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Intelligentized Methodology for Arc Welding Dynamical Processes

Visual Information Acquiring, Knowledge Modeling and Intelligent Control

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Preface

Welding handicraft is one of the most primordial and traditional technics, mainly by manpower and human experiences. Weld quality and efficiency are, therefore, straitly limited by the welder's skill. In the modern manufacturing, automatic and robotic welding is becoming an inevitable trend. However, it is difficult for automatic and robotic welding to reach high quality due to the complexity, uncertainty and disturbance during welding process, especially for arc welding dynamics. The information acquirement and real-time control of arc weld pool dynamical process during automatic or robotic welding always are perplexing problems to both technologist in weld field and scientists in automation.

This book presents some application researches on intelligentized methodology in arc welding process, such as machine vision, image processing, fuzzy logical, neural networks, rough set, intelligent control and other artificial intelligence methods for sensing, modeling and intelligent control of arc welding dynamical process.

The studies in the book indicate that the designed vision sensing and control systems are able to partially emulate a skilled welder's intelligent behaviors: observing, estimating, decision-making and operating, and show a great potential and promising prospect of artificial intelligent technologies in the welding manufacturing.

The book is divided into six chapters: Chap. 1 gives an introduction on development of welding handicraft and manufacturing technology; Chap. 2 mainly addresses visual sensing systems for weld pool during pulsed Gas Tungsten Arc Welding (GTAW); Chap. 3 mainly address information acquirement of arc welding process by image processing methods, including acquiring two dimensional and three dimensional characteristics from monocular image of GTAW weld pool; Chap. 4 mainly addresses modeling methods of weld pool dynamics during pulsed GTAW, including identification of linear models and nonlinear transfer function models of weld pool dynamical process; artificial neural network models and knowledge models for predicting and control of weld pool dynamical characteristics; Chap. 5 mainly addresses intelligent control strategies for arc welding process, including self-regulating PID, fuzzy, PSD controllers, neural network self-learning controllers, model-free controller and composited intelligent controllers for dynamical weld pool during pulsed GTAW; Chap. 6 mainly addresses real-time control of weld pool dynamics during robotic welding process, including intelligentized

welding robot systems with real-time monitoring and control of weld pool dynamics; and an application of intelligentized welding robot systems.

The ordinal reading of this book has two outlines: one reading line is compiled by current outline, i.e., sensing, modeling and control methodology for welding process; the other by classifying of welding technics and conditions, or welding materials, e.g., bead-on-plate, welding with wire filler, gaps variation conditions; steel and aluminium alloy welding workpiece. Bead-on plate welding is addressed in Sects. 3.1.2.2, 4.1, 5.3.2. Welding with wire filler is mainly addressed in Sects. 2.2.2, 3.1.2.3, 3.2, 4.3.3, 5.6.4, 6.3. Gap variation condition is mainly addressed in Sects. 5.4.2, 5.6.2, 6.4.1. Aluminium alloy welding is mainly addressed in Sects. 2.3, 3.1.3, 3.2, 4.2.1, 4.4.2, 4.4.3, 5.1, 5.2.2, 5.6.3, 6.2.2, 6.3, 6.4. Steel welding is mainly addressed in Sects. 2.2, 3.1.2, 3.2.3, 4.2.2, 4.3, 5.2.2, 5.3.2, 5.6, 6.1.

The research results in this book were mainly implemented in the Intelligentized Robotic Welding Technology Laboratory (IRWTL), Shanghai Jiao Tong University, P R China. The content in the book involves the following doctoral dissertations: Dr. Yajun Lou, Dr. Dongbin Zhao, Dr. Guangjun Zhang, Dr. Jianjun Wang, Dr. Bing Wang, Dr. Laiping Li, Dr. Wenjie Chen, Dr. Quanying Du, Dr. Wemhang Li, Dr. Xixia Huang, Dr. Hongyuan Shen, Dr. Chongjian Fan, Dr. Fenglin Lv and Dr. Huabin Chen's works, etc. As a supervisor of their doctoral dissertations, Professor Shan-Ben Chen would like to thank their contributions to this book.

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List of Abbreviations

ANN	artificial Neural Network
BP	Backpropagation
BRDF	bi-directional reflectance distribution function
CCD	Charge Coupled Device
δ	pulse duty ratio
D_l	depression on length
D_w	depression on width
DWP	direct weld parameters
FA	function approximator
GTAW	Gas Tungsten Arc Welding
GMAW	Gas Metal Arc Welding
H_t	topside height
I_p	peak value current
I_p	peak value welding current
MIG	metal inert gas
MFC	model-free adaptive controller
MAG	metal active gas
MIMO	Multiple-Input Multiple-Out-put
OIPWPVCS	Obtaining and Image Processing of Weld Pool Vision Characteristics System
RS	Rough sets
SFS	Shape From Shading
SISO	Single-Input-Single-Output
V_f	wire feeding velocity
VPRS	variable precision rough set
V_w	welding velocity
W_t	topside width