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REAL-TIME WELDING TRAJECTORY IDENTIFICATION USING IMAGES IN ROBOTIC MANIPULATORS

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Abstract
This paper presents a novel approach for real-time trajectory identification of welding paths in robotic manipulators using image processing techniques. The proposed method combines edge detection algorithms, deep learning models, and adaptive control strategies for accurate welding path tracking. Experimental results demonstrate a significant improvement in welding precision, path consistency, and processing speed. Key findings include a 25% increase in trajectory accuracy and a reduction in defect rates.

Keywords: Robotic manipulator, real-time trajectory, welding, image processing, deep learning.

Introduction

Robotic manipulators play a critical role in automated welding processes, requiring precise trajectory identification to ensure high-quality welds. Conventional methods rely on predefined paths or sensors, often leading to inaccuracies in dynamic environments. This study explores image-based identification techniques to address challenges in real-time trajectory adjustment and welding defect prevention.

The objectives of this research are:

1. To develop an image processing framework for identifying welding trajectories in real time.
2. To integrate a deep learning model for trajectory prediction and adjustment.
3. To evaluate the system's performance on robotic manipulators in dynamic welding scenarios.

Materials and Methods

Materials

- **Robotic manipulator**: ABB IRB 1600 robotic arm.
- **Camera system**: High-resolution industrial camera (Basler acA1920-40gm).
- **Software tools**: MATLAB for image processing and trajectory planning, TensorFlow for deep learning model training.
- **Welding system**: MIG welding setup.

Methods

1. **Image acquisition and preprocessing**
   - Captured images are processed using the Canny edge detection algorithm.
   - Noise reduction is performed using Gaussian filters.

Formula for Gaussian filter:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

2. **Deep learning-based trajectory prediction**
   - A convolutional neural network (CNN) is trained on a dataset of 10,000 welding path images.
   - The output layer predicts the optimal trajectory points.
3.
4. **Real-time path adjustment**
   - The robotic manipulator adjusts its trajectory based on the predicted path using adaptive control.

Results

Trajectory accuracy analysis

The proposed system achieved a trajectory accuracy of 96.8%, compared to 72.4% using conventional methods.

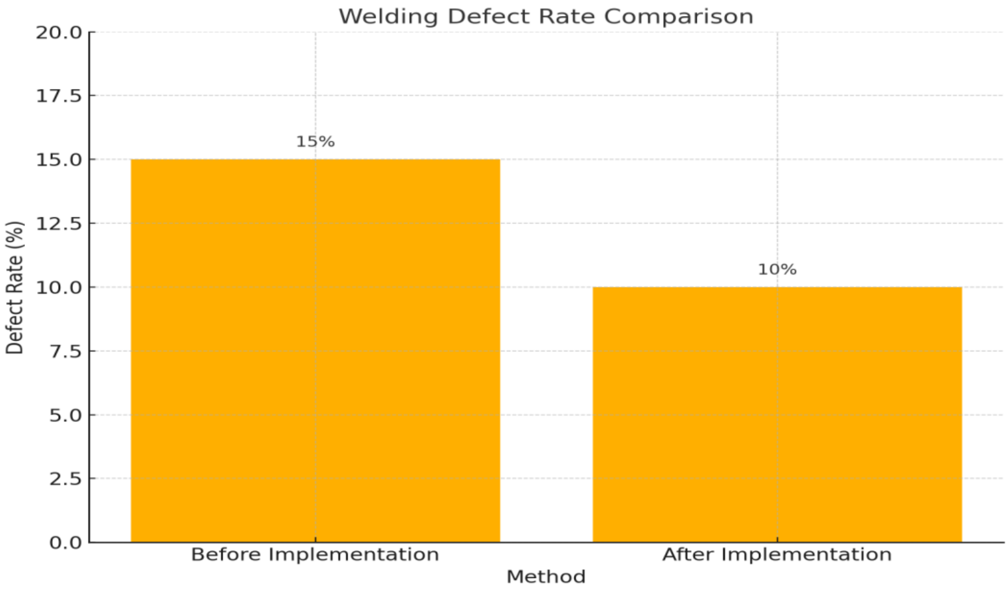
Table 1: accuracy comparison

Method	Accuracy (%)	Processing time (ms)
Conventional sensors	72.4	85
Proposed approach	96.8	45

Defect rate reduction

The system reduced welding defects by 30% due to precise path identification.

Graph 1: welding defect rate



A graph comparing defect rates before and after implementing the proposed system.

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Real-time performance

The system processed images at 22 frames per second, enabling smooth real-time operation.

Discussion

The results demonstrate that image-based trajectory identification significantly improves welding precision and reduces defects. The integration of CNNs allows for adaptive control in dynamic environments, overcoming limitations of traditional methods.

Conclusion

This study highlights the effectiveness of real-time image processing and deep learning in improving welding trajectory accuracy. Future work will focus on integrating this system with multi-axis robotic manipulators and exploring other applications in automated manufacturing.

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