

# CURRICULUM VITAE

## **1. Personal Information**

**SURNAME:** *Borisyuk*

**FORENAMES:** *Roman Matveevich*

**DATE OF BIRTH:** 03 February 1951

**EDUCATION AFTER SCHOOL:** Mechanical and Mathematical Department of the Moscow State University, Moscow, USSR, 1968-1973

### **QUALIFICATIONS**

- Diploma of Higher Education in Mathematics (equivalent to **MSc**) from Moscow State University, USSR, 1973
- Candidate of Physical and Mathematical Sciences in Biophysics and Mathematical Biology (equivalent to **PhD**) from the Institute of Biological Physics of the USSR Academy of Sciences, 1984
- Doctor of Physical and Mathematical Sciences in Biophysics and Mathematical Biology (equivalent to **DSc**) from the Institute of Experimental and Theoretical Biophysics of the Russian Academy of Sciences, 1996.

### **MEMBERSHIP OF PROFESSIONAL BODIES**

- 1990-date Member of the Russian Neural Network Society
- Member of International Neural Network Society
- Member of Society for Industrial and Applied Mathematics (SIAM)

## **2. Appointments**

### **CURRENT APPOINTMENT IN THE UNIVERSITY AND DATE:**

**Professor of Computational Neuroscience (since 1 September 1999), Centre for Theoretical and Computational Neuroscience, School of Computing, Communication, and Electronics, faculty of Technology, University of Plymouth**

### **PREVIOUS APPOINTMENTS AND DATES**

- 1998-1999 Senior Research Fellow, School of Computing, University of Plymouth, since 30 March 1998 till 1 September 1999.
- 1990-date Head of Neural Networks Laboratory, Institute of Mathematical Problems in Biology (IMPB) of the Russian Academy of Sciences (former Research Computing Centre, RCC), Pushchino, Moscow Region, Russia (on leave from the Institute since 1998)
- 1996-97 Visiting Research Fellow, Systems Science Center, Arizona State University
- 1994-96 Associate Professor (Docent) of Mathematical Biology at the Pushchino State University, Russia
- 1985-90 Head of Computer Education Laboratory at RCC, Team leader of a project "Software for Education"
- 1975-90 Part-time Lecturer, Department of Biology, Moscow State University, Moscow, Russia
- 1975-85 Junior Research Associate, Laboratory of Mathematical Modelling, RCC
- 1973-75 Research Assistant, Laboratory of Mathematical Modelling, RCC

1973-95      Teacher of courses for gifted students in advanced mathematics, Pushchino High School.

### **3. Research Output**

#### **PUBLICATIONS:**

##### **Authored books**

1. **Borisyuk R.M.**, Kreitzer G.P. and Levitin V.V. (1989) The programming for biologists. 60pp, USSR Academy of Sciences (in Russian).
2. Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kovalenko E.I. and Kryukov V.I. (1986) New methods for analysing of neural activity. 200pp, USSR Academy of Sciences (in Russian).
3. Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kovalenko E.I. and Kryukov V.I. (1986) Metastable and unstable states in the brain. 167pp, USSR Academy of Sciences (in Russian).
4. **Borisyuk R.M.** (1981) Steady-states of ordinary differential equations with parameter. Method and software. 81pp, USSR Academy of Sciences (in Russian).

##### **Authored chapters in books**

5. **Borisyuk R.**, Borisyuk G., Kazanovich Ya. (2001) Temporal structure of neural activity and modelling of information processing in the brain. In: Emergent Neural Computational Architectures based on Neuroscience. S.Wermter, J. Austin, D. Wilshaw (eds.), Lecture Notes in Computer Science and Artificial Intelligence, LNAI Vol. 2036, Springer, 237-254
6. Borisyuk G.N., **Borisyuk R.M.** and Kazanovich Y.B. (2000). Models of temporal structure of neural activity and information processing in the brain. Book Chapter In: *Time and the Brain*, R. Miller (ed.) Harwood academic publishers, 331-349.
7. Borisyuk G., **Borisyuk R.**, Kazanovich Y. and Strong G. (2000) Oscillatory neural networks: Modeling binding and attention by synchronization of neural activity. Book Chapter In: *Oscillations in Neural Systems*, V.Brown, D. Levine, T. Shirey (eds.), Lawrence Erlbaum Assoc. Inc., pp 261-283.
8. Kazanovich Y.B. and **Borisyuk R.M.** (1996) Synchronization modes in neural networks of phase oscillators with a central element. In: *Studies in Mathematical Biology*, E.E. Shnol (ed.), 124-150, USSR Academy of Sciences (in Russian).
9. **Borisyuk R.M.** (1991) Interacting neural oscillators can imitate selective attention. In: *Neurocomputers and Attention. I: Neurobiology, Synchronization and Chaos*, A.V. Holden, V.I. Kryukov (eds), 189-200, Manchester University Press.
10. Kryukov V.I., Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B. and Kovalenko Ye.I. (1990) Metastable and unstable states in the brain. In: *Stochastic Cellular Systems: Ergodicity, Memory, Morphogenesis*, R.L. Dobrushin, V.I. Kryukov, A.L. Toom (eds), part III, 225-358, Manchester University Press.

11. **Borisyuk R.M.** and Urzhumtseva L.M. (1990) Dynamical regimes in a system of interacting neural oscillators. In: *Neural Networks: Theory and Architecture*, A.V. Holden, V.I. Kryukov (eds), 9-20, Manchester University Press.
12. Kirillov A.B., Borisyuk G.N., **Borisyuk R.M.**, Kovalenko E.I., Kryukov V.I., Makarenko V.I. and Chulaevsky V.A. (1989) A unified submodule for a model of attention. In: *Advance in Neural Information Processing Systems I*, D.S. Touretzky (ed.), 560-567, Morgan Kauffman, San Mateo, CA.
13. **Borisyuk R.M.** (1988) Round-table discussion neurocomputers. In: *Discussion on Neurocomputers*, V.I. Kryukov (ed.), 8-12, Pushchino, USSR Academy of Sciences (in Russian).
14. Kirillov A.B., Borisyuk G.N., **Borisyuk R.M.**, Kovalenko E.I., Kryukov V.I., Makarenko V.I. and Chulaevsky V.A. (1988) Short-term memory as a metastable state. IV. A model of neural oscillator for a unified submodule. In: *Cybernetics and Systems'88*, R. Trappl (ed.), 991-998, Kluwer.
15. Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kovalenko E.I. and Kryukov V.I. (1986) Short-term memory: Diffusion approximation. In: *Interactive Markov Processes in Biology*, R.L. Dobrushin, A.L. Toom, V.I. Kryukov (eds.), 88-97, USSR Academy of Sciences (in Russian).
16. Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kovalenko E.I., Kryukov V.I. (1984) Short-term memory as a metastable state. II. Simulation model. In: *Cybernetics and System Research*, R. Trappl (ed.), v.2, 266-271, Elsevier.
17. Kovalenko E.I., Kryukov V.I., Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B. (1982) Neuronal memory: computational model of CA3 field of the hippocampus. In: *Interactive Markov Processes and Applications for Biological System Modelling*, V.I. Kryukov (ed), 77-107, USSR Academy of Sciences (in Russian).
18. Borisyuk G.N., **Borisyuk R.M.**, Dunin-Barkovskii V.L., Kovalenko V.N. and Kovalenko E.I. (1978) Estimation of information capacity of Purkinje cells. In: *Lecture Notes in Mathematics*, 72-90, Springer-Verlag.
19. Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kovalenko E.I. and Kryukov V.I. (1978) Statistical estimations of synaptic weights for multidimensional neural activity. In: *Interactive Markov Processes and Biological Applications*, V.I. Kryukov (ed), 152-177, USSR Academy of Sciences (in Russian).
20. Borisyuk G.N., **Borisyuk R.M.**, Dunin-Barkovskii V.L., Kovalenko V.N. and Kovalenko E.I. (1977) Estimation of information capacity of Purkinje cells. In: *Interactive Markov Processes in Biology*, V.I. Kryukov (ed), 82-102, USSR Academy of Sciences (in Russian).

#### **Articles in journals (refereed)**

21. **Borisyuk R.** and Kazanovich Y. (2003) Oscillatory Model of Attention-Guided Object Selection And Novelty Detection. *Neural Networks*, under consideration
22. **Borisyuk R.** (2003) Models of the hippocampal theta rhythm. *Journal of High Nervous Activity (Zhurnal visshoi nervnoi deytel'nosti)* (in Russian), forthcoming.
23. **Borisyuk R.** and Kazanovich Y. (2003) Oscillatory neural network model of attention focus formation and control. *BioSystems*, forthcoming.

24. Borisyuk G.N., **Borisyuk R.M.**, Kazanovich Y.B., and Ivanitsky G.R. (2002) Modelling the dynamics of neural activity and information processing in the brain: the results of the decade. (*Uspekhi fizicheskix nauk – Physica - Uspekhi*), v. 172, N. 10, pp. 1189-1214 (in Russian),
25. Borisyuk G.N., **Borisyuk R.M.**, Kazanovich Y.B., Ivanitskii G.R. (2002) Models of neural dynamics in brain information processing - the developments of the decade. *PHYSICS-USPEKHI*, v. 45 (10), pp 1073-1095
26. **Borisyuk R.** (2002) Oscillatory activity in the neural networks of spiking elements. *BioSystems*, v. 67(1-3), pp. 3-16
27. Kazanovich Y., **Borisyuk R.** (2002) Object selection by an oscillatory neural network. *BioSystems*, v. 67(1-3), pp. 103-111
28. Stuart L, Walter M., and **Borisyuk R.** (2002) Visualisation of Synchronous Firing in Multi-dimensional Spike Trains. *BioSystems*, v. 67(1-3), pp. 265-278
29. **Borisyuk R.** (2001) Puzzle of chaotic neurodynamics. *Behav Brain Science*, v. 24, no. 5, October 2001, pp 812-813.
30. **Borisyuk R.**, Denham M., Kazanovich Y., Hoppensteadt F. Vinogradova O., (2001). Oscillatory Model of Novelty Detection. *Network: Computation in Neural System*, 12, 1-20.
31. **Borisyuk R.** (2000) Encyclopedia of computational neuroscience: The end of the second millennium. *Behavioral Brain Science*, 23, 534-535.
32. Denham M., **Borisyuk R.** (2000) A Model of Theta Rhythm Production in the Septal-Hippocampal System and its Modulation by Ascending Brainstem Pathways. *Hippocampus*, 10, 698-716.
33. **Borisyuk R.**, Borisyuk G. (2000) Complex Dynamics of Interactive Neural Oscillators. *Journal of Chaos Theory and Applications*, v.5, no. 2, pp. 45-62
34. **Borisyuk R.**, Denham M., Kazanovich Y., Hoppensteadt F. Vinogradova O. (2000). An Oscillatory Neural Network Model of Sparse Distributed Memory and Novelty Detection. *BioSystems*, v. 58, pp. 265-272
35. **Borisyuk R.**, Denham M., Denham S. and Hoppensteadt F. (1999) Computational models of predictive and memory-related functions of the hippocampus. *Reviews in the Neurosciences*, v.10, pp.213-232.
36. **Borisyuk R.**, Hoppensteadt F. (1999) Oscillatory model of the hippocampus: A study of spatio-temporal patterns of neural activity. *Biological Cybernetics*, v. 81, no.4, pp 359-371.
37. Kazanovich Y.B. and **Borisyuk R.M.** (1999) Dynamics of neural activity with a central element. *Neural Networks*, v.12, 149-161.
38. **Borisyuk R.**, Borisyuk G. and Kazanovich Y. (1998) Synchronization of neural activity and information processing. *Behavioral and Brain Sciences*, v.21, 833.
39. **Borisyuk R.M.** and Hoppensteadt, F. (1998) Memorizing and recalling spatial-temporal patterns in an oscillator model of the hippocampus. *Biosystems*, v.48, 3-10.
40. Cymbalyuk G., **Borisyuk R.**, Muller-Wilm U. and Cruse H. (1998) Oscillatory network controlling six-legged locomotion. Optimization of model parameters. *Neural Networks*, v.11, 1449-1460.
41. **Borisyuk R.**, Borisyuk G. and Kazanovich Y. (1998) The synchronization principle in modeling of binding and attention. *Memb. Cell Biol.*, v.11, 753-761.
42. **Borisyuk R.** (1998) Oscillatory neural network models of information processing in the brain. *European Journal of Neuroscience*, v.10, 268.
43. **Borisyuk R.**, Borisyuk G and Kazanovich Y. (1997) Pre-attention and attention modeling based on synchronization of neural activity. *Biologicheskije membrani, Journal of the Russian Academy of Sciences*, v.14, 614-620 (in Russian).

44. **Borisyuk R** and Borisyuk G. (1997) Information coding on the basis of synchronization of neural activity. *BioSystems*, v.40, 3-10.
45. **Borisyuk R**, Casolino M, DePascale MP, Morselli A, Picozza P, Ogurtsov A, Ricci M and Sparvoli R (1996) Gamma-ray energy determination using neural network algorithms for an imaging silicon calorimeter. *Nuclear Instruments & Methods in Physics Research*, A 381, 512-516.
46. Borisyuk G.N., **Borisyuk R.M.**, Khibnik A.I. and Roose D. (1995) Dynamics and bifurcations of two coupled neural oscillators with different connection type. *Bull. Math. Biol.*, v.57, 809-843.
47. Cymbalyuk G.S., Nikolaev E.V. and **Borisyuk R.M.** (1994) In-phase and anti-phase self-oscillations in a model of two electrically coupled pacemakers. *Biological Cybernetics*, v.71, 153-160.
48. Kazanovich Y.B. and **Borisyuk R.M.** (1994) Synchronization in a neural network with the central element. *Biological Cybernetics*, v.71, 177-185.
49. Borisyuk G.N., **Borisyuk R.M.** and Kazanovich Y.B. (1994) Modeling of preattentive and attentive information processing based on synchronization of neural activity. *Izvestiya Vuzov, Radiofizika*, v.8, 933-944 (in Russian).
50. Kazanovich Y.B. and **Borisyuk R.M.** (1994) Synchronization of phase oscillator neural network with a central element. *Mathematical Modeling*, v.6, 45-60 (in Russian).
51. **Borisyuk R.M.**, Borisyuk G.N. and Kazanovich Y.B. (1993) A role of mathematical modeling in brain research. *International Journal of Neurosciences*, v.74, 154.
52. Khibnik A.I, **Borisyuk R.M.** and Roose D. (1992) Numerical bifurcation analysis of a model of coupled neural oscillators. In: *International Series of Numerical Mathematics*, Birkhauser Verlag Basel, v.104, 215-228.
53. Borisyuk G.N., **Borisyuk R.M.**, Kazanovich Y.B. Luzyanina T.B., Turova T.S. and Cymbalyuk G.S (1992) Oscillatory neural networks. *Mathematical Modelling*, v.4, 3-43 (in Russian).
54. **Borisyuk R.M.** and Kirillov A.B. (1992) Bifurcation analysis of a neural network model. *Biological Cybernetics*, v.66, 319-325.
55. **Borisyuk R.M.** and Kirillov A.B. (1992) Bifurcation analysis of a neural network model. *Biol. Systems and Holonic Technology*, v.2, 153-162.
56. Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kovalenko E.I. and Kryukov V.I. (1986) Short-term memory as a metastable state. III. Diffusion approximation. *Cybernetics and System Research*, v.17, 169-182.
57. Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kovalenko E.I. and Kryukov V.I. (1985) A new statistical method for identifying interconnections between neuronal networks elements, *Biofizika*, v.30, 492 (in Russian).
58. Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kovalenko E.I. and Kryukov V.I. (1985) A new statistical method for identifying interconnections between neuronal networks elements, *Biological Cybernetics*, v.52, 301-306.
59. Goduhin O.V., Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B. (1982) Study of neuronal spike activity and interconnections between identified neurons in the rat neostriatum. *Neirofiziologiya*, v.14, 470-475 (in Russian).

60. Goduhin O.V., Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kovalenko E.I. and Kryukov V.I. (1981) Study of neuronal spike-train types and interconnection types in the neostriatum of the rat. *Neirofiziologiya*, v.13, 571-579 (in Russian).

#### Refereed conference contributions: papers

61. Borisyuk R.M., Vinogradova O.S., Denham M., Kazanovich Y.B., Hoppensteadt F. (2001) Model of novelty detection in the hippocampus based on frequency coding. In: *Neuroinformatics 2000*, Moscow, January 2000, abstracts, p. 26.
62. **Borisyuk R.**, Borisyuk G., Kazanovich Ya. (1999) Temporal structure of neural activity and modelling of information processing in the brain. In: *EmerNet: International Workshop on Emergent Neural Computational Architectures Based on Neuroscience*, S.Wermter, J. Austin, D. Wilshaw (eds.), Edinburgh, Scotland, September 1999, pp. 71-75.
63. **Borisyuk R.** Hoppensteadt (1999) Oscillatory model of the hippocampal memory. *International Joint Conference on Neural Networks, IJCNN'99*, Washington DC, July 1999, CD with the Conference Proceedings, no. 567.
64. **Borisyuk R.** and Borisyuk G. (1996) Complex dynamics of oscillatory neural networks. In: *International Conference of Selected Topics of Mathematics*, 135-136, Samarkand.
65. **Borisyuk R.M.** and Borisyuk G.N. (1995) Complex Dynamic behavior of oscillatory neural networks: examples and applications. In: *WCNN'95, World Congress on Neural Networks*, v.1, 330-333.
66. **Borisyuk R.** and Kazanovich Y. (1995) Synchronization of neural oscillators: Attention modeling. In: *Proceedings of Workshop "Supercomputing in Brain Research: from Tomography to Neural Networks" SCBR'94*, H.J. Herrmann, D.E. Wolf, E. Poeppel (eds.), 407-413, Juelich, Germany, World Scient. Publ. Co.
67. **Borisyuk R.M.**, Wickens J.R. and Kotter R. (1994) Reinforcement Learning in a Network Model of the Basal Ganglia. In: *Proc. 12 European Meeting on Cybernetics and System Research*, Trappl (ed), 1681-1686, EMCSR'94-Vienna.
68. **Borisyuk R.**, Casaleggio A., Kazanovich Y. and Morgavi G. (1994) Some results on the analysis of dimension of time series by a network of phase oscillators. In: *Proc. of Eur. Conf. on Artificial Neural Networks ICANN'94, Sorrento*, M. Marinaro, P. Morasso (eds.), v.1, 759-762, ICANN'94, Sorrento, Italy
69. **Borisyuk R.**, Borisyuk G., Kazanovich Y. and Strong G. (1994) Modeling of binding problem and attention by synchronization of multilayer neural activity. In: *IMACS International Symposium on Signal Processing, Robotics and Neural Networks*, 602-605, Lille, France
70. Borisyuk G.N., **Borisyuk R.M.** and Khibnik A.I. (1992) Analysis of oscillatory regimes of a coupled neural oscillator system with application to visual cortex modeling. In: *Neural Network Dynamics, Proceedings of the Workshop on Complex Dynamics in Neural Networks, Perspectives in Neural Computing*, J.G. Taylor, E.R. Caianiello, R.M.G. Cotterill and J.W. Clark (eds.), 208-225, Springer-Verlag.

71. Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kryukov V.I. and Singer W. (1990) Modeling of oscillatory activity of neuron assemblies of the visual cortex. In: *Proceedings of International Joint Conference on Neural Networks*, v.2: 431-434, San-Diego.

**Refereed conference contributions: abstracts**

72. Borisyuk R. (2001) Information coding in neural models of spiking elements with external forcing. 4th International Workshop on Neural Coding, September 2001, Plymouth, Abstract Book, pp. 22-24, University of Plymouth
73. Stuart E., Walter M., Borisyuk R. (2001) Visualisation of multi-dimensional spike-trains. 4th International Workshop on Neural Coding, September 2001, Plymouth, Abstract Book, pp. 47-48, University of Plymouth
74. Kazanovich Ya., Borisyuk R. (2001) Object selection by an oscillatory neural network. 4th International Workshop on Neural Coding, September 2001, Plymouth, Abstract Book, pp. 55-57, University of Plymouth
75. Borisyuk R (2001) Neural interactions and macrodynamics of neural activity. Sixth SIAM conference on applications of dynamical systems, May 2001, Snowbird, Abstracts, pp 62, SIAM.
76. Borisyuk R (2001) An oscillatory model of memory formation. 5<sup>th</sup> International Conference on Cognitive and Neural Systems, Processing, Boston University, May 2001, #20.
77. Borisyuk R, Kazanovich Y (2001) Oscillatory model of sparse coding for novelty detection. 5<sup>th</sup> International Conference on Cognitive and Neural Systems, Processing, Boston University, May 2001, #19.
78. Borisyuk R. (2000) A computational model of the septal pacemaker. In: Ninth Annual Computational Neuroscience Meeting, Brugge, Belgium, July 2000, Abstracts, p. 21.
79. Denham M., Borisyuk R. (2000) Computational modelling of septo-hippocampal theta-rhythm production. In: Ninth Annual Computational Neuroscience Meeting, Brugge, Belgium, July 2000, Abstracts, p. 38.
80. Borisyuk R. (2000) Computational modelling of septal pacemaker. In: European Journal of Neuroscience, v. 12, supplement 11, Forum of European Neuroscience, Abstract Book, p. 241.
81. Kazanovich YA., Borisyuk R. (2000) Oscillatory neural model of memory formation and novelty detection in the hippocampus. In: XXX Workshop on problems of higher nervous activity, 150 anniversary of I.P.Pavlov, St. Petersburg, May 2000 (in Russian).
82. Borisyuk R.M., Vinogradova O.S., Denham M., Kazanovich Y.B., Hoppensteadt F. (2000) Model of novelty detection in the hippocampus based on frequency coding. In: Neuroinformatics 2000, Moscow, January 2000, abstracts, p. 26.

83. Borisyuk R.M., Vinogradova O.S., Denham M., Kazanovich Y.B., Hoppensteadt F. (2000). In: Proceedings of Neuroinformatics 2000, Moscow, January 2000, MIFI, v.1, pp 145-156 (in Russian)
84. Borisyuk R., Denham M., Hoppensteadt F., Kazanovich Ya., Vinogradova O. (1999) Oscillatory model of novelty detection in the hippocampus. The Third International Workshop on Neuronal Coding, Osaka, Japan, 11-15 October, 1999, Program and Abstracts, p. 215.
85. Borisyuk R., Borisyuk G., Kazanovich Ya. (1999) Temporal structure of neural activity and modelling of information processing in the brain. In: EmerNet: International Workshop on Emergent Neural Computational Architectures Based on Neuroscience, S.Wermter, J. Austin, D. Wilshaw (eds.), Edinburgh, Scotland, September 1999, pp. 71-75.
86. **Borisyuk R.** Hoppensteadt (1999) Oscillatory model of the hippocampal memory. *International Joint Conference on Neural Networks, IJCNN'99*, Washington DC, July 1999, Abstracts, no. 567.
87. Denham M.J. and **Borisyuk R.M.** (1999) An oscillatory model of the septal-hippocampal inhibitory circuit and the modulation of hippocampal theta activity. *Cognitive and Neural Systems Conference. Boston -99*.
88. **Borisyuk R.**, Denham M. and Hoppensteadt F. (1999) Oscillatory model of novelty detection in the hippocampus. *Cognitive and Neural Systems Conference. Boston -99*.
89. **Borisyuk R.** and Denham M. (1999) A study of oscillatory activity in the model of septo-hippocampal system. *Proc. of the Fifth SIAM Conference on Dynamical Systems and Applications*, p.
90. **Borisyuk R.**, Hoppensteadt F. and Vinogradova O. (1998) Computational models of theta-rhythm septal generator. *Proceedings Second International Conference on Cognitive and Neural Systems*, 48, Boston University.
91. **Borisyuk R.** and Borisyuk G. (1997) Synchronization in neural networks with integrate and fire elements. *International Symposium "Electric Activity of the Brain: Mathematical Models and Analytical Methods". Abstracts*, 5, USSR Academy of Sciences (in Russian).
92. **Borisyuk R.** and Hoppensteadt F. (1997) Analysis of amplitude and frequency patterns in a segment model of the hippocampus. *International Workshop "Neuronal Coding '97". Abstracts*, 4, INRA Versailles, France.
93. **Borisyuk R.** and Hoppensteadt F. (1997) Memorizing spatial-temporal patterns in oscillator models of the hippocampus. *International Workshop "Neuronal Coding '97". Abstracts*. 3, INRA Versailles, France.
94. **Borisyuk R.** and Borisyuk G. (1995) Information coding on the basis of synchronization of neural activity. In: *International Workshop "Neuronal Coding". Abstracts*, 6, Prague, Center for Theor. Study.
95. **Borisyuk R.M.**, Borisyuk G.N. and Kazanovich Y.B. (1993) Mathematical models of binding problem. In: *24th Annual Meeting of European Math. Psychology Group*, Moscow'93, Abstracts, 1pp
96. **Borisyuk R.M.**, Borisyuk G.N. and Kazanovich Y.B. (1993) A role of mathematical modeling in brain research. In: *11th International Australian Winter Conference on Brain Research, Abstracts*, 42.

97. Borisyuk G.N., **Borisyuk R.M.** and Khibnik A.I. (1992) Bifurcation analysis of a coupled neural oscillator system with application to visual cortex modeling. In: *Abstracts of Neural Information Processing Systems'92*, Colorado, USA, 1pp.
98. Borisyuk G.N., **Borisyuk R.M.** and Khibnik A.I. (1992) Bifurcation analysis of a coupled neural oscillator system with application to visual cortex modeling. In: *Abstracts of European Conference on Neural Mechanisms of Learning and Memory*, 33-34, Limerick, Ireland.
99. Borisyuk G.N. and **Borisyuk R.M.** (1992) Oscillatory models of visual cortex. In: *BIOMOD-92. Abstracts*, 2, Leningrad (in Russian).
100. Borisyuk G.N., **Borisyuk R.M.** and Khibnik A.I. (1992) Numerical bifurcation analysis of a coupled neural oscillators model with application to visual cortex modelling. In: *Conference of Former Soviet Republics on Theory of Differential Equations. Abstracts*, 26, Samarkand, Uzbekistan
101. **Borisyuk R.M.** (1992) A model of neural network for storage and retrieval of temporal sequences. In: *The RNNS/IEEE Symposium on Neuroinformatics and Neurocomputers*, v.2, 865-869, Rostov-on-Don, Russia.
102. **Borisyuk R.M.** (1990) A model of the neural networks for storage and retrieval of temporal sequences. In: *International Neural Networks Conference, Paris-90*, v.2, 788, Paris, France.
103. **Borisyuk R.M.** and Urzhumtseva L.M. (1989) Dynamical modes of system of interactive neural oscillators. In: *Proceedings of 9th USSR Conference on Cybernetics*, 346-347, Rostov State University, Russia (in Russian).
104. **Borisyuk R.M.** (1989) Interacting neuronal oscillators can imitate the selective attention. In: *International Workshop "Neurocomputers and Attention". Extended Abstracts*, 39-40, USSR Academy of Sciences.
105. **Borisyuk R.M.**, Kirillov A.B. (1984) Qualitative analysis of neural dynamics. In: *X International Conference on Nonlinear Oscillations*, 1pp, Kiev, USSR.
106. **Borisyuk R.M.** and Borisyuk G.N. (1984) Analysis of dependencies of point processes in neurobiology. In: *CompStat 1984. Summaries of Short Communic. and Posters*, 1pp, Prague.
107. **Borisyuk R.M.**, Borisyuk G.N. and Kirillov A.B. (1984) A program package for the statistical analysis of spike activity. In: *CompStat 1984. Summaries of Short Communic. and Posters*, 1pp, Prague.
108. **Borisyuk R.M.**, Kovalenko E.I. and Kryukov V.I (1984) Computational model of slow rhythm neural generator. In: *Modelling of Biological and Medical Systems, IV International Congress of Socialist Countries, Abstracts*, 735, Prague (in Russian).
109. **Borisyuk R.M.** and Kirillov A.B. (1982) Qualitative study of dynamical modes in the model of two interactive neural populations. I USSR Biophysics Congress, Abstracts, v.2, 177, Moscow (in Russian).
110. **Borisyuk R.M.** (1982) Statistical analysis of interconnections between elements of neural network. In: *Ist USSR Biophysics Congress, Abstracts*, v.3, 35, Moscow (in Russian).
111. Borisyuk G.N., **Borisyuk R.M.**, Vinogradova O.S., Kirillov A.B., Kovalenko E.I. and Kryukov V.I. (1982) Study of metastable state in the computational model of CA3 field

of the hippocampus. Abstracts, In: Ist USSR Biophysics Congress, Abstracts, v.3, 36, Moscow (in Russian).

112. **Borisyuk R.M.** (1981) Examples of study of interactive nonlinear oscillators. In: IX International Conference on nonlinear oscillations. Abstracts, 69-73, Kiev (in Russian).
113. Borisyuk G.N., **Borisyuk R.M.**, Kirillov A.B., Kovalenko E.I. and Kryukov V.I. (1978) On possibility of statistical estimation of synaptic weights in neural network under multi-electrode recording. In: Proc. of the USSR Conference on Biological and Medical Cybernetics, Moscow-Sukhumi, v.2, 153-155 (in Russian).

#### **Other**

114. **Borisyuk R.**, Borisyuk G. (2003) Spatio-Temporal Activity of Interactive Neural Oscillators. Technical Report, Institute of Mathematical Biosciences, Ohio State University
115. **Borisyuk R.M.**, Vinogradova O.S., Denham M., Kazanovich Y.B., Hoppensteadt F. (2000). Neural network model of novelty detection based on frequency coding. Preprint. Russian Academy of Sciences, Pushchino, Russia (in Russian).
116. Arnol'd VI, **Borisyuk RM**, Gel'fand EM, Il'yashenko YS, Lunin VY, Nikolaev EV, Radvogin YB, Roitberg MA, Sinai YA, Khibnik AI (1999) Emmanuil El'evich Shnol' (on his 70th birthday), Russian Mathematical Surveys, v. 54: (3) pp 677-683.
117. **Borisyuk R.M.** (1996) Oscillatory neural networks. *Dissertation of Doctor of physical and mathematical sciences*. 72pp, Russian Academy of Sciences (in Russian).
118. Kazanovich Y. and **Borisyuk R.** (1994) Synchronization in a neural network of phase oscillators with a central element. *Preprint*, 30pp, Russian Academy of Sciences.
119. Cymbalyuk G.S, Nikolaev E.V. and **Borisyuk R.M.** (1992) In-Phase and anti-phase self-oscillations in a model of two electrically coupled pacemakers. *Preprint*, 21pp, Russian Academy of Sciences.
120. **Borisyuk R.M.** (1990) A model of the neural networks for storage and retrieval of temporal sequences. *Preprint*, 6pp, USSR Academy of Sciences.
121. **Borisyuk R.M.** and Kirillov A.B. (1982) Qualitative analysis of the model of two interacting neural populations. *Preprint*, 17pp, Pushchino, USSR Academy of Sciences (in Russian).
122. **Borisyuk R.M.** and Khibnik A.I. (1976) Numerical experiments with a chain of interactive slow-fast oscillators. *Preprint*, 22pp, USSR Academy of Sciences (in Russian).
123. About 10 other abstracts, preprints and reports not included at this list.

#### **OTHER INNOVATIVE AND CREATIVE ACTIVITIES**

##### **Conferences/workshop contributions delivered – accepted on the basis of refereed abstracts**

1. Invited Talk. Workshop on Computational Neuroscience. Oxford Consortium on industrial and Applied Mathematics. “Complex neural dynamics and information processing in the brain.” 19 October 2001
2. Invited talk in seminar at Department of Cybernetics, Reading University. “Synchronisation based models of cognitive functions”. 25 October 2001.

3. Invited talk for BIOCOMP2002. "Oscillatory dynamics and memory modelling in neural networks of spiking elements". Italy, 3-9 June, 2002
4. Invited talk for a Special Session of the Research Council on Biophysics of the Russian Academy of Sciences devoted to Prof. Olga Vinogradova. "Mathematical and computational model of hippocampal function". Pushchino, Russia, 11 June, 2002
5. Fourth International Workshop on Neuronal Coding, September 2001, Plymouth, UK.
6. Third International Workshop on Neuronal Coding, October 1999, Osaka, Japan.
7. International Workshop on Emergent Neural Computational Architectures Based on Neuroscience, September 1999, Edinburgh, Scotland.
8. International Joint Conference on Neural Networks, July 1999, Washington DC.
9. Fives SIAM Conference on Applied mathematics, Snowbird, May 1999.
10. Third International Conference on Cognitive and Neural Systems, Boston University, May 1999.
11. Forum of European Neuroscience, Berlin, June 1998.
12. Second International Conference on Cognitive and Neural Systems, Boston University, May 1998.
13. International Symposium "Electric Activity of the Brain: Mathematical Models and Analytical Methods". Pushchino, Russia, May 1997.
14. International Conference on Selected Topics of Mathematics, Samarkand, Uzbekistan, October 1997.
15. International Workshop "Neuronal Coding '97". INRA Versailles, France, September 1997.
16. International Workshop "Neuronal Coding". Center for Advanced Theoretical Study Prague, 1995.
17. World Congress on Neural Networks, WCNN'95, Washington DC, USA, June 1995
18. Workshop "Supercomputing in Brain Research: from Tomography to Neural Networks" SCBR'94, Juelich, Germany, October 1994.
19. 12th European Meeting on Cybernetics and System Research, EMCSR'94-Vienna, April 1994.
20. European Conference on Artificial Neural Networks, ICANN'94-Sorrento, Italy, May 1994.
21. IMACS International Symposium on Signal Processing, Robotics and Neural Networks, Lille, France, 1994.
22. 24th Annual Meeting of European Mathematical Psychology Group, Moscow'93, 1993.
23. 11th International Australian Winter Conference on Brain Research, New Zealand, August 1993.
24. Neural Information Processing Systems'92, Colorado, USA, November 1992.
25. European Conference on Neural Mechanisms of Learning and Memory, Limerick, Ireland, October 1992.
26. International Conference on Biological Modelling, BIOMOD-92, Leningrad, Russia, August 1992.

27. Conference of Former Soviet Republics on Theory of Differential Equations. Abstracts, Samarkand, Uzbekistan, September 1992.
28. Workshop on Complex Dynamics in Neural Networks, Vietri, Italy, 1991
29. The Russian Neural Network Society and IEEE International Symposium on Neuroinformatics and Neurocomputers, Rostov-on-Don, Russia, October 1992
30. International Conference on Nonlinear Neural Dynamics, Tokyo, Japan, May 1990.
31. International Joint Conference on Neural Networks, San Diego, USA, June 1990.
32. International Neural Networks Conference, Paris-90, France, September 1990.
33. 9th USSR Conference on Cybernetics, Rostov on Don, Russia, May 1990.
34. International Workshop "Neurocomputers and Attention". Moscow, September 1989.
35. X International Conference on nonlinear oscillations, Kiev, USSR, 1884.
36. International Conference on Computational Statistics, CompStat-1984. Prague, October 1984.
37. IV Prague International Symposium of Socialist Countries "Modelling of Systems in Biology and Medicine", Prague, October 1984.
38. USSR First Biophysical Congress, Moscow, August 1982.
39. IX International Conference on nonlinear oscillations, Kiev, USSR, 1981.
40. USSR conference on Interactive Markov processes and Applications in Biology, Pushchino, Russia, 1976, 1978, 1982, 1986.

### **Invited seminars, lectures, and colloquiums**

I have been invited to present seminars, lectures, and colloquiums in many leading Neural Network Centres and Universities around the world, including the USA, Japan, New Zealand, Germany, Italy, Belgium (total number of invited presentations is about 25). Among the most prestigious centres where I have reported on my research are:

- seminar in the Institute for Brain Research, Frankfurt in Main, directed by Professor Wolf Singer (1990);
- seminar in the Institute for Neural Computation, UCSD, directed by Professor Terence Sejnowski and Professor Francis Crick (1993);
- colloquium in the Center for Neural and Adaptive Systems, Boston University, directed by Professor Stephen Grossberg (1997).

### **RESEARCH GRANTS AND CONTRACTS OBTAINED**

- |         |   |
|---------|---|
| 1993    | W.Evans grant for one month research work in the Otago University (New Zealand)   |
| 1993-95 | Principal Investigator, grant from McDonnell Foundation (USA) for research in cognitive neuroscience                            |
| 1994-95 | Principal Investigator, grant from the International Science Foundation, USA-Russia   |
| 1994-96 | Principal Investigator, grant from the Russian Foundation of Fundamental Research for the research in the mathematical modeling |
| 1995-96 | Principal Investigator, joint grant from the International Science Foundation (USA-Russia) and government of Russia             |

- 1997-1999 Co-Principal Investigator, Grant from Russian Foundation of Fundamental Research in support of Scientific School on intercellular interactions
- 2001-2002 Principal Investigator, Grant from Russian Foundation of Fundamental Research “Computational Modelling of the Hippocampal Function”
- 2001-2002 Principal Investigator, Grant EPSRC, “Oscillatory neural models of memory formation and novelty detection”.
- 2001 Co-Investigator of EPSRC grant to organise 4<sup>th</sup> International workshop on Neural Coding.

## **RESEARCH IN PROGRESS**

### **Brief summary of previous research**

I have been working in the field of neural networks for 30 years. The main direction of my research has been related to modelling the functional behaviour of structures in the central nervous system. I was among the first in the world to apply new mathematical tools – multidimensional interacting Markovian processes and fields - to the analysis of dynamical regimes in stochastic neural networks (large-scale approach using many variables).

I was engaged at Moscow in pioneer research concerned with developing numerical algorithms to investigate the bifurcations of steady states and limit cycles in nonlinear dynamical systems under parameter variation (small-scale approach using several main variables). These investigations showed that cooperative effects like physical phase-transitions and synchronisation phenomena occur normally in biological neural networks despite a very chaotic spike activity of single neurons. In addition, metastable states of neural networks were proved to be useful to model short-term memory in a series of theoretical and simulation works. This led to the development of a neural network model based on biologically plausible constraints on the elements of a network (similar to integrate-and-fire neurons) which was capable of demonstrating metastable states. This basic neural network model was used to model low frequency oscillations in the septum, the habituation in the hippocampus, metastable states in the cortex and the cerebellum.

I obtained considerable experience in artificial neural networks and their applications for pattern recognition working as a team leader of several applied projects. I participated in the team to develop a hierarchical structure of neural networks for recognition of printed musical symbols (independent of font). I also took part in some applications of neural networks for high-energy physics (for example, gamma-ray energy discrimination).

### **Research Goals**

I am currently working on the problems related to the study of complex dynamics and chaos of the oscillatory neural networks with various types of elements and architectures. In particular, the synchronisation modes are carefully studied. There are still many open questions in oscillatory neural networks, the networks of phase oscillators and the networks with time delayed coupling. The study of the problems related to training oscillatory neural networks (reinforcement learning) has been started in order to find the algorithms for network parameter modification which can be used to model neurophysiological and psychological data on attention switching and conditioning. The fulfilment of this program will form a unified approach to the solution of the problems of memory, binding, and attention.

#### **1. Modeling of the septo-hippocampal system: memory**

- To develop a septum model as a source of hippocampal theta rhythm where the main mechanism of rhythm generation is based on the interaction of the loci of pacemaker neurons with neighbourhoods.
- To develop a biologically plausible model of the hippocampus taking into account the spatial and temporal specific features of the hippocampal neurons, time courses of different neurotransmitters (ACh, GABA, etc.), time delay in signal propagating, rhythms with different frequencies (theta-rhythm, sharp waves, etc.), inputs from the septum and entorhinal cortex. This model should work as a comparator of incoming signals, novelty detector, and short-term memory (temporal sequences).

## **2. Modeling of interactive cortical zones: pre-attention**

- To develop multilayer networks of biologically plausible elements taking into account columnar structure of the cortex to study information representation and interaction in primary and secondary convergent zones.
- To show that the synchronisation of multifrequency oscillations can be used to bind the features of an analysed object (pre-attention).

## **3. A large-scale model of information processing: attention. Towards the brain theory**

- To develop and investigate biologically plausible models (modules) of the brain structures (cortical columns of different modalities, the septum, the hippocampus, the thalamus, the basal ganglia, the reticular formation, etc.).
- To develop a large-scale model of interactive modules where the thalamus and the hippocampus are central executives.
- To investigate the interplay between different brain structures during information processing and to link together evidence of neurophysiological experiments and psychological data.
- To formulate the main principles of the information processing and which can be checked by neurophysiological and psychological experiments and which can be considered as a framework for the future brain theory.

## **4. Research Students**

### **NUMBER OF RESEARCH STUDENT SUPRVISED**

#### **MPhil:**

##### ***Completed:***

1. Maxim Ol'shevec, Pushchino State University, 1994-96

#### **PhD:**

##### ***Completed:***

1. Alexei Skurikhin, PhD, Institute of mathematical problems in Biology, Russian Academy of Sciences, 1990-1996
2. Andrei Gribok, PhD, Institute of mathematical problems in Biology, Russian Academy of Sciences, 1990-1996
3. Gennady Cymbalyuk, PhD, Institute of mathematical problems in Biology, Russian Academy of Sciences and Department of Physics, Moscow State University, 1992-1996

## **5. Teaching**

### **SUMMARY OF CURRENT TEACHING COMMITMENT:**

Module “Computational Modelling”, MSc course in Computational Intelligence (COIN503), since 1998/99 academic year

### **PREVIOUS UNIVERSITY TEACHING COMMITMENT, CURRICULUM DEVELOPMENT**

- 1994-96 Associate Professor of Mathematical Biology at the Pushchino State University. Teacher of postgraduate course in neural networks and Leader of postgraduate student Scientific Seminar. Author of MSc module on neural networks.
- 1973-95 Director of Studies of three Ph.D. students and one MPhil Student, all successfully completed.
- 1973-95 Director of postgraduate program and PhD's program in computer science and bioinformatics for students with specialisation in biology and chemistry at the USSR Academy of Sciences. Teacher of postgraduate courses "Computer Science for Biologists" and "Bioinformatics".
- 1973-95 Teacher of undergraduate courses in computer science, bioinformatics, and mathematical modelling at Department of Biology, Moscow State University (in Pushchino, during summer semester). Co-author of undergraduate program "Mathematical and Computer Methods in Biology".
- 1973-95 Teaching of courses for gifted students in advanced mathematics, Pushchino High Schools.

### **6. Standing at National/International Level**

- 1990-date Member of Editorial Board of "Neural Networks" - the official Journal of International Neural Network Society.
- 1990-date Member of Editorial Board of International Journal "Chaos Theory and Applications"
- 2002-date Member of Editorial Board of Internal Journal “”Integrative Neuroscience””.
- 1990-date Member of Executive Board of the Russian Neural Network Society.
- 1985-96 Member of Scientific Council of Institute of Mathematical Problems of Biology of the Russian Academy of Sciences.
- Organising Committee Member of the 4<sup>th</sup> International Workshop on Neural Coding, Plymouth, 2001
  - Guest Co-Editor of special Issue of BioSystems Journal, Proceedings of 4<sup>th</sup> International Workshop on Neural Coding, 2002, v. 67, no. 1-3.
  - Co-Organiser and Co-Chair of the Special Session “Modelling of the Hippocampal Function” at the International Joint Conference on Neural Networks, Washington DC, July 1999
  - Co-Chair of the Special Session “Neural Network Research in Russia” at the International Joint Conference on Neural Networks, Washington DC, July 1999
  - Visiting Research Fellow, Systems Science Center, Arizona State University (November 1996-May 1997).
  - Co-organizer of first USSR Conferences on Neural Networks and Neurocomputing: "Neural Networks: Theory and Architecture (Pushchino, 1988)
  - Co-organizer of the International Conference "Neurocomputers and Attention" (Moscow, 1989).

- Co-organizer of the USSR conferences, "Computers and Education" (Pushchino, 1985, 1986, 1987).
- Member of Program Committee of First International RNNS/IEEE Symposium on Neuroinformatics and Neurocomputers (Russia, Rostov on Don, 1992).
- Co-organizer of the International Workshop on Analysis and Modeling of Neural Activity (Pushchino, 1997).