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A review on automated guided vehicle utilization in FMS System

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Abstract

In the current technology revolution there's a tremendous rise in the utilization of the automated guided vehicles (AGV). We can commonly see the use of AGV in material handling processes of warehouses and manufacturing facilities. AGV's help to reduce the workload of a person by loading and unloading the material like heavy pipes, boxes assembly parts and many more. Apart from this, there are some drawbacks of an AGV like High cost like not every individual can afford an AGV. It might be seen only in big industries. It also requires high maintenance and a skill full operator for controlling it. In this paper we will discuss about the following keywords- Automated Guided Vehicles, Simulation, Material Handling and Petri Nets. The logistics automation makes it possible with the help of Automated Guided Vehicle to move different materials like rawmaterials, work-in-progress items and finished products in most flexible way and without human involvement. Simulation helps us to know that how many number of vehicles will be required for a particular process. Material Handling is very crucial part in AGV as the transfer of materials depends solely on this. Petri Nets are used for the transition with the help of nodes.

1.Introduction

The logistics automation makes it possible with the help of Automated Guided Vehicle to move different materials like rawmaterials, work-in-progress items and finished products in most flexible way and without human involvement. For determining accurate number of vehicles needed, simulation has been proved to be the best method. In this paper the advantages of AGV their efficiency and flexibility is discussed. As because AGV being the most effective and main tool in AS/RS (Automated storage and Retrieval system), It takes the task of transportation of material from one place to other place. When it comes to Automated Guided Vehicle, Navigation or Guidance is the most complex part and it is beyond an individual's first expectations. An AGV is an intelligent and effective alternative which is widely used to perform various tasks which are not suitable for human to carryout. If the analyst or any industry has solely decided to use AGVs as their AS/RS tool, then Simulation is the best and most appropriate option. But it comes with few disadvantages like time consuming process and quite expensive to carry out at an initial stage. One another alternative to simulation is Analytical Model. When it comes to designing of manufacturing system, Material Handling is the most crucial part. Material Handling is nothing but moving materials or goods from one place to another in the most efficient way. As AGV is the most used tool for material handling in Flexible Manufacturing System, it increases the flexibility of material transfer from one work station to other. From the above discussion it is clear that the most important goal of Material Handling System is to decrease the wastage and cost and simultaneously increasing quality and efficiency. For Discrete event systems (DES), petri nets have been found as the widely used tool. Moreover, for evaluating the reliability of a system, Modelling using pertinent is proved to be widely used tool.

2.Automated Guided Vehicle

Many AGVs are being used by the industry for their material handling process whether it maybe in automobile or food industry. For operating an AGV the commands are executed in real time it maybe dispatching, routing or pickup. For dispatching a request is made for new transportation and the selected vehicle takes the request and complete the whole task. The routing system works in such a way that the AGV finds an obstacle free path for all its tasks whether it maybe delivery of goods or pickup of goods. [17]. AGV system consists of AGV itself, the stationary system control and peripheral & build lateral components. Nothing but only by the virtue of an errorless integration of all components, an effective operation can be ascertained. For the working the technical and building group mechanisms are to be feed to the components. The AGVs are restricted to the floor. It is the work of a navigation system to successfully led the vehicle to the described locations. Communication system makes it possible to communicate between vehicle and system. The hardware and software are covered under control system. It deals with the task of monitoring orders, drive optimization, arrangement, right way of

regulating etc. It also deals with tasks of statistics and visualization. For communication and guidance purpose a hand interface is also provided in the control system. [22]. Using a topological method, the environment map is explained. The node and arc structure which are termed as workstations and moving parts of AGV are stored in Grid data format. The assumptions are as follows:

1. The AGV operates at three constant speed of 0.2m/s in 2-D plane.
2. There's a 1 m distance between two adjacent workstations. The map is undirected.
3. AGV is considered as a particle.

As because AGV being the most effective and main tool in AS/RS (Automated storage and Retrieval system), It takes the task of transportation of material from one place to other place. For completing the task in an efficient way and within short time effective path planning in inevitable. Therefore, path planning has gained a significant attention in research purpose. Path planning follows one simple rule that is shortest distance. To overcome this issue of shortest path various algorithms are used such as neural network method, graph theory, dynamic programming method, genetic algorithm, hybrid algorithm and so on. [26]. Nowadays AGV system implemented in logistics is popular. However, there are few bottlenecks to overcome in this sector. In implementing aa efficient AGV system the only nail in its way is path planning. This path planning is not similar towpath planning of general vehicles. Navigation or Guidance is the most complex part and it is beyond an individual's first expectations. The two main issues which can possibly create a hindrance in guidance system are: the ambient environment is unpredictable and uncertain and the other issue is the thinking ability of an individual or perception are mismatched. It is hard to achieve a system which gives simplicity, reliability and cost efficient. AGV can respond or follow the pre-specified routes by its smart sensors and other intelligent devices. One of the most basic and efficient way of providing a guidance path to the vehicle is Wire Guided Guidance System. An energized wire is buried inside the ground around 1m deep. The sensors below the AGV sense those radiations emitted by the wire and follows the wire. This system is better than Magnetic Tape method as it is not affected by dust or any weather conditions. [27]. An AGV is an intelligent and effective alternative which is widely used to perform various tasks which are not suitable for human to carryout. As technology is moving fast, self-guidance system is taking a prominent place among other guidance systems. The most basic self-guidance system which is used across the globe is the GPS based guidance system. But this system also has its limitations. This system requires a direct sight of satellites on vehicles. So a large open space is required. Moreover, it is highly expensive. To reduce the cost and to obtain robust positioning results it necessary to apply vision sensors in the AGV system. [28]. The advantages of an AGV over any conventional material handling devices like Fork lifts, trucks and conveyors are flexibility and automation. It is said that the AGV is the material handling tool for "The Factory of the Future". Service industries are now adapting the AGV system. For this time pharma companies are using AGV because it helps to flow paperwork from one place to another place. But again the high cost per vehicle puts constraints in number of vehicles used. [31]. AGV is a selfguided vehicle which can follow its path through various known techniques like: Wire guided guidance system, GPS based guidance system, Laser Based guidance system and many such systems. It is a fact that the Automotive Industry is the biggest consumer of AGVs. AGVs are also used by other industries like food and beverages, e-commerce and healthcare. In above mentioned industries AGV has been found to improve the flexibility, space utilization and safety and simultaneously reducing overall production expense. On the basis of transferring of loads, AGVs can be differentiated as towing AGV, unit load AGV, pallet truck AGV, and fork truck AGV. [33]. As AGV carries and transport the materials from one destination to other, the human effort is eliminated and it increases efficiency because AGV does not experience fatigue. As a cell of FMS, AGV is used for material handling. Mainly three sensors are used for the navigation of an AGV they are magnetic sensors, laser sensors and optical sensors or cameras. Vision based AGV is more flexible and cost efficient. Some researchers have developed vision-based AGV on PC. In industries mostly all AGVs were controlled by an industrial computer also they are highly expensive. [34].

3.**Simulation**

Simulation is the best and most appropriate option when It comes to determine the required number of vehicles in an industry. But it comes with few disadvantages like time consuming process and quite expensive to carry out at an initial stage. Detailed simulation analysis is very likely to use for such purpose. Analytical model is an option to simulation. Observations of the effects of AGV dispatching rules on the system performance are done through simulation. Simulation is so far the most accurate way in determining number of vehicles required. Research has also been depended on simulation analysis. Egbelu (1982) developed simulation program in FORTRAN called AGVS in. AGVS in provides statistical measures on the performance of an AGVS. The results of simulation analysis can be justified by the fact that most of the industries uses simulation to predict the number of vehicles required. Two regression model fitting approaches can also be used in analysing the data generated from the simulation analysis. [36]. The comparison of efficiency of algorithm with some of the known dispatching rules is carried out through computer simulation in a hypothetical job-shop type automated manufacturing system. The following assumptions are made in to reduce the computation time during the simulation process.

- Unit load transfer at a time by an AGV
- Neglecting the breakdown of vehicles and workstations.
- Half minute is set constant for both pickup and dropping of a part.
- AGV to strictly follow the shortest path possible between two locations.
- Considering only the constant speed of an AGV. [39].

For a particular simulation model, the processing time of each job on each station and demand arrivals are deterministic and stochastic respectively. For two types of FMSs the simulation results are used to derive meta models. ARENA3.0 simulation software package was used to develop a simulation model. "Trace" to be the most powerful technique in verifying simulation program says Law and Kelton. [40]. The only way to describe a system which cannot be easily described by mathematical or analytical model is said to be simulation analysis. For configuration of production system in manufacturing sector, simulation can be used. By utilizing activity cycle diagram as graphical method in order to derive simulation models for conceptual flexible manufacturing system was presented by Hlupic and Paul. Aa integrated approach was presented by Chan et al for the design of flexible manufacturing system which uses multi criteria decision making and simulation techniques. Simulation analysis takes the input from the output generated by running the simulation models. Simulation based design includes the design parameters for the flexible manufacturing system. Apart from above discussion, a change of the Bow pattern is added in running simulation to verify the adaptivness of the particular dispatching algorithm. [43]. A simulation technique was used by Fazlollahtabar et al. (2012) to study the role of tandem Agv configuration for time optimization in production. A hybrid method for vehicle routing issue was introduced with the help of simulation by Dharmapriya et al. (2012). From the beginning the FMS issues are being solved using analytical technique but with the advent of simulation technique it is less likely to use. Simulation provides modelling and analysis of complex systems. Simulation technique facilitates user with animation and dynamic adjustability (Tunali 1997), real time observations and statistics collection. Moreover, it also provides means for controlling realistic shop floor and provides detailed performance data (Bhatia & Robinson 1995). At present WITNESS simulation software owned by lanner group is being used figure-out AGVs configurations. [50].

4.**Material Handling**

Material handling plays a very significant role in the design of a manufacturing system. Material Handling is the most crucial part. Material Handling is nothing but moving materials or goods from one place to another in the most efficient way. As because material handling is not termed as value adding aspect in manufacturing it is to be eliminated. As the aim for any material handling system is to achieve the desired task in economic fashion and in timely manner, it is very important to design an efficient Material Handling System by the designer. In the future era automated guided vehicles are the upcoming classes in the field of material handling industry. [36]. Usually AGV is used as a Material handling system, in Flexible manufacturing system environment. With the help of integration of computer control, numeric control machine and material handling devices FMS is developed. FMS consists of a group of material processing cells connected by an automated material handling system to manufacture a huge variety of product types with low to medium volumes. Another way FMS can be defined as the amalgamation of production tools, logically organized by a main computer and physically connected with MHS. As MHS in FMS provides flexibility in route selection through machines it adds to its importance. AGV configuration which is the pattern of its guide path is a crucial aspect in designing AGV based MHSs. Following things are to be considered while designing an AGV based Material Handling System: 1. Quantity of vehicles. 2. Configuration of AGV. 3. Rules for vehicle dispatching. 4. Positioning of idle vehicles to achieve the optimum performance. [55]. As we know that Material Handling is nothing but moving materials or goods from one place to another in the most efficient way and also it is the most used tool for material handling in Flexible Manufacturing System, it increases the flexibility of material transfer from one work station to other. Hence the primary goal of Material Handling System is to decrease the wastage and cost and simultaneously increasing quality and efficiency. An automated guided vehicle system (AGVS) includes not only the vehicle and its guidance system, but also the control of one or more such vehicles in the routine performance of the horizontal material handling tasks. A properly designed and controlled AGV system can provide significant savings in material handling costs and reductions in process inventories. [50]. Material Handling: "The storage, movements, control and safety of material during the entire process of distribution and manufacturing involves consumption and disposal of Material Handling System" said by – MHIA (Material Handling Institute of America). A profit cannot be earned by any manufacturer without the virtue of an effective material handling system. It is hard to estimate the cost of material handling system prior to the implementation, as it consumes average about 20-25% of the total manufacturing cost. The main factor attributing the material handling cost is wasted time. Labour factor is the second major factor in the material handling expenses. In addition, increasing labour and time compensation costs makes other alternatives of MHS more suitable. It is flexibility which helps AGV to outstand other material handling systems. [51].

5.**Petri Nets**

Petri nets (PNs) have been widely used in discrete event systems (DESs). There are many theories such as PN theories and Supervisory control theories which are used to prevent Discrete Event Systems from entering illegal states. As the semantics of extended PN is very complicated compared to ordinary PN, an AGV may be represented by an extended PN which is smaller compared to ordinary PN. But this creates a problem in validation and verification of PN models because extended PNs are hard to analyse, moreover it fails to understand the relations between PN structure and various control elements like wiring loops, coils and sensors. This makes it hard to automatically put PN supervisors by PLCs. [11]. In order to evaluate reliability of a system, Petri net has become more general tool However, till todays date PNs are hardly used to figure out the reliability of AGVs instead it has been practiced as a mathematical method to determine control strategies and route planning for AGV. For AGV systems performing various tasks Petri net simulation is considered to be efficient and adaptable. There are four symbols: circle, rectangle, arrow and tokens in Petri net bipartite graph method. The circle symbol represents condition or state like any type of failure. The rectangle represents transitions. [52]. For static dispatching and routing issues transition time petri net is used. Z is the set of all positive integers including 0, and N is natural numbers (N = $Z - \{0\}$). A timed Petri net TPN is defined by TPN = (P, T, w, M0, θ) where P = {p1, p2, . . ., p|P|} is the finite set of places, T = {t1, t2, . . ., t|T|} is the finite set of transitions, w: $(P \times T) \cup (T \times P) \rightarrow Z$ is the function representing incident relation between places and transitions, $M0 : P \rightarrow Z$ is the initial marking, and $\theta : T \rightarrow N$ is the firing duration time. For simplicity, a particular approach can be explained with transition timed Petri net with single firing duration time. In order to use standard equation of synchronized petri net with firing all the enabled transitions at a time the dynamics of TPN with single firing duration time must be equal to that of standard non timed petri net. [21].

6.Conclusion

This paper tells about few AGV guidance system which can be employed in industries. The AGV can direct itself by means of guidelines and signs, which are easy to be set in reasonably clean environments. An AGV system based on marker recognition has some advantages in terms of the cost of installation and changing routes. Simulation approach has been successful in modelling such a complex system. In order to decrease the waiting time for the load requests to an acceptable range, the system designer can either increase the number of vehicles or adopt a different work centre-initiated dispatching rule. We have also seen how to formally design PLC programs for preventing vehicle-collisions in an AGVS. Petri net decomposition approach for simultaneous dispatching and conflict-free routing AGVs for bidirectional lanes. In order to develop an efficient and reliable approach to assessing the reliability of AGVs, the PN method is adopted to calculate the mission and phase reliability of a typical AGV transport system.

References

[1].Lu, Shaoping, Chen Xu, Ray Y. Zhong, and Lihui Wang. "A RFID-enabled positioning system in automated guided vehicle for smart factories." *Journal of Manufacturing Systems* 44 (2017): 179-190.

[2].U Ragavendran, M Ramachandran, Multistage current starved VCO for switching applications, International Journal of Mechanical and Production Engineering Research and Development, 2018, August, 7-13.

[3].Nishi, Tatsushi, and Yuki Tanaka. "Petri net decomposition approach for dispatching and conflict-free routing of bidirectional automated guided vehicle systems." *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans* 42, no. 5 (2012): 1230-1243.

[4].Schulze, Lothar, and Lindu Zhao. "Worldwide development and application of automated guided vehicle systems." *International Journal of Services Operations and Informatics* 2, no. 2 (2007): 164-176.

[5].Qing, Guo, Zhang Zheng, and Xu Yue. "Path-planning of automated guided vehicle based on improved Dijkstra algorithm." In *2017 29th Chinese control and decision conference (CCDC)*, pp. 7138-7143. IEEE, 2017.

[6].Zhang, Hai-Bo, Kui Yuan, and Qing-Rui Zhou. "Visual navigation of an automated guided vehicle based on path recognition." In *Proceedings of 2004 International Conference on Machine Learning and Cybernetics (IEEE Cat. No. 04EX826)*, vol. 6, pp. 3877-3881. IEEE, 2004.

[7].Pulkit Purohit, M. Ramachandran, Selection of Flywheel Material using Multicriteria Decision Making Fuzzy Topsis, Indian Journal of Science and Technology, 8(33), 2015.

[8].Lee, Jeisung, Chang-Ho Hyun, and Mignon Park. "A vision-based automated guided vehicle system with marker recognition for indoor use." *Sensors* 13, no. 8 (2013): 10052-10073.

[9].Shubham Paliwal, M. Ramachandran, Vishal Fegade, Numerical investigation of rack and pinion for total deformation and von mises analysis, International Journal of Mechanical and Production Engineering Research and Development, 2018, December, 83-86.

[10].Wang, Chunbao, Lin Wang, Jian Qin, Zhengzhi Wu, Lihong Duan, Zhongqiu Li, Mequn Cao et al. "Path planning of automated guided vehicles based on improved A-Star algorithm." In *2015 IEEE International Conference on Information and Automation*, pp. 2071-2076. IEEE, 2015.

[11].Kahraman, Aykut F., Abhijit Gosavi, and Karla J. Oty. "Stochastic modeling of an automated guided vehicle system with one vehicle and a closed-loop path." *IEEE transactions on automation science and engineering* 5, no. 3 (2008): 504518.

[12].Wu, Xing, Peihuang Lou, Qixiang Cai, and Chidong Zhou. "Design and control of material transport system for automated guided vehicle." In *Proceedings of 2012 UKACC International Conference on Control*, pp. 765-770. IEEE, 2012.

[13].Yu, Jun, Peihuang Lou, and Xing Wu. "A dual-core real-time embedded system for vision-based automated guided vehicle." In *2009 IITA International Conference on Control, Automation and Systems Engineering (case 2009)*, pp. 207-211. IEEE, 2009.

[14].Arifin, Robert, and Pius J. Egbelu. "Determination of vehicle requirements in automated guided vehicle systems: a statistical approach." *Production Planning & Control* 11, no. 3 (2000): 258-270.

[15].Kanak Kalita, U Ragavendran, M. Ramachandran, Akash Bhoi, Weighted sum multi-objective optimization of skew composite laminates, Structural Engineering and Mechanics, Vol. 69, No. 1 (2019) 21-31

[16].Hwang, Hark, and Sang Hwi Kim. "Development of dispatching rules for automated guided vehicle systems." *Journal of Manufacturing Systems* 17, no. 2 (1998): 137-143.

[17].Kesen, Saadettin Erhan, and Ömer Faruk Baykoç. "Simulation of automated guided vehicle (AGV) systems based on just-in-time (JIT) philosophy in a job-shop environment." *Simulation Modelling Practice and Theory* 15, no. 3 (2007): 272284.

[18].V. S. Galgali, M. Ramachandran, G. A. Vaidya, Techniques for Optimal Placement and Sizing of Distributed Energy Resources: a Review, International Review of Automatic Control, Vol 10, No 6 (2017.

[19].Um, Insup, Hyeonjae Cheon, and Hongchul Lee. "The simulation design and analysis of a flexible manufacturing system with automated guided vehicle system." *Journal of Manufacturing Systems* 28, no. 4 (2009): 115-122.

[20].Kumar, Ravindra, Abid Haleem, Suresh K. Garg, and Rajesh K. Singh. "Automated guided vehicle configurations in flexible manufacturing systems: a comparative study." *International Journal of Industrial and Systems Engineering* 21, no. 2 (2015): 207-226.

[21].Kim, Sang Hwi, and Hark Hwang. "An adaptive dispatching algorithm for automated guided vehicles based on an evolutionary process." *International Journal of Production Economics* 60 (1999): 465-472.

[22].Arifin, Robert, and Pius J. Egbelu. "Determination of vehicle requirements in automated guided vehicle systems: a statistical approach." *Production Planning & Control* 11, no. 3 (2000): 258-270.

[23].Das, Suman Kumar, and M. K. Pasan. "Design and methodology of automated guided vehicle-a review." *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)* (2016): 29-35.

[24].Kumar, Ravindra, Abid Haleem, Suresh K. Garg, and Rajesh K. Singh. "Automated guided vehicle configurations in flexible manufacturing systems: a comparative study." *International Journal of Industrial and Systems Engineering* 21, no. 2 (2015): 207-226.

[25].Shen, Yu-Cheng, and John E. Kobza. "A dispatching-rule-based algorithm for automated guided vehicle systems design." *Production Planning & Control* 9, no. 1 (1998): 47-59.

[26].Luo, JiLiang, HuiJuan Ni, and MengChu Zhou. "Control program design for automated guided vehicle systems via Petri nets." *IEEE Transactions on Systems, Man, and Cybernetics: Systems* 45, no. 1 (2014): 44-55.

[27].Yan, Rundong, Lisa M. Jackson, and Sarah J. Dunnett. "Automated guided vehicle mission reliability modelling using a combined fault tree and Petri net approach." *The International Journal of Advanced Manufacturing Technology* 92, no. 58 (2017): 1825-1837.

[28].Nishi, Tatsushi, and Yuki Tanaka. "Petri net decomposition approach for dispatching and conflict-free routing of bidirectional automated guided vehicle systems." *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans* 42, no. 5 (2012): 1230-1243.

[29].U Ragavendran, M. Ramachandran, Multistage current starved VCO for switching applications, International Journal of Mechanical and Production Engineering Research and Development, 2018, August, 7-13.