Research on the Use of UVA and Pix4D RTK Technology for Logistics Park Planning and Warehouse Management

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Abstract. The integration of UVA and Pix4D RTK technology with high-precision GPS positioning in logistics park planning and warehouse management has significantly propelled the process of layout optimization. By utilizing drones equipped with RTK devices, this technology enables centimeter-level precise data collection, followed by 3D reconstruction on the Pix4D software platform to generate detailed digital models of warehouses. These models serve as the foundation for analyzing existing layouts and designing improvements. Through the simulation of different shelf configurations, aisle layouts, and other strategies, managers can estimate the impact of various scenarios on inventory capacity and picking efficiency without making physical changes. The integration of AI and big data analysis into this process further guides decision-making, such as dynamically adjusting storage areas based on commodity flow data or optimizing picking routes using intelligent algorithms. After implementing optimizations, continuous RTK monitoring ensures the effective execution of the layout and timely adjustments to adapt to operational changes. In summary, Pix4D RTK technology provides a comprehensive optimization solution for warehouses, from current status assessment to implementation and post-maintenance, making it an essential tool for achieving intelligent and efficient warehouse management.

Keywords: UVA,Pix4D RTK, Warehouse Layout, 3D Modeling

1 Introduction

1.1 Research Background

With the rapid development of the global logistics industry, the planning of logistics parks and warehouse management have become increasingly significant. Planning and layout optimization are among the crucial factors to improve warehouse efficiency and reduce costs. Traditional park planning and warehouse layout optimization often rely on manual measurement and analysis, which suffers from issues such as low efficiency, high cost, and insufficient precision. However, with the advancement

C. W. K. Chen et al. (eds.), *Proceedings of the 9th International Conference on Engineering Management and the 2nd Forum on Modern Logistics and Supply Chain Management (ICEM-MLSCM 2024)*,
Advances in Engineering Research 243,
https://doi.org/10.2991/978-94-6463-531-7_27

of drone technology, UVA and Pix4D RTK technology, as a high-precision drone aerial survey technology, has provided new possibilities for layout optimization.

1.2 Research Status

Currently, the study [1]-[6] on the planning of logistics parks and warehouse layout optimization primarily rely on traditional measurement and analysis methods, which have problems like low measurement accuracy, slow data acquisition speed, and high costs. Pix4D RTK technology, as a high-precision, rapid data acquisition drone aerial survey technology, can effectively address the issues of traditional methods. Through it, 3D modeling of the interior space of warehouses can be achieved, accurately obtaining spatial information within the warehouse, providing precise data support for layout optimization.

1.3 Research Purpose and Significance

By utilizing drone aerial survey technology to obtain high-precision data of the interior space of warehouses and combining it with layout optimization algorithms, the rational planning and layout of the interior space of warehouses can be achieved. The significance of this research lies in improving the efficiency and precision of warehouse management, reducing the cost of layout optimization, and providing new technological support for the development of the warehouse industry.

2 Application of UVA and Pix4D RTK Technology in Warehouse Layout Optimization

2.1 Principles of Pix4D RTK Technology

Pix4D RTK technology is a real-time positioning technology that combines data from the Global Navigation Satellite System (GNSS) and Inertial Navigation System (INS) to provide high-precision positional information. Its principle is based on the GNSS receiver receiving signals from satellites and achieving centimeter-level positioning accuracy through real-time corrections with phase differencing from a base station. At the same time, Pix4D RTK technology utilizes the inertial navigation system to improve the stability and accuracy of positioning.

2.2 Characteristics of UVA and Pix4D RTK Technology

Pix4D RTK technology possesses the following characteristics:

High Precision. It can achieve centimeter-level positioning accuracy, suitable for scenarios requiring precise positioning.

Real-time Capability. It can provide real-time positioning information, supporting positioning and navigation in dynamic environments.

Stability. Combined with the inertial navigation system, it can improve positioning stability and reduce errors and drift.

Ease of Integration. It can be integrated with drones, vehicles, and other carriers to achieve automated positioning and navigation functions.

2.3 Application Cases of Pix4D RTK Technology in Other Fields

Pix4D RTK technology has extensive applications in other fields, such as:

Agriculture. Used in precision agriculture to achieve precise management of crop growth monitoring, fertilization, and irrigation.

Construction. Used in building surveying and construction monitoring to improve construction efficiency and quality.

Geological Exploration. Used in geological exploration and resource exploration to achieve high-precision collection and analysis of geological information.

In warehouse layout optimization, Pix4D RTK technology can be combined with indoor positioning technology to achieve precise positioning and tracking of goods, equipment, and personnel within the warehouse. By monitoring and analyzing the operation of the warehouse in real-time, the warehouse layout can be optimized, improving cargo storage and management efficiency, reducing labor costs and error rates, and ultimately achieving intelligent and automated warehouse management. The high-precision positioning and real-time performance of Pix4D RTK technology provide powerful technical support for warehouse layout optimization.

From the comparison in the table 1, it is evident that in addition to the aforementioned advantages such as High Precision, Real-time Capability, Stability Ease of Integration, the advantages of UVA combined with PIX4d are very obvious compared to traditional modeling and simulation methods.

Table 1. Comparison on Three layout optimization methods

Method	Advantage	Disadvantage
Manual on Ground	Low cost of investment Autonomous and flexible Troubleshoot in real time	Low efficiency and accuracy Low response Highly influenced by ground traffic conditions
Helicopter	High efficiency High load of equipment High mobility	High cost High space restrictions Low flexible
UVA	Low cost Autonomous and flexible High efficiency High mobility Low restriction	Short range Low load

3 Application of Pix4D RTK technology in warehouse layout optimization

3.1 Three-Dimensional Modeling and Analysis of Warehouse Space

Pix4D RTK technology first shoots the internal and external environment of the warehouse through the high-resolution camera mounted on the UAV, and uses the centimeter-level positioning accuracy provided by RTK to ensure that the collected data has extremely high spatial accuracy. This image data is then fed into Pix4D software, which is automatically processed to quickly generate a high-precision 3D model[1] (figure 1) of the warehouse. This process can not only truly restore the spatial structure of the warehouse, including key areas such as shelves, channels, loading and unloading areas, but also record important information such as storage capacity and height limits in detail. Detailed methodology and more details on the specific processes and algorithms used for 3D reconstruction and simulation could be drawn from the documentation[2] of the Pix4D software. Due to space limitations, a detailed list is not provided here.

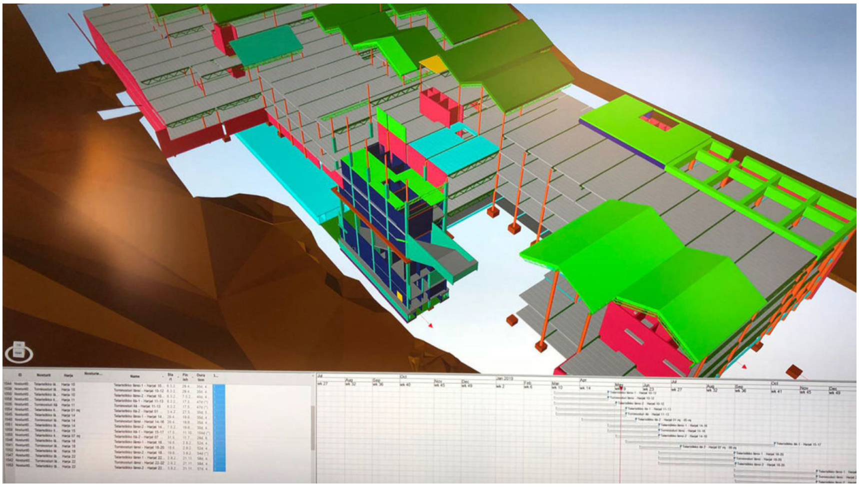

Fig. 1. Synchro PRO is seamlessly integrated with Pix4D software

3.2 Real-Time Tracking and Management of Warehouse Assets

After the 3D modeling is completed, managers can intuitively analyze the efficiency and bottlenecks of the existing layout of the warehouse. For example, by simulating different cargo sizes and storage needs, the rationality of shelf layout is assessed, or the spatial analysis function is used to identify underutilized areas and provide data support for subsequent layout optimization. In addition, light analysis and ventilation

[1]Figure1url :https://images.ctfassets.net/go54bjdzbrgi/3Gv6WsDDKU4msKmy26qcIQ/52bca3d748ed1276acc287915de74897/4D-scheduling-software_and_Pix4D.jpg?w=1200&q=80

[2] https://support.pix4d.com/hc

simulation can also help improve the working environment, improve job safety and employee comfort. Combined with historical data analysis[3] (Figure 2), it can also predict inventory demand, optimize inventory turnover, reduce the space occupied by redundant inventory, and further improve the efficiency of warehouse operations.

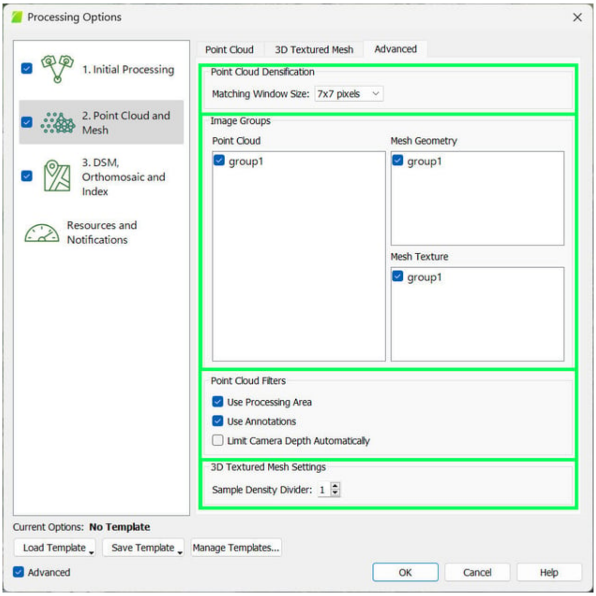

Fig. 2. Change the advanced processing options for the Point Cloud and the 3D Textured Mesh

3.3 Strategies and Methods for Warehouse Layout Optimization

Based on the accurate 3D model and real-time asset tracking data provided by Pix4D RTK technology, warehouse layout optimization can adopt the following strategies and methods:

Flexible shelf layout adjustment : The use of models to analyze shelf utilization, the implementation of dynamic shelf adjustment strategies, such as adjusting shelf height or position according to seasonal commodity changes, the introduction of automated three-dimensional warehouse systems to adapt to changes in storage needs in different time periods.

Optimization of picking path: Through the simulation and analysis of the flow of people and things in the warehouse, the shortest picking path is designed to reduce invalid movement and improve picking efficiency. Combined with intelligent guidance system, guide staff to efficiently complete the task of picking.

[3] Figure 2 url:https://support.pix4d.com/hs-fs/hubfs/Knowledge%20Base%20Import/18226746716445.jpeg?width=630&height=630&name=18226746716445.jpeg

Safety and Emergency evacuation planning: Simulate evacuation paths in emergency situations in a 3D model to ensure compliance with fire safety regulations, while optimizing the layout of emergency exits and firefighting facilities to improve the overall safety of the warehouse.

Environment and Energy consumption optimization : Analyze the lighting and ventilation conditions of the warehouse, rationally arrange the lighting and air conditioning system, adopt the green building design concept, reduce energy consumption and reduce operating costs.

4 Case Study

4.1 Research Object and Scene Description

The object of this case study is a large logistics distribution center located in South East China, with a total area of about 50,000 square meters, which is responsible for handling tens of thousands of orders per day. With the rapid growth of business volume, the original warehouse layout has been unable to meet the needs of efficient operation, which is manifested by lengthy picking path, low utilization rate of storage space, slow turnover of goods and other problems. Faced with these challenges, the center decided to introduce UAV and Pix4D RTK technology[4] (Figure 3) to optimize the warehouse layout to improve overall operational efficiency.

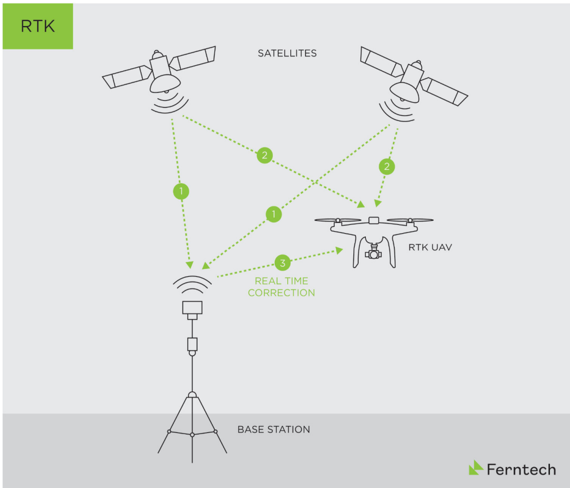

Fig. 3. A concept image to show how UVA and RTK work

4 Figure 3 url:https://images.squarespace-cdn.com/content/v1/5c5ba49a809d8e017ad51605/1589431182871-MM94ZO1GILUCP5V0VNE0/RTK+diagram+squarespace.jpg

4.2 Application Effect Analysis and Evaluation

Implementation effect. After the implementation of the new layout scheme, the overall storage capacity of the warehouse has been increased by about ***15%.*** , effectively alleviating the problem of storage shortage. Picking efficiency has increased by **20%**, mainly due to shorter travel distances and better picking sequence. In addition, through the rational planning of emergency access and fire protection facilities, safety compliance has been significantly improved.

Economic benefit assessment. Through financial data analysis, the warehouse layout optimization project driven by Pix4D RTK technology was implemented, with excellent performance in terms of input cost recovery cycle. Although the initial hardware acquisition, software licensing and consulting services incurred some expenses, labor cost savings due to improved operational efficiency and increased liquidity due to faster inventory turnover enabled the project to achieve positive returns in less than a year.

5 Conclusion

This study explores the application of UAV and Pix4D RTK technology in warehouse layout optimization, and proves that the technology can significantly improve the space utilization, work efficiency and security of the warehouse.

This study not only enriches the theoretical system in the field of warehousing and logistics, especially in the aspects of spatial optimization and management decision support, but also has direct guiding significance for practice.

However, due to time and space constraints, this study only points out the direction and conceptual verification in terms of quantification and case analysis, and there are opportunities to carry out further and more in-depth research in the future.

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