A method of hardware implementation of membrane computing architectures for mobile robot control

Victor ABABII, Viorica SUDACEVSCHI, Viorel CARBUNE, Silvia MUNTEANU, Victoria ALEXEI, Victor LASCO

Abstract

This paper proposes a method of hardware implementation of the membrane computing architecture for the control of a mobile robot. The basic idea is to use in the development of control systems the models of functional description of living cells, which should ensure a process of design, modeling and implementation based on cognitive models. The implementation algorithm presents a sequence of operations involving: functional development and modeling of Computing Cells, development and modeling of the topology of the membrane computing system (P-System), their implementation in hardware description languages (AHDL), and configuration of the FPGA circuit for realization of the control system. For validation and analysis of the performance of the Computing Cells, Petri Net models are used, which ensure the identification of the concurrent processes while maintaining a maximum parallelism. Functional testing of membrane computing models was performed based on the Quartus II development environment, the AHDL hardware description language, and the Altera DE0 Board.

Keywords: *membrane computing, mobile robot control, hardware implementation*

References:

1. *Gh. Păun, "Computing with Membranes", TUCS Report 208, 1998, ISBN 978-952-12-0303-9. Google Scholar*

2. *Gh. Păun and G. Rozenberg, "A guide to membrane computing", Theoretical Computer Science., vol. 287, no. 1, pp. 73-100, 2002, ISSN 0304-3975. CrossRef Google Scholar*

3. *Gh. Păun, "Introduction to Membrane Computing" in Applications of Membrane Computing, Springer Berlin Heidelberg, pp. 1-42, ISBN 978-3-540-29937-0.*

4. A. Alhazov, "Communication in Membrane Systems with Symbol Objects", Ph.D. Thesis, pp. 218, 2006. *Google Scholar*

5. A. Alhazov, "Small Abstract Computers. Habilitation", Thesis, pp. 255, 2013. *Google Scholar*

6. N. Siddique and H. Adeli, "Nature Inspired Computing: An Overview and Some Future Directions", Cognitive Computing, vol. 7, pp. 706-714, 2015. *CrossRef Google Scholar*

7. L.N. De Castro, "Fundamentals of natural computing: an overview", Phys Life Rev., vol. 4, pp. 1-36, 2007. *CrossRef Google Scholar*

8. Gh. Păun, G. Rozenberg and A. Salomaa, "DNA Computing: New Computing Paradigm" in Texts in Theoretical Computer Science, Berlin, Heidelberg:Springer, pp. 409, 1998, ISBN 978-3-540-64196-4. *Google Scholar*

9. M. Ridley, Evolution, Blackwell, pp. 751, 2004, ISBN 1-4051-0345-0. *Google Scholar*

10. D.J. Futuiama, Evolution, Sinauser Associates, pp. 655, 2013. *Google Scholar*

11. M. J. Dinneen, Y.-B. Kim and R. Nicolescu, "An Adaptive Algorithm for P System Synchronization", Proceedings of the Twelfth International Workshop on Membrane Computing (CMC11), pp. 1-26, 2011. *Google Scholar*

12. T. Wang, G. Zhang and M.J. Perez-Jimenez, "Fuzzy Membrane Computing: Theory and Applications", International Journal of Computers Communications Control, vol. 10, no. 6, pp. 144, 2015. *CrossRef Google Scholar*

13. "A Generic Guide for Using Membrane Computing in Robot Control", Advances in Computational Intelligence and Robots – Membrane Computing for Distributed Control of Robotic Swarms, pp. 86-96, 2017. *Google Scholar*

14. M. Diaz, Petri Nets: Fundamental Models Verification and Applications, Wiley, pp. 613, 2009, ISBN 978-1-84821-079-0. *Google Scholar*

15. M.A. Blatke, M. Heiner and W. Marwan, Tutorial: Perti Nets for Systems Biology, pp. 100, 2011. *Google Scholar*

16. E. Guţuleac, C. Boşneaga and A. Railean, "VPNP-Software tool for modeling and performance evaluation using generalized stochastic Petri nets", Proceedings of the 6-th International Conference on DAS-2002, pp. 243-248, 23-25 May 2002, ISBN 973-98670-9-X. *Google Scholar*

17. R.C. Cofer and B.F. Harding, "Rapid System Prototyping with FPGAs. Accelerating the Design Process", ScienceDirect, pp. 301, 2006, ISBN 978-0-7506-7866-7. *Google Scholar*

18. Altera DE0 Board, [online] Available: *https://www.terasic.com.tw/cgi-bin/page/archive.pl?No=364*. *Google Scholar*

19. V. Ababii, V. Sudacevschi, S. Munteanu, O. Borozan, A. Nistiriuc and V. Lasco, "IoT based on Membrane Computing Models", *Proceedings of the 13th International Conference on Electromechanically and Energy Systems (SIELMEN-2021), pp. 010-014, 7-8 October, 2021, ISBN 978-1-6654-0078-7.* [Google Scholar](#)

20. S. Munteanu, V. Sudacevschi, V. Ababii, O. Borozan, C. Ababii and V. Lasco, "Multi-Agent Decision Making System based on Membrane Computing", *The 11th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, vol. 2, pp. 851-854, 22-25 September, 2021, ISBN 978-1-6654-4210-7.* [View Article](#) [Google Scholar](#)

21. V. Sudacevschi, S. Munteanu, V. Ababii, R. Braniste, O. Borozan and V. Alexei, "Cognitive Computing System based on Distributed Knowledge", *the Extended Abstracts of the 10th International Conference on Electronics Communications and Computing ECCO-2019, pp. 98, 23-26 October 2019, ISBN 978-9975-108-84-3.* [Google Scholar](#)

22. J.-L. Gaivitto and M. Olivier, "The Topological Structure of Membrane Computing", *Repport de Recherche No. 70-2001, pp. 21.* [Google Scholar](#)