ISSN: 2582-4686 SJIF 2021-3.261,SJIF 2022-2.889
ResearchBib Impact Factor: 8.848 / 2023

THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY

VOLUME-3, ISSUE-3

Using Mecanum Wheels for Radio Shuttle

Nevliudov Igor, Maksymova Svitlana, Yevsieiev Vladyslav, Klymenko Oleksandr

Department of Computer-Integrated Technologies, Automation and Robotics, Kharkiv National University of Radio Electronics, Ukraine

Abstract:

Automation of production is inextricably linked with automation of warehouse systems. This is especially clear when applying the Industry 4.0 concept, since we see a clear development of the Warehouse 4.0 concept. This paper examines in detail the existing designs of the Radio Shuttle, as well as their areas of application. However, there are many limitations associated with the design features of these devices. We consider the main limitation to be low flexibility, as well as the inability to move in different directions. To solve this problem, the authors propose to use Mecanum wheels, which eliminate the problem of the impossibility of moving in the desired, that is, optimal, direction.

Key words: Radio Shuttle, Omnidirectional wheel, Mecanum wheel, Cargo, Warehouse system, Warehouse 4.0

Introduction

In the Industry 4.0 concept, the Warehouse 4.0 approach is becoming increasingly important [1]-[7].

In the modern world, automatic loading and unloading systems increasingly ensure the operation of warehouse complexes [8]-[13]. Such systems are usually called Radio Shuttle. Radio Shuttle is an electrical module that transports pallets. It transports goods inside the racking system.

In this case, the operator's attention/time is practically not required; he can solve other problems. Several of these modules can be controlled using one remote control.

Currently, there are different types of such carriers for different pallets, including those that can transport two different types of pallets. Now the maximum load capacity is 1500 kg.

To work with such devices, you can use any model of stacker or loader.

The main element of the Radio shuttle system is a mobile automatic platform capable of moving pallets within a racking system in a remotely controlled manner.

We can highlight a group of benefits of using the Radio Shuttle [12], [14]. But we also see a set of disadvantages in existing constructions of Radio Shuttles. The main of them is the limited flexibility.

We propose to use omnidirectional wheels (mecanum wheels) in order to eliminate or decrease this constraint. And further in this work we will propose our solution to this problem.

Related works

First of all let us consider what is happening in modern storage systems and in what way their development moves.

In [15] authors note, that storage technology selection is a very important design decision that greatly affects the future performance of a warehouse. In future we plan to change the storage structure in order to use our decision proposed in this paper ore efficiently.

ISSN: 2582-4686 SJIF 2021-3.261,SJIF 2022-2.889
ResearchBib Impact Factor: 8.848 / 2023

Kansy Dawid devoted plenty of his works to problems connected with storage technology and especially to shuttle racks systems organization [12], [14], [16]. In [16] he pays particular attention to planning storage location.

Scientists in [17] also write about storage organization necessity. But they also highlight an important problem connected with the applied general classification of storage systems and materials handling machines, as well as the clarification of the connections between them.

Paper [18] is considering principles “First In, Last Out” - FILO and “First-In, First-Out” - FIFO in order to optimize storage structure.

But we don’t see a lot of publications that propose to optimize a shuttle moving. And we want to make Radio Shuttle more effective by using omnidirectional wheels.

Plenty of scientists propose to use such systems in different fields.

Authors [19] note that the ability to move in any direction without altering even a single wheel makes this type of wheel useful for driving, especially in a narrowed or confined space. And in storage we have the same confined space.

At the same time Cao G. and co-authors remark that mecanum-wheeled mobile robots are widely used because they can easily realize omnidirectional movement and have flexible movement characteristics [20].

Scientists in [21], [22] also write about the superior mobility and maneuverability to move toward any position and attain any orientation simultaneously. They claim that mecanum wheeled omnidirectional mobile robot is playing an increasingly important role in modern transport and industry due to its high flexibility and maneuverability.

Researchers also say about the advisability of using omnidirectional wheels in [23]. Here we can also talk about their use in various robotic systems [24]-[28].

So we see very specific problems associated with limiting the movements of the Radio Shuttle. On the other hand, we see that the use of Mecanum wheels can solve many of the listed problems. Thus, the limitations of existing solutions in the development of the Radio Shuttle will be discussed in detail, as well as the benefits that are planned to be obtained from the introduction of Mecanum wheels will be analyzed in detail.

Mecanum wheels as a way to improve Radio Shuttle

Storage methods are influenced by Radio Shuttle design features, such as:

- limited flexibility of Radio Shuttle design: The disadvantages of LIFO and FIFO methods reinforce the limited flexibility of Radio Shuttle design. For example, if the system is LIFO, it is more difficult to distribute new goods and rearrange the storage of old goods due to fixed rails and racks. Such restrictions can make it difficult to optimize warehouse space and manage the movement of goods;

- difficulties in managing access to goods: If the system uses the LIFO method and the latest goods are stored closer to the exit, this may create restrictions on access to old goods, especially if there is a need for manual access to them. Similarly, in the case of FIFO, it is more difficult to organize quick access to new goods, since old goods may take up more accessible space within the system;

- optimizing space usage: Disadvantages in storage methods can increase the challenges of optimizing space usage within Radio Shuttle structures. Difficulties in efficient space using

ISSN: 2582-4686 SJIF 2021-3.261,SJIF 2022-2.889
ResearchBib Impact Factor: 8.848 / 2023

may arise due to the system's inability to adapt to different sizes and goods characteristics that require storage using certain methods (LIFO or FIFO);

- difficulties in configuration changes: If LIFO and FIFO methods require changes in goods distribution, this may require major changes in the configuration of the Radio Shuttle system. This, in turn, can be a labor-intensive and costly process, which creates difficulties in System control [16].

Thus, the disadvantages of LIFO and FIFO storage methods may exacerbate limitations and weaknesses in Radio Shuttle design, creating additional challenges in optimizing and cotrolling warehouse operations. The optimal solution in this situation requires a careful analysis of warehouse requirements and selection of a storage method that best meets the characteristics of the goods and warehouse operations[17], [18]. The main types of Radio Shuttle that are used within Warehouse 4.0 are presented in Figure 1 [19].

The use of Mecanum wheels can significantly improve the efficiency and flexibility of these designs. Here are the conclusions that can be drawn to justify the improvement of these structures through the use of Mecanum wheels:

a) b) c) d)

a) Radio Shuttle; b) Multi-deck Shuttle carrier; c) Four-way Shuttle system; d) Shuttle Carrier

Figure 1: Main Radio Shuttle Types That Are Used within Warehouse 4.0.

- good flexibility and maneuverability, Mecanum wheels have the ability to move in any direction without the need to turn the entire structure. This adds high agility and flexibility when moving goods in tight spaces. This is a key advantage when working in warehouse environments;

- easy access to goods, thanks to the ability to move sideways and diagonally, Mecanum wheels provide easy access to goods located at various levels and angles, reducing the complexity of moving goods in systems with many levels and complex configurations;

- efficient space using, Mecanum wheels allow optimal space using in the warehouse, as they allow movement in different directions without the need to rebuild the entire system, which is especially useful in systems with limited space;

- simplified control, moving in any direction without turning, systems with Mecanum wheels can be controlled more efficiently and accurately. This allows you to avoid collisions and optimize the planning of goods movements;

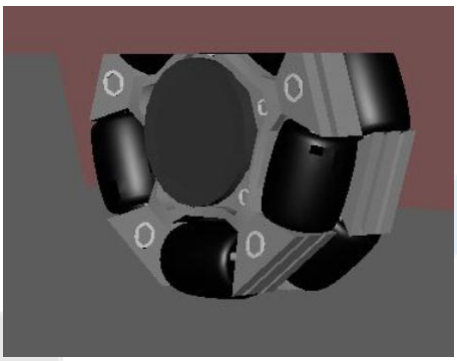
- easy implementation and integration, Mecanum wheels are easy to install and integrate, making it easy to upgrade existing designs without having to completely replace the system.

Thus, the use of Mecanum wheels improves the flexibility, maneuverability, accessibility and controllability of existing structures, making them more efficient and adaptable to different

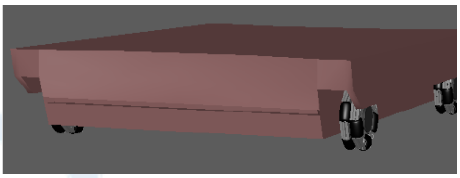
ISSN: 2582-4686 SJIF 2021-3.261,SJIF 2022-2.889
ResearchBib Impact Factor: 8.848 / 2023

working conditions in the warehouse. These advantages justify the decision to improve systems using Mecanum wheels .

Using 3D modeling, let us design a Radio Shuttle robotic platform with built-in Mecanum wheels; an example of implementation is shown in Figure 2.



a)



b)

a) Mecanum Wheels 3D Model;
b) Radio Shuttle Robotic Platform 3D Model General View

Figure 2: Mecanum Wheels 3D Model on 3D Radio Shuttle Robotic Platform

So, it is necessary to improve the supporting structure of the racks in order to realize the benefits of Mecanum wheels on the Radio Shuttle platform. Such researches are planned to be conducted in nearest future.

Conclusion

In proposed paper the authors present an innovative approach to improving the Radio Shuttle design using Mecanum wheels. This improvement significantly increases the system functionality and mobility, allowing the Radio Shuttle to move freely horizontally and vertically in any plane.

The integration of Mecanum wheels into the Radio Shuttle design has led to significant changes in the design of product storage racks. These changes created a more flexible and efficient storage system capable of moving in any direction and vertically, which was not previously possible with the Radio Shuttle system.

The findings highlight the significance of the proposed changes and their potential to optimize warehouse operations and improve overall performance in the logistics and storage of goods within Warehouse 4.0.

References:

1. Tubis, Agnieszka A., & Juni Rohman. (2023). Intelligent Warehouse in Industry 4.0–Systematic Literature Review. Sensors, 23(8), 4105.

2. Ahmad, M. A., & et al.. (2019). Computational complexity of the accessory function setting mechanism in fuzzy intellectual systems. International Journal of Advanced Trends in Computer Science and Engineering, 8(5), 2370-2377.

3. Albashir A. Youssef1 , Mohamed Atef El Khoreby1 , Hanady Hussein Issa1 , A. Abdellatif. (2022). Brief Survey on Industry 4.0 Warehouse Management Systems. International Review on Modelling and Simulations, 15(5).

ISSN: 2582-4686 SJIF 2021-3.261,SJIF 2022-2.889
ResearchBib Impact Factor: 8.848 / 2023

4. Tutam, M. (2022). Warehousing 4.0 in Logistics 4.0. In: İyigün, İ., Görçün, Ö.F. (eds) Logistics 4.0 and Future of Supply Chains. Accounting, Finance, Sustainability, Governance & Fraud: Theory and Application. Springer, Singapore.

5. Sotnik, S., & et al.. (2017). System model tooling for injection molding. International Journal of Mechanical Engineering and Technology, 8(9), 378-390.

6. Michal Zoubek, & Tomáš Broum. (2020). Methodology Proposal for Storage Rationalization by Implementing Principles of Industry 4.0. in a Technology-Driven Warehouse. Transactions of FAMENA, 44(4).

7. Igor Nevliudov, & et al. (2021). Evolutions of group management development of mobile robotic platforms in warehousing 4.0. Innovative Technologies and Scientific Solutions for Industries, 4 (18), 57–64.

8. Attar, H., & et al.. (2022). Control System Development and Implementation of a CNC Laser Engraver for Environmental Use with Remote Imaging. Computational Intelligence and Neuroscience, 2022.

9. Igor Nevliudov, & et al. (2022). Analysis of Software Products for Simulation Modeling of the Operation of the System of Shuttles for Warehousing. Manufacturing & Mechatronic Systems 2022: Proceedings of VIst International Conference, Kharkiv, October 20-21, 2022, P. 24-26

10. Abu-Jassar, A. T., & et al.. (2022). Electronic user authentication key for access to HMI/SCADA via unsecured internet networks. Computational Intelligence and Neuroscience, 2022.

11. Kansy Dawid, & et al. (2020) Optimization Model for Relocating Items in A Radio-Shuttle Compact Storage System, In: Education Excellence and Innovation Management: A 2025 Vision to Sustain Economic Development during Global Challenges / International Business Information Management Association (IBIMA), 2883-2892

12. Nevliudov, I., & et al.. (2020). Development of a cyber design modeling declarative Language for cyber physical production systems. J. Math. Comput. Sci., 11(1), 520-542.

13. Igor Nevliudov, & et al. (2021). Evolutions of Group Management Development of Mobile Robotic Platforms In Warehousing 4.0. Innovative Technologies and Scientific Solutions for Industries, 4(18), 57-64.

14. Kansy Dawid (2020) Pick up plan in the case of a shuttle racks warehouse–an optimization approach. Informatyka Ekonomiczna. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 1(55).

15. Nikola Pavlov, & et al. (2023). A Novel Two-Stage Methodological Approach for Storage Technology Selection: An Engineering–FAHP–WASPAS Approach. Sustainability, 15(17), 13037.

16. Kansy, Dawid. (2020). Pick up Plan in the Case of a Shuttle Racks Warehouse – an Optimization Approach. Informatyka Ekonomiczna. Prace Naukowe Uniwersytetu Ekonomicznego. We Wrocławiu, 38–59.

17. Николай Драгомиров, (2020) Фундаментални области на знанието при организацията на складовите площи. Knowledge: International Journal, 41.1.

18. Rodoljub Vujanac, & et al. (2021). Basis for the design of drive-in and drive-through racking, 81-87.

ISSN: 2582-4686 SJIF 2021-3.261,SJIF 2022-2.889
ResearchBib Impact Factor: 8.848 / 2023

19. ABD Mutalib, & et al. (2020) Prototype development of mecanum wheels mobile robot: A review. Applied Research and Smart Technology (ARSTech), 1.2, 71-82.

20. Cao, G., & et al. (2022) Fuzzy adaptive PID control method for multi-mecanum-wheeled mobile robot. J Mech Sci Technol 36, 2019-2029.

21. Zhe Sun, & et al. (2021), Path-following control of Mecanum-wheels omnidirectional mobile robots using nonsingular terminal sliding mode, Mechanical Systems and Signal Processing, 147.

22. Zhe Sun, & et al. (2021) Trajectory-tracking control of Mecanum-wheeled omnidirectional mobile robots using adaptive integral terminal sliding mode, Computers & Electrical Engineering, 96(A).

23. Hasana, Sameh F., & Alwan, Hassan M. (2021). Modeling and Control of Wheeled Mobile Robot With Four Mecanum Wheels. Eng. Technol. J., 39, 779-789.

24. Baker, J. H., & et al.. (2021). Some interesting features of semantic model in Robotic Science. SSRG International Journal of Engineering Trends and Technology, 69(7), 38-44.

25. Abu-Jassar, A. T., & et al.. (2021). Some Features of Classifiers Implementation for Object Recognition in Specialized Computer systems. TEM Journal: Technology, Education, Management, Informatics, 10(4), 1645-1654.

26. Nevliudov, I., & et al.. (2020). Method of Algorithms for Cyber-Physical Production Systems Functioning Synthesis. International Journal of Emerging Trends in Engineering Research, 8(10), 7465-7473.

27. Al-Sharo, Y. M., & et al.. (2021). Neural Networks As A Tool For Pattern Recognition of Fasteners. International Journal of Engineering Trends and Technology, 69(10), 151-160.

28. Sotnik, S., & et al.. (2020). Some features of route planning as the basis in a mobile robot. International Journal of Emerging Trends in Engineering Research, 8(5), 2074-2079.