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Study on the Robotic Arm Trajectory Compensation System with Deviation

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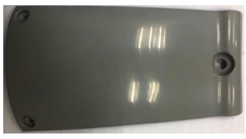
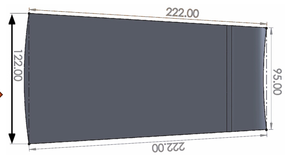
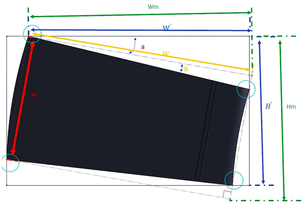
INTRODUCTION: This paper develops a trajectory compensation system for a robotic arm with offset perception. This system uses the concept of workpiece boundary projection and designs an offset calculation algorithm by comparing the dimensions of the workpiece drawings, correcting errors caused by missing corners of the workpiece. In terms of operation, the system uses photoelectric sensors to quickly scan the workpiece boundary and immediately calculate the displacement and rotational offset of the workpiece. Subsequently, when deviations occur due to different placement positions of the workpiece, the robotic arm's motion path and action must be corrected and compensated to maintain precision. Tests on selected workpieces show that the corrected rotational angle error is less than 0.4 degrees, and the translational error is less than 0.7 millimeters. Since these correction error values are lower than the 1.0 mm error threshold for the robotic arm's trajectory tracking control.

DEVIATION SENSING CALCULATION

Angle Offset calculation:

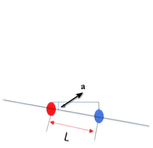


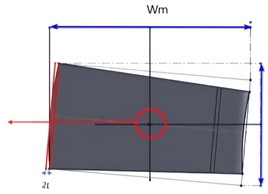




$$a = \frac{1}{2}sin^{-1}\left(\frac{H'^2+W'^2-H^2-W^2-W^2tan^2(\theta)+2WHtan(\theta)}{-2W^2tan(\theta)+2WH}\right) \qquad H_m = Hcos(a)$$
$$a = cos^{-1}\frac{H_m}{H}$$

Displacement offset calculations:

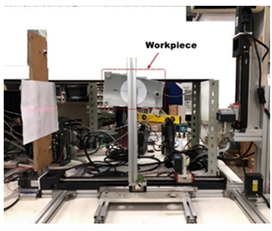




$$\Delta X = X'_c - X_c \qquad X_C = X_c' + Lcos(a)$$
$$\Delta Y = Y'_c - Y_c \qquad Y_C = Y_c' + Lsin(a)$$
$$\Delta Z = Z'_c - Z_c$$

EXPERIMENTAL PLATFORM OF DEVIATION SENSING AND 7-AXIS SUSPENDED ROBOTIC ARM

According to the needs of the manufacturer's automated production line for spray coating operations, the workpiece deviation angle ranges from 1 to 10 degrees, and the translation distance ranges from 1 to 15 mm.



Experimental Platform of the Deviation Sensing

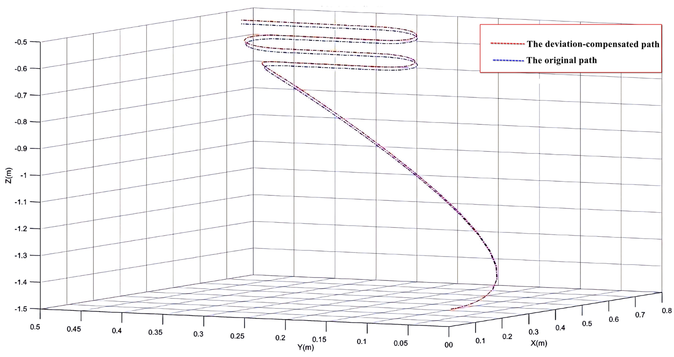
Experimental Platform of the Robotic Arm

EXPERIMENT OF THE ROBOTIC ARM TRAJECTORY COMPENSATION SYSTEM WITH DEVIATION SENSING

Testing results for workpiece angle and displacement

Workpiece Offset	Experimental displacement (mm)	Experimental angle (degrees)	Displacement error (mm)	Angle error (degrees)
Translation: 8 mm Rotation: 5 degrees	7.373	5.138	0.627	0.138
Translation: 12 mm Rotation: 5 degrees	11.359	5.367	0.641	0.367
Translation: 12 mm Rotation: 10 degrees	12.045	10.331	0.045	0.331

After the experimental tests, the three-dimensional trajectory tracking control results for the 7-axis suspended robotic arm are displayed in the following figure.



CONCLUSION

This study does successfully develop a robotic arm trajectory compensation system with deviation sensing capabilities. In the deviation sensing process, a method for calculating object offset is proposed. By using projection techniques, the shape and dimensions of the workpiece are obtained. When the workpiece is displaced, the new shape and dimensions are also captured through projection, allowing for the determination of the relationship between the two sets of dimensions. Due to the missing corners of the workpiece, large errors may happen in the deviation calculation, requiring further detailed correction of the method. The object offset calculation method is tested on an experimental platform, and the results show that the rotational angle error is less than 0.4 degrees, with a maximum rotational deviation error rate of 8.05%. The translation error is less than 0.7 mm, and the maximum translation deviation error rate is 5.54%, confirming the feasibility of this method. Furthermore, this deviation sensing approach is applied to the trajectory compensation experiment for a 7-axis suspended robotic arm. The results demonstrate that when the workpiece's angular and displacement offsets are known, the robotic arm can promptly adjust its initially planned processing path and posture in real time. Applying the robotic arm trajectory compensation system with deviation sensing to the manufacturer's automated spray coating production line significantly improved the precision and flexibility of the automatic coating operations, meeting the required standards for the manufacturer's spray operations.

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