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DR. UNIV. ATTILA FARKAS

- Application of artificial intelligence in robotisation of arc welding and its practical use in military vehicle production -

Author's summary of (PhD) thesis

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NATIONAL UNIVERSITY OF BUPLIC SERVICE

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1. DESCRIPTION OF SCIENTIFIC PROBLEM

AQAP 2000 documents declare that quality management is a process where the participants of it – among them with high importance the industry - facilitate the development, creation and maintain of military capabilities from forming out of concept till disposal. The military vehicle production has dominant role in the Hungarian military equipment manufacturing when introducing of the quality management system also means the application of high quality and reliable production equipment. Such equipment is the welding robot in the field of welding.

Since the military vehicle manufacturing typically uses thicker plates arises the demand to apply robots with intelligent features with sensor technology at the robotisation of welding processes. Thus in my thesis I set such targets that can contribute to work in praxis in this field with high efficiency by means of the result of praxis orientated experimental processing of this theme.

2. TARGETS OF RESEARCH WORK

2.1 Make an overview about the possibilities where can be applied the artificial intelligence in robotisation of welding processes.

2.2 Give an overview about the different and typical types of sensors that make possible intelligent working of robots in arc welding.

2.3 Work out an investigation method that makes possible the planning of sensor parameters for arc sensor which is the most frequently applied type of sensor in robotisation of arc welding.

2.4 Investigate the possibility of application of contact electric sensor for butt joints at an actual military vehicle production project.

2.5 Investigate whether it is possible to expand the application of an expert system that is used for judging robot applicability for welding even for sensor technology by means of the methods described above and thus make possible to combine this two anyway independent field of artificial intelligence.

3. METHODS OF RESEARCH WORK

I applied analysis, synthesis, induction and experimental analysis as general methods of research work during my work. I made investigation in professional literature in two directions: expert systems in practical robot technology and adaptive robot systems first of all in welding applications particularly in points of contact of this two fields.

The working features of arc sensor I explored with experiments where I leaned on my previous results of my former experiments.

The possibility of application of contact electrical sensor for butt joint I investigated by means of experimental method.

4. SUMMARY OF RESEARCH WORK CHAPTER BY CHAPTER

4.1 In the first chapter I made an overview of fields of application of artificial intelligence in arc welding. Bearing in mind the main objectives of the thesis I studied particularly detailed different expert systems and robotics and within robotics the sensors that make possible intelligent working of welding robots.

4.2 The second chapter contains the description of my research works that I made with the most frequently used arc sensor investigating its application features. I described a new method that I introduced for determining the application features of arc sensors used for seam tracking at application of arc welding robots.

4.3 In the third chapter I described a new searching method that I introduced for expanding the field of effective application for welding butt joints as well where sensor body is the welding wire itself in the welding torch of the robot.

4.4 In the fourth chapter I described a model of a complex expert system that was made by me. This system expands the application area of a basic expert system (that was designed to investigate the basic possibility of robotisation of arc welding) to the robot application where robots have agent features. This system includes also the off-line technology knowledge base of arc sensor that was described in the second chapter and the knowledge base of contact electric sensor that was described in the third chapter. In this way I could join two fields of artificial intelligence: expert systems and robotics in order to increase the effective application of arc welding robots.

5. SUMMARY OF CONCLUSIONS

I fulfilled the targets of my research work with proper methods of investigation. I made an overview of the professional literature focused on expert system in arc welding and robotics among the areas of artificial intelligence. I investigated more detailed within this scope sensor technology that makes possible the agents capabilities of welding robots. I made experimental tests investigating the application technology of arc sensor that is one of the most frequently used sensors for

arc welding robots. The results of these tests make possible the technological off-line programming of arc sensor. I worked out a new searching method for contact electric sensor that makes possible to expand the possibility of application of this sensor to butt weld joints with high efficiency and accuracy as well. This investigation was especially actual at a military vehicle production project. Leaning on the knowledge base of these results of experiments with both sensor types I worked out a model of a complex expert system that helps technological off-line programming even by robots that have agent features. This has particular importance in production of military vehicles since the robotic welding of such vehicles can be realized in most cases only with robots they have agent features i.e. the appropriate sensor technology. These results in military vehicle production can be surely good applied because they fit correctly to the development of military quality management systems. This makes possible the production of military devices with higher efficiency and higher quality. The application of quality devices are essential parts of high level of NATO defense capabilities.

6. THESES – NEW SCIENTIFIC RESULTS

6.1. I found that application features of seam tracking arc sensor basically determined by the following factors:

- Kinetic features of the arc sensor
- The relation of correction speed necessary for successful seam tracking and technological parameters of application
- conditions of stable seam tracking process

6.2. Worked out a new method for testing application features of seam tracking arc sensor that is based on the investigation of the features mentioned in the first thesis. By means of this method it became possible to plan sensor parameters that provides possibility to expand the technological off-line programming to the programming of welding seams have to be welded with arc sensor.

6.3. I introduced a new searching method for application of contact electric sensor that expands its application area to butt weld joints as well.

6.4. I worked out a model of a complex expert system for robotisation of welding that merge two anyway separate scope of artificial intelligence: expert systems and robotics.

7. PRACTICAL APPLICATION OF RESULTS OF THE RESEARCHES

Results of this research work can be directly utilized in robotized welding of military vehicle production. Promote the introduction and development of military quality management system in production of military equipment excluding in higher level of human factor from the production.

8. RECOMMENDATIONS

I recommend for utilization of the results for those experts they are working in assuring technical conditions of introduction and operation of military quality management systems.

I recommend this for all companies they intend to investigate the possibility of mechanization and robotisation of their welding processes.

I recommend these results also those people they want to study a possibility of robotisation of a certain product.

I recommend the overview of literature and also the results of research work for graduate and postgraduate education of engineers first of all in applied robotics.

9. PUBLICATIONS RELATED THE SCOPE OF RESEARCHES OF THE PHD CANDIDATE

Books, lecture notes

1. Dr. Bauer F., Dr. Becker L., Farkas A., Dr. Palotás B., Tóth L.: Robottechnika, Hegesztőrobotok Jegyzet, BME Mérnöktovábbképző Intézet, Bp., 1988. ISBN 963-431-706-5
2. Dr. Farkas Attila: „A hegesztés gépesítése, automatizálása” c. fejezet „Hegesztés és rokon technológiák kézikönyv” GTE 2007. p.370-384 ISBN 978-963-42-0910-2

Conference lectures, papers

3. Farkas A.: Hegesztőrobotok szenzorai Mechatroninfo `88 konferencia Eger, 1988. november 15-17. pp. 182-193.
4. Dr. Bauer F., Dr. Becker L., Farkas A., REKARD-IGM Limat RT280 típusú hegesztőrobot állomás üzemeltetésével kapcsolatos tapasztalatok Mechatroninfo `88 konferencia Eger, 1988. november 15-17. pp. 101-113
5. Dr. Becker L., Farkas A., Gyura L., Bagyinszki Gy.: Hegesztőrobot alkalmazástechnikai laboratórium a BME Mechanikai Technológia Tanszéken VIII. Hegesztési Szeminárium, Sopron, 1990. okt.16-18. pp. 170-190.

6. Dr. Becker L., Farkas A.: hegesztőrobot alkalmazástechnikai kutatások a Budapest Műszaki Mechatroninfo `90 Nemzetközi konferencia, Kecskemét, 1990. nov. 13-16. pp. 221-228.
7. Wild W., Schaar T., Farkas A.: A munkadarab anyagának hatása a varratkövető induktív szenzor működésére Mechatroninfo `90 Nemzetközi konferencia Kecskemét, 1990. nov. 13-16. pp. 385-394.
8. Dr. Palotás B., Dr. Becker L., Farkas A.: Fogyóelektródás védőgázas ívhegesztések hegesztési paramétereinek számítása, és az elmélet alkalmazása ívhegesztő robtokhoz Mechatroninfo `90 Nemzetközi konferencia Kecskemét, 1990. nov. 13-16. pp. 284-298.
9. Dr. Palotás B., Dr. Becker L., Farkas A.: Some Aspects of flexible automation of welding technology INTERTECHNO `90 Nemzetközi konferencia, GTE Budapest, 1990. pp. 56-70.
10. Becker L., Farkas A.: Problems of off-line programming of welding parameters for arc welding robots Automated Welding Systems in Manufacturing. Int. Konf Gateshead (UK) 1991. nov. 17-19. Paper 14.
11. Farkas A.: how should we use arc parameter sensing? Automated Welding Systems in Manufacturing. Int.Conf., Gateshead (UK) 1991. nov. 17-19. Paper 13.
12. Farkas A.: Application of arc sensor for sema tracking MECHATRONINFO ´94 Joint Hungarian-British International Mechatronics Conference, Budapest 21-23 September 1994.
13. Farkas A.: Quality assurance with robotic welding with application of arc sensor Robotics in Alpe-Adria Region RAA '95 International Conference, Pörtschach 6-8 July 1995.
14. Dr. Farkas Attila, Meiszterics Zoltán: Alumínium fogyóelektródás védőgázas hegesztése kettősimpulzus-technika alkalmazásával X. Országos Hegesztési Tanácskozás Siófok- Balatonszéplak-felső 1998. április 23-24. pp.125-129.
15. Farkas A.: Hegesztőrobotok alkalmazásának biztonságtechnikai kérdései XI. Országos Hegesztési Tanácskozás, Budapest, 2002. március 28-29.
16. Dr. Farkas Attila: Többrobotos ívhegesztő rendszerek - új perspektívák a gazdaságos robotalkalmazásban XI. Nemzetközi és IV.GTE-MHtE-DVS Hegesztési konferencia Budapest, 2004. augusztus 23-26. pp.92-98
17. Dr. Farkas Attila: Hegesztő automaták és robotok alkalmazási tendenciái és gazdaságosságuk 26. Balatoni Ankét, 2005. október 27-29., Siófok pp.130-136
18. Dr. Farkas Attila – Barabás Péter Hegesztőrobotok bevezetésének tapasztalatai Magyarországon XII Nemzetközi Hegesztési Konferencia GTE 2008. május 15-17. Budapest, pp. 135-141. ISBN 978-963-7154-71-3
19. Dr. Farkas Attila: Hegesztő robotrendszerek biztonságtechnikája GTE 25. Jubileumi Hegesztési Konferencia, Budapest, 2010. május 19 – 21. pp.: 75-84. ISBN 978-615-5018-00-8
20. Dr. Farkas Attila. A robotosítás hatékony módszerei az acél- és gépszerkezetgyártásban GTE 25. Jubileumi Hegesztési Konferencia, Budapest, 2010. május 19 – 21. pp.: 367-377. ISBN 978-615-5018-00-8
21. Paszternák G. – Farkas A. – Palotás B. Szakértői rendszer hegesztőrobotok alkalmasságának vizsgálatára, GTE 25. Jubileumi Hegesztési Konferencia, Budapest, 2010. május 19 – 21. pp.: 379-389. ISBN 978-615-5018-00-8
22. Dr. Farkas Attila: A mesterséges intelligencia szerepe a hegesztés robotosításában. 26. Hegesztési Konferencia és Kiállítás, Budapest 2012. ISBN: 978-615-5018-28-2 pp. 45-51.

Articles

23. Konkoly, T. - Bauer, F. - Becker, L. - Bödök, K. - Farkas, A. - Palotás, B.: Tudományos kutatómunka a hegesztés területén Budapest, Gép, 41, 1989/10. pp.: 390-397. ISSN 0016-8572
24. Farkas A.: Szenzoralkalmazás a gépesített ívhegesztéseknél Hegesztéstechnika V. évf. 1994/2 pp. 23-33. ISSN 1215-8372
25. Dr. Attila Farkas Investigation of Application-technics for Gas Metal Arc Welding GÉP XLVII. Évf. 1996/9. pp 37-41. ISSN 0016-8572
26. Dr. Farkas Attila: Az ívhegesztés rugalmas automatizálásának lehetőségei 3. GTE-MhtE-DVS Közös Nemzetközi Hegesztési Konferencia GÉP, LI. évfolyam 2000. 6. szám pp.67-69. . ISSN 0016-8572
27. Dr. Farkas Attila, Lénárt Attila: Préssor kiszolgálása robotokkal Műszaki Magazin, X. évf. 12./2000. ISSN 1417-0132
28. Dr. Farkas Attila: Többrobotos ívhegesztő rendszerek. Metalfórum III. évf. 53. szám (2004. szeptember 13.), pp14-15 ISSN 1588-4627
29. ifj. Győri Károly, dr. Farkas Attila: Készülék nélküli ívhegesztő robotrendszer alkalmazási tapasztalatai Hegesztéstechnika, XVII. Évfolyam 2006/4. szám pp 5-8. ISSN 1215-8372
30. ifj. Győri Károly, dr. Farkas Attila: Készülék nélküli ívhegesztő robotrendszer alkalmazási tapasztalatai GÉP, LVIII. Évfolyam 2007. 1. szám p 33-38. ISSN 0016-8572

31. Dr. Farkas Attila – Barabás Péter: Hegesztőrobotok bevezetésének tapasztalatai Magyarországon Hegesztéstechnika XIX. Évfolyam, 2008. 4. szám pp. 15-18. ISSN 1215-8372

32. Dr. Farkas Attila – Barabás Péter: Hegesztőrobotok bevezetésének tapasztalatai Magyarországon Gépgyártás XLVIII. Évfolyam, 2008. 5-6 szám pp. 43-47. ISSN 0016-8580

33. Dr. Farkas Attila, Terék Gábor: Utánfutó tengelyek hegesztése készülék nélküli robotrendszerekkel Hegesztéstechnika XIX. Évf. 2008. 3. szám pp. 42-44. ISSN 1215-8372

34. Barabás Péter, Dr. Farkas Attila, Nagy Ferenc: Autódaru gém merevítő lamelláinak robotos hegesztése a Pylon-94 Kft-nél Acélszerkezetek 2009. 2. szám pp.86-88. ISSN 1785-4822

35. Dr. Farkas Attila: Robotosítás hatékony módszerei az acél- és gépszerkezetgyártásban Acélszerkezetek 2009. 4. szám pp .23-27. ISSN 1785-4822.

10. CV OF THE PHD CANDIDATE

Name: Dr. Attila FARKAS

Birth: Hódmezővásárhely, 28. 09. 1961..

Education:

1994.: Title Dr. Univ

1987-1989: Technical University of Budapest: welding engineer

1981-1986: Technical University of Budapest: mechanical engineering

1976-1980: High school: fine mechanics, electronic, and automatic

Sp. languages: English (sec., C), German (prim, C)

Jobs:

2007- Flexman Robotics Kft.- owner manager

2006-2007 REHM Kft.- director of div. for robotics

2000-2006 REHM Kft. leader of div. for robotics.

1997-: Weltec Bt. welding engineer expert for REHM Hegesztéstechnika Kft.

1997- Technical University of Budapest: invited teacher (see detailed below)

1989-1997: Technical University of Budapest, Dept. for Mechanical technology and Material Science: research assistant then Assistant Professor.

1986-1989: Research fellow in Hungarian Scientific Academy: theme: investigation of application of seam tracking arc sensor

Professional activity:

Main profession: welding and within this field robotics, automation of welding, welding equipment. I have started to study this scope during my university studies. I wrote students working on thesis and also my thesis for university degree. I took part in starting and operation of the welding robot laboratory of the Dept. for Mechanical technology and Material Science of Technical university of Budapest. I published the results of my researches regularly in international and domestic conferences. Actually I have been working as a leader of the Hungarian distributor of Yaskawa-Motoman that is one the world leader manufacturer of industrial robots.

Education activities:

Since 1997: invited teacher at the Technical University of Budapest in the following subjects:

- Robot application (in module of automation of manufacturing)
- Robotics I. (High School edu, Mechatronics)
- Welding equipment (welding engineer education)
- Automated Engineering in Welding (welding engineer education)
- Consultant

1986-1997: teacher at Technical University of Budapest in Department for mechanical Technology and Material Science , touched the following subjects:

- Robotisation of welding
- Robot application
- Robotics I. (in Mechatronics edu.)
- Automated Engineering in Welding (welding engineer education)
- Material science and testing - practices
- Technology of Metals - practices
- Welding practices
- Material Science I-II. (German)practices
- Robot application in manufacturing (English) practices

Working out the following adult educational programs and accreditation procedure has done by the National Institute for education Development at Flexman Robotics Kft:

- Robot-application technics (PL-3773) – 2009.
- Robot programming (PL-4007) – 2010.

Professional public activity:

A member of Subcommittee for Welding of Technological Committee of Hungarian Scientific Academy.

A member of leadership of Welding group of Hungarian Society for Mechanical Engineering.

A member of the Hungarian Chamber of Engineers 01-12310

Welding expert (G-D-11)

Robotics expert (G-K-10)

Awards

Honorary associated professor Budapest Technical University (2003.)

Medal of Association of Hungarian Society for Mechanical Engineering (2006.)

Budapest, 13.09.2012.