Design of Intelligent Counting Equipment System for Uniform Materials

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Abstract. In fields such as manufacturing and agriculture, manual methods are generally used to count materials such as hardware parts and seeds, which had problems such as slow speed, low efficiency, and low accuracy, and a lot of pressure was put on people. Based on machine vision and motion control, a uniform material counting equipment system was designed. The equipment uses a two-stage conveyor belt for material transportation, and vibration frequency control and speed control of materials of different specifications were achieved. Because of application of precision motion control technology, the camera collects the image of the material and identifies the material to be inspected, and automatically counts the quantity of the material by calculating the area of the material. The test was implemented with screws, hole gaskets, soy, jujubes and other materials, and the results show that: materials with a size of 2mm-20mm can be detected; the detection accuracy rate is 100%.the system has realized high-speed, high-efficiency, high-accuracy automatic counting, and has good application value.

1. Introduction
In manufacturing, electronics, agriculture, medicine, food and other industries, hardware, electronic components, seeds, tablets and other uniform materials need accurate counting. At present, the traditional manual counting method is not only inefficient, also makes the operation personnel pay a larger labor, prone to error count, and bring the psychological pressure[1], the photoelectric sensor demanding counting equipment for material conditions, a single material must have a gap to accurate count, otherwise the data loses, and photoelectric counting method is time consuming and high cost problems[2]. It can be seen that the above two mainstream counting equipment cannot meet the requirements of high speed, high efficiency and high accuracy.

In recent years, with the continuous development of machine vision, high visual inspection judgement ability, high efficiency and high accuracy, can be widely used in large quantities of small particles detection, product quality grading and so on[3], the technology of image processing can be measured automatically from high resolution image of phenotypic parameters[4-5], machine vision technology using computer high-speed computing power to replace the human eye and ear for object recognition, combined with different algorithms, can realize the analysis judgment, etc.

Zang Linjie [6] designed equipment for identifying and counting the banding bar material in 2016, besides, the equipment could distinguish the adhesive overlapping type of bar material according to the
surface morphology characteristics of the bundling, and solve the problem of adhesion overlapping through an operation such as graying of section image, threshold processing and expansion and corrosion. XIE Tao [7] et al designed an automatic counting system for micro-chip components based on image processing, which is characterized by high efficiency and high accuracy. Ma Chuangchuang and Zhang Zedong [8] et al designed an automatic ball counting device. The above researches have played a good reference role in the research and development of material counting equipment, but only specific material objects are specified, lacking universality.

Combined with machine vision and motion control technology, the intelligent counting equipment system for uniform materials is studied and designed. The equipment system can realize the intelligent counting of uniform materials with high speed, high accuracy and high stability within the size range of 2mm-20mm, which can be widely used in agriculture, food, medicine, hardware and other industries.

2. Principle of equipment system
The counting equipment combines machine vision and precision motion control technology and is controlled by software running on the industrial computer side, the working principle diagram of system as shown in Figure 1, counting on the software system is set the target value of N1 and N2 value of count (N2 < N1), according to the value of setting, automatic computing differential numerical N3 meter. When the motion control module starts, the material enters the primary counting vibrating belt from the main counting hopper through the open stop valve, and the vibrating conveyor belt sends the material to the main counting secondary vibrating conveyor belt, and the secondary conveying belt is sequentially discharged when the trough is lowered, then the industrial camera installed in front of the blanking trough can acquire material images in real time with the cooperation of the light source, and the system software will process the images to realize the automatic counting function; when the count value reaches the set N2 value, the motion control module stops the two-stage vibration conveyor movement of the main count and the main count baffle valve closes. The system starts the differential counting and the differential counting motion control module starts, so the material enters the differential counting vibrating conveyor belt from the differential counting vibrating plate, from the vibrating conveyor belt to the blanking trough and descending, and the machine vision software performs the differential counting to reach when the N3 value is set, finally, the motion control module stops moving, and the differential compensation counting stop valve closes.
The software starts and the system is powered on

Count value setting, main count setting

The main counting module starts

Main counting feed hopper feed

The main counting vibration conveyor belt valve opens

The main counting level vibration conveyor belt conveys materials

Industrial cameras take real-time photos and visual processing

The main count result reaches the main count value.

The main counting feed and transfer stop, the valve is closed

Figure 1. Schematic diagram of the system

3. Design of equipment system

3.1. Design of equipment structure

The configuration diagram of the equipment system is shown in Figure 2, including: feeding module, frequency adjustable vibration module, machine vision counting module, motion control module and discharging module. Among them, the feeding module includes main count and differential count into the hopper and keep-off valve, adjustable frequency counting vibration module includes the main poles of the vibration conveyor belt and differential count of conveyor belt, machine vision counting module includes industrial camera, light source and the visual software, motion control module includes industrial control, motion control card, vibration controller and motor, and discharge module includes blanking trough, receiving a cup and rotary table. In Figure 2, 1 is the primary counting two-stage conveyor belt, 2 is the industrial computer and equipment software, 3 is the installation area of high-speed linear array industrial camera and light source, 4 is the blanking area and outlet, 5 is the main feeding hopper, 6 is the primary vibration conveyor belt, 7 is the vibration plate of difference complement counting, and 8 is the material outlet of difference complement counting. The two-stage vibration conveyor belt controllers of main count and differential count are connected through I/O port and motion control card, and the vibration frequency is set on the operating software of industrial PC to realize the adjustment of transmission speed.
3.2. Design of motion control system

The schematic diagram of the motion control system is shown in Figure 3, the system adopts the upper and lower computer architecture. The lower computer adopts high-precision and high-stability motion control card, the upper computer adopts industrial control computer and independently develops the upper computer system software, and the intermediate vibration module is composed of high-precision vibration controller, motor and vibration conveyor belt. Among them, the movement control cards by ETHCAT front-end ports and industrial control gigabit connection, vibration controller and the movement control cards, motor and vibration controller connection, when the motion control program on the computer side of the industrial computer is running, the motion control card sends the appropriate pulse frequency and number of pulses to the vibration controller to control the rotation of the motor to drive the vibration conveyor belt to convey the material at the corresponding vibration frequency and speed.

3.3. Design of software

The software system includes five modules: motion control, machine vision algorithm, user authority management, system setting and database management. The motion control module sets and controls the start and stop of the motion device; the algorithm deals with the goal of accurate counting; the user authority refers to the setting of user authority to meet the functional requirements of enterprise hierarchical use; the system setting module sets the parameters of the system; the database management
module accesses the product name, size, frequency and speed parameters, so that the best counting parameters can be directly called next time.

When the camera collects images of uniform materials falling in a waterfall at high speed, when the current frame of the material image captured by the camera is incomplete, in order to ensure the integrity of the image, the frame rate is designed to be slightly larger than the falling speed of the material. That is, the falling speed of the material can be controlled by adjusting the vibration frequency of the secondary vibration belt of the system, and the vibration frequency of the vibration belt can be adjusted by setting the value in the system software part.

If there is a repetitive area between two adjacent frames of images, the design algorithm will fill the area with the counted materials, as shown in Figure 4. The filling materials marked in red are those that have been counted in the real-time screen, and the unfilled materials without marking are those that will be counted in the real-time screen. Therefore, even if there are overlapping areas between two adjacent frames, the system software will not repeat counting.

![Figure 4. The identification image of area filling](image)

4. Experimental testing

In order to test the function and performance of the counting equipment, the experiment used soybeans, wheat, dates, tablets, pills, screws, capacitors, gaskets, and other uniform materials for testing. Figure 5 shows the software test effect diagram. Table 1 shows the data detected by the system. The results show that the counting method and equipment function meet the requirements, the performance is stable, and the counting speed of materials with a diameter of 2mm can reach 8000 pieces per minute, and accuracy is as high as 100%, the equipment realized the high speed, high efficiency, high accuracy of automatic counting. The counting equipment has been mass-produced and marketed in Guangzhou Fu Wei Electronic Technology Co., Ltd., and has good application value.
5. Conclusion
In fields such as manufacturing and agriculture, most of the materials are still counted by manual counting or photoelectric sensor counting. The equipment system of uniform material counting is designed by using precision motion control technology and machine vision technology. Through experimental tests, it is verified that the material detected by the equipment is not affected by the shape and color of the material, have strong versatility, have the characteristics of high speed, high accuracy, and high stability, and can be widely used in the counting demand of materials in manufacturing and agriculture fields, and produce obvious economic and social benefits.
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