AUTOMATIC RECONSTRUCTION OF THE CHARACTER AND TEMPERAMENT OF USERS BASED ON MULTI-AGENT TRAINING OF NEUROCOGNITIVE MODELS OF THE CONSCIOUS AND UNCONSCIOUS ACCORDING TO DATA ON USER BEHAVIOR IN THE INTERNET

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Annotation. The purpose of this study is to develop a system for teaching simulation models of users to the properties of character and temperament based on data on their behavior in the Internet. To model user behavior, the metaphor of designing an intelligent software agent is used; the agent is controlled on the basis of a multi-agent neurocognitive architecture, which is well suited for teaching specialized patterns of behavior of specific users, information about which can be collected in the Internet.

As a result of the study, the basic principles of imitation modeling of functional systems of unconscious and conscious cognitive processes were developed based on the invariant of a recursive multi-agent neurocognitive architecture. Algorithms for the simulation of functional systems of character and temperament based on the invariant of a recursive multi-agent neurocognitive architecture have been substantiated.

The results obtained can be used to develop basic principles, models, methods and algorithms for learning the invariant of a multi-agent neurocognitive architecture based on data on user behavior and mentions about it in the Internet space.

Keywords: artificial intelligence, behavior modeling, cognitive architectures, multi-agent systems, enveloping intelligence systems, predictive analytics

REFERENCES

1. Nagoev Z.V., Bzhikhatlov K.Ch., Nagoeva O.V., Sundukov Z.A., Kankulov S.A. Autonomous formation of a user model based on digital footprint data in the Internet space based on training multi-agent neurocognitive architectures. *Izvestiya Kabardino-Balkarskogo nauchnogo centra RAN* [News of the Kabardino-Balkarian Scientific Center of RAS]. 2020. No. 6 (98). Pp. 52–67. (In Russian)

2. Petukhov V.V. *Lektsii po obshchey psikhologii* [Lectures on general psychology]. Moscow: MGU. 1997. 597 p. (In Russian)

3. Shulgovsky V.V. *Vysshaya nervnaya deyatel'nost'* [Higher nervous activity]. Great Russian encyclopedia: 2005-2019. URL: https://bigenc.ru/biology/text/2337707. (In Russian)

4. Van Gulick R. Consciousness. The Stanford Encyclopedia of Philosophy, ed E.N. Zalta. 2018. URL: https://plato.stanford.edu/entries/consciousness/

5. Anokhin P.K. *Uzlovyye voprosy teorii funktsional'nykh sistem* [Key questions of the theory of functional systems]. Moscow: Nauka, 1980. 203 p. (In Russian)

6. Baars B.J. In the Theater of Consciousness. The Workspace of the Mind. Oxford: Oxford University Press. 1997. 88 p.

7. Shanahan M.P. A cognitive architecture that combines internal simulation with a global workspace. Consciousness and Cognition. 2006, 15, 433–449. DOI: 10.1016/j.concog.2005.11.005.

8. Franklin S., Madl T., D'Mello S., Snaider J. LIDA: a systems-level architecture for cognition, emotion, and learning. IEEE Transactions on Autonomous Mental Development. 2014. 6, 19–41. DOI: 10.1109/TAMD.2013.2277589.

9. Crick F., Koch C. The problem of consciousness. Scientific American. Special edition. 2002. Vol. 12. No. 1. Pp. 11–17.

10. Grossberg S. Towards solving the hard problem of consciousness: The varieties of brain resonances and the conscious experiences that they support. Neural Networks. Vol. 87. 2017. Pp. 38–95. https://doi.org/10.1016/j.neunet.2016.11.003

11. Luria A.R. *Yazyk i soznaniye* [Language and Consciousness]. Edited by E.D. Chomskaya. Moscow: MGU. 1979. 320 p. (In Russian)

12. Chalmers D. Facing up to the problem of consciousness. Journal of Consciousness Studies. 1995. No. 2(3). Pp. 200–219.

13. Dehaene S., Lau H., Kouider S. What is consciousness, and could machines have it? Science. 2017. Vol. 358. Pp. 486–492. DOI: 10.1126/science.aan8871.

14. Tononi G. Consciousness as integrated information: a provisional manifesto. Biol. Bull. 2008. 215. Pp. 216–242. DOI: 10.2307/25470707.

15. Floridi L. Consciousness, agents and the knowledge game. Mind Mach. 2005. No. 15. Pp. 415–444. DOI: 10.1007/s11023-005-9005-z.

16. Morin A. Possible links between self-awareness and inner speech. J. Conscious. Stud. 2005. No. 12. Pp. 115–134.

17. Holland O. Robots with internal models – a route to machine consciousness? J. Conscious. Stud. 2003. No. 10. Pp. 77–109.

18. Hesslow G. (2002). Conscious thought as simulation of behaviour and perception. Trends Cogn. Sci. 2002. No. 6. Pp. 242–247. DOI: 10.1016/S1364-6613(02)01913-7.

19. O'Regan J. K., Noë A. A sensorimotor account of vision visual consciousness. Behav. Brain Sci. 2001. No. 24. Pp. 939–973. DOI: 10.1017/S0140525X01000115.

20. Graziano M.S.A. The Attention Schema Theory: A Foundation for Engineering Artificial Consciousness image. Front. Robot. AI, 2017. 4:60. https://doi.org/10.3389/frobt.2017.00060

21. Igelström K., Webb T.W., Graziano M.S.A. Functional connectivity between the temporoparietal cortex and cerebellum in autism spectrum disorder. Cereb. Cortex. 2016. Vol. 27. No. 4. Pp. 2617–2627. DOI:10.1093/cercor/bhw079.

22. Reggia J.A., Katz G.E. and Davis G.P. Humanoid Cognitive Robots That Learn by Imitating: Implications for Consciousness Studies. Consciousness in Humanoid Robots. 2018. 5:1. DOI: 10.3389/frobt.2018.00001.

23. Manzotti R., Chella A. Good old-fashioned artificial consciousness and the intermediate level fallacy. Frontiers Robotics AI, 2018. 5:39. https://doi.org/10.3389/frobt.2018.00039

24. Linson A., Clark A., Ramamoorthy S., Friston K. The Active Inference Approach to Ecological Perception: General Information Dynamics for Natural and Artificial Embodied Cognition. Consciousness in Humanoid Robots. 2018. 5:21. https://doi.org/10.3389/frobt.2018.00021

25. Biehl M., Guckelsberger C., Salge C., Smith S.C., Polani D. Expanding the Active Inference Landscape: More Intrinsic Motivations in the Perception-Action Loop. Front. Neurorobot. 2018. 12:45. DOI: 10.3389/fnbot.2018.00045.

26. Winfield A. Why Did You Just Do That? Explainability and Artificial Theory of Mind for Social Robots. Frontiers in Artificial Intelligence and Applications Ebook. Vol. 335: Culturally Sustainable Social Robotics. 2020. Pp. 8–10. DOI: 10.3233/FAIA200892.

27. Cominelli L., Mazzei D., De Rossi D.E. SEAI: Social Emotional Artificial Intelligence Based on Damasio's Theory of Mind. Front. Robot. AI, 2018. 5:6. DOI: 10.3389/frobt.2018.00006.

28. Damasio A. The Feeling of What Happens: Body and Emotion in the Making of Consciousness. Spektrum Der Wissenschaft, 2000. 104 p.

29. Bosse T., Jonker C. M., Treur J. Formalisation of Damasio's theory of emotion, feeling and core consciousness. Consciousness and Cognition. 2008. Vol. 17, No. 1. Pp. 94–113. DOI:10.1016/j.concog.2007.06.006.

30. Kinouchi Y., Mackin K.J. A Basic Architecture of an Autonomous Adaptive System With Conscious-Like Function for a Humanoid Robot. Front. Robot. AI, 2018. 5:30. DOI: 10.3389/frobt.2018.00030.

31. Anderson J. Cognitive and psychological computation with neural models. IEEE Trans. Syst. Man Cybernet. 1983, 5. DOI: 10.1109/TSMC.1983.6313074.

32. Golden M. Stability and optimization analyses of the generalized brain state in a box neural network model. J. Math. Psychol. 1993. 37. Pp. 282–298. DOI: 10.1006/jmps. 1993. 1017.

33. Velde F. In Situ Representations and Access Consciousness in Neural Blackboard or Workspace Architectures. Front. Robot. AI, 2018. 5:32. DOI: 10.3389/frobt.2018.00032.

34. Balkenius C., Tjøstheim Trond A., Johansson B., Gärdenfors P. From Focused Thought to Reveries: A Memory System for a Conscious Robot. Front. Robot. AI, 2018. 5:29. DOI: 10.3389/frobt.2018.00029.

35. Chatila R. and et al. Toward Self-Aware Robots. Front. Robot. AI, 2018. 5:88. DOI: 10.3389/frobt.2018.00088.

36. Pei Wang, Patrick Hammer, Hongzheng Wang. An Architecture for Real-Time Reasoning and Learning. AGI 2020: Artificial General Intelligence, 2020. Pp 347–356. DOI: 10.1007/978-3-030-52152-3_37.

37. Nagoev Z.V. *Intellektika, ili myshleniye v zhivykh i iskusstvennykh sistemakh* [Intelligence, or thinking in living and artificial systems]. Nal'chik: Izdatel'stvo KBNTS RAN [KBSC of RAS Publishing House], 2013. 232 p. (In Russian)

38. Nagoev Z., Pshenokova I., Nagoeva O., Sundukov Z. Learning algorithm for an intelligent decision making system based on multi-agent neurocognitive architectures. Cognitive Systems Research. Vol. 66. 2021. Pp. 82–88. https://doi.org/10.1016/j.cogsys.2020.10.015.

39. Nagoev Z., Nagoeva O., Gurtueva I. Multi-Agent neurocognitive models of semantics of spatial localization of events. Cognitive Systems Research. Vol. 59. Pp. 91–102. DOI: 10.1016/j.cogsys.2019.09.015

40. Nagoev Z.V., Bzhikhatlov K.Ch., Pshenokova I.A. at el. Autonomous synthesis of spatial ontologies in the decision-making system of a mobile robot based on self-organization of multi-agent neurocognitive architecture. *Izvestiya Kabardino-Balkarskogo nauchnogo centra RAN* [News of the Kabardino-Balkarian Scientific Center of RAS]. 2020. No. 6 (98). Pp. 68–79. DOI: 10.35330 / 1991-6639-2020-6-98-68-79. (In Russian)

41. Pshenokova I.A., Sundukov Z.A. Development of a simulation model for predicting the behavior of an intelligent agent based on an invariant of a recursive multi-agent neurocognitive architecture. *Izvestiya Kabardino-Balkarskogo nauchnogo centra RAN* [News of the Kabardino-Balkarian Scientific Center of RAS]. 2020. No. 6 (98). Pp. 80–90. DOI: 10.35330 / 1991-6639-2020-6-98-80-90. (In Russian)

42. Anchokov M.I. Application of reinforcement learning to solve the problem of structuring the external environment. *Izvestiya Kabardino-Balkarskogo nauchnogo centra RAN* [News of the Kabardino-Balkarian Scientific Center of RAS]. 2020. No. 6 (98). Pp. 14–19. DOI: 10.35330 / 1991-6639-2020-6-98-14-19. (In Russian)

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