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3D visual rapid robot programming system

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University of Wollongong

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Cantor, Diego Adolfo Rodriguez, 3D visual rapid robot programming system, Doctor of Philosophy thesis, Faculty of Engineering, University of Wollongong, 2008. <https://ro.uow.edu.au/theses/3120>

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3D VISUAL RAPID ROBOT PROGRAMMING SYSTEM

A thesis submitted in fulfilment of the requirements for the award of the
degree

Doctor of Philosophy (PhD)

From

UNIVERSITY OF WOLLONGONG

By

DIEGO ADOLFO RODRIGUEZ CANTOR

Master of Engineering Practice in Mechatronics

Electronics Engineer

FACULTY OF ENGINEERING

2008

CERTIFICATION

I, Diego Adolfo Rodríguez Cantor, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Diego Adolfo Rodríguez Cantor
27 January 2008

ACKNOWLEDGEMENTS

I wish to acknowledge the help and support provided by Professor John Norrish who has always had confidence in me. I also have to thank the advice given by Doctor Alex Nicholson throughout this work.

I can not forget to thank my marvellous wife Catherine who always gave me support and encouragement to accomplish this stage of my professional life.

CONTENTS

CONTENTS	<i>i</i>
LIST OF FIGURES	<i>iv</i>
LIST OF TABLES	<i>vii</i>
ABBREVIATIONS AND NOTATION	<i>ix</i>
ABSTRACT	<i>x</i>
1. INTRODUCTION	<i>12</i>
1.1 OBJECTIVE	<i>12</i>
1.2 BACKGROUND	<i>12</i>
2. LITERATURE REVIEW	<i>15</i>
2.1 REPAIR WELDING	<i>15</i>
2.2 ROBOTICS	<i>16</i>
2.2.1 On-Line Programming.....	<i>18</i>
2.2.2 Off-Line Programming	<i>19</i>
2.3 MACHINE VISION	<i>22</i>
Machine vision may be used to supplement off-line programming as described by Nicholson [7] or to provide a complete off-line programming solution.....	<i>22</i>
2.3.1 Camera Calibration and Lens Distortion.....	<i>22</i>
Additional conceptsts regarding optics that can be useful to the reader may be found in Appendix F.....	<i>23</i>
2.3.1.1 The Geometric Method (Tsai method).....	<i>23</i>
2.3.1.2 The Planes Method.....	<i>31</i>
2.3.1.3 Lens distortion	<i>34</i>
2.3.2 Concepts in Digital Image Processing	<i>35</i>
2.3.2.1 The RGB (Red, Green and Blue) colour model.....	<i>36</i>
2.3.2.2 The YUV colour model	<i>37</i>
2.3.3 Structured Lighting.....	<i>39</i>
2.4 TRIDIMENSIONAL SURFACE EXTRACTION	<i>42</i>
2.4.1 Non-Contact Techniques.....	<i>42</i>
2.4.2 Contact Techniques.....	<i>45</i>
3. PROPOSED SYSTEM DESCRIPTION	<i>47</i>
3.1 MAIN COMPONENTS.....	<i>47</i>
3.1.1 Camera.....	<i>48</i>
3.1.2 Graphic Interface and Processing Software	<i>51</i>
3.1.3 Structured Light	<i>52</i>
3.1.4 Welding Power Supply	<i>52</i>
3.1.5 Robotic Arm	<i>53</i>
4. SYSTEM IMPLEMENTATION	<i>55</i>
4.1 MAIN PROCESSING STAGES DESCRIPTION	<i>55</i>
4.1.1 Camera Calibration	<i>56</i>
4.1.2 Artificial Characteristic Points Extraction	<i>59</i>
4.1.2.1 Artificial Characteristic Points Extraction	<i>65</i>
4.1.3 3D Coordinates and Surface Estimation	<i>71</i>

4.1.4 Weld Path Generation	84
4.2 USER INTERFACE DESCRIPTION.....	95
4.2.1 Main Window	95
4.2.1.1 The Main Menu.....	97
4.2.1.2 “Points data” Control Group.....	100
4.2.1.3 “Calibration” Control Group.....	101
4.2.1.3 “Camera Control” Control Group.....	101
4.2.1.4 “Robot Commands” Control Group.....	101
4.2.2 Welding Parameters Window	103
4.2.3 Camera Calibration Window	107
4.2.4 Calculate Coordinates Window	108
4.2.5 Estimate Function Window.....	112
4.2.6 Toolboxes.....	115
4.2.7 Automatic Sequence	116
5. EXPERIMENT.....	121
5.1 EXPERIMENTAL METHODOLOGY.....	121
5.2 ARTIFICIAL FEATURE POINTS.....	123
6. EXPERIMENTAL RESULTS.....	130
6.1 LENS DISTORTION	130
6.2 CAMERA CALIBRATION METHOD.....	131
6.3 POINT CALCULATION METHOD.....	138
6.4 PROGRAM GENERATION	140
6.5 WELDING TRIALS (VALIDATION)	141
7. DISCUSSION.....	146
7.1 ARTIFICIAL FEATURE POINTS.....	147
7.2 CAMERA	150
7.2.1 Camera Calibration	151
7.3 SURFACE MAPPING.....	152
7.4 WELD PATH GENERATION.....	154
7.5 ROBOT PROGRAM CREATION	155
8. CONCLUSION AND RECOMMENDATIONS.....	157
8.1 CONCLUSIONS	157
8.2 RECOMMENDATIONS.....	158
9. REFERENCES.....	159
10. BIBLIOGRAPHY.....	164
APPENDIX A.	169
APPENDIX B.....	196
APPENDIX C	199
APPENDIX D.....	203
APPENDIX E: EQUIPMENT SPECIFICATIONS.....	205

<i>APPENDIX F. OPTICS.....</i>	<i>207</i>
<i>APPENDIX G. LASER SAFETY.....</i>	<i>212</i>
<i>APPENDIX H. SPATIAL ROTATION AND TRANSLATION.....</i>	<i>215</i>
<i>APPENDIX I. MINIMIZATION OF THE DISTANCE FROM A POINT TO A LINE... </i>	<i>219</i>

LIST OF FIGURES

Figure 2.3.1.1-1. Coordinate system definitions. [31]	25
Figure 2.3.1.1-2. Simple camera model	25
Figure 2.3.1.1-3. Projection of target point in Y-axis of image plane.	26
Figure 2.3.1.2-1. Two planes calibration method	31
Figure 2.3.1.3-1. Lens distortion	35
Figure 2.3.2.2-1. RGB colour cube	38
Figure 2.3.2.2-1. YUV colour cube for Y=0 and Y=1. [48]	39
Figure 2.4.1-1. Laser triangulation arrangement	43
Figure 3.1-1. Diagram of the proposed system	48
Figure 3.1.1-1. Marlin 046C camera used in the system	49
Figure 3.1.1-2. Marlin 046C camera specifications. [67]	50
Figure 3.1.1-3. Different views of camera attached to the end effector	51
Figure 3.1.4-1. Fronius welding power supply	53
Figure 3.1.5-1. ABB IRB1400 Robotic Arm	54
Figure 3.1.5-2. ABB SC4 robot controller unit	54
Figure 4.1-1. System general flow diagram	56
Figure 4.1.2-1. Histogram using weighting values	61
Figure 4.1.2-2. Laser points extraction flowchart	63
Figure 4.1.2-3. Extracted points sorting	64
Figure 4.1.2-4. Artificial feature points on a curved surface	64
Figure 4.1.2.1-1. Function $f(\alpha)$ plots	69
Figure 4.1.2.1-2. Conceptual points sorting process flowchart	70
Figure 4.1.3-1. Binocular projection (without z displacement)	72
Figure 4.1.3-2. Binocular projection (with z displacement)	73
Figure 4.1.3-3. Vectorial approach to calculate the 3D position of a point	75
Figure 4.1.3-4. Effect of noise on data	79
Figure 4.1.3-5. 3D plot before and after filtering	79
Figure 4.12.3-6. 2D Low pass filter	80
Figure 4.1.4-1. Projection of parallel lines on a non-flat surface	85
Figure 4.1.4-2. User selected point projected on the work-piece	86
Figure 4.2.1-1. User interface main window	96

Figure 4.2.1.1-1. User interface main menu.....	98
Figure 4.2.1.4-1. User interface “Move Robot” window.....	103
Figure 4.2.2-1. User interface welding parameters window.....	104
Figure 4.2.2-2. User interface welding parameters window menu.....	104
Figure 4.2.2-3. Communications between the robot and the power supply.....	107
Figure 4.2.3-1. Camera calibration window.....	108
Figure 4.2.4-1. Calculate coordinates window (first mode).....	109
Figure 4.2.4-2. Calculate coordinates window (second mode).....	110
Figure 4.2.4-3. Camera calibration window menu.	111
Figure 4.2.4-4. Circular and squared FIR filter plots in spatial frequency domain.	111
Figure 4.2.5-1. Estimate function window.....	112
Figure 4.2.5-2. Estimate function window (expanded).....	114
Figure 4.2.5-3. Estimate function window menus.....	114
Figure 4.2.6-1. Camera setup toolbox.....	115
Figure 4.2.6-1. Robot status toolbox.....	116
Figure 4.2.7-1. Main window with area specified by user.....	117
Figure 4.2.7-2. Typical configuration of “Options” menu for automatic mode operation.....	118
Figure 4.2.7-3. Extracted dots from the two shots during a coordinate calculation sequence.....	118
Figure 4.2.7-4. Two dimensional surface area plot.	119
Figure 5.1-1. Paper and aluminium versions of the calibration grid.....	122
Figure 5.2-1. Parallel laserdiode beams matrix.....	124
Figure 5.2-2. Laser projector device.....	125
Figure 5.2-3. Laser projector driver circuit enclosure.....	125
Figure 5.2-4. Laser projector driver circuit schematic.....	126
Figure 5.2-5. Parallel laser diode beams matrix assembly.....	127
Figure 5.2-6. Divergent laser diode beams matrix.....	127
Figure 5.2-7. Laser diode assembly.....	128
Figure 5.2-8. Pattern used in digital projector.....	128
Figure 5.2-9. Pattern used in projector.....	129
Figure 6.4-1. Approximation of a surface by line segments.....	141
Figure 6.5-1. Pipe used as target for welding trials.	142
Figure 6.5-2. Weld trial 1 on pipe.....	142

Figure 6.5-3. Weld trial 2 on pipe.....	143
Figure 6.5-4. Weld trial 3 on pipe.....	143
Figure 6.5-5. Various weld trials on pipe.....	143
Figure 6.5-6. Work object with two curves.	145
Figure 6.5-7. Weld trials on curved surface.....	145
Figure 7.1-1. High intensity light source being reflected by work piece.....	148
Figure 7.1-2. High intensity light source being reflected by work piece (shutter value reduced).....	149
Figure 7.1-3. Laser module being reflected by working object.....	150
Figure 7.3-1. Extracted feature points (left) and plot of estimated 3D coordinates (mm) before filtering (right).....	154
Figure 7.3-2. Plot of estimated 3D coordinates (mm) after filtering. Before tactile correction (left) and after correction (right).....	154
Figure 7.5-1. Area with lines drawn on it for manual program generation (point-to-point).....	156
Figure B-1. Area selected by user (test 1).....	196
Figure B-2. First set of dots extracted (test 1).	196
Figure B-3. Second set of dots extracted (test 1).	197
Figure B-3. 2-D plot of area and weld lines (test 1).	197
Figure B-4. 2-D Final welding result (test 1).	197
Figure B-5. Area selected by user (test 2).....	198
Figure B-6. 2-D plot of area and weld lines (test 2).	198
Figure B-7. 2-D Final welding result. (test 2).	198
Figure D-1. Sequence of shots of a tactile (Touch) sensing process.....	203
Figure F.1. Convex and Concave Lenses.....	207
Figure F.2. Focal length of a lens.	208
Figure F.3. Effect produced by a diffraction grating element . [86].....	209
Figure F.4. Pinhole camera.	210
Figure H.1. Translation of a point.....	216
Figure H.2. Coordinate Frame Attached to an Object.	216
Figure I.1. Distance form a pint to a line.	220

LIST OF TABLES

Table 6.1-1. Errors (mm) obtained with and without distortion factors in the calibration equation.....	131
Table 6.2-1. Errors (mm) obtained using different camera calibration methods and calculation techniques.....	132
Table 6.2-2. Errors (mm) obtained using different camera calibration methods and calculation techniques and only x-axis data.	134
Table 6.2-3. Errors (mm) obtained using different camera calibration methods and calculation techniques using only x-axis data. (f_x and f_y refined for planes methods).....	137
Table 6.3-1. Maximum and average errors (mm) obtained for different point calculation methods.	138
Table 6.3-2. Maximum and average errors (mm) obtained for different point calculation methods using only x-axis data.	139
Table 6.3-3. Maximum and average errors (mm) obtained for different point calculation methods using only x-axis data (f_x and f_y refined for planes methods).....	140
Table A1. Data set 1 of errors (mm) obtained using different camera calibration methods and different extraction techniques	169
Table A2. Data set 2 of errors (mm) obtained using different camera calibration methods and different extraction techniques	173
Table A3. Data set 1 of errors (mm) obtained using different camera calibration methods and different extraction techniques and only x-axis data.....	178
Table A4. Data set 2 of errors (mm) obtained using different camera calibration methods and different extraction techniques and only x-axis data.....	182
Table A5. Data set 1 of errors (mm) obtained using different camera calibration methods and different extraction techniques and only x-axis data (f_x and f_y recalculated for planes methods).	187
Table A6. Data set 2 of errors (mm) obtained using different camera calibration methods and different extraction techniques and only x-axis data (f_x and f_y refined for planes methods).	191
Table C1. Data set 1 of errors (mm) obtained with and without using distortion terms. ...	199
Table C2. Data set 2 of errors (mm) obtained with and without using distortion terms. ...	200
Table C3. Data set 3 of errors (mm) obtained with and without using distortion terms. ...	201
Table E1. Welding Power supply technical data. [84]	205
Table E1. Robot technical data. [85].....	206

<i>Table G.1. Tissues affected by laser exposure. [88]</i>	212
<i>Table G.2. Equivalence Between attenuation factor an optical density. [89]</i>	214

ABBREVIATIONS AND NOTATION

mm	millimetres
m	metres
mW	milliWatts
O_c	Projection focal point
x_f, y_f, z_f	Focal plane coordinate frame axes
x_i, y_i, z_i	Image plane coordinate frame axes
x_w, y_w, z_w	World frame axes
x_c, y_c	2 dimensional image camera frame axes
f	Focal distance
f_x	Focal distance in pixels (using the scale in x)
f_y	Focal distance in pixels (using the scale in y)
α_x	Image scale in x (pixels/mm)
α_y	Image scale in y (pixels/mm)
R	Rotation matrix
T	Translation matrix
\cdot	Dot product
\otimes	Cross product
$\ \ $	Norm

ABSTRACT

Robotic welding may be used to enhance quality and improve operating conditions in manufacturing and repair situations. However, it may be difficult to implement robot automation for some applications which involve non-repetitive tasks such as in repair and reclamation work. The present work was aimed to address some of the robotic automation difficulties that arise in such situations where it is necessary to rapidly generate a robot program for every different task, in particular for weld repair.

A technique for rapidly generating off-line robot programs for weld repair was developed in this work. The system proposed uses a single camera in order to obtain information about the object to be welded. To perform the task, it is not necessary to know the geometry of the system “*a priori*” although smoothness of the overall shape of the object is assumed. Artificial feature points are used with the aim of being able to obtain the characteristics of the shape of the object in 3 dimensions.

A software application was developed which provides the system with an easy to use interface, sequence control and data processing which in combination with a vision system and a tactile technique allows weld repair jobs to be performed on complex curved surfaces.

A review of two camera calibration techniques was carried out as well as a review of commercial devices and techniques used to map 3D surfaces. A modification to the

planes camera calibration method was suggested and tested. Two methods to estimate 3D coordinates were review and tested, additionally a combination of these two methods was also tested. Results showing the errors obtained with the various combinations of camera calibration methods and 3D estimation methods were obtained. A technique to “unfold” a three dimensional surface (i.e. to create a two dimensional representation of a three dimensional surface) was proposed and used as an essential part of the image data processing. Tests were performed to evaluate the system and encouraging results were obtained.