7th International Conference on "Experiments/Process/System Modeling/Simulation/Optimization"
7th IC-EPSMSO
Athens, 5-8 July, 2017

OPTIMIZATION OF CENTRAL PATTERN GENERATORS FOR DEFINING HUMAN LOCOMOTION

Abdalftah Elbori[1], Mehmet Turan[2], Kutluk Bilge Arikan[3]

[1] MODES Department, Atilim University, 06836, Ankara-Turkey
elbori.abdalftah@student.atilim.edu.tr
[2]Department of Mathematics Atilim University, 06836, Ankara-Turkey
mehmet.turan@atilim.edu.tr
[3]Department of Mechatronics Engineering, Atilim University, 06836, Ankara-Turkey
kutluk.arikan@atilim.edu.tr

Keywords: Central Patterns Generators (CPGs), Modeling of One leg of Human, stability analysis, Optimizing CPGs, Bidirectional two CPGs.

Abstract. *This paper explores the effect of bidirectional central pattern generators (CPGs) on the fitness function using the Genetic Algorithm. It approaches this issue from two broad perspectives: the first is concerned with answering the question "Do small changes in some CPG parameters result in different walking gaits?" and the second is concerned with answering the question, "What are the underlying constraints that render the optimization of bipedal locomotion in robots feasible?" These concerns can thus be seen as leading to one general objective: to investigate how bidirectional two CPGs can best be optimized to generate effective rhythmic movement patterns. This paper, however, takes as its assumption, that unlike uncoupled and unidirectional CPGs, which result in instability, optimizing bidirectional two CPGs do not only enhance movement but also produce rhythmic patterns akin to the rhythmic patterns derived from real data that is not provided with input or any sensory feedback.*

REFERENCES

[1] Larsen, J.C., *Central Pattern Generators in modern Science.*
[2] Ijspeert, A.J., *Central pattern generators for locomotion control in animals and robots: a review.* Neural Networks, 2008. **21**(4): p. 642-653.
[3] Yu, J., et al., *A survey on CPG-inspired control models and system implementation.* IEEE Transactions on neural networks and learning systems, 2014. **25**(3): p. 441-456.
[4] Billard, A. and A.J. Ijspeert. *Biologically inspired neural controllers for motor control in a quadruped robot.* in *Neural Networks, 2000. IJCNN 2000, Proceedings of the IEEE-INNS-ENNS International Joint Conference on*. 2000. IEEE.
[5] Bucher, D., et al., *Central pattern generators.* eLS, 2000.
[6] Casasnovas, B. and P. Meyrand, *Functional differentiation of adult neural circuits from a single embryonic network.* The Journal of neuroscience, 1995. **15**(8): p. 5703-5718.
[7] Van Vreeswijk, C., L. Abbott, and G.B. Ermentrout, *When inhibition not excitation synchronizes neural firing.* Journal of computational neuroscience, 1994. **1**(4): p. 313-321.
[8] Arikan, K.B. and B. Irfanoglu, *A Test Bench to Study Bioinspired Control for Robot Walking.* Journal of Control Engineering and Applied Informatics, 2011. **13**(2): p. 76-80.
[9] Elbori, A.E.G., M. Turan, and K.B. Arıkan, *Optimization of Central Patterns Generators.* 2017.
[10] Jiaqi, Z., et al., *Dynamic walking of AIBO with Hopf oscillators.* Chinese Journal of Mechanical Engineering, 2011. **24**(4): p. 612-617.
[11] Marbach, D., *Evolution and Online Optimization of Central Pattern Generators for Modular Robot Locomotion.* Unpublished Master Thesis, Swiss Federal Institute of Technology Lausanne, 2004.
[12] Williamson, M.M., *Robot arm control exploiting natural dynamics*. 1999, Massachusetts Institute of Technology.
[13] Arena, P., et al., *An adaptive, self-organizing dynamical system for hierarchical control of bio-inspired locomotion.* IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), 2004. **34**(4): p. 1823-1837.
[14] Inagaki, S., H. Yuasa, and T. Arai, *CPG model for autonomous decentralized multi-legged robot system—generation and transition of oscillation patterns and dynamics of oscillators.* Robotics and Autonomous Systems, 2003. **44**(3): p. 171-179.

[15] Inagaki, S., et al., *Wave CPG model for autonomous decentralized multi-legged robot: Gait generation and walking speed control.* Robotics and Autonomous Systems, 2006. **54**(2): p. 118-126.
[16] Ijspeert, A.J. and A. Crespi. *Online trajectory generation in an amphibious snake robot using a lamprey-like central pattern generator model*. in *Proceedings 2007 IEEE International Conference on Robotics and Automation*. 2007. IEEE.
[17] Crespi, A. and A.J. Ijspeert, *Online optimization of swimming and crawling in an amphibious snake robot.* IEEE Transactions on Robotics, 2008. **24**(1): p. 75-87.
[18] Arena, P. *A mechatronic lamprey controlled by analog circuits*. in *Proceedings of the 9th IEEE mediterannean conference on control and automation*. 2001.
[19] Taga, G., Y. Yamaguchi, and H. Shimizu, *Self-organized control of bipedal locomotion by neural oscillators in unpredictable environment.* Biological cybernetics, 1991. **65**(3): p. 147-159.
[20] Taga, G., *A model of the neuro-musculo-skeletal system for anticipatory adjustment of human locomotion during obstacle avoidance.* Biological Cybernetics, 1998. **78**(1): p. 9-17.
[21] Aoi, S. and K. Tsuchiya, *Locomotion control of a biped robot using nonlinear oscillators.* Autonomous robots, 2005. **19**(3): p. 219-232.
[22] Endo, G., et al. *Experimental studies of a neural oscillator for biped locomotion with QRIO*. in *Proceedings of the 2005 IEEE international conference on robotics and automation*. 2005. IEEE.
[23] Torres-Huitzil, C. and B. Girau. *Implementation of central pattern generator in an FPGA-based embedded system*. in *International Conference on Artificial Neural Networks*. 2008. Springer.
[24] Van den Kieboom, J., *Biped locomotion and stability: a practical approach.* 2009.
[25] Amrollah, E. and P. Henaff, *On the role of sensory feedbacks in Rowat–Selverston CPG to improve robot legged locomotion.* Frontiers in neurorobotics, 2010. **4**: p. 113.
[26] Alexander, R.M., *Optima for animals*. 1996: Princeton University Press.
[27] Nolfi, S. and D. Floreano, *Evolutionary robotics: The biology, intelligence, and technology of self-organizing machines*. 2000: MIT press.