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Application of intelligent power plant based on computer vision technique

Qun Li, Jian-jun Li
Inner Mongolia University of Technology, Hohhot, China

The navigation frame is designed by the vision algorithm of autonomous navigation, the construction of the DWA model is completed by the optimization algorithm of SLAM sparse point cloud minimization, the dynamic obstacle avoidance of intelligent inspection robots is achieved and globally optimized on the basis of the existing smooth trajectory, and the inspection route of intelligent inspection robots is designed based on the ROS communication frame to complete the double matching of the fixed and custom coordinate points, so as to improve the complete inspection function of intelligent inspection robots.

Inspection robots can provide safe inspection modes for turbine rooms with complex equipment and boiler rooms with hollow steel plates, and, with the inspection path at a distance of a green safety channel or safety equipment as the data carrier, complete the real-time inspection by basic hot-line work, optimize the inspection route, and avoid the obstacle automatically. According to the existing design principle, segmentation treatment is carried out mainly by the global optimal route, and on the basis of the computer vision analysis, the comprehensive operation is carried out considering the PCL dual radar fusion of the robot dynamic learning model based on the algorithm layer and the minimized Snap of DWA, so as to complete the trajectory optimization of the minimized Snap, thereby improving the guidance of the computer vision algorithm, improving the role of the soft constraint function in data splicing and carrying out comprehensive analysis.

1. Application value of computer vision inspection in intelligent power plant

In recent years, China's economy has been transformed and upgraded, more high-quality enterprises have appeared, the degree of industrialization of the society has been steadily increasing, the level of urbanization has reached over 65%, and the demand for electricity in social production and the lives of residents has been significantly increasing. With the transformation and upgrading of technology, and the expansion of the market demand, the modernization of the manufacturing industry is making steady process, and independent inspection and intelligent inspection are bound to be strengthened in power inspection under such internal driving force and external pulling force, so as to improve the effectiveness of the management of power inspection, reduce the cost of power equipment operation, improve the comprehensive construction of the database, and meet the needs of intelligent substation construction and the needs of social enterprises and residents for high-quality power supply; advanced and intelligent inspection modes are adopted to make up for the deficiency of the existing manual inspection.

2. System design of computer vision inspection in intelligent power plant

Current mobile robots have such advantages as flexibility, high efficiency, wide coverage and little impact by external factors, and, combined with the computer intelligent sensing technology, remote real-time recognition technology, digital management technology and background operation technology, can greatly improve the safety management of the power system, enhance the early warning and risk control capacities, and improve the efficiency in analyzing the fault response decision [1]. Based on the actual production, they are mainly used by the following routes:

2.1. Mechanical structure design

Based on the infrastructure of substation inspection robots of Hkust Intelligent, physical structures are fully designed and analyzed. The main framework of the robot is composed of the sports chassis and monitoring platform, and the specific framework is a moving frame composed of the driving motor base, pan-tilt, the body of fixed plate, and structural plate, and the inspection method of intelligent inspection robots is designed based on the original Mecanum Wheel structure and the framework of substation inspection robots of Hkust Intelligent [2].

2.2. Motion control system

The decoder is automatically corrected by algorithm analysis method, structures of the pan-tilt, the body of fixed plate, structural plate and driving motor base are analyzed by four-coded motor-driven positive and inverse solution control, and the motion mode is spliced based on multi-laser radar point cloud data to form collaborative operation.

2.3. Computer vision analysis

2.3.1. Image processing and optimization

On the basis of vision SLAM, the cartographer algorithm is adopted and dual-radar assistance is used to provide an auxiliary data system for later information acquisition and collaborative information provision of intelligent robots, information construction is carried out to comprehensively capture the data of the mileage counting of the intelligent robot inspection, the point matrix map is obtained according to the deployment of the computer vision system to establish the sparse point cloud, and the mileage counting and data-driven acquisition are completed by the visualized ORB-SLAM and dense point cloud-based TAP-map , thus providing data support for the construction of the vision SLAM solutions [3].

In the future, this problem will be solved mainly by real-time correction and compressing and screening the existing data. In the computer theoretical system, the concept of image optimization is that data are constructed for nodes and edges by the optimization of data nodes and data structures, and the pose localization of the mobile intelligent robot can be changed after introduction of the laser SLAM, thereby optimizing the combination of nodes and transforming the relationship between nodes into that between edges.

The midpoint coordinates of the mobile intelligent robot are constantly changed by Skin to Map, so the point map information represented by Pn is different, and the coordinates of Pn obtained will not overlap [4]. According to this calculation, the above problem of position and pose definition can be transformed into the relationship between edges with constraints between positions, so that we can master the environmental constraint features in large scenes, and solve the nodes by constraints, namely completing the process of map optimization.

The specific process is as follows:

The node P_0 is (x, y, 0), and P_n is (x, y, 0)

$$\begin{pmatrix} xj \\ yj \\ \theta j \end{pmatrix} = \begin{pmatrix} xi \\ yi \\ \theta i \end{pmatrix} + \begin{pmatrix} R_i^T \begin{pmatrix} xj - xi \\ yj - yi \end{pmatrix} \\ \theta j - \theta i \end{pmatrix}$$

After further conversion, the error function is obtained:

$$eij = \begin{pmatrix} x` \\ y` \\ \theta` \end{pmatrix} - \begin{pmatrix} x`` \\ y`` \\ \theta`` \end{pmatrix} = \begin{pmatrix} R_i^{\prime} \begin{pmatrix} xj - xi \\ yj - yi \end{pmatrix} \\ \theta j - \theta i \end{pmatrix} - \begin{pmatrix} x`` \\ y`` \\ \theta`` \end{pmatrix}$$

The offset between the two points is (xyo'y)

Its center is the conversion matrix

$$Pij = \begin{pmatrix} -R_i^T \dfrac{\partial R_i^T}{\partial \theta i} \begin{pmatrix} xj - xi \\ yj - yi \end{pmatrix} \\ 0 - 1 \end{pmatrix}$$

R=($0g$-ng), s=(x θ).

The construction optimization theoretical method is solved. In the real production workshop, all except for the starting points are uncertain unknowns, which are the very accurate data offset measured by the laser radar subsequently [5]. At this time, $\lambda = \Sigma neTe$, and the minimum error should be obtained.

The problem is converted and solved:

$min\lambda = \Sigma eTAyey$

For each eA, e

The first order is expanded by Taylor

Finally, the results are accumulated to obtain the sum, namely the approximate expansion:

It is simplified to: $Hij \triangledown Sij = -bij$

2.3.2. Basis for construction of sparse point cloud system

In the system, the ORB-SLAM2 algorithm is used to create the cloud map; the ORB-SLAM algorithm is improved on the basis of PTAM in two aspects: real-time loopback detection, and robustness enhancement tracking and real-time loopback detection, and ORB-SLAM2ORB-SLAM continues the original PTAM scheme, that is, the tracking class is constructed at multiple levels, and then the feature points are extracted [6].

Assuming that the P value was previously in grids, then we let the function M~(x) update the value in the function clamp, as shown below:

M~(x)=clamp(odds-'(odds(Ma»(x))·odds(Pm,)))

After Scan matching, the least squares method is used to optimize the optimal position of the point beam obtained in Scan in Submap after pose transformation, and this can be expressed as:

$$\arg\min \sum_{k=1}^{k} \left(1 - Msmooth\left(T_\eta h_k\right)\right)^2$$

Cartographer builds high-precision maps that meet the needs in all respects in large scenes by using multiple Submaps. The pose of the target matching with multiple LaserScans is accurate and reliable in a short time, but it needs to be corrected after a long time. Thus, the loopback detection is used at the back end to optimize the errors accumulated for a long time, and the Submaps created and the LaserScan of the current frame will be matched with Scan as input, as shown in Figure 1.

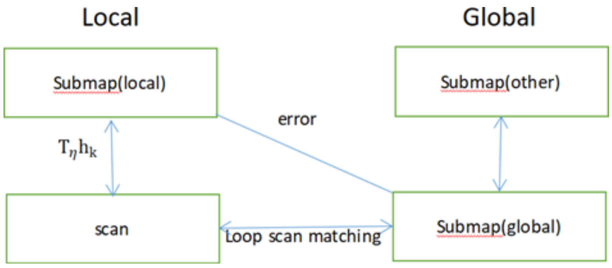

Figure 1. Scan and Submap diagram

This algorithm is used to optimize the pose errors between Scan and Submap in Figure 1, and then a smaller error is obtained. At present, the basic structures intelligent inspection robot produced in the market mostly adopt this system algorithm. We believe that with the development of the society, the technology will be further innovated and adapts to a wider range.

2.4. Function of intelligent obstacle avoidance

Robots un the Move-base framework can avoid obstacles more flexibly. Samples can be collected from the actual working state space at fixed time by DWA algorithm to meet the requirements of the robot motion model, and then the static route can be further optimized and improved to make the whole route conform to the scene of the actual production site [5], as shown in Figure 2.

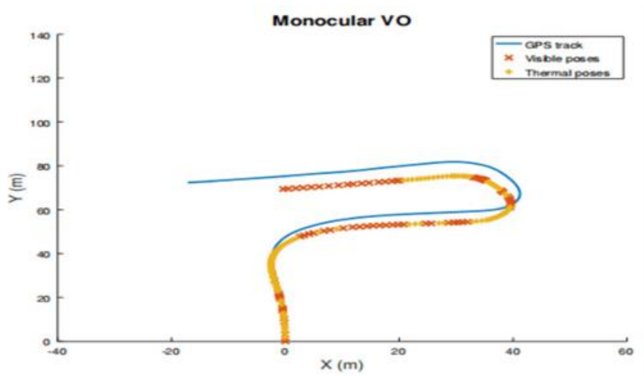

Figure 2. Trajectory map of intelligent obstacle avoidance

DWA (Dynamic Window Approach), an algorithm with the mechanism of selecting the velocity, needs to simulate the motion trajectory of the robot in a short time by combining it with the motion model of the robot, and control multiple groups of sampling velocity within a certain range according to the limitations of the robot itself and the surrounding environment. There are several constraints for this algorithm: there are constraints in the maximum and minimum velocities, acceleration, deceleration and other aspects of the robot for safety reasons, and the robot can avoid obstacles and advance towards the target at a higher speed in a shorter time [7].

This algorithm quickly reacts by route selection and simple calculation and gets the trajectory. After route selection, the dynamic trajectory is calculated based on the optimal velocity calculated. The whole operation process is simple and effective, and robots can run more intelligently, as shown in Figure 3.

There are infinitely many groups of velocities in the two-dimensional space of the velocity (v, w); according to the robot dynamics and map layout constraints, the sampling velocity is controlled in the specified range and a velocity sampling model is established:

Vn=(v, w)

There are limitations in the maximum and minimum velocities of robots:

VE[Vmin, Vmax]

WE[wmin, Wmax]

Limited by the hardware platform, mobile robots have a dynamic window for the maximum acceleration, and the velocity value in the window is the actual value that robots can reach:

[vE[vc-a2Δ, v.+a, Δ1]

we[w.-a, Δt, w.+a3Δ], where v. and w. are the current velocity states, a1 is the maximum linear acceleration, a2 is the maximum linear deceleration, a3 is the maximum angular acceleration, and a4 is the minimum angular acceleration.

The anti-collision constraints under the maximum deceleration condition are established:

v≤/2a2dist (v, w)

w≤J2a,

In the velocity state quantity of dist (v, w) sampling, the evaluation function is defined to select the optimal trajectory:

G (v, w)= σ (α heading(v, w)+β dist (v, w)+y velocity (v, w)).

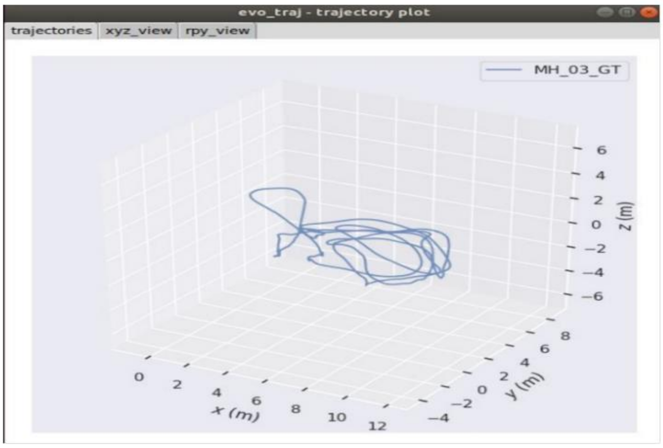

Figure 3. Optimal trajectory diagram of intelligent obstacle avoidance

The azimuth evaluation function is used to evaluate the angle difference between the direction of the end of the trajectory and the target at the current speed. dist (v, w) indicates the distance from the nearest obstacle to the current trajectory of the robot [8]. If there are obstacles in the environment of the site, the route will be abandoned. velocity (v, w) is used to evaluate the size of the velocity, and the value of velocity to the target point, with short motion time and small changes in velocity, is selected.

3. Conclusion and prospect

The system model is built by mapping and localization based on the SLAM algorithm; the laser SLAM adopts the Catgraph algorithm; the vision SLAM deploys the ORB and RTAP-map respectively; the dule-radar splicing provides richer feature information and improves the vision obstacle avoidance capacity of robots; the autonomous navigation algorithm, relying on the Move Base navigation framework, completes the optimization of the global optimal smooth trajectory by the minimum Snap optimization, completes the dynamic obstacle avoidance function with the DWA algorithm, achieves the design of the inspection external end of the custom orbit coordinates and fixed coordinate points under the ROS communication framework, and has the functions of control the motion of robots, mapping for navigation and publishing relevant information in the local area network.

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