[White Paper] From Manual Handling to Intelligent Handling: Pallet Recognition Technology Leads to Efficient Logistics

With the rapid advancement of Industry 4.0 and intelligent manufacturing, automated warehousing has become a key method for enterprises to improve efficiency and reduce costs.

Automation technology not only solves the traditional warehousing management problem of low labor efficiency but also significantly improves operational safety, especially in the face of high-intensity, repetitive tasks that show significant advantages.

According to Deloitte's *China Intelligent Logistics Development Report*, the intelligent logistics market is growing rapidly, and the market size is expected to exceed one trillion yuan by 2025. The rapid expansion of this market demonstrates the increasing demand for automation technology, especially in warehousing and logistics, where more and more companies are introducing unmanned forklifts with a variety of autonomous mobile robots to achieve round-the-clock, efficient, and accurate handling operations.

Autonomous Mobile Robots (AMRs), as the core equipment of automated warehousing, not only reduce manual intervention and labor costs but also significantly reduce safety accidents caused by human operation. According to the data given by the UK Health and Safety Executive**,** there were 25 fatal accidents caused by mobile device collisions in the United Kingdom in

2023/24 1. By introducing **autonomous mobile robots**, companies can significantly reduce the risk of such accidents and further ensure the safety of employees.

Automation innovations at Amazon and JD.com

Amazon's presence in logistics automation is massive, especially in the areas of autonomous mobile robots (AMRs). Since acquiring Kiva Systems in 2012, Amazon has deployed more than 750,000 robots across multiple warehousing centers worldwide [2]. These robots have significantly improved warehousing and distribution efficiencies by automating the handling of goods while reducing the burden of repetitive tasks on workers.

Amazon has been pushing warehouse automation since it acquired Kiva Systems in 2012. In 2022, Amazon unveiled its first fully autonomous mobile robot, Proteus, capable of moving freely through crowds, reducing employee workload and walking distances. Additionally, Amazon's Cardinal and Sparrow robots use computer vision and machine learning technology to automatically identify, pick, and sort orders, further improving warehouse efficiency. These robots mark another major advancement in Amazon's warehouse automation.

JD.com is also deploying AGV in large numbers in China. It realizes unmanned sorting and warehousing automation operations, significantly improving logistics efficiency and accuracy. The application of these technologies not only reduces human error but also sets a benchmark for the entire industry. This large-scale deployment of robots demonstrates the logistics industry's future trend toward unmanned and intelligent operations, inspiring many small and medium-sized enterprises.

The Importance of Unmanned Forklift Pallet Recognition

As more and more companies follow the example of industry giants, the application of automation equipment expands from sorting to handling. Unmanned forklifts, as an important piece of equipment in warehouse automation, bear the burden of pallet handling. However, there is often uncertainty in the position and angle of pallets in warehousing, a problem that stems from human intervention or pallet placement errors, which poses a serious challenge to the navigation accuracy of unmanned forklifts. In this context, accurate pallet visual recognition technology becomes the core to guarantee the efficient and accurate operation of unmanned forklifts.

Automated pallet recognition technology utilizes advanced vision sensors and image processing technology, which can provide the precise position and attitude information of the pallet in real-time, significantly improving the navigation and handling efficiency of unmanned forklifts. By applying this technology, the unmanned forklift is able to overcome the problems of unstable pallet position and irregular angle, ensuring that accurate docking can still be achieved in complex environments, and promoting the development of warehouse management towards intelligence and efficiency.

Challenges and Solutions for Pallet Recognition

In practice, unmanned forklifts face a variety of challenges when handling pallets, notably complex storage environments, uneven lighting and deviations in pallet placement. Traditional 2D or barcode technology relies on clear labels and regular placement angles, which are effective in structured environments but prone to failure in complex environments, affecting the ability of the forklift to handle pallets.

In contrast, **3D ToF (time-of-flight)** camera-based pallet recognition technology demonstrates higher robustness and better adaptability in coping with complex pallet shapes and environmental changes.

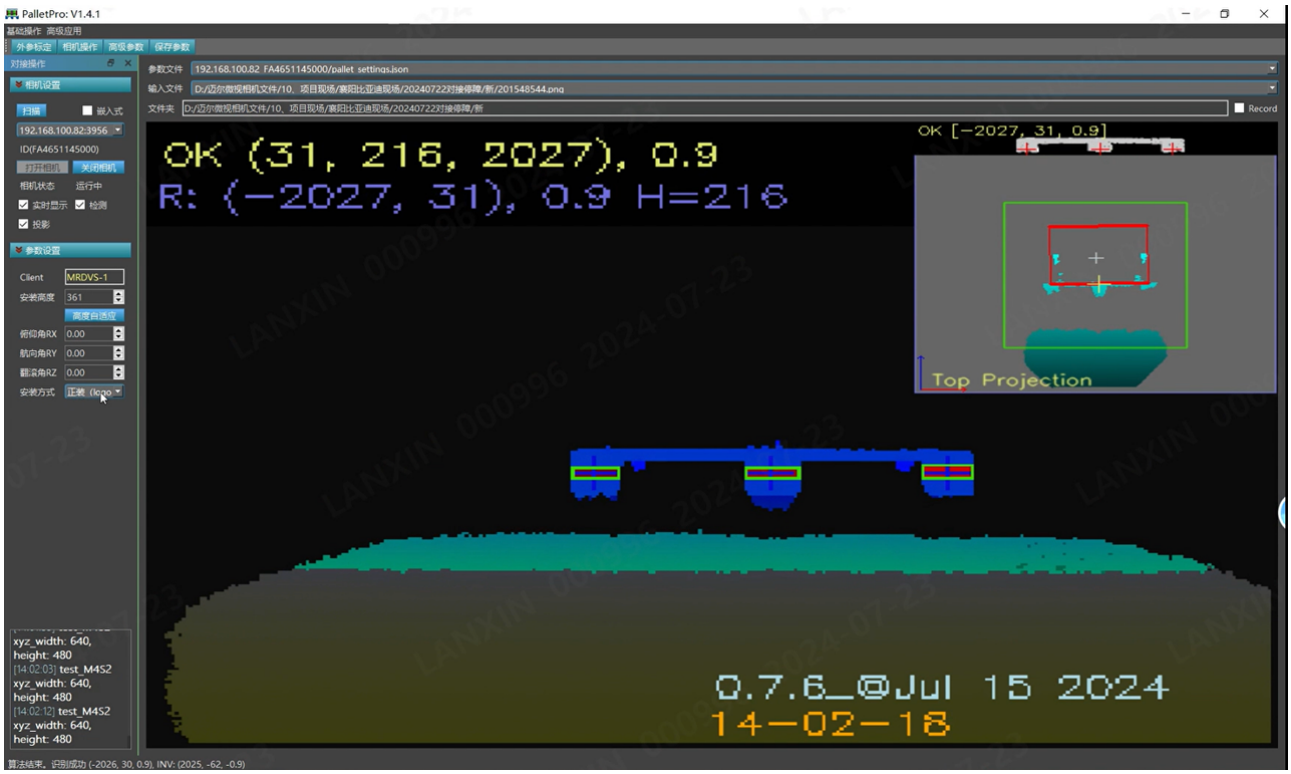
Although 2D LiDAR is also used for pallet recognition, it usually requires drawing templates for different types of pallets, and the system is less compatible, making it difficult to flexibly respond to pallets of different shapes. In addition, LiDAR is more sensitive to the complex structure of the bottom of the pallet, and it is easy to misjudge the pallet leg as an obstacle, which affects the docking of the unmanned forklift with the pallet

MRDVS Pallet Recognition System PalletPro: Breaking Pallet Recognition Automation Challenge

Based on 3D ToF (Time of Flight) vision technology, MRDVS's PalletPro pallet recognition system is designed to address the need for pallet recognition in complex warehouse environments. The system combines 3D cameras with intelligent algorithms, which not only accurately recognize

the position and orientation of pallets, but also have excellent environmental adaptability to ensure that unmanned forklifts can efficiently realize automated handling under complex conditions.

- **Integration and efficiency improvement**
  By integrating the recognition algorithms inside the camera, the PalletPro system is able to process depth data in real-time, dramatically improving computational efficiency and responsiveness. The system can provide real-time pallet recognition results at a processing speed of **10 frames per second (10FPS)**, ensuring that unmanned forklifts are able to perform pallet handling operations quickly and accurately.
- **Deployment and intelligent docking**
  Deploying the 3D camera between the two arms of the forklift, the PalletPro system utilizes auto-calibration technology to identify the position of the pallet in relation to the coordinates of the forklift shop, enabling fast and intelligent docking operations. The algorithm recognizes the leg and crossbar structure of the pallet based on point cloud features in deep data, supporting standard two-legged and four-legged pallets, and multi-pallet stacks, as well as customizable solutions for legless or specially shaped pallets. The PalletPro system does not need to collect additional data for model training, and it can be adapted to **more than 90% of the pallet types** available on the market
- **Ease of use and compatibility**
  PalletPro is easy to deploy and users can quickly get started with an introductory tutorial without algorithm development experience. The system is compatible with European standard pallets, suitable for high-level storage, complex stacking, and other scenarios, provides real-time pallet recognition results, and can operate stably in a variety of storage environments, ensuring that unmanned forklifts operate efficiently under diverse pallet conditions.



PalletPro系统界面

- **Multi-condition adaptability and robustness**

  For outdoor scenes with strong illumination, MRDVS's pallet recognition solution adopts the ToF depth camera M series equipped with 940nm infrared emitters to effectively cope with complex lighting conditions. 940nm wavelength belongs to near-infrared light, which is more resistant to interference in strong light environments and is not easily affected by visible light, thus ensuring the stability and accuracy of the depth data.

  Go to YouTube to watch the outdoor scene test of the MRDVS tray recognition

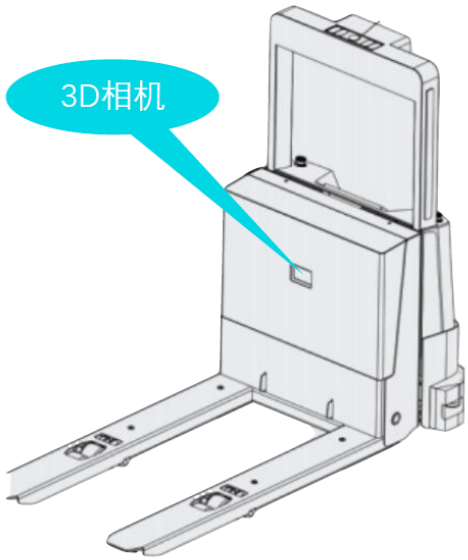
  For black pallets with low reflectivity, the M-Series depth camera provides accurate depth data up to 2.5 meters from the pallet, ensuring system robustness and compatibility.

  Go to YouTube to watch the MRDVS black tray recognition test

Recognition and Docking

The MRDVS M-Series camera is installed between the two fork arms of a forklift, capturing the depth information of the pallet and utilizing depth recognition algorithms to achieve accurate identification of the pallet.

When the forklift receives a task from the dispatch system, it will move to the docking point in front of the pallet, about 2 meters away from the front edge of the pallet. At this position, the forklift is initially located and the 3D vision system outputs positional information to help the forklift adjust for angular deviations. Then, the forklift continues to move forward to a position of 1.5 meters for precise positioning, and the 3D vision system again outputs the pallet position information to help the forklift adjust the left and right deviations to ensure the accuracy of the docking process.



The solution supports two docking modes: **Two-time Docking Mode** and **Real-time Docking Mode** to meet the needs of different application scenarios.

1. **Two-time Docking Mode**
   The two-time docking mode is divided into three steps: distal localization, proximal calibration and blind walk fork fetch:
   - **Distal localization:** After receiving the dispatch task, the forklift moves to the docking point and enables the camera to recognize the pallet point cloud data. Through the motion control system, the forklift adjusts the angular and horizontal offset within a range of 1800mm to 2800mm from the pallet.
   - **Proximal calibration:** When the fork tip is about 200mm away from the front edge of the pallet, the camera recognition data is acquired again to check whether the docking accuracy meets the fork-picking requirements. If accuracy meets the requirements, the forklift carries out the picking; if it does not meet the requirements, the forklift carries out the picking operation again after adjusting in situ.

2. **Real-time Docking Mode**
   The real-time docking mode is realized by continuously acquiring the camera recognition data and dynamically adjusting the position. When the forklift moves to approximately 200mm from the pallet's front edge, the system makes fine adjustments and completes the fork pick operation. This mode relies on the time stamp of the data to update to avoid incorrect adjustments due to delays.

Communication method

To provide users with a more easily integrated product, the solution supports interfaces such as TCP, UDP, CAN, 485, API, etc., and can be switched between recognition algorithms and obstacle avoidance algorithms to achieve efficient, accurate, and versatile automation of pallet recognition.

Case sharing

Case 1: Fiber optic communication enterprise unmanned stacker tray and cable tray hole identification project

Customer background
FiberHome Communication Technology Joint Stock Company (FiberHome Technology) is a leading global fiber optic communication enterprise, actively promoting industrial automation and intelligent manufacturing. In Wuhan, FiberHome Technology has deployed a digital intelligent factory, using unmanned stacker trucks to undertake the main logistics tasks. This project focuses on the accurate identification and handling of pallet and cable tray holes in its intelligent factory using unmanned stacker trucks.

Solution

1. **Pallet recognition real-time docking**
   By installing the MRDVS PalletPro tray recognition system, real-time capture of tray depth and position information is achieved. Combined with the intelligent control system, the stacking height and parking posture are dynamically adjusted. When about 200mm in front of the tray, the system is fine-tuned to ensure accurate docking, greatly improving accuracy and reducing errors.

2. **Identification of cable reel hole position**
   Unmanned stacking vehicles accurately identify the cable reel hole position through 3D vision technology, and adjust the vehicle position in real-time to ensure the docking process is correct, significantly improving handling efficiency.

Project Effectiveness

This solution significantly improves the automation level of factory logistics through real-time visual recognition technology, further demonstrating the technical strength of Fiberhome Technology in industrial automation.

Case 2: Non-standard pallet identification project in the glass fiber industry

Customer background

China Jushi Group is a leader in the global fiberglass industry, committed to promoting intelligent manufacturing. Its Tongxiang base aims to achieve intelligent handling of the entire production process by introducing unmanned forklifts.

Business needs and project challenges

The internal logistics of Jushi Group uses various customized metal pallets with different shapes, which brings challenges to the automation system for pallet recognition and handling. Conventional laser and non-intelligent vision solutions make it difficult to cope with these irregular pallets, and the pallets often tilt, increasing the difficulty of precise forklift picking by unmanned forklifts.

Solution

Lanxin Technology has deployed an unmanned forklift solution for Jushi Group, equipped with the MRDVS PalletPro pallet recognition system, which obtains pallet depth data, performs real-time correction of pallet position and posture, and achieves efficient automatic handling.

Project Effectiveness

The solution successfully solved the problem of custom pallet recognition, significantly improved the logistics efficiency of Jushi Group's intelligent manufacturing base, helped the development of its fully automated production process, and reduced the error and cost of manual operation.

Cite sources

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MRDVS YouTube Channel:

https://www.youtube.com/@MRDVS-2024

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