基于视觉的工业机器人缝制作业系统设计

摘要

传统布料的缝制占用大量劳动力，人工操作效率较低，生产成本也在不断增加，而工业机器人的自动化生产对缝制行业发展十分有利。

本文要实现基于视觉的工业机器人缝制作业系统设计，首先用 D-H 参数法建立 UR5 机器人连杆坐标系，采用 Matlab 进行机器人模型仿真。然后进行机器人正运动学分析，得到从基坐标系到末端坐标系的齐次变换矩阵，采用分离变量法进行逆运动学分析，得到各个关节角的值，用微分变换法解雅克比矩阵得到 UR5 机器人三种奇异位形，最后通过 Matlab 验证正逆运动学的正确性。

采用 VS+OpenCV 进行基于机器视觉的布料形状识别，对图像进行灰度处理，使用中值滤波去噪、大津法进行二值化，Canny 算法进行边缘检测，采用霍夫线变换和圆变换识别布料形状，提取特征坐标点，通过 Matlab 的 camera calibrator 标定出相机内外参数。

采用笛卡尔空间 S 型速度的轨迹规划方法，对直线和圆弧轨迹的位置和姿态分别进行插补。接下来进行缝制布料的综合实验，将读取的布料像素坐标转换到基坐标系，作为末端轨迹的起点与终点，设置插补速度和加速度的范围和插补周期，对插补位姿求逆解得到对应的关节角度。最终 Matlab 的仿真效果较好，曲线连续，速度过渡平滑，不会造成机械系统的冲击，机器人拖动布料走出的轨迹比较稳定。

关键字：UR5 机器人；运动学分析；机器视觉；笛卡尔空间轨迹规划；布料缝制

Design of industrial robot sewing system based on vision

Abstract

The sewing of traditional fabrics takes up a lot of labor, the efficiency of manual operation is low, and the production cost is also increasing. The automated production of industrial robots is very beneficial to the development of the sewing industry.

In this paper, to realize the design of vision-based industrial robot sewing operation system, first use D-H parameter method to establish the UR5 robot link coordinate system, and use Matlab to simulate the robot model. Then, the robot's forward kinematics analysis is performed to obtain the homogeneous transformation matrix from the base coordinate system to the terminal coordinate system. The inverse kinematics analysis is performed using the separated variable method to obtain the value of each joint angle. The Jacobian matrix is solved by the differential transformation method to obtain UR5 Three singular configurations of the robot, and finally the correctness of forward and inverse kinematics is verified by Matlab.

Using VS + OpenCV for machine vision-based cloth shape recognition, gray-scale image processing, median filter denoising, Otsu method for binarization, Canny algorithm for edge detection, Hough line transformation and circle transformation for cloth recognition Shape, extract feature coordinate points, and calibrate the camera's internal and external parameters through Matlab's camera calibrator.

The trajectory planning method of S-speed in Cartesian space is used to interpolate the positions and postures of straight and circular trajectories respectively. Next, conduct a comprehensive experiment on sewing fabrics, convert the read fabric pixel coordinates to the base coordinate system, as the starting point and ending point of the end trajectory, set the interpolation speed and acceleration range and interpolation cycle, and calculate the interpolation pose The inverse solution gives the corresponding joint angle. In the end, Matlab's simulation effect is better, the curve is continuous, the speed transition is smooth, and it will not cause the impact of the mechanical system. The trajectory of the robot dragging the cloth is relatively stable.

Keywords: UR5 robot; kinematics analysis; machine vision; Cartesian space trajectory planning; cloth sewing