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Investigation of a 7-Axis Suspended Robotic Arm for Automated Spraying System

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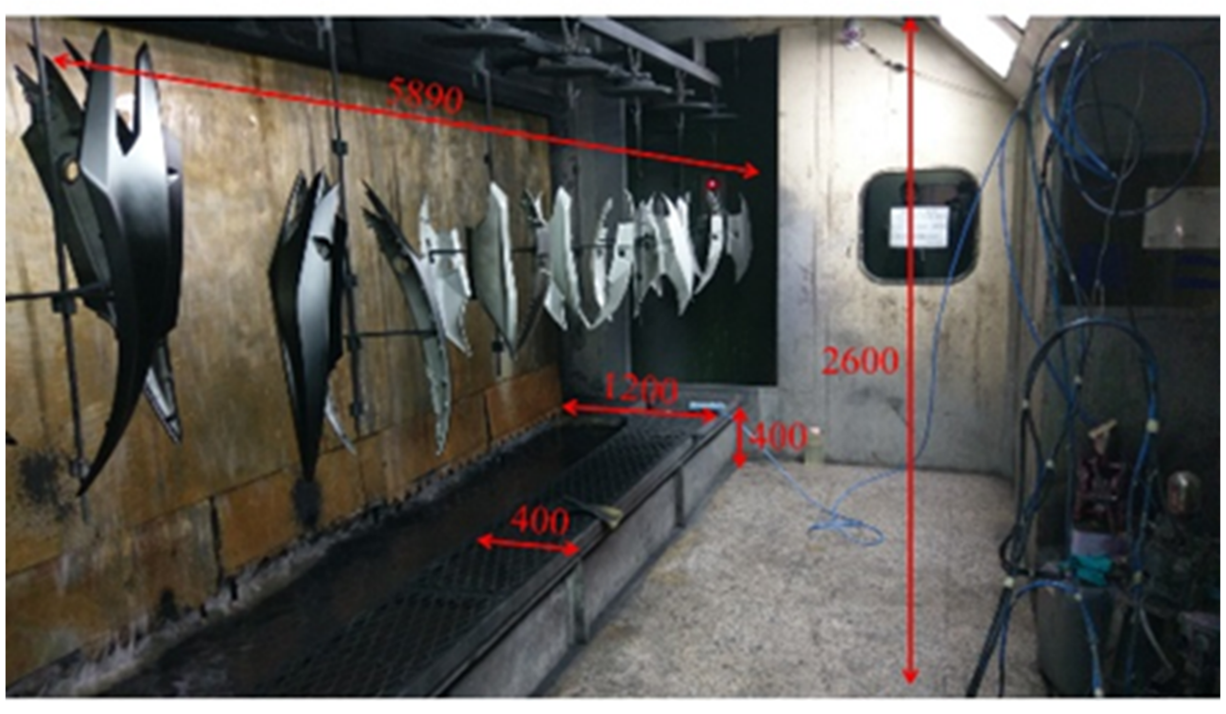
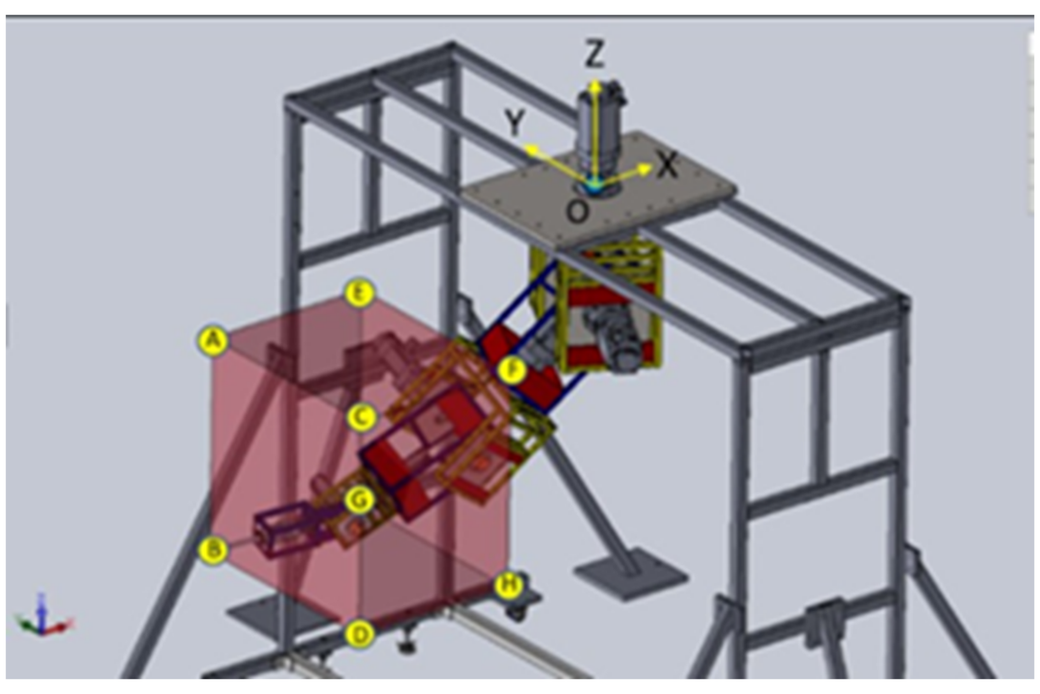
INTRODUCTION: The design and fabrication of the arm are completed according to specifications for structural strength, load capacity, rated torque output, and rotational speed. Kinematic analyses, both forward and inverse, are applied to determine the posture and position of the 7-axis robotic arm, facilitating the planning and design of the spraying trajectory. The control system architecture utilizes a multi-axis servo control board, integrated with a manifold deformation control method for trajectory tracking. The results from the simulations of MATLAB analyses show that the maximum tracking error is less than 0.4 mm. In experiments with the robotic arm, the maximum error is less than 0.7 mm. The results of the simulation and experiment are quite close, indicating that the deformation control method effectively operates the posture and movement of the 7-axis suspended robotic arm. Therefore, the 7-axis suspended robotic arm developed in this study will be effectively utilized in the production line of the automated spraying system.

STRUCTURAL DESIGN OF THE 7-AXIS SUSPENDED ROBOTIC ARM

Dimensions of the spraying area (mm)



The operational range in its spray job.

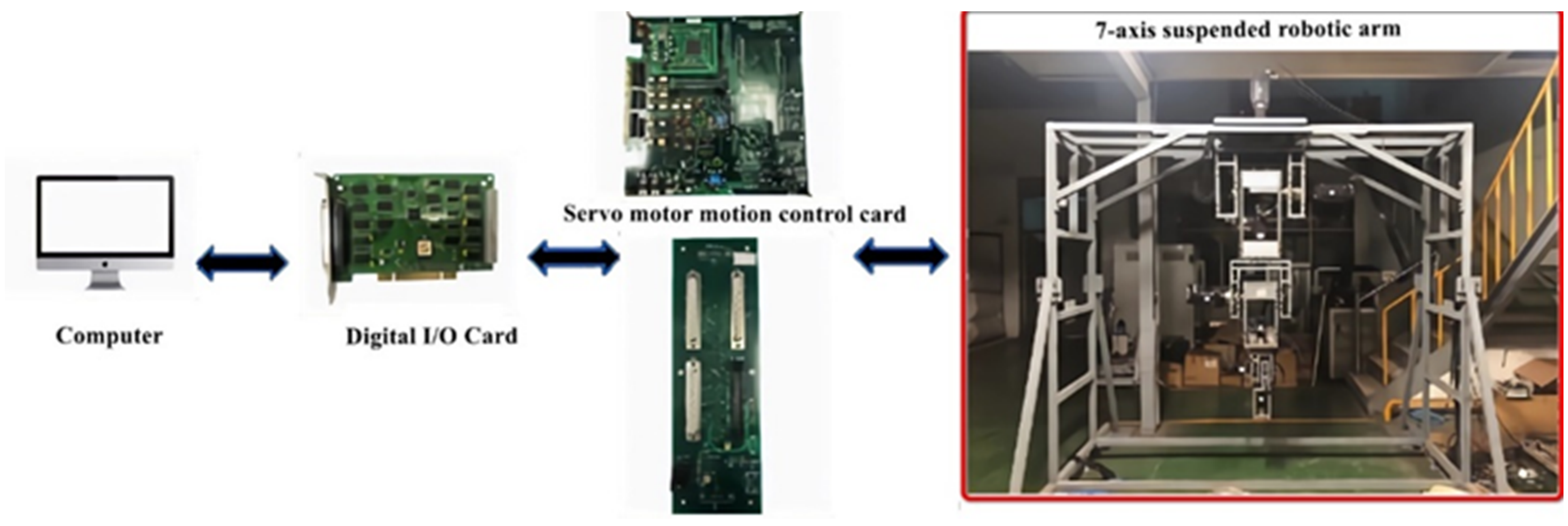


The coordinates of designated points within the workspace of the 7-axis suspended robotic arm

Eight corner points	X(mm)	Y(mm)	Z(mm)
A	-1435	475	-400
B	-1435	475	-1300
C	-1435	-425	-400
D	-1435	-425	-1300
E	-735	475	-400
F	-735	425	-400
G	-735	475	-1300
H	-735	-425	-1300

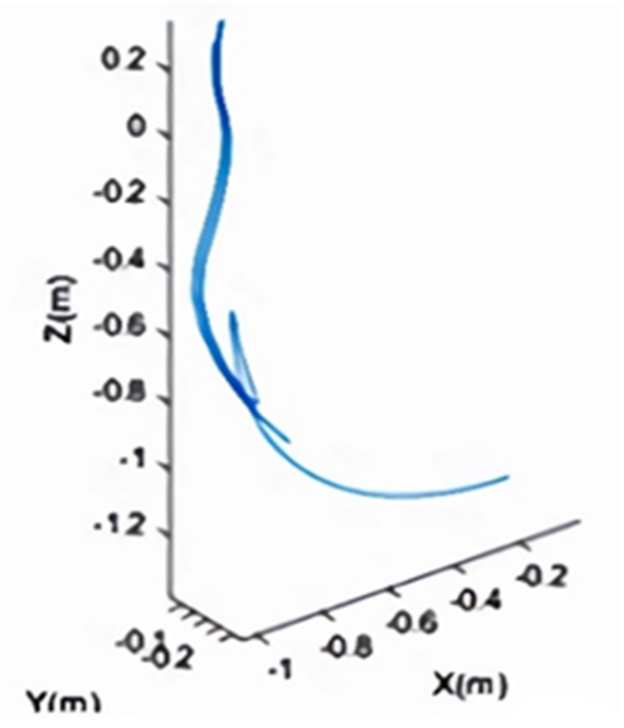
CONTROL SYSTEM OF THE 7-AXIS SUSPENDED ROBOTIC ARM

The control system architecture for the 7-axis suspended robotic arm



SIMULATION AND EXPERIMENTATION OF SPRAYING TRAJECTORIES FOR THE 7-AXIS SUSPENDED ROBOTIC ARM

Car Shell Spraying Path



Physical Car Shell for Spraying

Maximum Positional Error for Spraying Path in Car Shell

Axis	Simulation Path (mm)	Experiment path (mm)
x	0.378	0.700
y	0.267	0.198
z	0.192	0.566

CONCLUSION

This study successfully develops a 7-axis suspended robotic arm for an automated spraying system, considering factors such as flexible job, the dimensions of the spraying area, the shapes of the workpieces, and the degrees of freedom required for the robotic arm. Utilizing SolidWorks software, simulations confirm that the arm's end effector can reach all designated positions within the workspace. The physical design and manufacturing of the robotic arm are based on specifications regarding structural strength, load capacity, torque output, and speed. By applying both forward and inverse kinematics analyses, the arm's posture and position are determined, facilitating the planning and design of the spraying trajectory. The control system architecture contains a multi-axis servo control board integrated with a controller employing a manifold deformation control method for trajectory tracking. The simulation and experimental results using the car shell workpiece provided by the manufacturer indicate that the maximum tracking error in the simulations is less than 0.4 mm, while the experimental results show a maximum error of less than 0.7 mm. Despite slight discrepancies between simulation and experimental values, but the results are close, demonstrating that the manifold deformation control method effectively manages the posture and movement of the 7-axis suspended robotic arm. Overall, this research highlights the arm's potential for precise and flexible applications in automated industrial spraying processes.

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