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Design of Automatic Dispensing Platform Based on Machine Vision

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Abstract

Aiming at the problems of low dispensing efficiency and accuracy caused by manual or semi-automatic dispensing commonly used in medium and small electronic enterprises, an automatic dispensing platform was designed with RJDNEL PCB board as the research object. Based on machine vision, the regional positioning information of point glue was extracted, and the optimal path of dispensing was planned by simulated annealing algorithm. To improve the automation platform, dispensing accuracy and efficiency of dispensing. The automatic dispensing platform was built, the collected images were preprocessed and the parameter information of dispensing area was extracted with the minimum peripheral rectangle algorithm. The operation of the dispensing platform was verified by experiments. The results showed that the dispensing efficiency improved by 20%~30% after path optimization. In the complete dispensing process of 20 PCB boards, the average time of the total dispensing time was 296.48s, and the average time of the whole dispensing platform process was 326.8s.

Keywords

Dispensing platform construction; Machine vision; Location information extraction; Simulated annealing algorithm.

1. Introduction

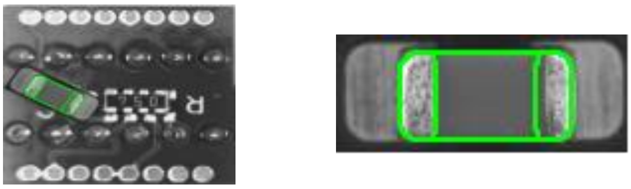
In recent years, the size of electronic products and chip packages has been shrinking, dispensing technology has been popularized, the price of dispensing and packaging equipment has increased, and the labor cost has been increasing. The traditional dispensing process and production mode have shortcomings such as low efficiency, high labor intensity, many human uncertainty factors, and unstable quality. Since the beginning of 2020, novel coronavirus has ravaged the world, impacting the production of circuit electronics. Due to the special manufacturing process of the semiconductor industry, close industrial correlation, long industrial chain and short product production cycle, relevant enterprises in the industrial chain of electronic products and chip packaging production are striving to improve the product automation level, upgrade the production process technology and equipment, and minimize the impact of labor shortage on production efficiency and product quality [1-2].

With the improvement of the market's requirements for production efficiency and accuracy, many enterprises have promoted the efficient development of machine vision technology and product equipment in the process of continuously meeting the market requirements [3]. Cheng Fang [4] and others used image preprocessing and morphological operation to locate the dispensing position based on the problems such as low production efficiency and limited accuracy caused by manually inputting the dispensing path to control the dispensing valve movement of traditional dispensing equipment, which improved the positioning accuracy of the dispensing position and solved the problems such as low open-loop control accuracy and poor stability. Aiming at the problems of colloid accumulation and uneven dispensing in the traditional peristaltic dispensing machine, Ye Qing [5] and others deduced the complementary motion relationship between the peristaltic pump and the dispensing head, designed the control system of the three-axis linkage peristaltic dispensing machine with the independent motion controller as the numerical control core, and improved the dispensing accuracy. He Xianghua [6] and others used machine vision technology to detect the dispensing quality in view of the high cost and low efficiency of traditional dispensing defect detection, which improved the accuracy and detection time. Wang Dongsheng [7] and others raised the problems of low precision and slow dispensing speed of high-voltage electric numerical control dispensing trajectory control, and proposed the trajectory tracking method of the numerical control dispensing machine based on Fuzzy PID control. This controller can improve the overall performance of the dispensing system. Huang Ziqing [8] used binocular vision camera to calibrate the chip dispensing, and proposed an algorithm that can improve the positioning accuracy, reducing the shortcomings of traditional algorithms and improving the overall performance of the dispensing system.

In this paper, the rjdnel PCB on the RJ45 crystal socket of an electronic product manufacturer is taken as the main technical index. On the basis of meeting the packaging production process and quality requirements, the machine vision technology and automatic control system are used to develop and design the components and structures of the machine, The collected images are processed and the location information of the dispensing area is extracted using the minimum circumscribed rectangle algorithm. The simulated annealing algorithm is used to optimize the dispensing path. Compared with the traditional dispensing equipment, the dispensing accuracy and dispensing efficiency are greatly improved.

2. Overall scheme design of dispensing platform

Fig. 1 is a schematic diagram of PCB board and dispensing object. The dispensing object is the midpoint capacitance part of rjdnel PCB, and the size of the whole PCB is 13.5 mm×11 mm×1 mm, as shown in Fig. 1 (a), Fig. 1 (b) is the area to be glued on the capacitor part of the PCB, with a size of 4 mm×2 mm.



a) PCB board b) Dispensing object

Fig. 1 a schematic diagram of PCB board and dispensing objects

In the actual production process, the CNC molding machine is used to cut the PCB into the required size, and the output quantity is 20 PCB boards as a group, and the PCB boards are randomly placed on the code plate and then enter the dispensing process through the assembly line. Each PCB board will have certain errors in the cutting process of the molding machine. If multiple PCB boards are placed in the jig for programmed dispensing, there will be accumulated errors and the glue accuracy will be reduced, Therefore, the PCB board is randomly placed in the tray, and the PCB board collection and dispensing area is shown in Figure 2.

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Fig. 2 the PCB acquisition and dispensing area

Glue dispensing is carried out on the products, and glue is applied on the designated positions by means of automatic machinery, glue spraying valve, needle, etc. to achieve the functions of bonding and fixing with other components, heat dissipation, conduction or sealing and waterproof. The main process flow of the dispensing platform is shown in Fig. 3. After the PCB board dispensed flows out from the previous process, it reaches the location of the dispensing vision system, collects the image information of the dispensing point, and the upper computer receives the information for image processing. The identified dispensing coordinates are converted into the coordinates of the dispensing position, and then the converted information of the actual dispensing position is used for path planning, Integrating the path optimization algorithm into the dispensing human-computer interaction system software, the approximate optimal dispensing sequence can be obtained, and the sequence coordinates can be transmitted to the control system through serial communication. The dispensing needle of the three-axis machine dispenses glue according to the optimized path. After the dispensing operation is completed, the information will be saved locally and uploaded to the upper computer system. Finally, the PCB board flows out of the conveying mechanism and enters the next process.

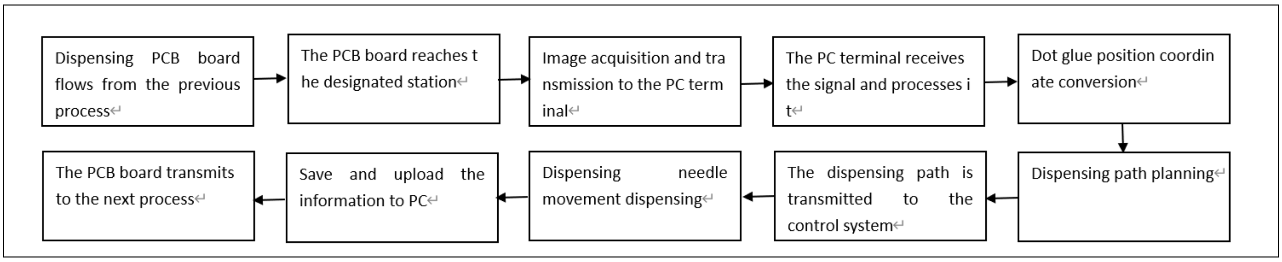


Fig. 3 dispensing process flow chart

According to the dispensing process flow, it is required to meet the movement of PCB board on the conveying mechanism, so as to realize image acquisition and dispensing. A conveying mechanism is added in the design to realize the connection between the dispensing process of PCB and the front and rear processes. Dust prevention, long-time operation and subsequent scalability are considered. It is also considered that it can be used in the production line and cooperate with other equipment on the intelligent production line. The numerical control three-axis linear cantilever mechanical structure is used for dispensing, which can realize the free movement in X, y and Z directions. The X, y and Z axes have positive limit switches, negative limit switches and origin switches.

The front and rear conveying mechanism of PCB board is mainly completed by the conveying track and motor. The code plate with PCB board is placed on the conveying mechanism, and the conveying mechanism is driven to move by the motor to bring out the PCB board of the previous process; When it is transferred to the dispensing visual collection place, the position sensor monitors the conveying position. When it reaches the designated position, the code disk loaded with the PCB board is fixed at the preset camera acquisition position and dispensing position due to the operation of the limit switch. When the last dispensing is completed, the PCB board is transferred to the next work sequence.

According to the process flow and dispensing procedure of the dispensing platform, the mechanical structure of the whole dispensing machine is completely designed. The three-dimensional design of the dispensing platform is shown in Fig.4. It is generally composed of the following parts: frame, conveying mechanism, code plate, dispensing head, three-axis mechanical part and machine vision system. The overall structural design size is 1000 mm×500 mm×870 mm。

The specific steps of each part are as follows: after the device is initialized, the PCB board is loaded, the conveying mechanism (b) conveys the PCB board to the vision system (d), the position sensor is triggered, and the industrial camera is collecting images; Determine the dispensing coordinates through image processing and coordinate conversion on the upper computer, process the dispensing coordinates through path optimization algorithm, and then transmit the coordinate information to the motion controller for compilation through signal transmission; The conveyor mechanism conveys the code disk to the bottom of the three-axis module (E, F, g), the x-axis (E) and the y-axis (g) make plane motion, and the dispensing head (H) moves up and down through the z-axis (f) to realize dispensing of PCB board. After dispensing, the conveyor mechanism (b) moves and enters the next process. The whole mechanical structure has the characteristics of small volume, low cost, simple assembly and maintenance, and the three-axis mechanical structure can perform linear interpolation movement.

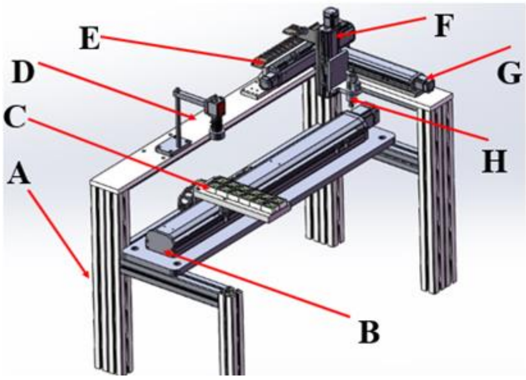


Figure 4 3D design of dispensing platform

A-rack; B-conveying mechanism; C-code disk and PCB board; D-vision system; E-X axis; F-z axis; G-Y axis; H-dispensing mechanism

3. Extracting location information of dispensing area by minimum circumscribed rectangle algorithm

For the extraction of dispensing position information data, it is mainly through image acquisition, image processing, minimum circumscribed rectangle algorithm and other operations to realize the extraction of dispensing position information data. The minimum circumscribed rectangle algorithm is used to extract the four point coordinates of the rectangle of the dispensing area for the image after preprocessing feature extraction, and the center coordinates of the dispensing area are obtained according to the four point coordinates. The calculation principle diagram of the center coordinates of the dispensing area is shown in Fig. 5. P0, P1, P2 and P3 are the four vertex coordinates of the smallest external rectangle.

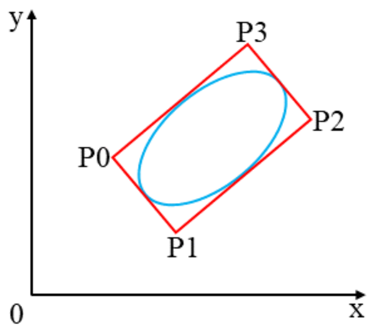


Fig. 5 Schematic diagram of minimum circumscribed rectangle calculation

3.1. Extract the vertex coordinates of the dispensing area

The appearance shape of the dispensing area can be short-sighted as a rectangle. By calculating the minimum circumscribed rectangle of the dispensing area, the midpoint coordinates of the dispensing area can be obtained by using the vertex of the minimum circumscribed rectangle. At present, the algorithms for solving the minimum circumscribed rectangle include rotation algorithm, scanning algorithm, vertex chain code algorithm [9-10], and Cao Yuanwen et al. [11] optimized the convex shell boundary rotation algorithm. According to its theory and in combination with the dispensing object, the boundary rotation algorithm is used to calculate the minimum circumscribed rectangle for the boundary of the dispensing area. The main steps include: determining the boundary value of the dispensing area, and then rotating the obtained boundary value to obtain the minimum circumscribed rectangle of the dispensing area, and then P0, P1, P2 and P3 are the four vertex coordinates of the minimum circumscribed rectangle. The calculation steps of minimum circumscribed rectangle are as follows:

(1) Determination of boundary value of dispensing area: take the maximum value in x-axis direction and the minimum value in Y-axis direction of dispensing boundary as the initial minimum circumscribed rectangle of boundary rotation, and record the area of the initial minimum circumscribed rectangle and the maximum and minimum coordinates on the boundary.

(2) Boundary rotation of dispensing area: determine the included angle of each boundary line segment on the boundary of dispensing area relative to the X direction α_i. Calculate the included angle of each boundary line segment on the boundary of the dispensing area with respect to the X direction in the anticlockwise direction. The rotation angle calculation formula is:

$$\theta_i = arctan\left(\frac{y_{i+1} - y_i}{x_{i+1} - x_i}\right) \quad (1)$$

Where, θ_i is the rotation angle of the ith line segment of the dispensing area boundary, x_i, y_i respectively represent the abscissa and ordinate of the ith point of the dispensing area boundary, and x_{i+1}, y_{i+1} respectively represent the abscissa and ordinate of the ith point of the dispensing area boundary. The boundary of the dispensing area is in accordance with the rotation angle $\theta_1, \theta_2, \theta_3, \cdots, \theta_i$ The order of I rotates clockwise around the coordinate origin, and the point rotation transformation under the same coordinate system. The rotation coordinate formula is derived as:

$$x_i = r\cos\alpha_i \quad (2)$$

$$y_i = r\sin\alpha_i \quad (3)$$

$$x_i' = r\cos(\alpha_i - \theta_i) = r\cos\alpha_i\cos\theta_i + r\sin\alpha_i\sin\theta_i \quad (4)$$

$$y_i' = r\sin(\alpha_i - \theta_i) = r\sin\alpha_i\cos\theta_i - r\cos\alpha_i\sin\theta_i \quad (5)$$

$$x_i' = \cos\theta_i x_i + \sin\theta_i\, y_i \quad (6)$$

$$y_i' = \cos\theta_i y_i - \sin\theta_i\, x_i \quad (7)$$

$$(x_i' \quad y_i')^T = \begin{pmatrix} \cos\theta_i & \sin\theta_i \\ -\sin\theta_i & \cos\theta_i \end{pmatrix} * \begin{pmatrix} x_i \\ y_i \end{pmatrix} \quad (8)$$

$$\theta_i = acrtan\left(\frac{y_{i+1} - y_i}{x_{i+1} - x_i}\right) \quad (9)$$

Where, x_i', y_i' espectively represent the abscissa and ordinate of the ith point on the boundary of the dispensing area after rotation, α_i is the angle between the ith line segment of the dispensing area boundary and the X-axis direction.

Taking the maximum value in theX-axis direction and the minimum value in the Y-axis direction of the boundary of the rotated dispensing area as the circumscribed rectangle after the boundary rotation, calculating the circumscribed rectangle area after the rotation, and comparing it with the initial minimum circumscribed rectangle area, retaining the four vertex coordinates and rotation angles of the circumscribed rectangle with the minimum value of the circumscribed rectangle area, And the circumscribed rectangle with the smallest area is displayed in the image. Then, the boundary of the dispensing area with the circumscribed rectangle is rotated back with the same rotation angle. The reverse coordinate formula is:

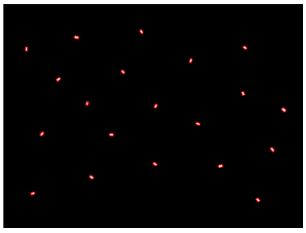
$$(x_i'' \quad y_i'')^T = \begin{pmatrix} \cos\theta_i & -\sin\theta_i \\ \sin\theta_i & \cos\theta_i \end{pmatrix} * \begin{pmatrix} x_i' \\ y_i' \end{pmatrix} \quad (10)$$

Where, x_i'', y_i'' are the horizontal and vertical coordinates of the ith point on the boundary of the dispensing area after the reverse rotation.

The initial position of the dispensing area is perpendicular to the horizontal X-axis θ Angle. Determine the boundary value of the dispensing area. The black rectangle is the initial minimum circumscribed rectangle of the dispensing area. Rotate the dispensing area clockwise around the coordinate origin to the horizontal position to find its circumscribed rectangle, and then rotate the dispensing area counterclockwise to the initial position at the same rotation angle. Wherein, the No. 1 solid line is the rotation track line of the dispensing area, the No. 3 rectangle is the circumscribed rectangle of the area obtained after clockwise rotation, and the No. 2 rectangle is the smallest circumscribed rectangle of the dispensing area after counter rotation.

(3) Calculate the minimum circumscribed rectangle: the boundary of the dispensing area is the rotation angle $\theta_1, \theta_2, \theta_3, \cdots, \theta_i$, if the area of the circumscribed rectangle obtained after rotation is smaller than the area of the previous circumscribed rectangle, the area of the current circumscribed rectangle, the coordinates of the four vertices and the rotation angle will be retained until all the boundaries are rotated. The rectangle with the smallest area is the smallest circumscribed rectangle, and the smallest circumscribed rectangle is connected in sequence through the four vertex coordinates. Fig. 6 shows the minimum circumscribed rectangle of the dispensing area. Wherein, FIG. 6-a) is the minimum circumscribed rectangle of the single dispensing area, and Fig. 6-b) is the minimum circumscribed rectangle of the multi dispensing area.

a) Minimum bounding rectangle of single dispensing object



b) Minimum circumscribed rectangle of multi dispensing area

Figure 6 minimum circumscribed rectangle of dispensing area

3.2. Center coordinate point extraction of dispensing area

After extracting the minimum circumscribed rectangle of the dispensing area, $P_0(x_0, y_0), P_1(x_1, y_1), P_2(x_2, y_2), P_3(x_3, y_3)$ are known as the four vertex coordinates of the minimum circumscribed rectangle. The calculation expression of the central coordinate points $P_4(x_4, y_4)$of the dispensing area is:

$$x_4 = \frac{x_3 - x_1}{2} = \frac{x_2 - x_0}{2} \tag{11}$$

$$y_4 = \frac{y_3 - y_1}{2} = \frac{y_2 - y_0}{2} \tag{12}$$

4. Visual dispensing path planning

In the dispensing process, the target information parameters collected by the camera cannot be directly applied to the dispensing of the manipulator. It is necessary to calibrate the camera of the dispensing vision system and convert the image coordinates to the end coordinate system of the manipulator before dispensing of the manipulator. After the location information of the dispensing object is extracted, if the identified point coordinates are directly sent to the motion control, the dispensing will be carried out smoothly according to the sending, and the optimal dispensing path cannot be ensured. Therefore, the path optimization algorithm needs to be introduced. After the dispensing path is optimized through the corresponding optimization algorithm, it is sent to the control system, The dispensing efficiency can be effectively improved. In this paper, the Eye to hand calibration method is used for calibration.

4.1. Dispensing movement path planning

The traditional dispensing process is to convert the extracted center point coordinates, and the converted center point coordinates are directly transmitted to the control system. The control system will directly dispense in sequence according to the given sequence, which cannot ensure the optimal dispensing path, resulting in low dispensing efficiency. In this paper, the dispensing path optimization method is adopted. Before the vision system transfers the extracted coordinates to the dispensing motion control system, the dispensing path is optimized first, and then the planned coordinates are transferred to the motion control system of the pipette in order to shorten the dispensing path and improve the working efficiency of the dispensing system.

In the process of automatic continuous dispensing of the dispensing system, in order to make the path of the dispensing needle in the dispensing system reach the optimal state, path optimization is adopted to shorten the dispensing path and improve the working efficiency of the dispensing system. Fig.7a) shows the traditional dispensing path. The traditional dispensing is to transfer the randomly marked dispensing position collected by the camera to the dispensing controller for dispensing after coordinate conversion. The dispensing sequence is as follows: the dispensing needle starts from the zero point, dispenses the No. 1 object first, runs back to the original point after dispensing, corrects the coordinates, and then runs to the No. 2 point for dispensing, Until No. 5 glue dispensing is finished and returns to the original point, the control of this dispensing method is relatively simple. After the dispensing is completed, the original point is revised. The operation time of this method is long, the efficiency requirements cannot be met, and the operation track is complicated. Fig. 7b) shows the dispensing sequence after the optimization of the dispensing path. The dispensing needle starts from the origin and runs to point 1 to dispense. After the dispensing is completed, it does not return to the origin. It goes directly to target points 2 and 3, and finally returns to the origin. The entire dispensing path is clear, and the dispensing efficiency can be greatly improved. After that, coordinate error can be revised to meet the accuracy requirements. Comparing the two path planning methods, the improved method not only meets the dispensing requirements, but also meets the application of the path algorithm under the current general trend.

a) Traditional dispensing path b) Improved dispensing path

Fig. 7 path analysis of multi-target dispensing position

4.2. Dispensing motion path optimization algorithm

The problem of multi dispensing path planning can be analyzed as that the dispensing head starts from the origin, does not repeatedly pass through each dispensing center position, and finally returns to the origin, which belongs to the traveling salesman [12-13]. At present, the path planning optimization algorithms mainly include mountain climbing algorithm, genetic algorithm, simulated annealing algorithm and so on. Among them, the mountain climbing algorithm is simple and fast, but it is not applicable to the model with large amount of data and many constraints. Genetic algorithm has strong ability to solve constraints, but its convergence speed is slow, its running time is long, and it is easy to be disturbed by other parameters in the process of running. Simulated annealing algorithm has a wide range of application to various types of optimization variables, good global convergence, fast running speed, and has obvious advantages in path optimization. Therefore, simulated annealing algorithm is used to solve the dispensing path.

Calculation process of simulated annealing algorithm: simulated annealing algorithm is a process that simulates physical annealing. Particles of high-temperature objects change from high-energy state to low-energy state, and there is randomness in changing from low-energy state to high-energy state. The lower the temperature of the object, the harder it is to change from low-energy state to high-energy state, and finally all particles change to the lowest energy state. The physical principle corresponding to the annealing algorithm is the Metropolis criterion [14-15].

Assuming that the N_{ij} (i=1,2,...,M; j=1,2,...P) matrix is the node set in the dispensing path, the total demand T_j (j=1,2,...,P) of the path in the M direction to the j direction can be calculated. T_j can be expressed as:

$$T_j = n_{j1}r_1 + n_{j2}r_2 + \cdots + n_{jM}r_M$$

$$= \begin{bmatrix} N_{11} & N_{12} & \cdots & N_{1M} \\ N_{21} & N_{22} & \cdots & N_{2M} \\ \cdots & \cdots & \cdots & \cdots \\ N_{p1} & N_{p2} & \cdots & N_{pM} \end{bmatrix} \cdot \begin{bmatrix} r_1 \\ r_2 \\ \cdots \\ r_M \end{bmatrix} = \sum_{i=1}^{M} n_{ji} r_i \tag{13}$$

The ideal demand in direction j can be calculated and S positions can be calculated. The demand in direction j can be expressed as:

$$C_{js} = N_{j1} \cdot x_{1s} + N_{j2} \cdot x_{2s} + \cdots + N_{jM} \cdot x_{Ms}$$

$$= \begin{bmatrix} N_{11} & N_{12} & \cdots & N_{1M} \\ N_{21} & N_{22} & \cdots & N_{2M} \\ \cdots & \cdots & \cdots & \cdots \\ N_{p1} & N_{p2} & \cdots & N_{pM} \end{bmatrix} \cdot \begin{bmatrix} x_{1s} \\ x_{2s} \\ \cdots \\ x_{Ms} \end{bmatrix} = \sum_{i=1}^{M} n_{ji} \cdot x_{is} \tag{14}$$

Since the direction of the path from the dispensing point is random, it is necessary to compare the directions of the dispensing paths. Through comparison, the optimal path can be obtained.

$$E = Min(\left|C_{1js}(t) - C_{2js}(t)\right|) \tag{15}$$

The total path direction of dispensing can be obtained by the above formula. The direction j(1,2,3,...,P) is in the first S(S=1,2,3,...,P) positions in the total path planning. The objective function of the consumption rate in the optimal direction can be obtained by the square sum of the deviation between the ideal usage and the actual usage:

$$F = min \sum_{r=1}^{R} \sum_{j=1}^{P} (S \cdot - \sum_{i=1}^{M} N_{ji} \cdot x_{is})^2$$

It can be calculated that:

$$F = min \sum_{i=1}^{R} \sum_{j=1}^{P} (S \cdot d_j - C_{js})^2 \tag{16}$$

The constraint conditions in the formula are:

$$\sum_{i=1}^{M} x_{is} = s, \tag{17}$$

$$x_{is} - x_{i,s-1} \le 1, \tag{18}$$

$$x_{is} - x_{i,s-1} \ge 0, \tag{19}$$

$$0 < x_{is} < r_i, \tag{20}$$

Where, $i = 1,2, \cdots, M; s = 1,2, \cdots, R$

The optimal path space solution is determined as:

$$N_{ij} = [K_{p1}, T_{i1}, T_{d1}; K_{p2}, T_{i2}, T_{d2}]$$

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5. Example verification and analysis

Verify the above design and the automatic dispensing platform system. The physical objects used in the experiment are shown in Fig. 8. In the whole path planning, a single dispensing object needs to conduct a separate dispensing path planning. Since the dispensing PCB board is placed randomly, after the dispensing needle reaches the midpoint of the dispensing area, it cannot directly dispense. It needs to add a path on the dispensing capacitor, which is mainly the extraction of the starting coordinate point. The dispensing direction and path length can be determined according to the starting coordinate point. After completion, the single dispensing path control is added to the whole path planning as a subroutine. The traditional path is the path arranged according to the calibration sequence of the image during image acquisition. After coordinate conversion, the dispensing path is directly planned. In this paper, simulated annealing is used to plan the path of the extracted dispensing positioning information. The initial condition parameters are set as shown in Table 1.

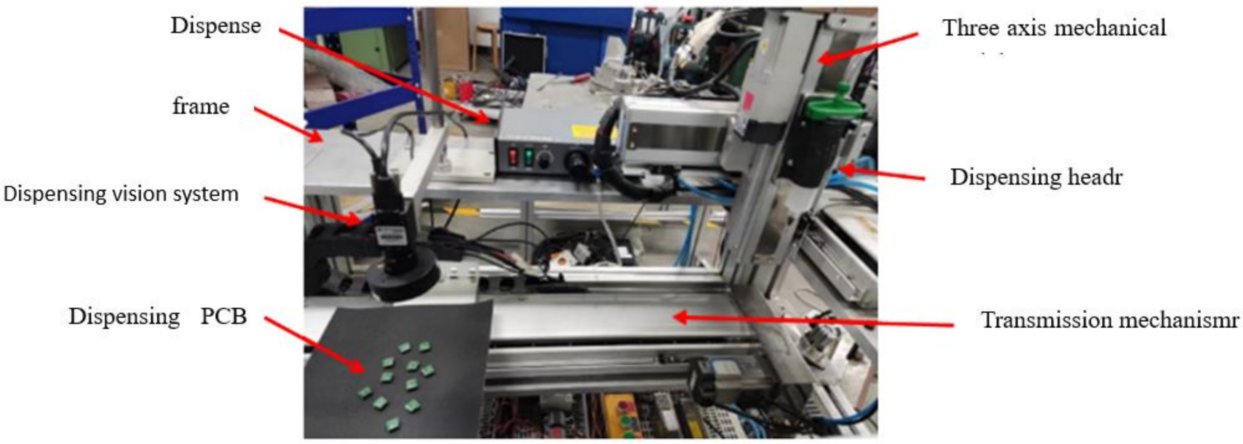
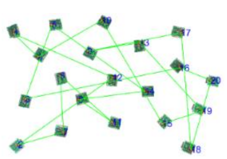


Fig. 8 physical diagram of fully automatic dispensing platform

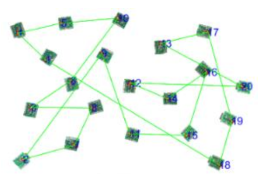
Table 1 parameter setting of simulated annealing algorithm

parameter	numerical value
Initial temperature (T0)	1000
Cooling coefficient（Δt）	0.98
Number of iterations (n)	500
Temperature value after annealing (EPS)	1e-14

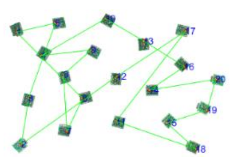
A total of 20 PCBs were randomly placed in this experiment, and 3 groups of images were collected. The path optimization simulation of simulated annealing algorithm was carried out. The results are shown in Table 2. Fig. 9 is the comparison result of the traditional dispensing path and PCB position path optimization under different temperatures in the first group of experiments.



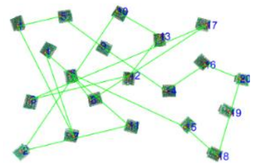
20Optimized front path of PCB board



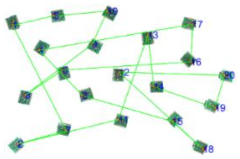
Temp = 1000 ° optimized path



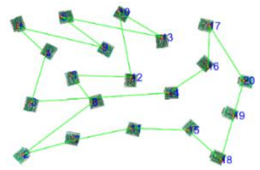
Temp = 910 ° optimized path



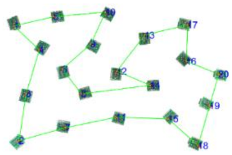
Temp = 810 ° optimized path



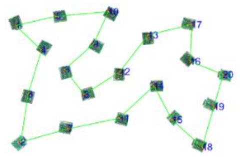
Temp = 656.1 ° optimized path



Temp = 590.49 ° optimized path



Temp = 185.302 ° optimized path



Temp = 64.6108 ° optimized path

Fig. 9 is a comparison of traditional dispensing path and PCB position path optimization under different temperatures

Table 2 path length extraction of simulated annealing algorithm

Group number	Traditional dispensing path length L1 (mm)	Time (s)	Optimized dispensing path length L2 (mm)	Time (s)
1	1654.9	4.38	940.1	2.69
2	1713.4	6.31	959.8	3.74
3	1707.4	5.24	949.2	3.56

The built experimental platform was verified and five groups of experiments were conducted. 20 PCBs were randomly placed in each group. The dispensing speed was 1mm/s and the dispensing volume was 1ml/s. The comparison of the total dispensing time before and after the route optimization is shown in Table 3.

Table 3 Comparison of total dispensing time before and after route optimization

Group number	Dispensing quantity	Traditional dispensing time / S	Dispensing time after optimization / S	Efficiency improvement percentage
1	20	429.4	297.6	30.7%
2	20	420.3	298	29.1%
3	20	397.6	295.1	25.8%
4	20	374	293.6	21.5%
5	20	396.4	298.1	24.8%

As can be seen in FIG. 9, the traditional dispensing paths are disordered and the paths are repeated and alternate. The total path is 1654.9 mm, and the road planning time is 4.38 s; After the optimization of the dispensing path, the dispensing path is clear when the temperature is 64.6108°, the total dispensing path is 940.1 mm, and the path planning time is 2.69 s. It can be seen that the path difference before and after optimization is obvious, and the optimized path is 714.8 mm less than the traditional dispensing path. According to the comparison results of dispensing after route optimization through physical verification, table 3 shows that the dispensing time under the traditional dispensing route is longer, the dispensing time after optimization is reduced, and the dispensing efficiency is increased by 20% ~ 30%.

6. Conclusion

In order to improve the automation degree, production efficiency and dispensing accuracy of dispensing equipment for small and medium-sized enterprises, the overall dispensing platform built meets the automation requirements; The location information of dispensing area is extracted by machine vision technology, which makes the dispensing position more accurate and improves the dispensing accuracy requirements of products; The path planning of dispensing objects further shortens the dispensing journey and improves the dispensing efficiency. 20 PCB boards are used for complete dispensing. The average time from the first board to the last board is 296.48 s, and the average time of the whole dispensing platform is 326.8 s. The optimized dispensing efficiency is increased by 20% ~ 30%.

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