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Design of Intelligent Weighing and Picking System based on Sensing Technology

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Abstract: In recent years, with the development of advanced technology, the replacement of labor by intelligent and automatic equipment has become the main direction of enterprise transformation. In this paper, according to the current epidemic situation, when weighing and packing fresh agricultural products, there are many problems to cope with, like order delay and the non-standard specification and quality, which lead to repeated manual weighing, low efficiency and huge order quantity. Based on the sensing technology, an intelligent weighing and sorting system is designed to solve the problem of terminal sorting. Moreover, by using facilities such as weight sorter and target counterweight machine, the quality of sorted objects can be graded according to specific conveying devices, thus improving the sorting accuracy of agricultural and sideline products, polishing up the end packing efficiency and saving economic costs.

Keywords: Intelligent Sorting; Weight Sensor; Quality Classification; Target Counterweight.

1. Introduction

1.1. Background

Combined with the rapid advancement of contemporary Internet technology, the preference of people's online shopping and consumption behavior in the new era has given rise to the booming development of the e-commerce industry. With the diversification of sales platform channels and the increase of sales opportunities under the epidemic, the sales volume of fresh agricultural products has increased dramatically. Based on factors such as fresh produce logistics sorting pressure, manual sorting cost and logistics sorting efficiency, intelligent and automated fresh produce logistics sorting system has become a new direction for the current fresh e-commerce logistics transformation and development. Therefore, the logistics order picking of fresh agricultural products should attract attention as one of the highest operating costs. In view of the high labor cost and low efficiency of manual sorting in the process of fresh produce sorting, an automated intelligent weighing and picking logistics system is of great practical significance in optimizing the picking operation of fresh produce, reducing sorting costs and improving logistics and transportation efficiency.

1.2. The Status of Logistics Sorting Development

Unpacking and picking is the most labor-intensive and most likely outbound bottleneck in the logistics warehouse operation chain, but with the support of IoT and information technology, the sorting chain also benefits from the evolution of the logistics industry. From the traditional manual production of paper sheets and label sorting in the past, to the emergence of RFID radio frequency automatic diagnosis technology, electronic label semi-automatic sorting technology, and then to the current domestic logistics enterprises to develop AGV automatic guidance transport trolley, automated multi-layer shuttle and sorting machine, logistics sorting technology under the support of the continuous progress of Internet technology is also continuing to strengthen innovation, continuous innovation to overcome technical problems to balance a good The relationship between the logistics costs of merchandising platforms, consumer satisfaction and the direction of industry development in the context of the epidemic's new retailing, to improve the efficiency of picking and packing.

1.3. Significance of the Study

(1) The scientific and effective system design has certain theoretical value. The practicality, relevance and accuracy of the weighing and sorting system, the precise and transparent management of the fresh agricultural products out of the warehouse and packing process which is difficult to control and supervise, the ability of data to be remotely controlled and collected, and the improvement of the timeliness of data sharing with other logistics links, have certain theoretical and practical significance for the development of the current retail and logistics industry.

(2) Multiple perspectives research, research angle novel. This study does not take a different approach to consider the problems of wasted space and low human efficiency in picking and packing from the direction of intelligent weighing. Instead of focusing on the standard weight of orders, the intelligent weighing tool is used to make the picking and packing process more flexible in situations where the pressure of picking increases due to the huge volume of orders.

(3) It is highly applicable and has certain significance and promotion value for other enterprises with similar picking dilemmas in logistics picking.

2. Question Analysis

For the characteristics and nature of fresh agricultural products, the warehouse distribution process is mainly composed of two major processes: receiving and packing. When the fresh produce is sold and discharged from the warehouse, the picker will encounter various problems in the picking operation of picking goods against the order details：

2.1. Low Manual Sorting Efficiency and Inflexible Order Sorting

While the fresh produce e-commerce platform welcomes huge development opportunities, it also faces various problems such as huge pressure on sorting and packaging of fresh produce due to the surge of orders, and low efficiency of end sorting and review operations. Due to the special nature of fresh agricultural products, the order volume is huge and there are many kinds of individual fresh agricultural products, and there is no standard classification level for the weight of various kinds of agricultural products, so it is impossible to standardize and measure whether the orders are qualified or not. At the same time, it is difficult to control and supervise the process of sorting and unpacking fresh products.

2.2. The Waste of Manual Sorting and Double Checking

In the past, manual handwritten labels for paper work were not only difficult to identify when sorting, but also caused a lot of difficulties in the manual sorting process, reducing the efficiency of sorting operations. At the same time, traditional manual sorting requires repeated checks of outgoing goods, which is to ensure the accuracy of packing out, but does double the unnecessary time and labor costs. This problem of manual double-checking with high repetition rate will increase the labor cost of logistics warehouses substantially and restrict the long-term sustainable development of logistics sorting in the future.

3. Intelligent Weighing-based Logistics Sorting System

3.1. Weighing Sensor

Weighing sensor is a common force measurement system based on gravity-electric signal phase conversion, and the force-sensitive element converts this force-change signal into an electric signal for output. According to different sensing theories, the common load cells can be divided into resistive sensing, capacitive sensing, magnetoelastic sensing, hydraulic sensing, grating sensing and other types; according to different structures, load cells can be divided into column sensing, cantilever beam type, wheel type and other types.

Here for the sorting work of fresh agricultural products, our load cell selection of the most common resistance strain gauge load cell is sufficient. When the sensitive resistive metal wire original receives the gravitational squeeze of the mass of the measured object deformation occurs by pressure or tension, which leads to a change in the magnitude of the resistance. The weighing instrument panel receives this output electrical signal based on the change in capacitance caused by the change in resistance value and converts it into a specific mass value for display.

3.2. Structural Components of the System

In the design of sensor-based intelligent weighing and picking system for fresh agricultural products, the weighing and picking module mainly consists of weight sorting machine, target counterweight machine and other parts.

3.2.1. Weight Sorting Machine

The intelligent weighing and sorting system designed in this paper uses an automatically controlled weight-based sorter to replace manual grading and improve the accuracy of weight grading of fresh agricultural products. The workflow of the weight sorting machine is mainly divided into five links: automatic conveying, dynamic weighing, automatic rejection, weight sorting, and weight grading completion.

First, the conveyor belt automatically transports the product to be sorted, and then the load cell is used to dynamically weigh the product to obtain the original product weight data. Then the conveyor belt transports the product to the automatic reject section, where overweight and underweight products are rejected according to the pre-set product quality requirements.

The next grading process is mainly completed by the weight sorter. The total function of automatic weight grading requires the cooperation of four parts: weighing unit, grading unit, control unit and conveying unit, which are coordinated with each other.

(1) The weighing unit mainly applies the force-electric signal conversion function of the load cell to extract the weight signal of the fresh agricultural products to be graded dynamically during the movement of the conveyor belt and derive its weight data.

(2) The control unit processes the product weight data stored after the weighing unit is completed to obtain the weighing results and compares them with the pre-set weight range boundary values to obtain the fresh produce quality grading results. At the same time, the control unit controls the material flaps so that the products delivered to the correct position are rolled down to the correct sorting box position. The quality of the fresh produce can be classified into several grades according to the needs. If it is divided into $n+1$, use m to denote weight of actual fresh product, and use M_1, $M_2 \cdots\cdots, M_n$ to denote the boundary values of the weight classification range. So, when $m \le M_1, m$ belongs to the first class. When $M_1 < m < M_2, m$ belongs to the first class. And so on, when $M_{n-1} < m < M_n, m$ belongs to the n class, and when $m > M_n, m$ belongs to the $n+1$ class. When the identified fresh produce is transported to the correct sorting position, the control unit controls the corresponding numbered material baffle to cause the product to roll down to the correct grading exit and fall into the corresponding grading bin. The product of the n+1st stage can be directly conveyed by the conveyor to the final grading outlet at the end, so that the material baffle is no longer needed for the last stage of grading.

(3) The grading unit consists of a conveyor belt, photoelectric induction switch, material baffle, etc. Through the photoelectric signal sensed by the photoelectric induction switch, the weight of the items on the conveyor belt is further judged to be within a predetermined grading weight range, and then the grading result is obtained.

(4) The conveyor unit uses sterilized and sterile automatic conveyor belts to transport the fresh produce awaiting weight classification to the designated weight classification link. In the first process, the conveyor belt transports the fresh agricultural products to be weighed at a certain distance to the dynamic weighing area of the weighing machine, where the weight data is initially obtained by using the load cell; next, the conveyor belt enters the weight sorting area in the second stage, where the underweight and overweight products are first automatically rejected and then graded on the grading conveyor belt, so that the products of different grades The last section of conveyor belt completes the final weight

classification.

Through the division of labor of the above four functional units, the weight sorting machine will complete the weight classification picking of fresh agricultural products.

3.2.2. Target Counterweight Machine

The logistics sorting process for fresh produce includes the packing of products based on specific orders from consumers, with different combinations of products within each order. The automated target weighting machine uses a control system to derive the best product mix for the order and then delivers it to the packing station to finalize the dosing and packing requirements. The de-manualized target weighting machine for fresh produce orders can reduce the frequency of operational errors in the weighting and packing process, provide a good guarantee for efficient operation during the special period of order surge, and effectively promote the intelligent management process of fresh produce e-commerce and platforms.

The equipment of the target weighing machine is mainly composed of weighing pallets, conveyor belt, storage box, control processor and other parts. 14 weighing pallets are placed symmetrically on both sides of the conveyor belt respectively. The weighing process consists of four main parts: weighing and discharging, system weighing, combined discharge and aggregate packing.

Fresh produce of different weight range grades is first placed on each pallet according to the weight classification of the weight sorter. The target counterweight machine is equipped with multiple pallets to support multiple product stations working simultaneously for continuous loading. Subsequently, the weight data recorded by the sensing is uploaded to the control processing system through the automatic sensing weighing operation of the multi-station weighing pallets, and the optimal product combination that meets the order target is calculated with the customer's order requirement as the target quantity. Once the selection of the optimal weight is completed, the products in the selected pallets that match the best combination of the order are dropped from the weighing pallets onto the synchronized conveyor belt, and the products automatically follow the conveyor belt to the packaging station for packing.

At the same time, according to the product characteristics of fresh agricultural products that are perishable and perishable, products that are not selected to achieve the best counterweight in the storage box within a period of time will be automatically rejected and eliminated, so as to ensure the quality of the products and not to interfere with the accuracy and counterweight speed of the target counterweight machine.

3.3. Staffing

Manager: Mainly responsible for the daily management and maintenance operation of the entire operation process of the intelligent weighing system, acting as an important role in the timely coordination of the smooth cooperation of the various organizational parts of the system for picking. For abnormal situations that may occur during the picking operation of the intelligent weighing system, be able to calmly analyze, calmly direct and arrange for appropriate personnel to solve them, and implement measures to safeguard efficiency and sorting accuracy

Picking group: The picking staff follows the arrangement and dispatch of the person in charge of the picking group and strictly implements the various operational processes of the intelligent weighing and picking process. The staff responsible for different weighing and picking links should regularly check the safety, stability and accuracy of the relevant weighing equipment in the picking line and perform regular maintenance.

Handling team: mainly responsible for the handling and transportation of fresh agricultural products in the sorting warehouse, responsible for the handling of goods from the shelf storage area to the weighing and sorting area, from the shelf storage area to the review and replenishment area and packing and shipping.

Logistics team: mainly responsible for the normal work of weighing and picking equipment routine maintenance, regular maintenance and timely repair work after the equipment failure, in the event of unexpected situations to be able to coordinate the work of other working groups in a timely manner. According to the characteristics of perishable and perishable products of fresh agricultural products, the logistics team will do a good job of cleaning the weighing equipment in time to ensure a clean and healthy working environment.

Order Group: Mainly responsible for the processing of order information, from receiving customer orders to confirming and uploading order information and then sending order information to the picking group, the entire process is controlled by the documents group. The order processing support work of the documents group is the basis for the picking operations of other picking groups, handling groups, and review groups.

Checking team: Mainly responsible for checking and checking again the products of the orders that have been sorted and packed before distribution, using the weighing and rechecking car to check the quantity, type and weight information of the products already recorded on the shelves to ensure the quality stability and sorting accuracy of the orders.

3.4. Workflow

For the sorting and distribution process of fresh agricultural products, the operation mode and workflow of the intelligent weighing and picking system based on sensor technology has been greatly improved and advanced from the previous traditional manual sorting mode.

Quality grading: Firstly, the handling team members carry the fresh produce corresponding to the order to the picking area conveyor belt for automatic transmission to the weight sorting area of the work station. The intelligent weight sorting machine performs weight grading of the products on the conveyor belt, so that products of different weight grades fall into different grade storage boxes for temporary storage, pending the next stage of the target weighting process.

Counterweight packing: The target weighing machine first calculates the best method of product combination based on the type, quantity and weight requirements of the products on the order. Then the control system receives the product combination order, opens the storage bins that meet the requirements based on the completion of the weighing and grading in the previous section, and the picker picks up the products and places them on the weighing pallet of the counterweight machine. The pallet with the best combination that meets the target counterweight will light up while automatically transferring the products to the middle conveyor belt, completing the intelligent counterweight packing session at that stage.

Weight check inspection: The sorted order products will

follow the automatic conveyor belt into the weighing and rechecking area. The check team will use the weighing and rechecking cart to first scan the products to check the types and quantities within the order, then place the products into the totes of the weighing and rechecking cart and compare the actual weight from the check with the target weight shown in the order. If the difference between the actual weight and the target weight is less than or equal to 50 grams, the product will pass the check and be ready to enter the next packing and sealing process; if the difference between the actual weight and the target weight is greater than 50 grams, the product will be returned to the picking station to check the cause of the error and be revised in time.

Filling, sealing and bundling: After the order is reviewed, it will be transferred to the filling and packing station and the bundling station, and the order will be filled and sealed according to certain filling standards.

Print Order Face Sheet: Login to the order information system, scan the labels of the packed products, and print out a whole order face sheet. The printed face sheet is then attached to the goods box in a conspicuous identification location. At this point, the picking of the order products is complete.

4. Summary

This paper first introduces the theoretical basis of load cells, and then flexibly combines the weighing sensing technology to design an intelligent weighing picking system to solve the current problems of fresh produce e-commerce and platform product sorting. The structural composition and working mode of the intelligent weighing and picking system are described in detail, and the before-and-after changes between previous traditional manual sorting and intelligent weighing and picking are analyzed and compared. In response to the characteristics of multi-species, small batch and diverse orders in the new retail market under the epidemic, the intelligent weighing and picking system can well abandon the shortcomings of the past manual picking, such as high cost, long timeframe and error-prone, to quickly respond to orders and reduce order delays in the case of huge order volumes.

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