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Design of Industrial Robot Sorting System Based on A * Search Algorithm

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ABSTRACT

Robotic sorting system based on Machine Vision can quickly place the workpiece to the specified location. Gaussian transform, contour detection, binarization processing, image processing and other polygonal fitting methods were used to identify the shape of the workpiece; Histogram technology was used to build a small text signature database method for image character recognition; A * search algorithm was used for path planning. Experimental results show that using A * search algorithm to determine the grab order of geometry, and the optimality pruning and binary state compression method to optimize the algorithm, it is faster than the local search method and the best first search method by 1 to 2 seconds, thus reducing the computation time.

Keywords

Robot sorting, A * search algorithm, path planning, image processing

Introduction

By analyzing the working process of the robot, it is not hard to find handling and sorting are the foundation of all the work, no matter what field it is applied, is inseparable from the handling and sorting procedure. Robot sorting system ,compared with the traditional manual sorting, is more rapid and accurate, and especially in some poor environmental and sanitary conditions the fomer has incomparable advantages. Machine vision is the key to implementing the robot handling and sorting work. If its positioning is improper, the sorting work will be greatly influenced, or even fail[1].

This paper designed and developed a robot sorting system based on A * search algorithm, and studied the relevant image processing methods. A * search algorithm

was adopted to determine the fetching order of the geometry, and at the same time the optimality pruning and binary state of compression method was used to optimize this algorithm, which could efficiently solve the shortest path problem. when the workpiece was sorted.

1 Sorting robot research status at home and abroad

In order to pick out the bad vegetable and fruit, in the early 1970s,the British have designed a remote control of mechanical system, using the TV screen to observe the images of the potato. If there is a bad potato, with its image clicked on the screen by a specific pointer, a special device can pick it out. Although this system has replaced partial manual operation, but it still needs the full manual participation. Then optical method is invented to pick potatoes, and 3 tons of potatoes only need one hour to be done, the equivalent work of six labor workers.

Now with the continuous development of technology, automatic sorting robot has been widely promoted and applied. For example, Japan developed the apple automatic dispensing machine. It only takes 1 minute to get more than 500 apples classified according to different size, color, gloss, and then sent to different production lines[3].

In China, many kinds of robots have been used in different fields, but the overall level of research is still in the primary stage, and more and more is based on foreign research to improve or to carry out the secondary development. The real machine vision sorting robot is only in the research stage. Therefore, the research, development and application of machine vision robot sorting system is of great significance.

2 The composition and working principle of the sorting system

In this paper, the robot sorting system is designed on the basis of A* search algorithm and composed of two parts: hardware and software. The hardware consists of three parts: the working platform, the visual system, the robot control system. Work platform unit is mainly used to place the required sorting workpiece; vision system is mainly composed of CCD camera, camera support and visual processing software; the robot control unit is responsible for analyzing the received parameters, controlling the robot to achieve the appropriate action, and completing the ultimate goal of the identification, capturing, and placing of workpiece. Software part is self-developed control platform based on OpenCv library. The system main interface is shown in figure 1.

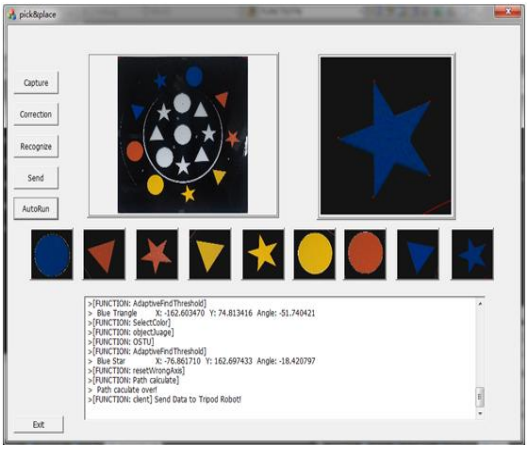


Fig.(1) System interface figure

The basic process of the whole design system is to use the camera to take pictures of the working platform, and to recognize the shape and character of the geometry, and obtain the actual coordinates, and then control the Tripod robot to put the geometry to the specified position. The concrete implementation scheme is shown in figure 2.

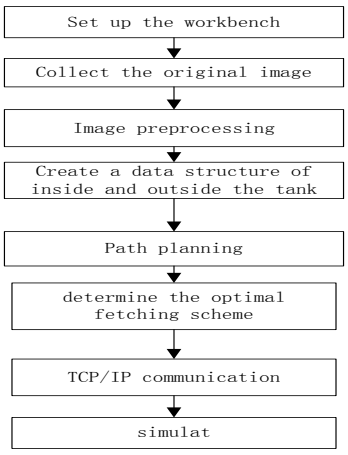


Fig.(2) Implementation scheme

3 The description of the problem and the key of the image processing part

3.1 The problem need to solve

On the outer ring of the disc there are nine geometry workpiece, their initial position shown in Figure 3, five geometry printed with "B", "&", "R" character, and only one geometry printed with "& . " Recognize the geometrical body of the outer circle printed with "&"and the place it in the middle of the disc. Other geometry, by identifying, is eventually captured and put in the location, as is shown in figure 4. The robot is required to find the best fetching order in the shortest time.

Fig.(3)Initial position

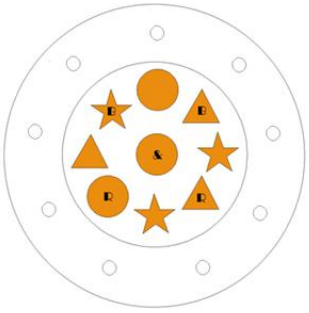


Fig.(4) Final position

3.2 The shape recognition

Due to interference from other devices and external environment, a variety of noise will be present in the resulting image. Gaussian transform can effectively reduce the image noise and reduce the level of detail. So in this paper, we use the Gauss transform to filter out the noise ; Because the contour line of the inner and outer groove of the image is needed, the edge detection is used to detect the edge of the pixel, and the actual edge is indicated; In order to eliminate the interference of color, the image is carried out by binarization; when the inner and outer contours of the groove is determined, it is necessary to determine its shape. With Polygonal fitting, some contour features can be extracted to fill the inside and outside slot data structures, for the subsequent use of follow-up path planning. The last step is to calculate the coordinates of artifacts, thereby preparing for TCP/IP communications. The flow chart of shape recognition is shown in Figure 5, the design sketch of shape recognition in Figure 6, and the calculation of coordinate values in Figure 7.

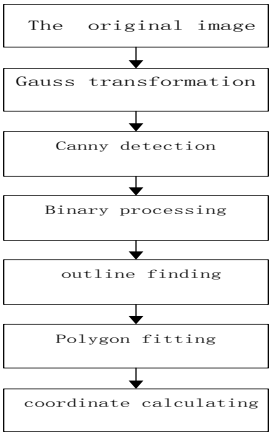


Fig.(5) The flow chart of shape recognition

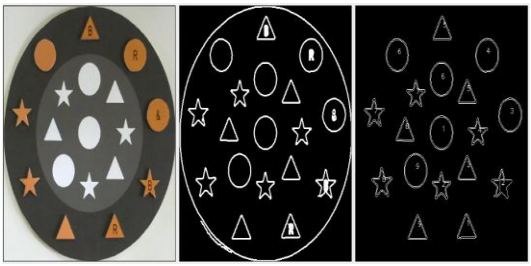


Fig.(6) The design sketch of shape recognition

3.3 Character recognition

Since the recognition of the text is three standard characters, the scheme of this paper is to build a small text feature library. The characteristic library is established through histogram method.

OpenCV is used to determine the location of the geometry of the text, and to obtain the local screenshots, record text process, which turns 2D image matrix information into two one-dimensional array. This operation essentially seeks summation of the elements of each row and each column of the binary image matrix and calculates the covariance coefficients of the two dimensional array and the standard two-dimensional array of the image to recognize the character. Note that in the process of identifying if the resolution selection is too large, it will increase the amount of computation; if the too small, it will lead to distortion of character feature extraction. Through the experiment many times, therefore, the resolution of character standard matrix of this paper is 32*48.

Specific process of character recognition is as follows: first, image characteristics are extracted to build standard image feature library; later, the current image feature is extracted to match standard library; finally comparison results are normalized, and according to certain rules, the best match combinations are selected to complete the identification. Character recognition process is shown in Figure 7. Figure 8 shows specific text histogram statistics results.

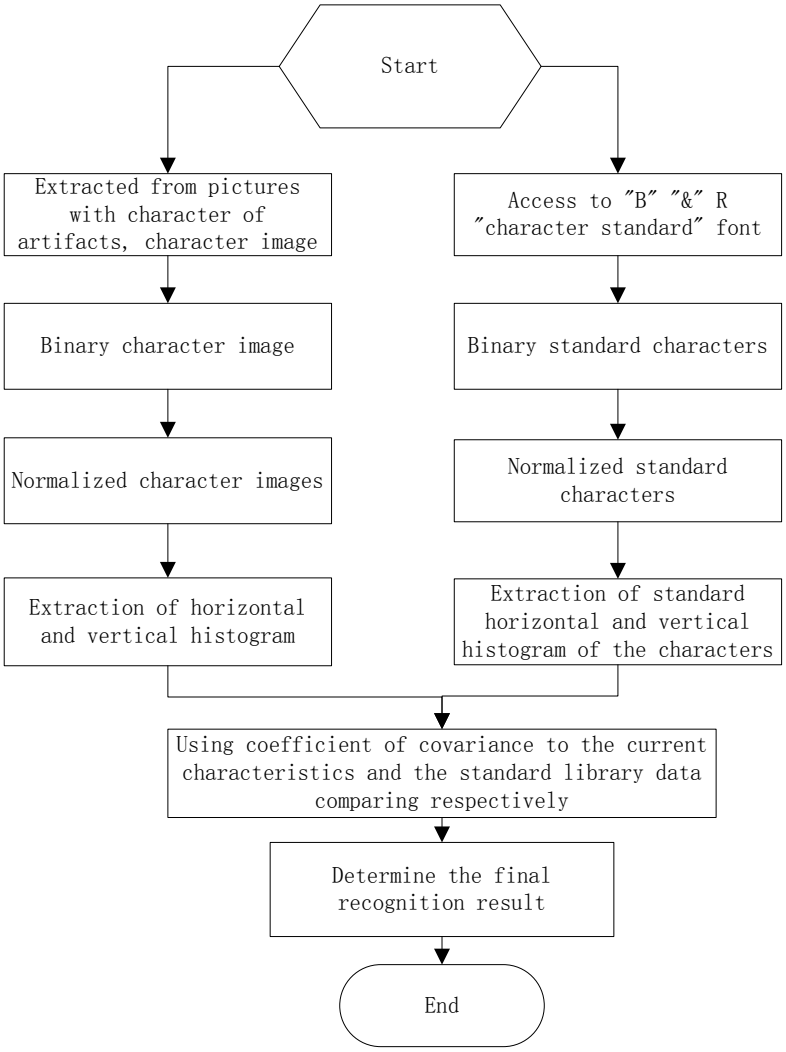


Fig.(7) The flow chart of character recognition

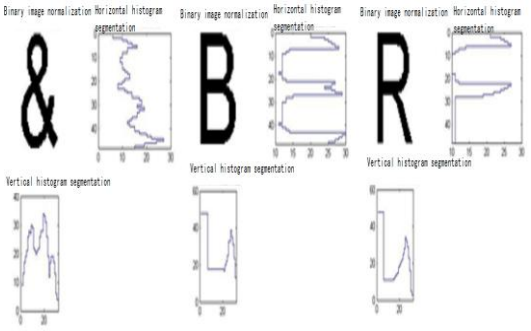


Fig.(8) The process and result of character recognition

After deal with characters, then run the system, we can see that the system can accurately determine sorting text type on the element.The final results shown in

Figure 9 .

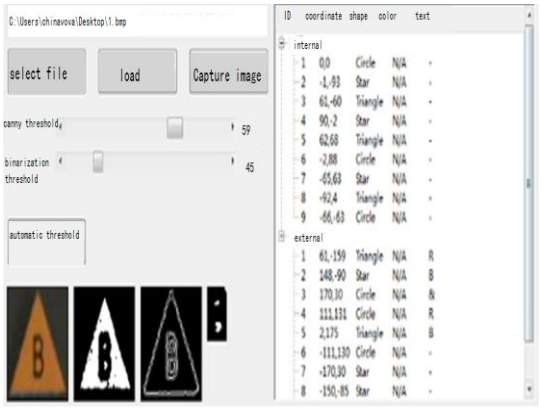


Fig.(9) The system interface of character recognition

3.4 the path planning

After the image recognition and acquisition of the relevant data structure of the internal and external groove, it is needed to control the Tripod robot hand to grasp all the geometrical bodies and place them in a specified position, and make the mobile distance as small as possible to find a shortest path.

At present there are many kinds of algorithms to solve such problem : simulated annealing algorithm, genetic algorithm, search algorithm and artificial neural network algorithm, Dijsktra algorithm, ant colony algorithm[4]-[6]. In the process of problem solving each algorithm has its own advantages and disadvantages. Their advantages and disadvantages are shown in table 1.

Table 1 The advantages and disadvantages comparison table of all kinds of algorithms

Algorithm	Advantages	Disadvantages
Simulated annealing algorithm	High quality, strong initial robustness, generally easy implementation	Optimization process is longer than the other
Genetic algorithm	Implicit parallelism and global search solution space	Prone to premature convergence and poor convergence performance

Search algorithm	Local search ability is very strong	the dependence on the initial solution is stronger, serial iterative search process
Artificial neural network algorithm	Simple, standard, fast	Optimization and robustness are not strong
Ant colony algorithm	Parallel essence, positive feedback, it can obtain the shortest path	Relatively complex, the search time is longer

Considering the above advantages and disadvantages, as well as the current problem, search algorithm is used. The commonly used search algorithm includes local optimal search algorithm, the best first search algorithm, A * search algorithm . These algorithms all have in common are using heuristic function, but the difference is that they use different methods to choose optimal searching node.

3.4.1 Local optimal search method

This algorithm, in the process of searching the best node, initiatively discards other siblings, and in the process of discarding the best node is also likely to be cast off by mistake, because the optimal node in the solving process may only be the best in one stage, not necessarily the best of the whole process. As a result, this algorithm has some shortcomings[7].

3.4.2 The best first search method

Different from local optimal algorithm, this algorithm in the search process does not discard nodes (except dead nodes), in order to prevent the best node from mistakenly being thrown away. In every step of the estimate the previous and the current node are compared to discard the high cost search path and choose the path of least cost to continue down the search. However, this method does not guarantee the obtained path is the shortest[8].

3.4.3 A * search algorithm

For computing the shortest path problem in the static network, A * search algorithm is one of the most effective ways. This algorithm is put forward based on the merits of best-first search algorithm and Dijsktra algorithm in 1968. Therefore, in addition to

the advantages of the speed of the algorithm, even though the heuristic value is not guaranteed to be optimal, it can also search for the shortest path. The current problem belongs to the static simple pathfinding problems. Therefore, A * search algorithm can be used to achieve the same speed as greedy best-first search algorithm. At the same time it can well solve the problem that the greedy best-first search algorithm does not guarantee to find the optimal path problem[9].

The principle of the algorithm is: if the evaluation function is able to find the shortest path, it is called the admissibility. $f'(n)=g'(n)+h'(n)$ is the valuation function of A* search algorithm. $g'(n)$ is the starting point to the shortest path of a node n. $h'(n)$ is the heuristic value of the shortest path of the node n to the destination. $f(n)$ is the valuation every possible test points, it has two parts: the one part is $g(n)$, which represents the cost from the initial search point to the current point, the other part or $h(n)$, which represents the heuristic search, the most important part of the value of the current node to the destination node.Since $f'(n)$ is difficult to determine in advance, it can be replaced by the $f(n)$ approximation. Under the condition of $g(n) \geq g'(n)$, the $g'(n)$ is replaced by $g(n)$.Under the condition of $h(n) \leq h'(n)$ the $h'(n)$ is replaced by $h(n)$. Using the evaluation function, the shortest path can be obtained, which can be adopted.

3.4.4 The optimality pruning method

The optimality pruning is generally deal with the issue of the optimal solution. To the minimum number between two states, for example, search the minimum step process: In general, we need to preserve a "current minimum number of steps", which is a lower bound of the current solution d. In the traversal of the search tree leaf node, a new interpretation, and preservation of the lower bounds for comparison, if a new interpretation of the number of steps smaller, make it become the new lower bounds. After the end of the search, the solution is the minimum number of steps. And when we have searched the k Ayumi, if we can through some way to estimate the current state to the goal state is the theoretical minimum number of steps s, you can calculate the starting point to the target point of the theoretical minimum number of steps: valuation function $h=k+s$, then current circumstances are the necessary conditions of the optimal solution is $h<d$, otherwise it can prune. Optimality pruning is to optimize the process of solution space.

Program flow chart is shown in figure 10. The optimal path planning result is shown in figure 11.

Fig.(10) The flow chart of path planning

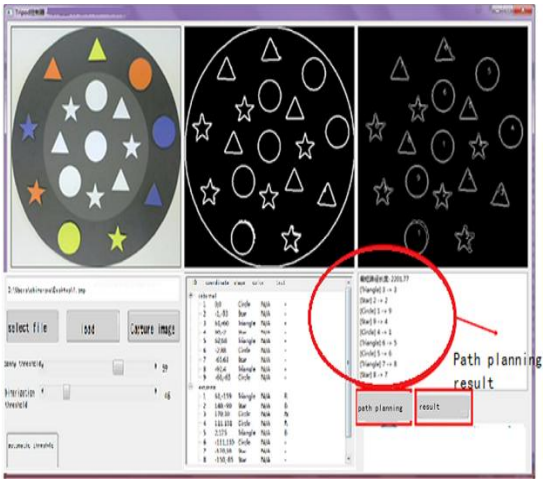
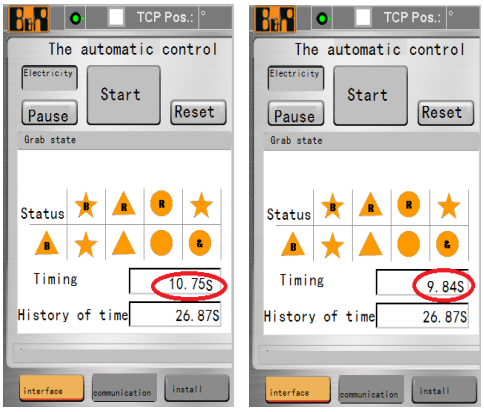


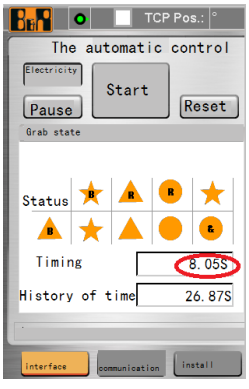
Fig.(11) The shortest path display interface

4 Results and Discussion

Respectively using the local optimal search method, the best first search method and A * search algorithm for path planning, through the B&R Robotic simulations with the Visualization simulation platform, the system of the experimental results are shown in figure 13.



(a)Time for local search (b) Time for best first search



(c) Time for A * search

Fig.(13) Time comparison of three methods

Experimental results show that using A * search algorithm to determine the grab order of geometry, and the optimality pruning method to optimize the algorithm, if the color condition is not considered, it also uses the method of memory search, it is faster than the local search method and the best first search method by 1 to 2 seconds, thus reducing the computation time.

5 Conclusion

With the continuous development of computer control technology, the trend that machine replaces manpower is inevitable, which enables the robot technology to have a wide and in-depth development. Traditional robot is only a substitute for human repeated work, which does not have the ability to correct error and self-adapt[10]. And with the development of technology, today's mainstream online robots are basically closed-loop controlled and artificially intelligent, and even some possess self-learning ability. The current system is designed in this context. The technical route, as well as the functions of the system, is as follows:

(1) The system is based on the path of the A * search optimization method and optimized through optimality pruning algorithm to obtain the shortest path fast and accurately in the end.

On the shape, color, character recognition method, this paper, by using gauss transformation, edge detection, and many other image processing method of image preprocessing, realized the pattern recognition of accurate and robust.

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