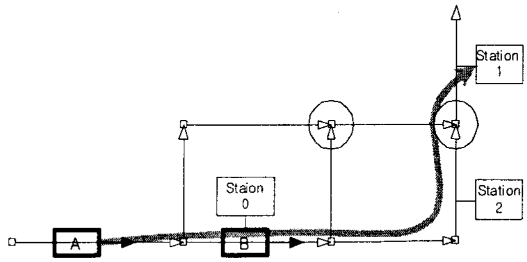

Fig 2. Initial path planning of AGV A

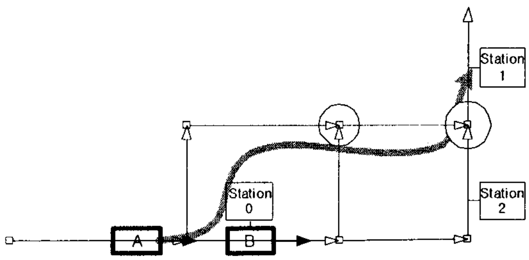

Fig 3. Roundabout path planning of AGV A

The second method is zone blocking. Zone blocking is easily the most popular and widely used type of traffic management. On sections of a guide path requiring zone blocking, only one vehicle at a time will be allowed into a given zone. sections of a guide path typically include intersections, stations and turns. In this paper, Zone blocking is classified into a stop zone and a deceleration zone. From Fig. 4, AGV A enters the deceleration zone and the AGVS checks to see if other AGV is presently traveling through the intersection. If no AGV is currently traveling through the intersection, the AGVS passes AGV A. Assume now that AGV B approaches the deceleration zone while AGV A is still traveling through the intersection. The AGVS passes AGV A and decelerates AGV B up to stop zone to avoid a collision. As a result, an object under the control of AGVS is changed over from AGV A to AGV B. Eq(2) is used to determine the deceleration zone size to avoid a collision.

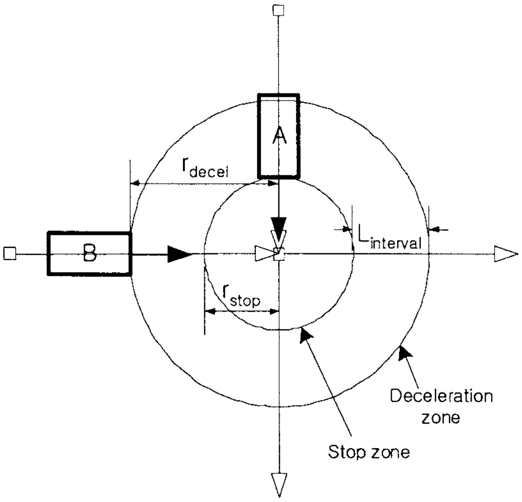

Fig 4. Zone blocking

$$r_{stop} \geq \frac{1}{2} L_{AGV} + L_{decel} \qquad (2)$$

where, r_{stop} is the stop zone size

L_{AGV} is the AGV length.

L_{decel} is a breaking distance

2.3 The Data Manager

Operation requests happen on FA management system, The data manager stores paths, traffic zones, stations, and process table and manages them. It creates paths, traffic zones and stations with Vector Drawing method and easily makes a process table by GUI. It updates data which AGV manager needs to calculate working ratio of AGVs and required working time.

2.4. The Command Manager

The command manager interprets commands received by user or FA manager system and sends commands to each manager. It can send a process, a task and a moving instruction of AGV. It can show the status of a current process and the number of them.

3. The User Interface

This tool is developed with Visual C++, divided into on-line mode and off-line mode. From Fig.5, 'A' shows all data related to on-line mode. 'B' is command window to create a process table. 'C' shows all listed system models. 'D' shows the property and information of system model. 'E' is an edit window that creates system model with Vector Drawing method on off-line, simulates the AGVS on on-line. Fig. 6 shows that it performs the simulation.

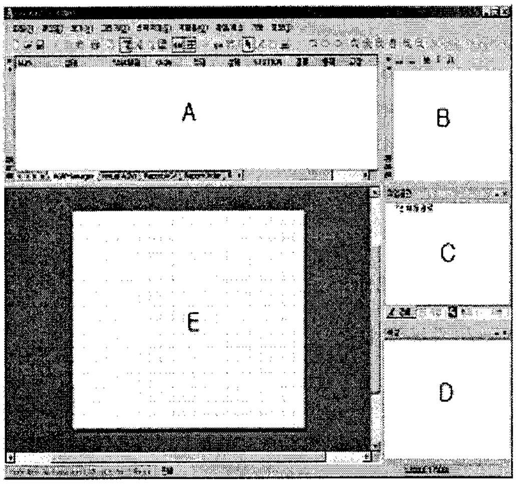

Fig. 5 Main window of AGVS

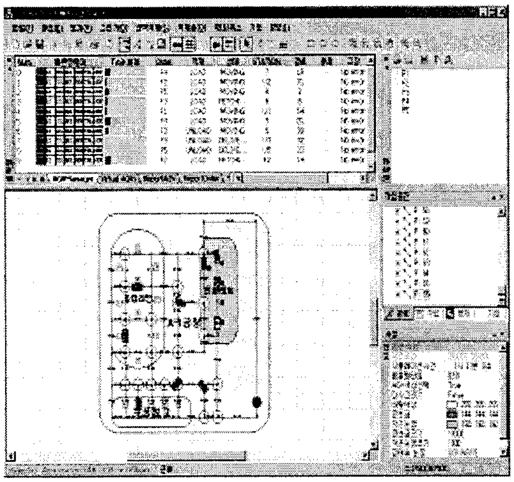

Fig. 6 Simulation window of AGVS

4. Simulation and result

Simulation is the modeling of a system to gain a better understanding of the performance of that system in operation. Assume that the factory A-1 consists of a parts warehouse, assembly line and pallet collection station. The loading and unloading device are installed in the assembly line. To evaluate performance of the AGVS, AGV periodically conveys from the parts warehouse to assembly line. Table 1 shows AGV and VAGV Spec. for simulation and Table 2 shows process table. The simulation was performed with a traffic control and without it for 12 hours. From table 3 and table 4, if AGVS uses the proposed traffic control, stop times reduce to 28.7%, control times reduce to 58.8% and average working time reduces 0.8 minute.

Table 1. AGV and VAGV Spec

AGV Spec.	Workstation Size	67.5m x 65m
	Station number	20
	Load type	5
	Wait station	1
	Path number	66
	Zone block number	20
	AGV number	10
VAGV Spec.	Size	4m x 2m
	Velocity	1m/s
	Turing radius	2m
	Collision safety	Forward sensor, bumper
	Loading/unloading time	120 s

Table 2. Process table

Process	Working interval time	Work Instruction	
F1	10 min	FETCH	F1
		DELIVER	1
		FETCH	2
		DELIVER	U1
F2	10 min	FETCH	F2
		DELIVER	3
		FETCH	4
		DELIVER	U2
F3	5 min	FETCH	F3
		DELIVER	5
		FETCH	6
		DELIVER	U3
F4	15 min	FETCH	F4
		DELIVER	7
		FETCH	8
		DELIVER	U4
F5	12 min	FETCH	F5
		DELIVER	8
		FETCH	10
		DELIVER	U5

Table 3. The result of navigation without traffic controls

AGV ID	Stop times	Control times	Process	Average working time
0	162	58	F1	15
1	180	50	F2	16
2	188	79	F3	14
3	176	76	F4	22
4	195	91	F5	16
5	170	75	-	-
6	190	90	-	-
7	190	72	-	-
8	175	78	-	-
9	171	76	-	-
Avg	179.7	74.5	-	16.6

Table 4. The result of navigation with traffic controls

AGV ID	Stop times	Control times	Process	Average working time
0	158	35	F1	13
1	134	26	F2	15
2	116	26	F3	14
3	113	29	F4	23
4	133	39	F5	14
5	116	26	-	-
6	120	37	-	-
7	123	32	-	-
8	131	32	-	-
9	137	40	-	-
Avg	128.1	32.2	-	15.8

5. Conclusion

Through this study, we have developed AGVS including simulating functions for automatic logistics and suggested VAGV. VAGV makes the performance of AGVS evaluated exactly. Since VAGV is an AGV-based design, AGVS excluding VAGV can operate with AGV practically. We can perform system modeling faster by adopting a vector drawing method. We made groundwork to do various tests by making it operated on a PC. The whole efficiency and productivity of AGVS is improved by setting decelerating zones and by leading it to the roundabout path when traffic is congested.. As modification became easy by importing the system with a hierarchical structure, we expect it will help us study a traffic control algorithm after this study.

References

[1] B, Mahadevan, and T. T, Narendran, "Design of an Automated Guided Vehicle-Based Material Handling System for a flexible Manufacturing System", *Int. J. Prod. Res*, Vol. 28, No. 9, pp 1611-1622, 1990

[2] Jung Hoon Lee, Beom Hee Lee, "A Real-Time Traffic Control Scheme of Multiple AGV Systems for Collision Free Minimum Time Motion: A Routing Table Approach" *IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS*, vol 28, No. 3, p347-358, May 1998

[3] Patrick Henry Winston, "Artificial Intelligence", *Addison-Wesley Publishing Company*, Second edition p102~117, 1984

[4] Bülent Sezen, "Modeling Automated Guided Vehicle Systems in Material Handling", *Dogus Üniversitesi Dergisi*, Vol 4, No. 2, p207-216, 2003

[5] Shay-Ping T. Wang, "Animated Graphic Simulation of An Automatic Guided Vehicle System (AGVS)", *in Proc. Winter Simulation Conference*, pp 252-256, 1985

[6] Sudha Arora, A. K. Raina "Collision Avoidance among AGVs at Junctions", *Proc. of IEEE Intelligent Vehicles Symposium*, pp.585~589, 2000