The Key Technology of Drug Delivery Robot based on Compound Sensing in Patient Location

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Abstract: The core function of the robot facing the scene of drug delivery in hospital is to deliver the medicine to the patient. Locating the position of the patient's limbs in space relative to the robot is a key technology. Traditional technology based on single sensor is difficult to identify human body in complex scenes. In this paper, based on the fusion of sensing information between the two-axis Laser radar and the visible camera, the support vector machine (SVM) algorithm, which combines the normal filter and the dimensionality reduction of point cloud data, can effectively locate the patient's body. Effective and reliable limb positioning is achieved at relatively low cost.

1. Introduction

With the rapid development of artificial intelligence technology, robots for hospital patient care have become popular. For example, the Obi Robotic Dining Companion, the automatic feeding device. Through the manual teaching of the feeding robot arm trajectory and stay position, the automatic feeding robot can repeat the corresponding route to achieve feeding action. Researchers at the Santa ana school in Pisa, Italy, and Swiss federal Institute of Technology in Lausanne have developed a smart exoskeleton device that can help the wearer to rebalance When he loses balance, and preventing falls.

With the increasingly serious problem of aging population in China, the number of patients in the inpatient department of the hospital has increased significantly. On the other hand, there is a shortage of nursing staff, which will affect the service time and quality of patients.

Automatic drug delivery robot can effectively alleviate the workload of nursing staff, nursing staff can spend more time and energy on patient care. For drug delivery scenarios, the key technology is not just how to let the robot navigate to the patient without obstacles. Because the patient's mobility is limited, it requires that the drug be delivered precisely to the patient. Therefore, positioning the upper limbs of patients relative to robots in space is one of the key technologies.

2. Research Status at Home and Abroad

At present, there are two main methods in target detection technology at home and abroad. Machine Vision Target Detection Technology Based on Visible Light and Target Detection Technology Based on Three-Dimensional Point Cloud.

The classical object detection technology based on machine vision is the Radial Gradient Histogram Detection HOG+SVM method proposed by Dalal N.

In this algorithm, the radial gradient histogram of the target image is computed as the eigenvalue (Fig. 1). Classical classification algorithms such as Support Vector Machine (SVM) and Boost are used to classify and learn a large number of positive and negative samples of targets to achieve target recognition.

Later, P. Felzenszwalb proposed an improved DPM (Deformable Part Model) algorithm based on classical HOG (Histogram of Oriented Gradient), and the recognition rate was doubled. (Fig. 2)

Target detection based on machine vision can achieve better recognition rate under the premise of better visual environment of target image, but it does not perform well under the condition of multi-target stacking or insufficient illumination.

On the other hand, the actual physical position of the object cannot be accurately positioned simply by using only visible target recognition. Binocular vision positioning with two cameras solves the problem that the accuracy of hierarchical operation of visual elements [3-4] which is not very accurate (Fig. 3). Due to the difference of illumination brightness in the inpatient ward, the patient location based on visible light alone has great uncertainty. Influenced by the difference of illumination brightness in the inpatient ward, the location of patients based solely on visible light is uncertain.

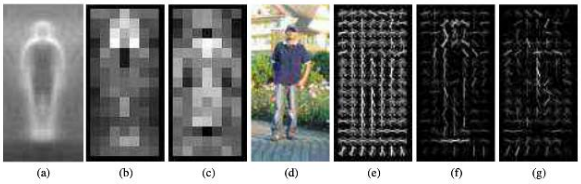


Fig 1. Extraction of Image Gradient Characteristics of Samples by HOG [1]

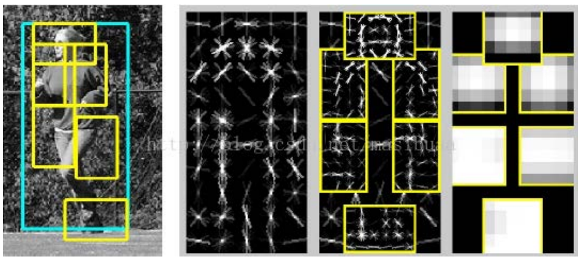


Fig 2. Extracting Image Gradient Characteristics of Samples by DPM [2]

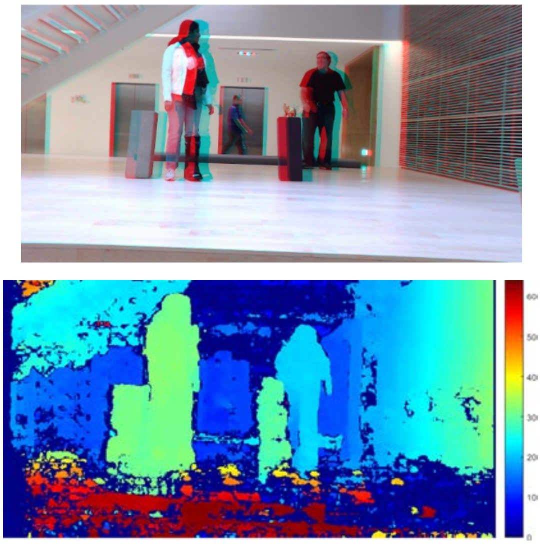


Fig 3. Target Distance Detection Based on Binocular Vision [4]

There are also two common methods in three-dimensional target detection technology. Among them, there is a method of target detection method based on the three-dimensional physical model for fitting and matching plane image [5]. The recognized object of this method is still a two-dimensional image, but the recognized target is a three-dimensional model. Among them, there is a target detection based on physical model for fitting and matching plane images. The object of recognition by this method is still two-dimensional image, but the target is three-dimensional model. The object of recognition by this method is still two-dimensional image, but the target is three-dimensional model.

This method has a higher recognition rate for relatively simple objects, but a lower recognition rate for more complex objects, such as animals.

In recent years, with the development of 3D scanning technology, target recognition technology based on 3D Point Cloud technology has emerged.

Because the object of study is the point cloud formed by full 3D scanning of stationary objects, this method can recognize objects with relatively complete contour scanning with high recognition rate.

For the laser radar installed on the body of the robot, it is difficult to scan moving objects to form a complete 3D point cloud, so the target detection based on simple outline point cloud is difficult to apply to the application scenario of the drug delivery robot in this paper.

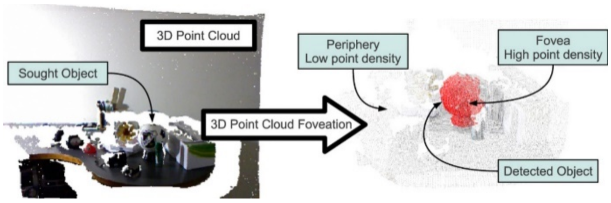


Fig 4. 3D object detection technology based on point cloud [8]

3. Experiments

3.1 A Delivery Robot Chassis with Composite Sensors

In order to complete the function of the dispensing robot and make up for the deficiencies of visible vision analysis and point cloud analysis of 3D physical scanning, we designed a dispensing robot. The chassis of the dispensing robot will be equipped with a network camera and a laser radar simultaneously.

Visible camera plays an important role in environmental feature extraction. The Laser radar rotates 180 degrees horizontally to and front to scan the object in front of it. Web cameras can real-time image back to the server for image processing and analysis, record the running process of the car, and assist in face detection.

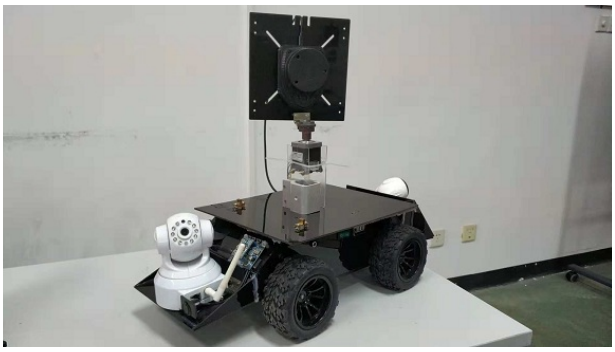
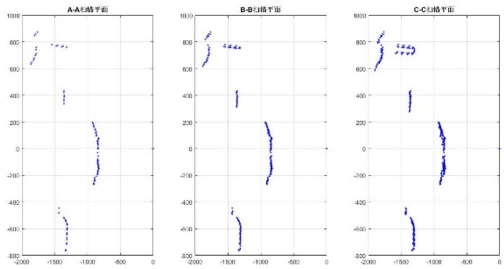


Fig 5. Delivery robot chassis

In the process of data acquisition, it is easy for a single Laser radar to scan the object to make the human body locally linearized because the laser does not have penetrability to the object, which brings difficulties to the later data processing.

Fig. 6 (b) is a scan of three sections of Fig. 6 (a). It can be seen that the chest scan and background scan of the figure in the picture are basically linear. Therefore, the results of single-angle and single-level scanning cannot be used to locate the human body

(a)Scanning the target



(b)Stratified scan result

Fig 6. Single Laser radar layered scan results

Using dual-radar parallel-axis scanning, the distance between Laser radars is set to 0.5 meters, which can make the contour curve of human body more realistic and the data more valuable for research. Figure 7 shows the human frontal point cloud generated by the superposition of the biaxially scanned Laser radar data.

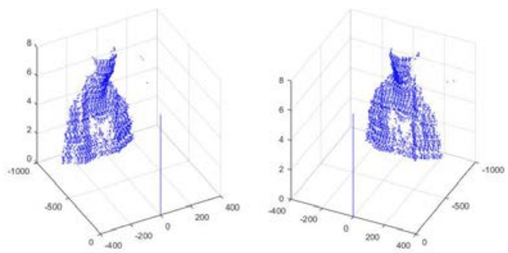


Fig 7. Point Clouds on Human Body Surface Obtained by Two-Axis Scanning with Laser radar

3.2 Feature Extraction and Classification Learning

Spatial point clouds have a huge amount of data. About 200,000 sampling points can be obtained in one scan cycle. The computation of extracting three-dimensional feature from surface fitting is very large, which puts forward higher requirements for computing hardware. In order to improve the operation speed, the point cloud data can be dimensionally reduced and the 3D information can be converted into plane information for analysis.

For the outline of the human body shown in Figure 7, the histograms of the two directions are obtained by projecting the X-axis and Y-axis, counting the sum of the pixels and normalizing them.

Through multi-angle sampling of human body contour, we can get multiple positive sample histograms, as shown in Figure 8 (a) - (c). Positive sample:

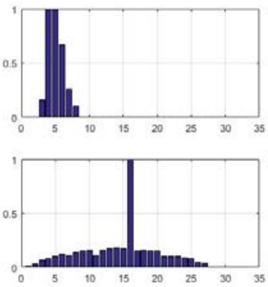
$$p_p=[p_{pi}|i\in 1,2,\cdots N]$$

Negative sample histogram can be obtained by using the same method for non-human external contour, as shown in Fig. 8 (e) - (g). Negative samples:

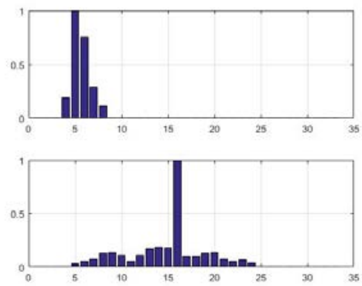
$$p_n=[p_{ni}|i\in 1,2,\cdots M]$$

When the number of samples is large enough, the accuracy of sample classification can be effectively improved by using SVM support vector machine learning. The histogram in this paper uses the projection of point clouds into 32 equal intervals of X-axis and Y-axis to obtain support vector $M_{svm.}$

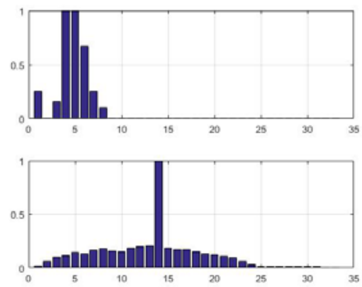
$$M_{svm} = \mathrm{F}(p_{p,}p_n)$$



(a)

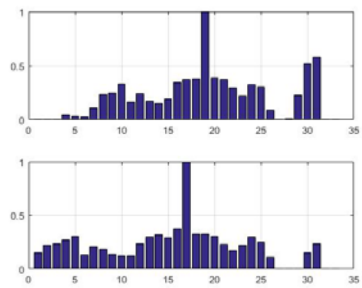


(b)

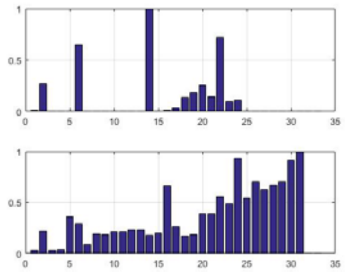


(c)

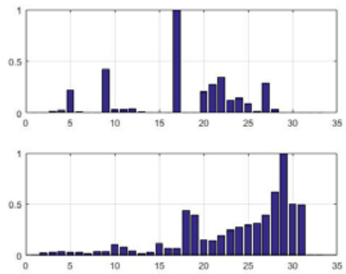
(a)-(c): Positive sample



(e)



(f)



(g)

(e)-(g) Negative samples

Fig 8. The sample histogram after dimension reduction

In this paper, the support vector machine is trained with 310 samples, in which the proportion of positive and negative samples is 1:2. When the robot is put into use, the point cloud data P1 and P2 of the dual Laser radar are merged to form P.

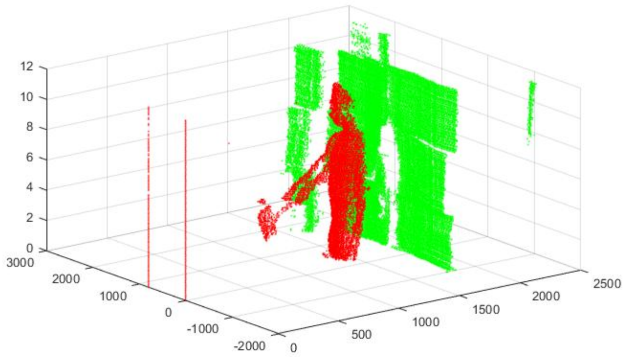
By rotating the point cloud coordinates, the points in P are projected to X and Y axes. This method can calculate P maximum and point cloud region, and then obtain several solid point cloud regions in the space.

$$\left\{P_{\mathrm{ci|i}} \in_{1,2\cdots N,} \sum PCi = p\right\}$$

Support vector machine (Msvm) is used to classify and betray the solid point clouds in turn, which can recognize the entities satisfying the human contour characteristics in the scene and return to the nearest point in the solid point clouds to the Laser radar (Fig. 9).

So far, the automatic dispensing robot has completed the precise positioning of the patient's spatial position, and can tell the nearest point coordinates to the dispensing manipulator for dispensing medicine.

(a)



(b)

Fig 9. The control algorithm can locate the patient's spatial position

4. Conclusion

The biaxial Laser radar is used to scan the object within the detection distance in front of the robot, and the obtained point clouds are superimposed in space. Relatively independent entities in space are extracted by cutting the maximally connected entity domain. The dimensionality reduction of point cloud data is realized by projecting the solid point cloud data to the axial direction. Combining with support vector machine classification algorithm, the location of patient's body in space can be realized efficiently and quickly. Experiments show that this detection method is more reliable and stable than face recognition and binocular camera location based on visible camera alone.

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