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Review on Issues Related to Material Handling using Automated Guided Vehicle

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Abstract

Today in the 21st century, the uses of automated guided vehicles (AGVs) are becomingly more common in the manufacturing industries especially in larger manufacturing companies. The ease of the manufacturing companies to handle materials is due to the implementation of AGVs in their manufacturing system especially in the production lines and inventories. The usages of AGVs are becomingly more important not just to handle material but also for multi-tasking other jobs related to the manufacturing industry. This paper reviews the issues related to automated guided vehicles (AGVs) in the automated manufacturing industry when dealing with AGVs in the industries.

Keywords: Automated guided vehicle; Manufacturing; Autonomous navigation in manufacturing, cost, control; Supervisory

Introduction

Automated Guided Vehicles (AGVs) has been defined by Sen et al. [1] in his paper, as automatic load carriers that transfer load/objects from one location in the factory to another depending on the task given. AGVs are the key element to perform flexible transport tasks in industrial production. These kind of vehicle simplify the challenge of course-plotting by constraining their pathways to established routes, which are normally demarcated by simply striping the floor for some reason or through the use of buried cords, said by Arkin and Murphy in their research [2]. The leading method with earlier industrial automatic guided vehicle (AGVs) had been some sort of cable hidden from the flooring state [3]. Nowadays, AGVs are increasingly being used in today's industries to deliver work pieces between specified locations. AGVs are being set with destinations called station that determined the robots point to point destinations. Villagra et al. [3] mentioned that as a way to perform the common transportation tasks between pickup and delivery stations, AGVs should get around between stations and also achieve precise pick-up and drop operations. Navigation among two stations is referred as point-to point navigation. There are what basically AGVs are all about. In this review paper, input and relation and comparisons between papers have been done on AGVs to find few of the advantages in application of AGV and issues that are usually related to the material handling system. These issues are based on the findings that usually come across in the literature review.

Navigation Issue

The first issue regarding AGV system is the navigation of the vehicle. Arkin et al. [2] discussed on the simulation studies, motivation and experimental results demonstrating the feasibility of migrating schema-based navigation into a Flexible Manufacturing System (FMS). The advantage of this navigation is it provides a framework that is readily adaptable to the manufacturing industry. It also simplifies the problem of navigation by restricting their paths to the predetermined routes and uses the diversity of sensors and sensors strategies and selection of specific and relevant motor actuators for the particular domain which will limit drive path problems [2]. However, it requires significant restructuring of the workplace in order for the AGV to be useful. It also embeds significant amount of knowledge for both environmental and behavioral. Thus giving better and greater latitude for interacting with the environment. The modifications in the production line for the AGVs cause great expenses [3].

In the other discussion about the navigation of AGV, Schilling et al. proposed RETRARO application to support intelligent control an AGV in an industrial production process, making use of the services provided by the REAKT (Real Time Knowledge Based Tool). The application is free navigation capability thus achieves a higher operational flexibility. It also able to adapt to changing production configurations and economic sensor systems to provide navigation and obstacle avoidance functions [4]. However, it is limited by the IR-reflectors and by a code-mark. The transport must always be on an efficient path. They use inexpensive sensors to provide less exact measurements. The energy consumption of the transport is huge [5].

Schulze et al. [6] also conclude that significant technological advancements contributed to the increasing of the attractiveness of AGV systems for the users. They essentially concern with the modularity, the standardization, the navigation system, the energy concept, the automation of series vehicles and the safety system. This technology advancement can reduce complexity of the modules and the establishment of compatibility between various AGV'S producers [6]. The navigation systems have the task to lead the vehicles after given strategies to their destination. The problem of this navigation system are it need wide variety of maintenance and part logistics and it need guided by optical or inductive guidelines which the disadvantage is inflexibility concerning the modification and changing of the routing and the necessity of installations on or in the ground [7].

AGV Routing System

There are 3 main points that determine the Automated Guided Vehicle (AGV) behavior discussed by Vivaldini et al. [7] in their paper. The first is the routing algorithm (that computes the overall task execution time and the minimum global path of each AGV using a topological map of the warehouse). Second is the local path planning

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algorithm (based on A* it searches for the local minimum path between two nodes of the warehouse topological map). And the third is an auto-localization algorithm (that applies an Extended Kalman Filter – EKF – to estimate the AGVs actual positions). As the result, before sending the final paths to the robots, the obtained router developed was able to solve traffic jams and collisions. They were using only simulation and algorithm which has not been tested and done in real life situations [8].

Takenaga et al. on the other hand study to prepare the method to run the vehicle through a lane based on the vision feedback avoiding collision or collapse with obstacles providing intelligence for a number of AGVs through the dynamical processing of circumferential information by vision sensing [9]. The benefit of this method is it has vision feedback avoiding collision or collapse with obstacles. It also has sensor provides feedback which is usual especially during trouble shooting and development to improve the system used in the AGV. The drawback of this method is it needs mounted PC that is treated as an agent which causes the AGV to be highly expensive, fragile and bulky. Proper application is limited due to the mounted PC on top. Power consumption is an issue in this method. It requires special skill worker to operate, trouble shoot which the more the complex the system is the more it is prone to errors [10]. The advantage of the coordination discuss by Takenaga [9] is navigation part consists on calculating and following the trajectory to reach the goal, which is calculated considering the plant layout and recalculated to avoid the non-modelled obstacles when they are sensed during the navigation. But, this coordination type has weaknesses. It dependent on the mapping of the environment, it cannot self-localize, and calculation of the AGV movement and plant layout may result to inaccuracy of the AGV's position [11].

Kelly et al. [12] had developed a virtually infrastructure-free AGV that uses four distinct vision systems to exploit naturally occurring visual cues instead of relying on infrastructure. It coupled with a highly capable trajectory generation algorithm; the system produces four visual servos that guide the vehicle continuously in several contexts. But unfortunately, it has limitations in performance and adaptability and also it is highly expensive due to vision sensor at each AGV (each contains a number of vision sensors) but accurate [12].

Control Factors Related to AGVs

The issue of control arises in many of the articles, proceedings and journals which concerns with AGVs. As done previously by authors, Espufia et al. [13] back in 1990, they have proposed and research on transport planning and scheduling using AGVs in which integrates with CIM environments in the factory plant. The advantages of these approaches are decision making related with the transport system is integrated and co-ordinated with the overall plant decision-making. Other than that, the system can be used to evaluate the performance of an specific transport system in different production scenarios, so giving to the user the production cost (i.e., in terms of productivity, production time, equipment idle time, etc.) associated to this specific configuration. Never the less, this approach has multiple draw backs which are such as distance covered and availability of the AGVs introduce additional complexity, and even uncertainty, in the evaluation of the influence of transport operations [13]. Besides that, the vehicles are powered by batteries, a simple model of battery consumption in terms of the operation time of each vehicle has been used in order to control battery load thus battery consumption and energy use is a huge factor. Mathematical complexity of the scheduling model and stochastic is another issue.

In another research done by authors Lozoya et al. [14], almost similar approach was done in the factory plant but using different method which uses real-time wireless control which gives the company information that is sent and received within precise time-bounds. Proposed statistical estimation algorithms by evaluating the vehicle's travelling time and path deviation [14] is another method done by Lozoya et al. [14]. The AGVs control systems may consist in an external controller sending and receiving, through a wireless network, the control commands to the vehicle. Using real-time wireless control is limited which depends on the connectivity and range of wireless. Radio channels and the medium access control (MAC) generate random communication delays which causes severe performance problems. This also presents random and long access.

Different control method for different purposes was proposed by authors Rose et al. [15]. In which the control method was implemented to detect bottleneck among AGVs. This was the two most common bottleneck detection methods, based on the utilization and the waiting time, with the shifting bottleneck detection method developed by them, for AGV systems. Three bottleneck detection methods based on the utilization, the waiting time, and the shifting bottleneck are applied to the system. The true bottleneck is also determined experimentally by improving the different machines or the AGV speeds [15].

Authors Fauadi et al. [16] also proposed dynamic task assignment of autonomous AGV System which is based on Multi Agent Architecture. This is done to test the capability of the AGVs for different purposes. This will enable control the material handling activities and also the AGVS will equipped with decision making capability to plan and execute their responsibilities autonomously or collectively when needed. Lastly, it will support dynamic attributes of AGV task assignment mechanism [16]. But by proposing these method it requires complex algorithms and skill personnel is required to operate the autonomous decision making capability to plan and execute AGV's responsibilities.

Finally, the estimation and control of AGV proposed by authors Butdee et al. [17] addresses the problems of factory navigation and modeling with focus on keeping automatic travelling along the control path of the AGV [11]. In which requires personnel expertise to operate, maintain and trouble shoot the system.

Supervisory of AGVs

In journal written by Sen et al. [1] they conclude that the supervisory system is the traffic controller which interfaces the AGVs fleet with other activities in the factory. The supervisory system executes the dispatching, scheduling, communicating and monitoring operation of the fleet. It performs dynamic rescheduling if unexpected obstacles or conflict situations arise for the selected vehicles. But, it need to uses various algorithms that lead to complexity and trouble arise when trouble shooting. It also requires special skill and train employee or personnel to operate. In the production line and system of a company, it requires high expensive to implement and require detail design [17].

In journal titled Research on the AGV Based Robot System Used in Substation Inspection, written by Shengfang [18] used laser guided AGV based robot system used in substation inspection. They were using monitor devices instead of traditional artificial means like listen and see to inspect running status of equipment more accurately and scientifically. But, this AGV requires much severe to ground and combining gap should be avoid occurring on the road. To insure security of AGV Barrier detection, alarm and emergency stop protection are often installed on AGV but this will cause bulkiness and weight issues which sometimes affect the maneuverability and flexibility of the AGVs. This AGV requires wireless connection which is sometimes has a limited range [18]. AGV Allows for developing a reliable decentralized coordination scheme which is suitable for systems with large number of vehicles. But coordination problems due to the gains in terms of scalability [17].

Three frequently discussed algorithms for position tracking are compared in this journal: the Extended Kalman Filter, the Unscented Kalman Filter and the Monte Carlo Particle Filter. The advantage of this algorithm for position tracking is it can reduce costs of an AGV, distance measurements of the required safety laser range finder (LRF) are used. But the drawback is it dependency on the particle set. If there is no particle at the correct pose, it is impossible to estimate the pose accurately. Only the UKF and MCP can handle large movement noise because they do not linearize the movement function f [18].

Advantages and Disadvantages

Automated guided vehicle is known as is the simple machine used to do little more than move a part or material from one defined location to the next. Nowadays, AGV not only used in the manufacturing industry, but also in the military, theme park, healthcare, and transportation logistic. Automated guided vehicle system can easily be interfaced with other modules of flexible manufacturing system, such as robots, automatic storage and retrieval system (AS/RS), CNC machines, etc. So, it is widely used. AGV system is considerable flexible because it is adaptable to change in product as well as production. AGV can optimize the efficiency of the manufacturing system and also improve the productivity. AGVs delivery method is very safe and predictable, while avoiding interference with human and building factors. AGVs can operate for a long time, without stop. AGV also widely use because it can operate in extreme temperatures conditions and hazardous environments that may not be suitable for human [19].

Even though AGV gives many advantages to industries, there are several strong disadvantages. The main disadvantages of guidelines are the inflexibility concerning the modification and changing of the routing and the necessity of installations on or in the ground if the vehicles were guided by optical or inductive guidelines. The wire that carries an electric current is embedded in concrete along the pre-determined path, used to carry communication cables so messages can be transmitted to the AGV. This wire guidance is not suitable for systems that are frequently changed. The wires will become brittle and break in a long time [6].

Conclusion

Many methods have been proposed by many researchers and authors related to AGVs in manufacturing industries. Some of these methods have successfully been implemented in the industries today which have their advantages and also disadvantages. This paper has successfully pointed out and discussed several main issues and factors when dealing with AGVs in the computer applications manufacturing industries. The main issue here can be categorized into three which are navigation, control and supervisory. It is hoped by pointing out these issues, future research and development can be done to improve the problems facing by AGVs users especially in the manufacturing industries.

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