Automated Guided Vehicle Design Methodology - A Review

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Abstract:- Material handling is a key task and a non-value added an activity for the growth of a company. In order to make material handling smoother and stable, use a fully automated guided vehicle (AGV) as it reduces the human efforts, improve the customer services as well as increase the efficiency and the productivity along with the reduction in time. AGV design methods, monitoring, Controlling along with focus on the different design methodology used for AGV designing.

Keywords: Material handling, Navigation, Drive System, AGV, Traffic Management System, Communication System.

1. Introduction

Available material handling is many times semi-automated as a human operator is needed for operations such as loading and unloading which makes it tough and increase the cost. Drastic growth in automation and robotics leads to a fully automated guided vehicle. It not only reduces the manual work but also lower the cost with increased accuracy. Leading towards to higher responsiveness and better consistency also eliminate the repetitive process. Material handling is nothing but moving materials within short distances in a storage area. AGV is the effective and the best option for material handling. AGV automated guided vehicle is a smart vehicle designed and built with lots of features used in industrial application for transportation purpose, delivering the raw material, it is also known as a system without driver. Because of their user friendly nature and affordable price AGV are becoming more popular. Industries currently using AGVs are manufacturing, automotive, warehouses, hospitals, chemical industries, and assembly line for different applications. AGV consists of lots of subsystems such as navigation system, drive system, control system, safety system, hooking system, traffic management system, communication system. AGVs are battery powered the type of the battery may be either of lead acid battery or lithium ion battery lithium ion battery has lots of advantage because of its advantages over the lead acid battery as it of compact size, light in weight, high duty cycle, fast and efficient charging capacity, less maintenance required and have more life. Load can be in either in the tugger form or in the overhead format. Making the use of tugger and a trolley is tugged and used for the automatic hooking and unhooking of the trolley. There is lots of navigation system available previously navigation was done on the magnetic tape, color, spot, and wire but now days with development in technology using optical, laser or natural navigation is increased. AGV are said to be intelligent transportation as it deliver the material at right place within right time. It does not have any adverse effect on environment and safe to use. As we are focusing on review of an AGV based on the design method, and the material handling based. The review is done with best of my knowledge based on the different research papers available in this field.

2. Literature review

The research is focused on design method in the AGV.

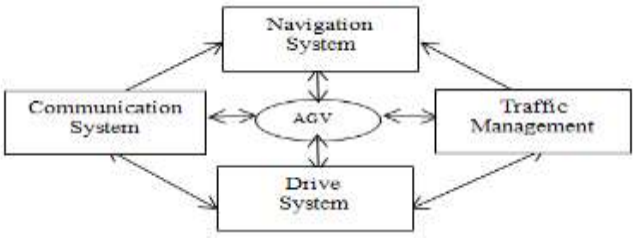

Fig1. Factors affecting the AGV design and control.

Various systems are considering for the design purpose such as navigation system, drive system, communication system and traffic management system.

2.1 Navigation System

Most important and part of AGV is the navigation method which shows movement of AGV around provided place and it also shows the exact position of the automated vehicle. Natural navigation focus on using a laser navigation sensor to in deep lanes, etc. It is mainly used for trailers loading and unloading. This way, the trailers need not to be changed to allow the vehicles to navigate within them. Jeisung Lee [1] used GPS for navigation system which is extensively used in determining the actual position of vehicle and is excellent for the out-of-doors purpose although not existing in indoor since the satellite signal are blocked within the building. Arkin [2] focused on simulation study, and results explaining the feasibility of migrating scheme based navigation into flexible

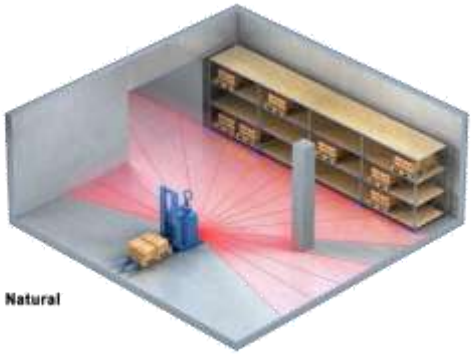

Fig 2. Natural Navigation

manufacturing system (FMS). It simplify the problem of navigation by limiting their paths to predetermined routes, it use the range of sensors its strategies. Anga Rusdinar [5] in his paper proposed vision-based interior localization technique they mounted digital camera on AGV as a vision sensor to mark simulated landmarks. A point detector is used to get the natural features. In order to get direction and vehicle translation optical flow recognition algorithm is used. To assess the vehicle translation and calculate exact vehicle position a kalman filter was used. According to his paper outcome entrenched that planned approach can be carry out in realistic approach. We are working on the natural navigation system in our AGV as it overcomes various drawbacks of the different methods. It does not need any kind of the track installation which is required in magnetic or color navigation method it saves the cost as installing the track is expensive and altering a path from time to time may be a difficult task.

2.2 Drive System

AGV drive system is the combination of motor and the driver fig.2 shows the drive system of AGV. Motor is the mechanical or electrical device that develops linear or the rotational force used to power a machine. Driver is an electronic device which regulates electrical energy and provides the electricity into the motor in variable amount at various frequencies thereby indirectly controlling the motor torque and speed. Drive System for AGV should be efficient, durable, high torque for good reliability and high performance. The motor can be any one out of this such as brushless, brushed and a stepper motor. Brushless DC motor has more advantage over the brushed and a stepper motor so we go for the brushless DC motor like quick response and acceleration, high power density, high speed operation, higher efficiency, high torque, reliability, long life span.

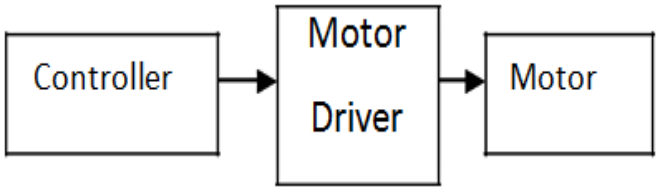

Fig. 3 Drive System

K. Jamoussi [6] stated the acceleration mechanism regulation of an induction motor. For motor velocity regulation Field-oriented control (FOC) near powerful drift mode was connected and to avoid cackle induced by Sliding Mode Controller (SMC) a stable function was added in a sequence. Here 2 methods are suggested have two phases first deals with formation of flux in size and the direction while second deals with control flux which was established by monitoring component of stator current. As the flux was constant within the machine the speed relegate was enforced. Here the simulation conclusion demonstrates that advancement done by our method related to the classic PID control. Suksri [7] stated the model and application of a "voltage source inverter type space vector pulse width modulation (SVPWM)" for induction motor to calculate it's the speed. Here system leads to regulate the speed of the motor by governing the frequency of the stator voltage along with its amplitude, and keeping the ratio of stator voltage to frequency as constant. While testing the induction motor from zero load condition to rated condition outcomes are accomplished by this we can control the speed of induction motor. In extension, when the load varies motor speed to be kept constant. Onwubolu and Godfrey [8] specially designed method for the control system drive wheels of robot, namely i.e. ROVER 3, for closed-loop motion controlling of each robotic wheel further than the configuration of a line tracer sensor component on the robot. By setting the control system of one wheel totally independent of the other wheel. Model created here focus on turning motion.

Singh and Ravinesh [9] worked on path data information, controlling position and speed, tracing of line and node, detection of obstacle and station, monitoring the battery voltage using PIC arranged in a star scattered architecture. As limited amount of pins available on the motor controller PIC boot loader board, only 3 bit speed control indication was used to control the position and speed of ROVER 2. In order to avoid the complication along the path a speed regulation model similar to ROVER 3 was Microcontroller generated PWM signals control the drive motor's speeds. Depending on the signals received by sensors both the motors work in the same direction or reverses its motion. When one motor works and the other motor reverses, in this case the AGV turn in the direction of the motor which has reversed. When both the motors continuously work in forward direction then the AGV will move straight. By the use of these conditions the AGV follow the pre-defined path followed. Kyung hoon Jung [10] did analysis of direction method or system of AGV with the use of adaptive network fussy inference system. Focused on driving technique which noticed object feature example driving path and gangway. It is having an advantage of getting extra records in AGV than that of induction sensor. As the camera used here is acutely affected by disturbance generated by intensity of light. So they build dark room surroundings to lower its affect. It is tough to manage by PID used in controlling for driving, on driving path.

Hence proposed steering method of AGV victimization ANFIS. By using fussy system steering angle is updated by two times input of wheel and it is used for driving control. Kongezos and Valentinos K[16] here the robot was designed as a three wheeler robot with two separately controllable wheels at the back and unpowered caster wheel in the front which balances turning in vehicle. The robot is controlled by ATmega16 microcontroller, with feedback from sensor.

3. Traffic Management

Traffic management is prime concern in industries to avoid congestion in required area automatic warehouses need a high delivery rate therefore working continuously and hence AGV requirement is growing faster. For proper traffic management their motion need to be controlled to drop AGV is at proper destination with greater speed. Problem of coordinating the vehicle in a well-organized way is difficult. If the traffic control is not done appropriately it leads to deadlocks or blocking and collision may occur which may block the part of system that leads to stopping the AGVs. Some random events can take place i.e. Material can drop while carrying it or vehicle can stop abruptly leads to unplanned obstacle due to this warehouse is semi-automated and other parts are controlled by human. Prefect management should be able to avoid collision and reduced delivery time. Li et al [11] recommended a set of traffic rules, should be checked when any vehicle depart from region, for prevention of blocking and vehicle collision. Using these traffic rules, it guarantees that no vehicle crash can occur every vehicle can finish fixed task on given route with flexibility and efficiency. Li, Qin, et al[12] paper is based on "container terminal" for traffic controlling algorithms are designed for accurate output. Here each path needs at least two zones where provided area is restricted. For higher performance layout of path and algorithm is required such approach is needed to work with the routing algorithm, and we can relate the feedback from report of real time traffic. Jung Hoon and Beom Hee Lee[13] proposed a two-staged traffic restraint scheme, here fixed paths are defined and used for multiple AGV system. For conflict free movement of AGV traffic management system is designed having two models one "off-line routing table generator (RTG) and online traffic controller (OTC).With this algorithm RTG finds path from node to another and store it in table format, OTG lets tables to provide collision free and reduced time among different path this is used for several AGV in practical approach. Secchi, Cristian, et al. [14] paper show the outcome of the "TRAFCON" experiment introduced a novel traffic management based on synchronized movement of AGVs, this experiment is done on real plant with good output with reduction in installation time with improved output. kumanan [20] using nontraditional optimization represent multi objective task scheduling of AGV in flexible manufacturing environment. Based on algorithm of natural selection process genetic algorithm is

examined, two types of control system used in the workplace for potent control that are stationary control system and peripheral control system.

4. Communication System

AGV manufacturer need a robust and cost-effective wireless solution that meet the needs of their mobile vehicles. The manufacturer moved toward a type of solutions to ensure reliable communication coverage an industrial wireless access point. The wireless access point solved a critical concern of providing secure Wi-Fi communication, while maintaining a short roaming handover time. The access points used the latest WPA2 enterprise (IEEE 802.11i/IEEE 802.1x) in combination with Opportunistic Key Caching (OKC) to guarantee the highest of level of wireless security and improve roaming handover time. When OKC was used in coordination with a central wireless local area network (WLAN), the manufacturer could deliver fast authentication between multiple access points throughout a network. Once originated with a Wireless LAN, OKC helped establish an uninterrupted supply of communication, or fast roaming. This capability which is now minimized to just milliseconds is measured by the handover time between access points. There are lots of benefits of using a wireless access point and client were purpose to the manufacturer's selection in delivering optimized operation and error reduction throughout their networks. Huge information transfer speeds, up to 867 Mbit/s and meets IEEE 802.11 standard for network speed. Low signal conflict, meeting the demands of industrial markets, including vibrations and electromagnetic compatibility (EMC). High system accuracy with expanded management, redundancy and security functions with specialized operating systems. Boosted ware house performance through exceptional WLAN roaming for moving vehicles. Better machine time and easier AGV fleet scalability due to very quick wireless set up, centralized setting changes and update. Lower complexity and installation time with less frequency of AGV planning via 2.4 and 5 GHz bands, providing more non-overlapping channels Kongezos, Valentinos K., and Charles R. Allen[16] in their research, they specified and Evaluated a communication system for AGVs and planed resource for FMS. The method used by them was based on evolutionary and incremental prototyping. The aim of this research is to supply the communication system as an aid in establishing traffic control and hardware in the loop simulations where online communication with the AGV is required. Advantages of this model are the LEGO R MINDSTORMS R NXT is highly configurable which allow researcher to give the model of the required attributes. The MIT App Inventor framework allows the fast processing of applications for smart phones provided with the Android OS, with less programming knowledge. Hardware platform used in the "MIT Inventor framework" made the development of the communication infrastructure easy. Piyare, Rajeev K., and Ravinesh Singh [17] proposed the C.A.N. field bus for industrial environments. The controller is heavily loaded C.A.N frames processing. Hence software that controls the data exchange between the protocols is written in assembly language. Other, Characteristics of the software is its capacity to control loss of info or errors during data format process, and report the sender for starting new transmission. Fellan, Amina[18] presents the structure, development and experimental results of Radio frequency (RF) based on wireless control recognized as ROVER II. they use transceivers for receiving data on ROVER II and sending the two bit path data from the remote computer site and sends it to the Master controller.

Here Physical communication port is a serial interface from the remote PC to the PIC16F877 Boot loader board. Udhayakumar P, and S. Kumanan [19] Proposed communication technologies for material handling using UVs, which may be important component for the proper production of automation ecosystems. Testing various use cases for solution of the Industry 4.0 3GPP, and 5G Public-Private Partnership (5G-PPP). The maximum need for the UVs' use cases are potency and reliability, with current wireless technologies.

5. Survey Table

Sr. No.	*Paper*	*Technique*	*Advantages*	*Description*
1.	"A vision-based automated guided vehicle system with marker recognition for indoor use".	GPS	Position Controlling	Widely used in positioning which is used for outdoor purpose
2.	"Autonomousnavigationina manufacturing environment"	Flexible Manufacturing System (FMS)	Simplifies the problem of navigation	Provides framework adaptable to various industries and set the drive path problem.
3.	"Design of flexible autonomous transport robots for industrial production"	RETRARO application	Huge operational flexibility, Obstacle avoidance	Support intelligent controlling of an AGV with the help of real time information based system.
4.	"A tracking algorithm for autonomous navigation of AGVs in a container terminal"	Navigation algorithm which is used to unite various model algorithm	Immediately notice turning motions along with minimizing the error of root mean squares for linear motions.	Navigation system is based on sensors. The navigation algorithm which is used to unite various model algorithms. Two models are given i.e. velocity model and constant-speed turning model
5.		Optical flow detection	Estimate the vehicle's	Digital camera used as a vision sensor

	"Vision-Based Indoor Localization Using Artificial Landmarks and Natural Features on the Ceiling with Optical Flow and a Kalman Filter"	algorithm and Kalman filter	position precisely	optical flow detection algorithm used to detect the vehicle movements
6.	"A sliding mode speed control of an induction motor"	Field-oriented control and Sliding form Controller.	Acceleration mechanism regulation in induction motor.	Here 2 methods are having two phases first deals with formation of flux in size and direction while second deals with control flux which was established by monitoring component of stator current.
7.	"Fuzzy logic control for a speed control of induction motor using space vector pulse width modulation"	Pulse width modulation based on space vector	Controlled the induction motor speed	Speed controlling of motor using fuzzy logic. It is enforced to speed signal model of motor and is then computed into a model.
8.	" Platform controller with an effective data communication protocol"	Rover III	arrangemen Control t of a wheel totally separate of the supplementary wheel achieved by the turning motion	Controlling movement of robotic drive wheel of robot.
9.	"A Distributed PIC Microcontroller Architecture for AGV Application"	FivePIC16F877 microcontroller	Speed and position control.	Obtaining data information of path, detection of station and obstacle, tracing of node and line by PIC microcontrollers organized in a star scattered architecture.
10.	"Vision guidance system for AGV using ANFIS"	adaptive system fussy inference model	Extra data points than other induction sensor	AGV design made upon study for camera surroundin with g of dark-room and information is competent by fussy approach
11.	"Modeling and control of the AGV system in an automated container terminal"	ATmega16 micro-controller	AGV follow the pre-defined path	Three wheeler robot with two separately controllable wheels at back and a complimentary un-powered caster wheel in the front. Controller is used to generate PWM signals were used to control the drive motor's speeds.
12.	"Modeling and control of the AGV system automated container terminal"	Traffic rules set	Good time efficient low time complexity	No inter-vehicle collisions arises for prevention of deadlocks route for every task of an automated vehicle can be done online
13.	"Design and control of automated guided vehicle systems: a case study".	Container Terminal	Output efficiency	Traffic control design and routing algorithm. Here each lane must lane must have 2 zones
14.	"A real-time traffic control scheme of multiple AGV systems for collision free minimum time motion: a routing table approach"	Two stage traffic restraint scheme.	Reduced the time improved performance.	Architecture is divided into 2 parts one is RTG and second is OTG for reduced time movement on k path.
15.	"TRAFCON traffic control of AGV in automatic warehouses"	TRAFCON	No tuning is needed to be done.	Validate on imitated real plant and on small scale warehouse
16.	"Task scheduling of AGV in FMS using non-traditional optimization technique"	Genetic algorithm & ACO algorithm	Flexible manufacturing environment	For traffic controlling here two types of control systems are used stationary and Peripheral
17.	"Proposal for an AGV communication system using a cell bot framework"	Cell bot frame work	developmen Quick t of applications for smart phones	Evolutionary and incremental prototyping based on "LEGO R MINDSTORMS R NXT kit and the MIT App Inventor" framework
18.	"Wireless communication between AGVs (autonomous guided vehicles) and the industrial network CAN (controller area network)"	CAN field based	Flexible and low cost	In order to avoid the loss of frame during delay of controller it should be refined at greater speed
19.	"Enabling Communication Technologies for Automated Unmanned Vehicles in Industry 4.0"	ROVER II.	Good efficiency	Here the vehicle control is set by command window to send valuesto direct the approach

6. CONCLUSION

Here we focused on material handling system in AGV along with its factors. By the reviewing this we found a need of area of research on material handling in AGV based material handling. We are designing an AGV to Reduced human efforts with great efficiency and in order to reduce floor installation cost and for obtaining higher efficiency we are using Natural Navigation. For

good aesthetics and design, accuracy in speed, proper path following we will work on AGV Drive System and for traffic management issues we will work on communication between two automated guided vehicle.

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