Camera-Based Seam Tracking Using Active Contour Model

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ABSTRACT

In the recent decades much research has been performed in order to allow better control of arc welding processes, but the success has been limited. Closed-loop control requires the extraction of characteristic parameters of the welding groove close to the molten pool. The typical industrial solution is using laser scanner containing a camera as well as a laser source illuminating the groove. However, this solution is still suffering from some limitations which motivate us to find a camera solution without external illumination. In this project, we propose a novel image analysis scheme based on active contour model for close-to-arc seam tracking.

INTRODUCTION

Figures above illustrate seam tracking for pipe welding. The left figure shows a laser scanner solution which utilizes the monochromatic property of laser light to filter out the high-intensity interference using narrow band-pass filters. In this project, we develop a new camera solution without external illumination. A typical image captured without external illumination is shown in right figure. Our aim is to extract the four lines marked with color lines in real time.

METHOD

A Lightweight Line-Detection Snake

Due to the interference of high-intensity spatters and the poor illumination of the groove, the traditional edge detection techniques have found their difficulties to extract the lines. Herein, we develop a lightweight line-detection snake for close-to-arc seam tracking.

Energy Function of Line-Detection Snake

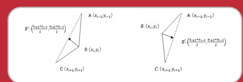
$$E_{snake} = \int \left\| (x_{ss}, y_{ss}) \right\|^2 - \left\| \nabla (G_\sigma * I)(x,y) \right\|^2 ds$$

Minimization of the Proposed Energy Function

Here we developed a modified Evolution Strategy, *(1,1)-ES with search-biased mutation*, to minimize the energy function.

(1,1)-ES with Search-Biased Mutation

Direction to minimize the internal force.

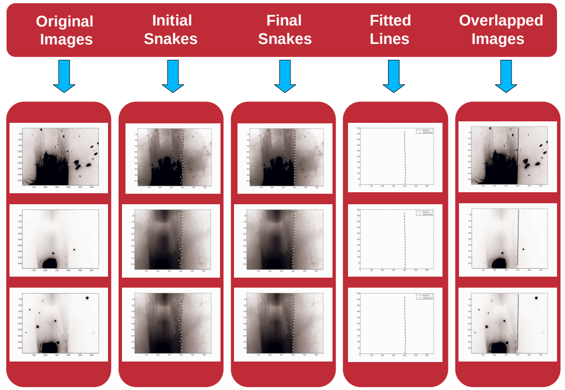


Direction to minimize the image-dependent force

Negative Gradient $\frac{-\nabla (G_\sigma * I)(x,y)}{\left\| \nabla (G_\sigma * I)(x,y) \right\|}$

A Scheme for Line-Detection from Image Sequences

RESULTS



The proposed snake has been tested on a image sequence captured during welding. The results show that the proposed snake can track the edges successfully and continuously. Three frames were selected and shown here.

CONCLUSIONS

For close-to-arc seam tracking without external illumination, we develop a lightweight line-detected snake, as well as a control points resampling technique which locates snakes from one frame to another. The experiments demonstrate the feasibility of the approach.