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Simulation Approach for Logistical Planning in a Warehouse: A Review

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Abstract

Simulation approach has been widely utilized for design and planning of a warehouse logistic system. As technology advances, better simulation tools have been developed. This enables decision makers to create more realistic models to represent the actual scenario. As a result, better evaluation could be made especially regarding dynamic factors within system. Thus, complex logistic problems could be solved. This paper reviews the fundamentals of warehouse logistic and the simulation tools available to analyze logistic problems.

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Introduction

One of the most important aspects of Logistics Warehouse (LWs) is queuing systems.[1] The systems are used for managing traffic flow and goods distribution within a warehouse. During all stage of a logistic process, raw materials and finished goods are stored in a warehouse facility. It is critical for warehouse management to operate to achieve the important goals of logistic systems that are to ensure customers' satisfactory and to operate at minimum cost. As the world is becoming a more interconnected marketplace, customers have also become more demanding. Therefore, increasing productivity, flexibility and reliability of supply chains are the most important aspects to improve logistic processes in a warehouse.

Capacity planning, technical requirement and material handling are among the factors when selecting strategies for warehouse operations. In

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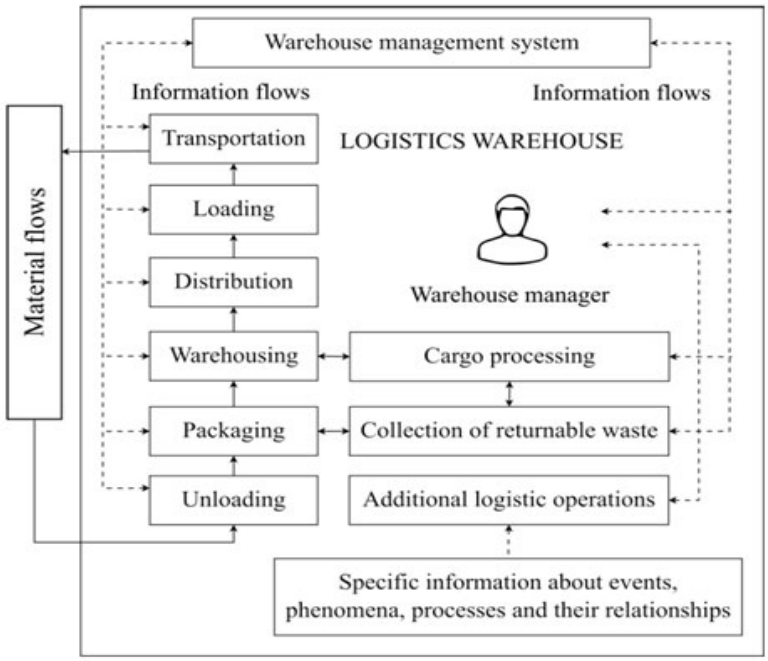

Fig. 1: The Operation of a Logistics Warehouse[1]

measuring the effectiveness, time and cost could be considered as the most commonly used indicators for individual storages operations for warehouse space or labour resources. Figure 1 shows the operation of a logistics warehouse. Material and information flows of the related operations are shown in the figure.

Besides, Sulírová *et al.,*[2] explained the important part of logistic management is to provide a satisfactory level of customer service. However, as technology advances, customer's expectation also increases. Therefore, manufacturer must be able to increase productivity by having efficient transportation, handling and storage of materials as stated by other researches as well.[3-4] Basically there are two main aspects that need to be focused which are the fundamental of warehouses and the simulation tools that can be used to optimize the processes.

The remainder of the article is organized as follows: Section 2 provides the fundamentals of process flow in a warehouse. Meanwhile, Section 3 describes the automated material handling system through Automated Guided Vehicle (AGV) implementation. Section 4 presents the simulation methodology and illustrates its effectiveness in supporting decision-making. Finally, Section 5 provides the concluding remarks and potential directions for future extensions.

Warehouse Process Flows

The design of warehouse layout can be classified as the systematic way to organize the relative location of function, department and equipment of warehouse facility. There are six main material flow activities for a warehouse which include receiving material, transfer and shipping out, accumulation or sortation, order picking or selection, shipping and cross-docking. The importance of designing appropriate warehouse layout is to minimize the output costs of processing in the warehouse. In this study, warehouse layout can easily reduce the time for the process need order or a bunch of order.[4] The total travel distance required for the process to take an average order are the important thing that can affect the cost.[5] Figure 2 shows an examples of typical warehouse function and flows which is in a U-shape of warehouse layout. The U-shape layout are commonly use in the industry especially in a shopfloor that requires cross-docking operation.

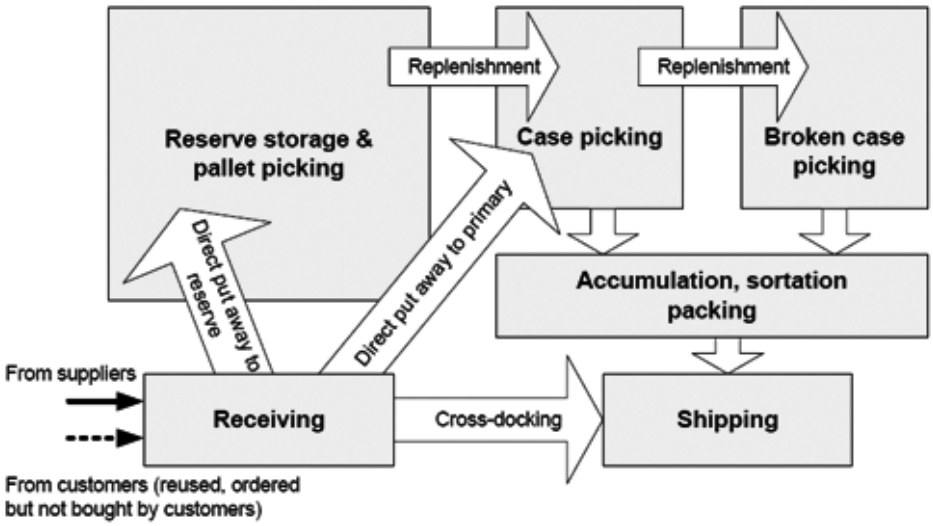

Fig. 2: Conventional Warehouse Function and Flows[6]

The various configuration of warehouse design layouts provide the efficiency for warehouse operations and the capacity to add storage volume for future expansion. Among the important objectives that need to be considered when designing a layout for warehouse include:[2-5]

1. To minimize transportation requirement
2. To minimize the labour requirement
3. To minimize the space utilization
4. To minimize use of equipment and tools
5. To increase work safety

The same case applies for warehouse that is located within a manufacturing environment where the material handling for intra-warehouse and the production floor-warehouse need to be considered.[7] In many cases, intelligent techniques are applied in the various aspects of intelligent vehicles.[3,5] Safety, efficiently and effective of material transportation are the main objectives. There are several of material which are usually carried by material handling which are:[7]

1. Raw material
2. Part purchase from supplies
3. Work-in-progress (semi-process parts)
4. Rework
5. Scrap
6. Disposed material
7. Tooling

In an automated system such as warehouse, Automated Guided Vehicle (AGV) system is used to pick-up and drop-off load because it provide more accurate and precise operation. The main characteristic for AGV system is to carry pallet loading and unloading over the floor.

A warehouse is a place to store of goods and product. It also known as a distribution center. In a warehouse management, the distribution of goods include the process of allocating of incoming good, storage and material tracking.[7] Nowadays, warehouse management system is able to be intergrated with an automated system. These includes radio frequency identification (RFID) and voice recognition. The effective control of the movement of material in the warehouse critical for any warehouse management system.

AGV as a Material Transportation

Culler and Long[8] described AGVs as the commonly used in manufacturing and material handling. Predetermined lanes are typically used to enable the AGV to travel within the facility. Meanwhile, Shneier and Bostelman[9] stated that aside from factories and warehouse, there are other workplaces where AGVs were utilized including in cargo port and hospital. Transportation operations are determined by the level of efficiency that transportation could be carried out that include speed of deliveries, costs of operations, the usage of facilities and service

quality by implementing management techniques and principles.[9-10]

The main goal of optimizing the AGV system is to maximize the efficiency of materials flow. Additionally, transportation system in a warehouse need to be flexible in order to adapt to the system dynamic. Leite *et al.,*[11] agreed that in order to achieve the objectives of flexible manufacturing system (FMS), the material handling and delivery times need to be shorten. AGV have to provide the required materials in the right quantity and at the right time. There are several advantages of AGV in flexible manufacturing system which is:

1. Driverless operation
2. Better throughput
3. Reduce of the broken parts due to manual handling

In order to automate the internal material flow an automated guided vehicles (AGV) are commonly used in warehouse, distribution centers and manufacturing plant. Typically, the design of AGV system to transport big and heavy transport units such as Euro pallets or mesh pallets. For a small transportation units such as just-in-time (JIT) inventory management and lean production need to allow one-piece-flow. An AGV system are used to solve the problem. In this study, they localization and tracking of small AGV system for the solution. RFID transponders to detect a localization.

Simulation Methods

There are various features of AGV system which is design of system. The difficult task in AGV system are to design a control system. Number of the vehicle are the important thing to start the design of system. Simulation will help the designers to build a model. Leite *et al.,*[11] describes the flow of material in the production system that can be optimized by having an efficient AGV system. In the paper, they state simulation software Promodel 7.0 are used to optimize the use of AGV system.

Although there are some criticism on the accuracy obtained by simulation software, Negahban and Smith[12] found that the Discrete Event Simulation (DES) approach for a manufacturing system is capable to provide a good insight on how the proposed solutions could affect the system. AGV are the important element in the material handling system. They state that productivity will increase by used an AGV system. The advantages of conceptual simulation of the AGV are can built a complicated design and operation of AGV system.

There are several control strategies focusing on AGV steering system which is neutral network, fuzzy control and an intelligent coordinate control.[13] Method of least square is utilized to minimize distance error and orientation angle error. In order to design the AGV controller, the intelligent coordinate control strategy are used to improve the dynamic performance of the system.

The simulation model is capable to show the result for the logistic system that can fulfil the requirement of the future company to optimize material supply, increase the operation areas and able to create layout.[14] Using simulation, it is feasible to do the same process such as logistic, production areas and assembles in the real manufacturing industry. In this study, number of vehicles is used in static calculation as a method to build a simulation model. For the basic model to initial validate only used a calculation base for dynamic simulation as depicted in Figure 3. Based on the result of simulation experiment, static calculation shown different result. Therefore, for the dynamic simulation it need more input parameters.

Additionally, among the most difficult characteristics of scheduling problem are stochastic dynamic job shop scheduling problem.[15-17] In that study, they evaluated nine objective functions which are makespan, maximum flow time, quantity of tardy jobs, total setup time, mean setup time, mean flow time, maximum tardiness, mean tardiness and other performance measures. A discrete event simulation was used in that experiment using nine dispatching rules. NP- hard scheduling problem is an important in assembly job scheduling problem (AJSSP). Relationship between jobs and product structure are complex so it very difficult to solve the problem. In this paper, they used systematic multi-attribute and preference selection index method in dispatching rules to ranking priority for scheduling in assembly job shop. For the experiment a simulation model is used. To determine a multi-objective environment are the best effect priority dispatching rule.

In assembly line, during supplying part the just-in-time (JIT) conept has been widely used in production [18]. An automated transportation of the AGV system are commonly used to transport parts and to guide the part to be fed to assembly units. It is because AGV is the efficient transportation method. However, there are some potential resource misallocation in AGV system such as inappropriate AGV dispatching rules which can lead to queuing part and traffic vehicles.

The important factor to increase the productivity in warehouses and increase efficiency by the improvement of the automation system mention.[15-16] The problem for the AGV system is to determine the vehicle to transfer and load to be transfer. The time to transport of loading and loading pallet need to fast. In the study, the objectives are to reduce the costs by reduce the number of vehicles and travel time to fulfil the demand. The lower number of AGVs is consider to implement the transportation demand in a certain time.[17-18] For the task, comparison between the shortest processing time dispatching rule and meta-heuristic Tabu Search technique was conducted. Simulation result show the operation cost for material handling can be reduce and the number

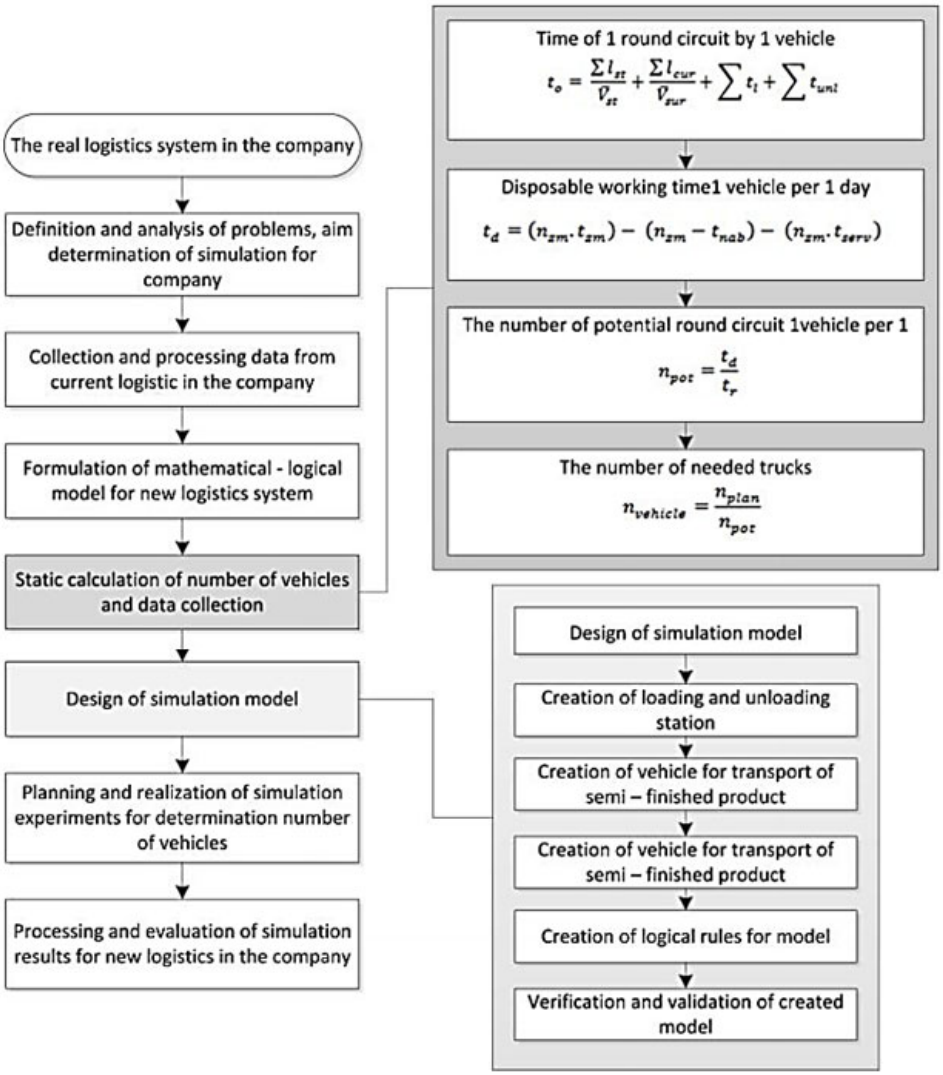

Fig. 3: The Method of Simulation Model Development for the Factory[14]

of vehicles can be estimate. The technological advancement of AGV has been accelerated throughout the years.[19] This is partially due to the fact that computing technology has advances and demand for automated transport soars rapidly as previously reviewed.[20]

Simulation Software

There are several criteria that are typically considered in selecting software for simulation. Among the common criteria are price, functionality, model development, case problem requirement, decision support functionality, open-ended programming functionality, data analysis, compatibility and exchangeability, animation and technical support. Nevertheless, more often than not, the options will be narrowed based on budget and the application requirements. This research select some of most widely used software for consideration. The software are:

- Simul8 - SIMUL8 [21] could be utilized to simulate logistic systems that involve processing the activities of discrete entities at discrete times. Apart from warehouse logistics, other suitable applications include optimization of production and other processes in services[22-24]. The main strength of SIMUL8 is that it allows user to add advanced logic to the simulation model created.[21] This allows user to take into account real life constraints, capacities and other dynamic factors affecting the system performance.[23]
- Promodel - ProModel Optimization Suite[25] refers to a simulation tool capable to model different types of manufacturing systems including warehouse operation, small job shops, assembly lines and workcells, flexible manufacturing systems and supply chain.[26]
- Anylogic – Anylogic is a software that support general purpose multimethod simulation.[27] Its flexible features are capable to accommodate various real world scenarios. Additionally, it is also capable to model the behaviour of a decentralized system with minimum programming skill required. On the other hand, advanced programmer may code additional requirement in Java language and connect it to Anylogic. Besides, application could also be run online via AnyLogic Cloud web service.[28-29]
- FlexSim - FlexSim[30] is a user-friendly simulation software containing objects with pre-built logic and task execution to imitate the resources utilization activities in real-world operations. The software support 3D animation thus very graphical and very suitable for presentation.[31-33]
- Arena – Arena is very suitable to simulate and analyze existing and proposed systems as well as operational analysis.[34-35] It has been widely used to model manufacturing and warehouse operations[36-37]
- Witness – Witness[38] is a desktop software for professional modelling and application development. The software is user-friendly and is capable to predict simulation model quickly.[39-40]

Conclusion

Research on simulation approaches for warehouse logistics is entering a new phase with the availability of commercial software capable of modeling dynamic and realistic environment. Furthermore, as it is becoming ever critical to optimize warehouse operations, simulation is a viable option to forecast the effects when changes are made. Furthermore, some of the softwares are even equipped with artificial intelligence and advanced analytics. These approaches should be fully utilized in order to enable Industrial Revolution 4.0 to be adapted more easily.

References

1. I.Bychkov, G. Oparin, A. Tchernykh, A. Feoktistov, V. Bogdanova, Yu Dyadkin, V. Andrukhova, and O. Basharina, “Simulation modeling in heterogeneous distributed computing environments to support decisions making in warehouse logistics.” *Procedia Engineering* 201, pp. 524–533, 2017.
2. I. Sulírová, Ľ. Závodská, M. Rakyta, V. Pelantová, “State-of-the-art approaches to material transportation, handling and

warehousing," *Procedia Engineering*, vol. 192, pp. 857 – 862, 2017

3. M.H.F.B.M. Fauadi, S.H. Yahaya, T. Murata, "Intelligent combinatorial auctions of decentralized task assignment for AGV with multiple loading capacity," IEEJ Transactions on electrical and electronic Engineering, vol. 8 no. 4, pp.371-379, 2013.
4. R. De Koster, T. Le-Duc, and K.J. Roodbergen, "Design and control of warehouse order picking: A literature review," *European journal of operational research*, vol. 182 no. 2, pp.481-501, 2007.
5. E. H. Grosse, C. H. Glock, M. Y. Jaber & W. P. Neumann, "Incorporating human factors in order picking planning models: framework and research opportunities," *International Journal of Production Research*, vol. 53, no. 3, pp. 695-717, 2015.
6. J.A. Tompkins, J.A. White, Y.A. Bozer, E.H. Frazelle, and J.M.A. Tanchoco, Facilities Planning, NJ: John Wiley & Sons, 2003.
7. S. Bandyopadhyay (ed.): Intelligent Vehicles and Materials Transportation in the Manufacturing Sector: Emerging Research and Opportunities: Emerging Research and Opportunities, IGI Global, 2017.
8. D. Culler and J. Long, "A Prototype Smart Materials Warehouse Application Implemented using Custom Mobile Robots and Open Source Vision Technology Developed using EmguCV," Procedia Manufacturing. vol. 5, pp. 1092–1106, 2016.
9. M. Shneier, R. Bostelman: Literature Review of Mobile Robots for Manufacturing, National Institute of Standards and Technology, US Department of Commerce, 2015.
10. M.H.F.B.M. Fauadi, W.L. Li, and T. Murata, "Combinatorial auction method for decentralized task assignment of multiple-loading capacity AGV based on intelligent agent architecture," In Innovations in Bio-inspired Computing and Applications (IBICA), IEEE 2011 Second International Conference on, 2011, pp. 207-211.
11. L.F.V. Leite, R.M.A. Esposito, A.P. Vieira, F. Lima, "Simulation of a production line with automated guided vehicles: A Case Study," *Independent journal of management & production*, vol. 6 no. 2, pp. 269-285, 2015.
12. A. Negahban, J.S. Smith, "Simulation for manufacturing system design and operation: Literature review and analysis," *Journal of Manufacturing Systems*, vol. 33, no. 2, pp. 241-261, 2014.
13. Y.D. Zhan, Y.G. Guo, J.G. Zhu, "Intelligent coordination steering control of automated guided vehicle," In Applied Superconductivity and Electromagnetic Devices (ASEMD), 2011 IEEE International Conference on, 2011, pp. 204-207.
14. V. Vavrik, M. Gregor, P. Grznar, "Computer simulation as a tool for the optimization of logistics using automated guided vehicles," Procedia engineering, vol. 192, pp.923-928, 2017
15. M.H.F. bin Md Fauadi, H. Lin, T. Murata, "Dynamic task assignment of autonomous AGV system based on multi agent architecture," In Progress in Informatics and Computing (PIC), 2010 IEEE International Conference on, vol. 2, 2010, pp. 1151-1156.
16. M.H.F. bin Md Fauadi, H.W. Lin, and T. Murata, "Dynamic Task Assignment of Autonomous Distributed AGV in an Intelligent FMS Environment," IEEJ Transactions on Electronics, *Information and Systems*, vol. 132 no. 5, pp.697-705, 2012
17. P. Sharma, A. Jain, "Stochastic Dynamic Job Shop Scheduling with Sequence Dependent Setup Times: Simulation Experimentation. *Journal of Engineering and Technology*", vol. 5, pp. 19-25, 2017.
18. R. Pisuchpen, "A simulation of AGV dispatching rules for supplying parts to assembly lines," *International Journal of Modelling in Operations Management* vol. 2, no. 1, pp. 1-25, 2012
19. K. Vivaldini, L.F. Rocha, N.J. Martarelli, M. Becker, A.P. Moreira, "Integrated tasks assignment and routing for the estimation of the optimal number of AGVS," *The International Journal of Advanced Manufacturing Technology,* vol. 82 no. 1-4, pp. 719-736, 2016.
20. I.F.A.Vis, "Survey of research in the design and control of automated guided vehicle systems," *European Journal of Operational Research*, vol. 170, no. 3, pp. 677-709, 2006.
21. J.W. Hauge, K.N. Paige: Learning SIMUL8:

The Complete Guide, Second Edition, Plain Vu Publishers, 2004.

22. T.L. Garwood, B.R. Hughes, M.R. Oates, D. O'Connor, R. Hughes, "A review of energy simulation tools for the manufacturing sector," *Renewable and Sustainable Energy Reviews*, vol. 81, pp.895-911, 2018.
23. O. Omogbai, K. Salonitis,. "Manufacturing system lean improvement design using discrete event simulation," Procedia CIRP, vol. 57, pp.195-200, 2016.
24. M. Badr, M.M.A. Sayed, A.E.R. Aref, and A. Salah, "New Model for Material Transportation to Improve Efficiency of Production Line," *International Journal of Science and Qualitative Analysis*, vol. 4 no. 2, pp. 60-64, 2018.
25. D. Benson, "Simulation modeling and optimization using ProModel," In Proceedings of the 29th conference on Winter simulation - IEEE Computer Society, 1997, pp. 587-593.
26. M. Kljajic, I. Bernik, A. Skraba, "Simulation approach to decision assessment in enterprises," Simulation, vol. 75 no. 4, pp.199-210, 2000.
27. A. Borshchev: The Big Book of Simulation Modeling: Multimethod Modeling with Anylogic 6, AnyLogic North America, 2013.
28. A.B. Nikolaev, V.S. Starikov, G.G. Yagudaev, "Analytical And Simulation Planning Model Of Urban Passenger Transport," *International Journal of Advanced Studies*, vol. 7 no. 1, pp. 65-77, 2017.
29. M.Topolski "Application of a telematics system to the improvement of transport processes in intelligent high bay warehouses," Archives of Transport System Telematics, vol. 9, no. 2, pp. 52-56, 2016.
30. FlexSim Software Products, Inc. FlexSim 3d Simulation Software- User Manual FlexSim 2017 Update 1. 2017.
31. B.S. Kumar, V. Mahesh, B.S. Kumar, "Modeling and analysis of flexible manufacturing system with FlexSim," *International Journal of Computational Engineering Research*, vol. 5 no. 10, pp. 1-6, 2015.
32. Y.R. Wang, A.N. Chen, "Production logistics simulation and optimization of industrial enterprise based on Flexsim," *International Journal of Simulation Modelling*, vol. 15 no. 4, pp.732-741, 2016.
33. F. De Felice, A. Petrillo, F. Zomparelli, "Prospective design of smart manufacturing: An Italian pilot case study," Manufacturing Letters, vol. 15, pp.81-85, 2018.
34. J. Garrido, "Introduction to Arena," In: Object Oriented Simulation, Springer, Boston, MA, 2009, pp. 19-29.
35. Rockwell Software Inc. Arena User's Guide (Doc ID ARENA-UM001A-EN-P). Rockwell Software Inc. 2004
36. S.B. Emami, S.M. Arabzad, S.M. Sajjadi, "A simulation study on warehouse loading system: the case of poultry feed production factory," *International Journal of Logistics Systems and Management*, vol. 19 no. 3, pp.347-355, 2014.
37. R. Peixoto, L. Dias, M.S. Carvalho, G. Pereira, C.A. Geraldes, "An automated warehouse design validation using discrete simulation," In Intelligent Transportation Systems (ITSC), 2016 IEEE 19th International Conference on, 2016, pp. 199-204.
38. R. Al Aomar, E.J. Williams, O.M. Ülgen: Process Simulation Using WITNESS, John Wiley & Sons, Inc. 2015
39. E.M. Abogrean, M. Latif, "Effective maintenance enabled by the use of witness simulation in a Libyan cement factory," *International Journal of Advances in Management and Economics*, vol.1 no. 5, pp. 138-147, 2018.
40. J. Dobránsky, P. Baron, E. Vojnová, D. Manduľák, "Optimization of the production and logistics processes based on computer simulation tools," Key Engineering Materials, vol. 669, pp. 532-540, 2016.