A Technical Note about Design Thought of AGV logistics based on Floyd Method

Qiunan Feng[1, 2, a]

[1]Information Science Academy, China Electronics Technology Group Corporation, Beijing 100086, China

[2]Beijing Key Laboratory of Advanced Manufacturing Technolog, Beijing University of Technology, Beijing 100124, China

[a]1142946030@qq.com

Keywords: smart factory planning, logistics essential, Floyd method.

Abstract. As the world industrial production requiring higher and faster efficiency, a series of manufacture processes is facing new challenges. Especially, there are two main parts according to potential profitability during each process steps. One has potential profitability that is logistics step and another is un-logistics. In this paper, there is a higher efficiency logistics system and about loading platform, material distribution and storage for shipment. The Floyd method would be an important role for planning the material distribution. An example is making the thought coming true. From the result, the production cycle that is from unloading materials to storage for shipment has be decreased with 10% to 20%. It has higher efficiency and better benefit for the factory. With the rapid development of industrial process, the higher efficiency means for that the industry holds importance position in the world.

1. Introduction

With the increase of worldwide industrial competition, being able to propose new products in a short lead-time and with low cost is an important concurrence advantage for companies. In order to achieve these targets, companies should concentrate on effective ways to design products faster, minimizing not just only cost and problems related to the design project phase, but also considering problems of others phases of product lifecycle. [1] In this context of collaborative engineering, the digital prototyping (based on the concepts of digital models representing the product, its physical behavior, and its manufacturing process) is a solution to test and validate a product earlier in its lifecycle [2]. This work, associated to these digital prototypes, becomes an essential tool to provide a way to design factory, during upstream phases of the product lifecycle, and so it allows reducing time spent in the product design by helping the decision making process [3].

Digital Factory (DF) was born to design and simulate production systems throughout the product design process [4, 5]. However, if simulation of the product physical behavior can be considered well integrated to the product design project [6] and if available technologies and systems in DF exist, such approach is still not widespread and they cannot meet business needs [7]. Moreover, different actors in the company, with very different points of view are interacting in the DF scope: shipment, logistic among crafts and storage (Fig.1). Indeed, the solution adopted for product development is to integrate different types of information (product, process and resources) as soon as possible to make the right decisions at the right time [8].

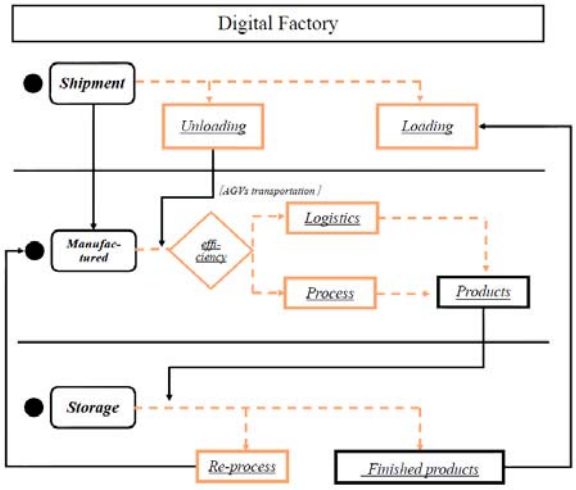


Fig. 1 Digital Factory design scope

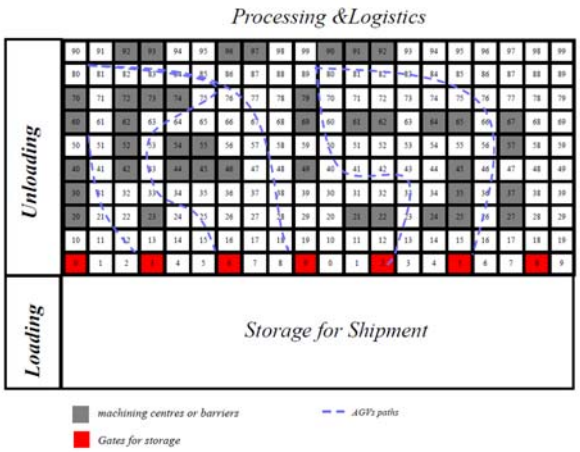


Fig.2 The sketch of the DF planning

With economic development, the human logistic is face to be eliminated. Therefore, the Automated Guided Vehicles(AGVs) is rising in response to the proper time and conditions. The key issue is the automatic path search in today's increasingly large and dense transport system. The all vertices shortest path algorithm proposed by Floyd is used to calculate the shortest path between all nodes [9, 10]. Optimal path planning is the first network of roads and surface features as points and lines, and then start and end in the known circumstances, finding a shortest (or a time, least cost, shortest distance) path. In addition to the optimal path to solve a lot of ways, such as Floyd algorithms, graph theory, dynamic programming, neural network method, it is the most conventional graph search method for depth and breadth of search algorithm.

2. The Method For Designing Logistics

The AGVs are more and more used here. How to make local and global path planning is main idea in this paper. The local path planning is always used in unknown or part unknown situation. The AGVs are according to the feedback of sensors and know about the size and position of barrier. Finally, the AGVs will calculate an optimal path to finish its works. The AGVs have made great development with artificial intelligence and simulation algorithms. The more and more methods are used in path planning. However, in this paper, Floyd algorithm method is used here whose advantages are according to the crafts. The detail method will display as following. At first, grid map should be built. The grid rules as following (as the Fig.2):

(1) The environment map which is support AGVs working can be divided to 100×100 grid.

(2) The AGV occupies a square of 1×1 grid.

(3) The barriers and machines occupy many grids whose area are form1×1 to n×n. And the value ranges of n is from 1 to 100.

After mashing, the AGVs moving directions should be planning in grid map. If the position of moving AGV was (x_i, y_i), and it had 8 directions. When the AGV moves one unit, the position will change to (x_i+1, y_i+1), (x_i, y_i+1), (x_i-1, y_i+1), (x_i-1, y_i), (x_i-1, y_i-1), (x_i, y_i-1) and (x_i+1, y_i-1). The distances are $(\sqrt{2}, 1, \sqrt{2}, 1, \sqrt{2}, 1)$, respectively.

The optimal path in planed of AGV. The basic rules for Floyd algorithm is to calculate the optimal path from note v_i tov_j. If this path is an arc, the distance A_{ij} is path between v_i andv_j. However, the path is not the best way and the optimal path should be test *n* times. The AGV optimal path planning procedure is showed as followed. The Floyd algorithm is based on known nodes weights and directions. By the way the AGVs path is according to nodes selections of digraph. Firstly, the nodes need to be selected from path. VLL (Vertical Line Locus) is used and the points of intersection are between the normal of tangent vectors of path and grid which is used to confirm nodes. The procedure of path planning is showed as Fig.3.

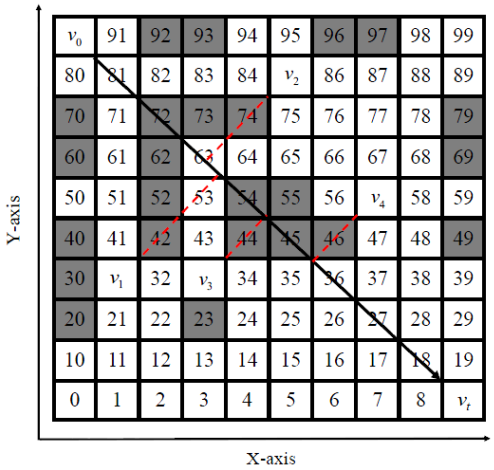


Fig. 3 choosing the nodes using VLL

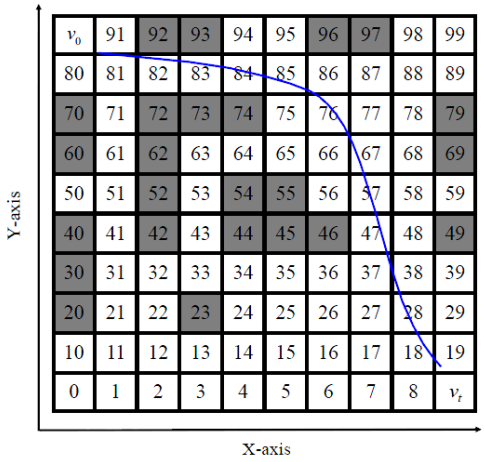


Fig.4 The path of AGVs based on Floyd

Adjacency matrix is calculated by digraph. And weights can be gotten by the position of nodes amongv_0, v_1, v_2, v_3, v_4, v_t. Taking S_{01} for example, which is weight between v_0 andv_1, S_{01}=5+$\sqrt{2}$ represents the distance between every two points. If there is an obstacle which the path could not pass, the weight is∞. The form principle of error compensation is that the path is along the direction *t*. By the way, the nodes at same side of direction is used to be defined. The direction of each other is no limit for nodes at different side. And in this Floyd algorithm, the nodes have one order and direction merely. According to the direction to target node and obstacle, weighted graph of path is shown in Fig.5, and the Eq.(1) is adjacency matrix of digraph.

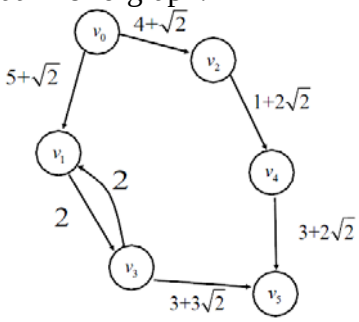


Fig. 5 AGVs path graph with weight and its adjacent matrix

Step.1 the weight matrix S_{01} should be built from node v_i to node v_j without middle nodes. The weight and direction relationship amongv_0, v_1, v_2, v_3, v_4, v_5. Can be found.

$$A_0 = \begin{bmatrix} 0 & 5+\sqrt{2} & 4+\sqrt{2} & \infty & \infty & \infty \\ \infty & 0 & 2 & \infty & \infty & \infty \\ \infty & \infty & 0 & 1+2\sqrt{2} & \infty & \infty \\ \infty & 2 & \infty & 0 & \infty & 3+3\sqrt{2} \\ \infty & \infty & \infty & \infty & 0 & 3+2\sqrt{2} \\ \infty & \infty & \infty & \infty & \infty & 0 \end{bmatrix} \quad (1)$$

Step.2 A minimum node weight value is calculated between v_i and v_j. A middle note v_r is across by to v_j. The shortest distance which from node v_i to node v_j is $A_{ij}^1 = \min_r \left\{ v_{ir} + v_{ij} \right\}$. And the shortest weight matrix is $A_1 = (A_{ij}^1)$.

Step.3 Setting No. *k* node between v_i and v_j, which is the shortest among weight matrices before. The shortest distance is $A_{ij}^{k\text{-}r} = \min_r \{A_{ir}^r + A_{rj}^{k\text{-}r}\}$. And the shortest weight matrix is $A_k = A_{ij}^k$. In this example, the weight matrix of path is gotten by adding 2 nodes as Eq.(2).

$$A_2 = \begin{bmatrix} 0 & 5+\sqrt{2} & 4+\sqrt{2} & 2 & 5+3\sqrt{2} & 7+7\sqrt{2} \\ \infty & 0 & \infty & 2 & 6+\sqrt{2} & 4+4\sqrt{2} \\ \infty & \infty & 0 & \infty & 2\sqrt{2} & 3+3\sqrt{2} \\ \infty & 2 & \infty & 0 & 4+\sqrt{2} & 3+3\sqrt{2} \\ \infty & \infty & \infty & \infty & 0 & 3+2\sqrt{2} \\ \infty & \infty & \infty & \infty & \infty & 0 \end{bmatrix} \quad (2)$$

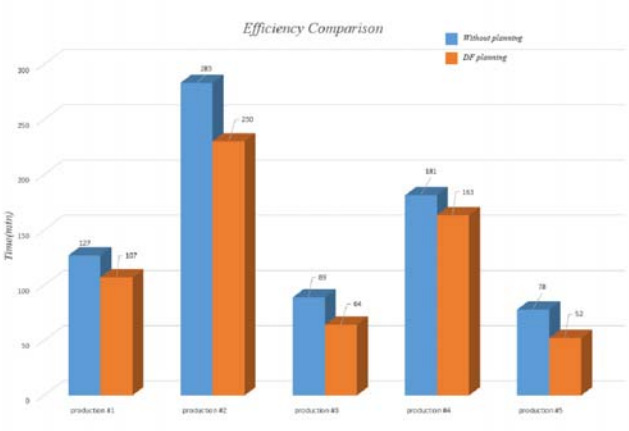
Step.4 Judging $|v_r|_y \leq L_{limit}$ or not. If it is true, the compensation would be outputted. If it is not, grid would be changing to $n = n \times n$ and the process would go to Step.1. The process would be going on and iteration is running till condition is satisfied.

Finally, the path planning is according to the Floyd algorithm and the AGVs path is setting as Fig.4 shown. Furthermore, the crafts can add path weight matrix. The logistic which uses AGVs to complete and whose path planning uses Floyd algorithm will improve efficiency. The logistic includes receiving shipment (Fig. 6 (a)), transporting (Fig. 6 (b)) and putting in storage (Fig. 6 (c)). This example has executed the design. The same production which need to be processed use less time. That means for during the same time, more and more production can be processed. And more and more benefit will be gained. The (Fig. 6 (d)) is showing about comparison between without planning and executing design. From the result, the efficiency is improved obviously.

(a)

(b)

(c)



(d)

Fig. 6 The AGVs logistic applications in planning factory

3. Conclusion

This paper main introduce how to plan the AGVs` path to make the processes more efficiency. Especially, for logistic system, which has potential profitability, the Floyd algorithm is added for AGVs path planning. The whole redesign thinking is practicable for a factory. With the designing, the efficiency and benefit is improved. With the increase of worldwide industrial competition, being able to propose new products in a short lead-time and with low cost is an important concurrence advantage for companies. That is the meaning for our works. Furthermore, in our next work, we try to think about more detail in craft join process.

References

[1]. Briggs, Ted L., Thomas C. Rando, and Thomas A. Daggett. "Reuse of ship product model data for life-cycle support." Journal of ship production 22.4 (2006): 203-211.

[2]. Hoppmann, Joern. The Lean Innovation Roadmap-A Systematic Approach to Introducing Lean in Product Development Processes and Establishing a Learning Organization. Diss. 2009.

[3]. Gedell, Stellan, Marcel T. Michaelis, and Hans Johannesson. "Integrated model for co-development of products and production systems-a systems theory approach." Concurrent Engineering 19.2 (2011): 139-156.

[4]. Bracht, Uwe, and Thomas Masurat. "The Digital Factory between vision and reality." Computers in Industry 56.4 (2005): 325-333.

[5]. Kuehn, Wolfgang. "Digital factory-integration of simulation enhancing the product and production process towards operative control and optimisation." International Journal of Simulation 7.7 (2006): 27-39.

[6]. Giudice, F., F. Ballisteri, and G. Risitano. "A concurrent design method based on DFMA-FEA integrated approach." Concurrent Engineering (2009).

[7]. Nag lingam, Sev V., and Grier CI Lin. "CIM—still the solution for manufacturing industry." Robotics and Computer-Integrated Manufacturing 24.3 (2008): 332-344.

[8]. Hägele, J., et al. "The CAE-Bench Project-A Web-based System for Data, Documentation and Information to improve Simulation Processes." 2nd MSC Software Automotive Conference. 2000.

[9]. Ju-zhou, H. U. "An Algorithm for Distribution Center Based on the Floyd-Shortest-Path [J]." Journal of Hunan Agricultural University 4 (2004): 025.

[10]. Tsitsiashvili, G. Sh, and Aleksandr Sergeevich Losev. "Application of the Floyd algorithm to the asymptotic analysis of networks with unreliable ribs." Automation and Remote Control 69.7 (2008): 1262-1265.