http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 6 (2): 304-309, 2007
ISSN 1812-5638

Evaluating of an AGV System in a CIM Unit: A Simulation Approach

J. Razmi, M.R. Taghizadeh and S.M. Asadzadeh
Department of Industrial Engineering, Faculty of Engineering,
Research Institute in Energy Management and Planning,
University of Tehran, P.O. Box: 11365/4563, Tehran, Iran

Abstract: AGV system implementation needs a large amount of investment. Therefore, many approaches have been engaged in order to optimize AGV systems. Among these approaches simulation as a methodology for systems analysis has a paramount significance in the industrial world. In this study an AGV system has been simulated in a specified CIM unit. For evaluating this AGV system, a profit index based on sailing price and operation, transportation, inspection and warehousing costs have been applied. In this study, Visual Slam software been used to simulate the AGV system. Two strategies have been undertaken to select the machining station in order to sending primary parts. These two strategies are characterized with NNQ(I) and NNCNT(I) functions. Also these strategies have been compared using mentioned index. Since all industries should be coordinated in the supply chain, knowing of production cycle time distribution is very beneficial. Therefore an investigation on the production cycle distribution function has been implemented and revealed the existence of a Gamma distribution.

Key words: Computerized simulation, visual slam software, AGV, index

INTRODUCTION

AGV systems are used for internal and external transportation of materials. Formerly these equipments were used in manufacturing systems but recently the scope of their use has been expanded to terminals, warehouses and underground transportations. The ability and power of simulation in modeling complex industrial systems, the simplicity of modeling, the easiness of model understanding and the ability of creating a model similar to the real system, made simulation different from other modeling techniques.

According to the Liu *et al*. (2004) by simulation of one AGV system in port terminals, have studied the effect of using these systems on the efficiency of transportation. In their study they took into account special assumptions for terminals yard and the estimation function of system efficiency is a multi-feature function. They demonstrated that the setting of terminal's yard has a great influence on transportation efficiency. Also, Kim *et al*. (2004) invoked simulation methods for designing controlling software of AGV systems in terminals. Flexible manufacturing system (FMS) including six machining centers capable of performing a variety of tasks, an automated guided vehicle based material handling system and a single input, single output storage-retrieval system connected to the manufacturing system by conveyors has been simulated in Prakash *et al*. (1995) work. By simulation of AGV systems in different functions, Moorthy *et al*. (2003) have tried to identify system's deadlock and subsequently eliminate them by changing systems parameters. Their study has been limited to simple layout and small number of AGV. Xu *et al*. (2003) Wu *et al*. (1999) Mezgar *et al*. (1997) and Evers *et al*. (1996) have applied simulation method for confirming the validity of their design method in automatic underground transportations. Bookbinker *et al*. (1997) applied the simulation approach for lane selection in an AGV-based asynchronous parallel assembly line. Also Mc Haney *et al*. (1997) have developed a material handling system simulation to predict the AGV requirements necessary for a major manufacturer to maintain desired levels of production in one of its automobile assembly plants. Maza and Pierre (2005) have used developed simulations for analyzing the efficiency of their approach to conflict-free routing of bi-directional AGVs. Wang *et al*. (2004) have used discrete event simulation model to evaluate the performance of an automated material handling system (AMHS) for a wafer fab with a zone control scheme avoiding all vehicle collision. They use the simulation model to determine distributions of most stockers for interarrival times. Their study was also investigated to determine the vehicle numbers in an automated guided vehicle-based intrabay

Corresponding Author: M.R. Taghizadeh, Research Institute in Energy Management and Planning, Industrial Engineering Department, Faculty of Engineering, University of Tehran, P.O. Box: 11365/4563, Tehran, Iran Tel: +98 21 88021067

material handling system. Also Alvarez *et al*. (1999) have used simulation results for traffic flow control in automated highway systems. In their study, A highway topology with a discrete number of lanes is considered. Vehicles can have different destinations and perform diverse maneuvers. Vis (2004) has performed a Survey of research in the design and control of automated guided vehicle systems. It is concluded that most models can be applied for design problems at manufacturing centers. Some of these models and new models already proved to be successful in large AGV systems. In fact, new analytical and simulation models need to be developed for large AGV systems to overcome large computation times, NP completeness, congestion, deadlocks and delays in the system and finite planning horizons. According to what was mentioned, it can be found out that simulation approach is a well-known method to analyzing AGV systems. In this study, we have tried to show the application and robustness of Visual Slam software to AGV system analysis. In this study, it has been assumed that a company with AGV system has been existed. Therefore, this study tries to maximize the company benefit by decreasing operational costs (carts, CNCs and man powers).

The paper is structured as follows: at the first the AGV system has been described in a specified CIM unit and thereafter the benefit has been proposed as an index to evaluating AGV system and the relevant equation has been derived. Then AGV system has been simulated by using Visual Slam software. In this simulation, NNQ(I) function has been invoked to choose the machining station in order to send primary parts, after that the model has been run and index has been calculated and also NNCNT(I) function has been utilized for the machining station selecting, also the model has been performed and the index has been evaluated. Eventually these two machining station choosing strategies have been compared, using the mentioned index. It should be noted that all the other parameters can be changed easily and the results can be analyzed by index evaluating and be compared with other cases. Because of significance of production cycle distribution, an investigation on the production cycle distribution function has been implemented and revealed the existence of a Gamma distribution.

DESCRIPTION OF ONE AGV SYSTEM IN ONE CIM UNIT

A CIM (Computer Integrated Manufacturing) unit include CNC machines, automatic system transportation materials, warehouses with automatic control. The considered CIM unit in this study includes three similar CNC machines, an inspection part and one warehouse and automatic system of material handling. Material handling in this Manufacturing unit is performed automatically and with two carts. At the first, all parts are placed on the pallets in the warehouse (pallets capacity is 10 pieces) and with the use of the existing cart in warehouse (in the beginning there are two carts in the warehouse) they go towards the machine in front of which the least number of pallets exists. After arriving at CNC machine and removing pallet, cart is settled near that machine, so as to be requested. It must be mentioned that cart after arriving to any destination must be stopped in the existing place, until it will be requested for new function. After finishing the whole pieces, one cart is requested and the production process cannot be started until the cart arrive (i.e., the block action happens). It is necessary to mention that when a cart is needed, is requested by pressing a key bottom by operator. Here the condition of cart's location is studied automatically by system and the nearest cart to the requested condition is sent. Then pallet is transferred to the inspection section. After the inspection process, the investigation of one cart is requested as long as the cart doesn't arrive (again the block action occurs). The inspected pallet is transferred to warehouse by cart and the pieces are separated from pallet. So the pallet is prepared to a give service. The layout of factory and the time of carrying the cart between different the sections have been shown in Fig. 1 and Table 1.

Six pallets have been considered in this study and it has been assumed that 10 unit of time needed to place and align each parts on the pallet.

Table 1: Time periods for carts movement between different departments

	Warehouse	CNC1	CNC1	CNC1	Inspection
Warehouse	0	2	2	2	1
CNC1	2	0	2	2	1
CNC1	2	2	0	2	1
CNC1	2	2	2	0	1
Inspection	1	1	1	1	0

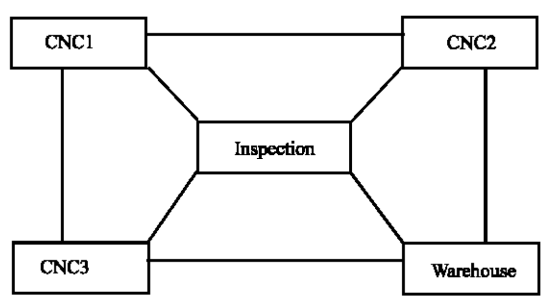

Fig. 1: The layout of production unit

DEFINITION OF INDEX: DETERMINATION OF PROFIT FUNCTION

Here with the determination of suitable index, we obtain criteria for measuring AGV system (CIM unit). The objective of the CIM unit is profit. Therefore, we consider benefit as expected index.

$$\text{Profit} = \text{income} - \text{cost}$$
$$B = I - TC \quad (1)$$

For obtaining the expected equations, a period of one week is considered which include 5 working days each of which include 8 h of work. So a period is equal to 2400 min. It is necessary to mention that the whole units of time in this project are min.

Computation of income amount

$$I = (\text{sale amount})(\text{price of sailing each goods unit}) = \left(\frac{T}{C}\right)(p) \quad (2)$$

T : Available time
P : Price of sailing each goods unit
C : Production cycle.

Computation of cost amount

Here we compute the total cost of GIM unit.

Computation of machining cost related to CNC machines

$$MC = MOC + MIC = ((T)(SP)(M\,C_o)) + ((T)(IP)(M\,C_I)) \quad (3)$$

MC : Cost should be computed separately for each CNC machine because the percentage of service times and idle time for three CNC machine is different.
MOC : Machining cost related to service times for CNC machines.
MIC : Machining cost related to idle times for CNC machines.
T : Available time
SP : Percentage of time which a service machine needs. the cost of each time unit related to times of services of CNC machines.
IP : Percentage of time when the machine is idle.
MC : Cost of each time unit related to the idle times of CNC machines.

Computation of inspection cost

$$IC = IOC + IIC = ((T)(IOP)(IC_O)(IN)) + ((T)(IIP)(IC_I)(IN)) \quad (4)$$

IC : Inspection Cost
IOC : Inspection cost related to times when the inspector is working.
IIC : Inspection cost related to the times when the inspector is idle.
T : Available time
IOP : A percentage of time when the inspector is working.
ICO : The cost of every Inspection time unit.
II P : A percentage of time when the inspector is idle.
ICI : Cost of every time unit for inspector when the he is idle.
I N : Numbers of investigation.

Computation of cost of holding early pieces in warehouse

$$HC = HC_1 + HC_2 = ((Lq_1)(Wq_1)(H_1)) + (Lq_2)(Wq_2)(H_2)) \quad (5)$$

HC : Cost of holding early pieces in warehouse
HC1 : Cost of holding early pieces in warehouse which are waiting for pallet.
HC2 : Cost of holding early pieces in warehouse which are waiting for cart.
Lq1 : The average number of existing pieces in warehouse which are waiting for pallet.
Wq1 : The average time of waiting for each piece.
H1 : Cost of holding each unit of early piece in warehouse for each time unit.
Lq2 : Average number of existing pallet in warehouse which are waiting for cart.
Wq2 : Average number of waiting for each pallet.
H2 : Cost of holding each pallet in warehouse for each unit of time.

Computation of carts cost

$$CC = COC + CIO = ((T)(COP(CCO)(CN)) + ((T)(CIP)(CCI)(CN)) \quad (6)$$

CC : Carts cost
COC : Cost of carts related to the times when carts are busy (used).
CIO : Cost of carts related to the times when carts are idle.
T : Available time
COP : Percentage of time when one cart is used.
CCO : Cost of each unit of time of a cart when it is used.
CN : Cart numbers.
CIP : Percentage of time when one cart is idle.
CCI : Cost of time unit related to a cart when it is idle.

Thus we have :

$$TC = MC + IC + HC + CC \quad (7)$$

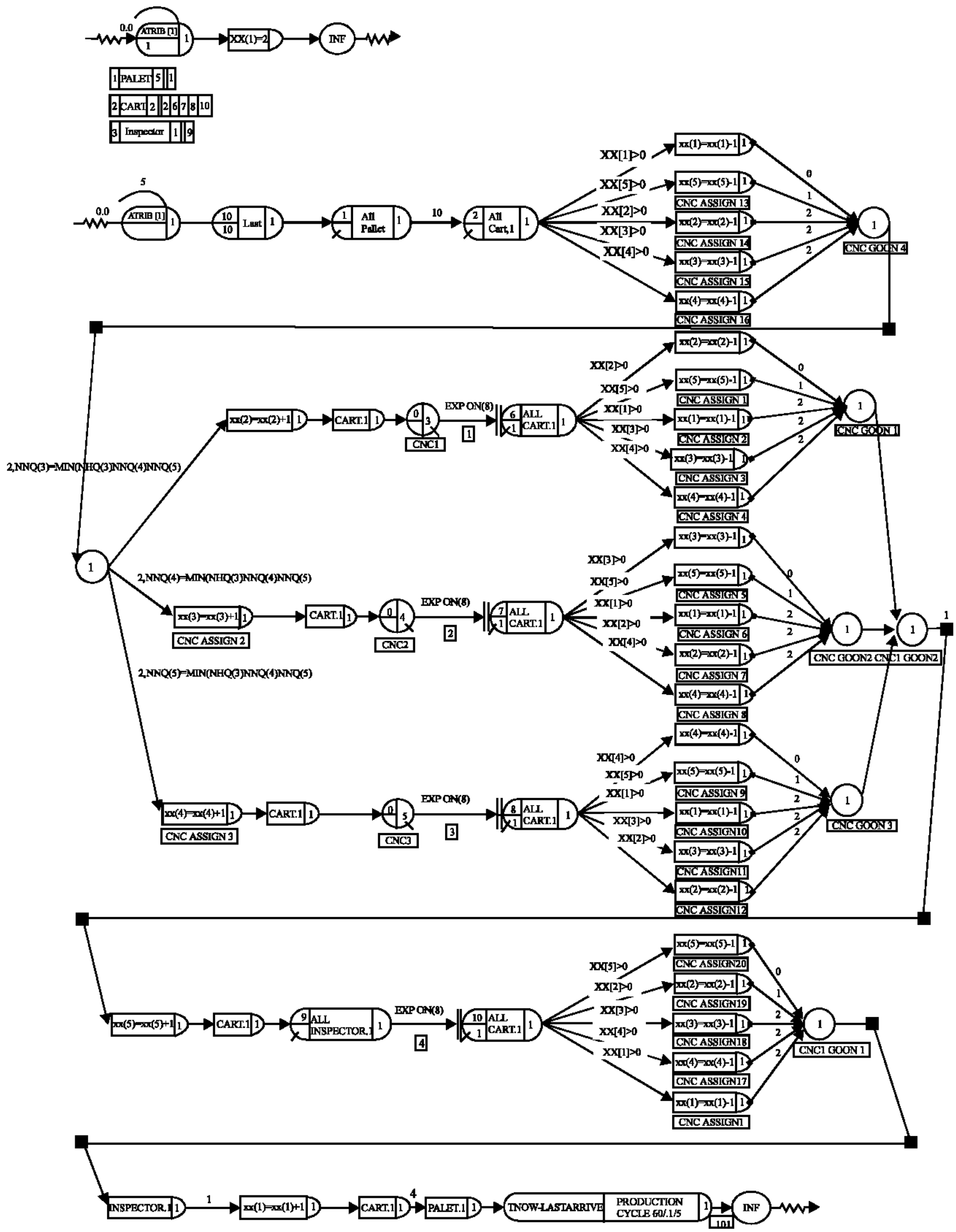

Fig. 2 (Appendix): Simulation model

Now with regard to the relations (1),(2),(7) we have :

$$B = I\text{-}TC = (TP/C)\text{-}(MC\text{+}IC\text{+}HC\text{+}CC) \quad (8)$$

THE PROPOSED MODEL

In Fig. 2 (in Appendix) a simulation model has been introduced using Visual Slam Software. The entrance of entities is occurred in CREATE node. Entities are classified in 10-size batches. This node called ACCUMULATE node. The entities request pallets and carts are waiting in AWAIT nodes. XX[i] represent the number of carts that are in position i. The process should pass from the all 5 positions which are shown by I = 1 to I = 5. I = 1: warehouse, I = 2: CNC1, I = 3: CNC2, I = 4: CNC3, I = 5: inspection.

Releasing the entity from AWAIT node verifies that at least one cart is idle. This entity should call the nearest cart to its position. According to the fact that the conditions after AWAIT node are checked from up to down,so the activities emanated from AWAIT node are sorted in increasing distance order of current position. After putting the pallet on carts, the destination CNC platform is selected. The selection factor is the minimum number of pallets waiting in CNC queue. After selecting the CNC platform, the cart moves to destination CNC platform. After machining, cart is requested. Machining the next pallet will not be started until the cart has arrived. This event is performed with blocking the service activity. Requesting the carts in machining platform is similar to requesting the cart in warehouse.

After inspection, if the inspected pallet had not been carried to warehouse, inspection of the next pallet will not be started. Pallets call the nearest available cart and then they will be carried to warehouse. At the time of moving the cart, inspector will be released and at the time of arrival the cart at the warehouse, cart will be released. Cycle time information is stored in COLLECT node.

RESULTS

After running the proposed model, index has been computed. The profit index for the defined example is 766/268. It is necessary to mention that at the first the proposed model used NNQ (I) function for choosing CNC machines. Then instead of NNQ (I) function, NNCNT (I) function has been used and the new index equal to 11511/963 has been obtained which shows the first function (i.e., NNQ (I)) is more suitable.

Production cycle time can be of prime importance, since the produced parts can be the entrance of another system (e.g., queue system). So, It is of interest to test or

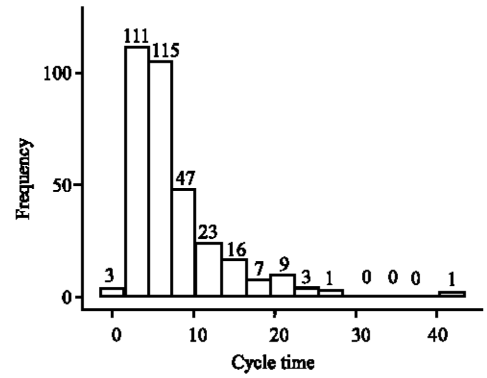

Fig. 3: The frequency histogram of the cycle time data

Table 2: The testing results of the cycle time by different models

	Model		
	Gamma	Lognormal	Exponential
Square Error	0.002587	0.004695	0.017388
x^2 test	9.41*	7.24*	30.6**
p-value	0.095	0.215	<0.005
K-S test	0.0619	0.0607	0.18
p-value	>0.15	>0.15	<0.01

* = With 5 degree of freedom
** = With 7 degree of freedom

confirm that the interval time data is from some particular distribution. In this study, COLCT and WRITE nodes have been used to collection and depiction of frequency histogram of production cycle data. In Fig. 3 frequency histogram of production cycle (Visual Slam and Minitab soft wares output) has been depicted. According to this histogram, one can guess three candidates for distribution function which are Gamma, Lognormal or exponential distribution function. Thus, in order to justify the underlying distribution of interval time from this data set, a goodness of fit technique is implemented to determine the best fitted division. In Table 2, the testing results of analysis have been presented. Among the different candidate distributions, Gamma distribution has the least total error squares and is the best fitted distribution function comparing other distribution functions.

CONCLUSIONS

The study shows that there are many models for designing AGV system and these simulated AGV systems has valuable help to designing these kinds of systems. Because they conquered the problems related to long time of computation and show efficiency of parameters model such as congestion, deadlock, delay. This study defines an index for assessment of AGV system and a simulation model has been developed by Visual Slam Software. It has been concluded that the use of NNQ (I) function is more appropriate to compare with NNCNT (I) function for choosing machining station for transferring early pieces. It is understand that the Probability distribution function of production cycle time is Gamma distribution. It must be mentioned that all parameters in the model can be easily modified for sensitivity analyze and the results can be compared by index assessment. Instead of maximizing of profit, one can maximize the utilization of carts CNCs and man powers. The authors are studying the optimization of utilization of the above system.

REFERENCES

Alvarez, Luis Roberto Horowitz and Li. Perry, 1999. Traffic flow control in automated highway systems. Control Engineering Practice, 7: 1071-1078, September.

Bookbinder, J.H. and M.D. Kirk, 1997. Lane selection in an AGV-based asynchronous parallel assembly line. Comp. Ind. Eng., 32: 927-938, September.

Joseph, J.M. Evers and S.A.J. Koppers, 1996. Automated guided vehicle traffic control at a container terminal. Transportation Research Part A: Policy and Practice, 30: 21-34, January.

Kim, K.H., H.W. Seung, L.K. Jae and T. Teruo, 2004. An Architectural design of control software for automated container terminals. J. Comp. Ind. Eng., 46: 741-754, July.

Liu, C.I., J. Hossein, V. Katarina and I. Petros, 2004. Automated guided vehicle system for two container yard layouts. J. Transportation Research Part C: Emerg. Technol., 12: 349-368, September.

Maza, S. and C. Pierre, 2005. A performance-based structural policy for conflict-free routing of bi-directional automated guided vehicles. Comp. Indu., 56: 719-733, September.

Mezgar, I. Cs. Egresits and L. Monostori, 1997. Design and real-time reconfiguration of robust manufacturing systems by using design of experiments and artificial neural networks. Comp. Ind., 33: 61-70, August.

Moorthy, R.L., G. Wee Hock, Ng Wing and P.C. Teo, 2003. Cyclic deadlock prediction and avoidance for zone-controlled AGV system. J. Intl. Prod. Econ., 83: 309-324, March.

Prakash, A. and C. Mingyuan, 1995. A simulation study of flexible manufacturing systems. Comp. Ind. Eng., 28: 191-199, January.

Roger, W.M. and D.E. Douglas, 1997. Multivariate regression metamodel: A DSS application in industry. Decision Support Systems, 19: 43-52, January.

Vis, Iris F.A., 2004. Survey of research in the design and control of automated guided vehicle systems. J. Eur. Operational Res., In Press.

Wang, F.K. and J.T. Lin, 2004. Performance evaluation of an automated material handling system for a wafer fab. Robotics and Computer-Integrated Manufacturing, 20: 91-100, April.

Wu, Kun-Hsiang, H. Chin Chen and J.M.K.D. Lee, 1999. Path Planning and Prototype Design of an AGV. J. Mathe. Comp. Model., 30: 147-167, October.

Xu, F., B.V. Hendrik, N. Marnix and M. Ronny, 2003. Concepts for dynamic obstacle avoidance and their extended application in underground navigation. J. Robotics and Autonomous Systems, 42:1-15, January.