Medical Applications of Artificial Neural Networks

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Abstract – Medical decision-making is an essential activity and, most often, it is a very difficult one, implying a large number of medical and technical aspects. But, more important, it involves humans: on the one hand, the patient, who has a medical problem and who requires the best solution; on the other hand, the physician, who should be able to provide, in any circumstances, a decision or a prediction regarding the current and the future medical status of the patient. The technology aims to help both of them and it is assisted by appropriate theory regarding modeling tools. One of the most powerful mechanisms that can be used in this field is the Artificial Neural Networks (ANNs). This paper presents some of the results obtained by the Process Control group of the Politehnica University Timisoara, Romania, in the field of ANNs applied to modeling, prediction and decision-making related to medical systems. The paper includes authors' concerns in this domain and emphasizes that these intelligent models, even if they are artificial, can characterize human behavior, being a real help in medical activity.

Key words: artificial neural networks, medical diagnosis, medical prediction, prosthetic hands, recurrent neural networks

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REFERENCES

[1] S. J. Russell and P. Norvig, "Artificial Intelligence: A Modern Approach", 3rd ed. Upper Saddle River, NJ, USA: *Pearson*, 2010.

[2] J. M. Zurada, "Introduction to Artificial Neural Systems", Mumbai, India: *Jaico Publishing House*, 2012.

[3] A. Albu, "Decisional methods applied in medical domain", in *Proc. 5th International Symposium on Applied Computational Intelligence and Informatics*, Timisoara, Romania, 2009, pp. 123-128.

[4] A. Albu and L. Stanciu, "Benefits of using artificial intelligence in medical predictions", in *Proc. 5th IEEE International Conference on E-Health and Bioengineering*, Iasi, Romania, 2015, pp. 1-4.

[5] T.-A. Teban, R.-E. Precup, T. E. A. de Oliveira and E. M. Petriu, "Recurrent dynamic neural network model for myoelectric-based control of a prosthetic hand", in *Proc. 2016 IEEE International Systems Conference*, Orlando, FL, USA, 2016, pp. 1-6.

[6] T.-A. Teban, R.-E. Precup, E.-C. Lunca, A. Albu, C.-A. Bojan-Dragos and E. M. Petriu, "Recurrent neural network models for myoelectric-based control of a prosthetic hand", in *Proc. 22nd International Conference on System Theory, Control and Computing*, Sinaia, Romania, 2018, pp. 1-6.

[7] M.-B. Radac, R.-E. Precup, E. M. Petriu and S. Preitl, "Iterative data-driven controller tuning with actuator constraints and reduced sensitivity", *Journal of Aerospace Information Systems*, vol. 11, no. 9, pp. 551-564, Sep. 2014.

[8] M.-B. Radac, R.-E. Precup, E. M. Petriu and S. Preitl, "Iterative data-driven tuning of controllers for nonlinear systems with constraints", *IEEE Transactions on Industrial Electronics*, vol. 61, no. 11, pp. 6360-6368, Nov. 2014.

[9] M.-B. Radac, R.-E. Precup and E. M. Petriu, "Constrained data-driven model-free ILC-based reference input tuning algorithm", *Acta Polytechnica Hungarica*, vol. 12, no. 1, pp. 137-160, Jan. 2015.

[10] M.-B. Radac and R.-E. Precup, "Data-based two-degree-of-freedom iterative control approach to constrained non-linear systems", *IET Control Theory & Applications*, vol. 9, no. 7, pp. 1000-1010, May 2015.

[11] M.-B. Radac and R.-E. Precup, "Three-level hierarchical model-free learning approach to trajectory tracking control", *Engineering Applications of Artificial Intelligence*, vol. 55, pp. 103-118, Oct. 2016.

[12] M.-B. Radac, R.-E. Precup and R.-C. Roman, "Model-free control performance improvement using virtual reference feedback tuning and reinforcement Q-learning", *International Journal of Systems Science*, vol. 48, no. 5, pp. 1071-1083, Apr. 2017.

[13] M.-B. Radac and R.-E. Precup, "Data-driven model-free slip control of anti-lock braking systems using reinforcement Q-learning", *Neurocomputing*, vol. 275, pp. 317-329, Jan. 2018.

[14] M.-B. Radac, R.-E. Precup and R.-C. Roman, "Data-driven model reference control of MIMO vertical tank systems with model-free VRFT and Q-learning", *ISA Transactions*, vol. 73, pp. 227-238, Feb. 2018.

[15] A. Zare, M.-A. Zare, N. Zarei, R. Yaghoobi, M.-A. Zare, S. Salehi, B. Geramizadeh, S.-A. Malekhosseini and N. Azarpira, "A neural network approach to predict acute allograft rejection in liver transplant recipients using routine laboratory data", *Hepatitis Monthly*, vol. 17, no. 12, paper e55092, DOI: doi: 10.5812/hepatmon.55092, Dec. 2017.

[16] L. Bertolaccini, P. Solli, A. Pardolesi and A. Pasini, "An overview of the use of artificial neural networks in lung cancer research", *Journal of Thoracic Disease*, vol. 9, no. 4, pp. 924-931, Mar. 2017.

[17] S.-A. Korkmaz, H. Binol, A. Akcicek and M.-F. Korkmaz, "An expert system for stomach cancer images with Artificial Neural Network by using HOG Features and Linear Discriminant Analysis: HOG_LDA_ANN", in Proc. *IEEE 15th International Symposium on Intelligent Systems and Informatics*, Subotica, Serbia, 2017, pp. 327-332, 2017.

[18] A. Esteva, B. Kuprel, R.-A. Novoa, J. Ko, S.-M. Swetter, H.-M. Blau and S. Thrun, "Dermatologist-level classification of skin cancer with deep neural networks", *Nature*, vol. 542, no. 7639, pp. 115-118, Feb. 2017.

[19] E.-J. Lee, Y.-H. Kim, N. Kim and D.-W. Kang, "Deep into the brain: artificial intelligence in stroke imaging", *Journal of Stroke*, vol. 19, no. 3, pp. 277-285, Sep. 2017.

[20] K.-W. Johnson, J.-T. Soto, B.-S. Glicksberg, K. Shameer, R. Miotto, M. Ali, E. Ashley and J.-T. Dudley, "artificial intelligence in cardiol-

ogy", *Journal of the American College of Cardiology*, vol. 71, no. 23, pp. 2668-2679, Jun. 2018.

[21] D.-M. Filimon and A. Albu, "Skin diseases diagnosis using artificial neural networks", in *Proc. 9th IEEE International Symposium on Applied Computational Intelligence and Informatics*, Timisoara, Romania, 2014, pp. 189-194.

[22] I. Tanasoiu and A. Albu, "A connectionist model for cerebrovascular accident risk prediction", in Proc. *6th IEEE International Conference on E-Health and Bioengineering*, Sinaia, Romania, 2017, pp. 45-48.

[23] UCI Machine Learning Repository - Dermatology Data Set, http://archive.ics.uci.edu/ml/datasets/Dermatology, last accessed 2018.

[24] World Health Organization, http://www.who.int, last accessed 2018.

[25] R. Avram, *Elemente de clinică medicală: aparat cardiovascular*. Timisoara: Editura Orizonturi Universitare, 2012.

[26] H. Asadi, R. Dowling, B. Yan and P. Mitchell, "Machine learning for outcome prediction of acute ischemic stroke post intra-arterial therapy", *PLoS ONE*, vol. 9, no. 2, paper e88225, DOI: 10.1371/journal.pone.0088225, Feb. 2014.

[27] R.-E. Precup, T.-A. Teban, E. M. Petriu, A. Albu and I.-C. Mituletu, "Structure and evolving fuzzy models for prosthetic hand myoelectric-based control systems", in *Proc. 26th Mediterranean Conference on Control and Automation*, Zadar, Croatia, 2018, pp. 1-6.

[28] S. Hochreiter and J. Schmidhuber, "Long short-term memory", *Neural Computation*, vol. 9, no. 8, pp. 1735-1780, Nov. 1997.

[29] F. A. Gers, J. Schmidhuber and F. Cummins, "Learning to forget: continual prediction with LSTM", *Neural Computation*, vol. 12, no. 10, pp. 2451-2471, Oct. 2000.

[30] R.-E. Precup, M. L. Tomescu and S. Preitl, "Lorenz system stabilization using fuzzy controllers", *International Journal of Computers Communications & Control*, vol. 2, no. 3, pp. 279-287, Sep. 2007.

[31] J. Vaščák, "Adaptation of fuzzy cognitive maps by migration algorithms", *Kybernetes*, vol. 41, no. 3-4, pp. 429-443, Mar. 2012.

[32] S. Blažič, I. Škrjanc and D. Matko, "A robust fuzzy adaptive law for evolving control systems", *Evolving Systems*, vol. 5, no. 1, pp. 3-10, Mar. 2014.

[33] R.-E. Precup, R.-C. David and E. M. Petriu, "Grey wolf optimizer algorithm-based tuning of fuzzy control systems with reduced parametric sensitivity", *IEEE Transactions on Industrial Electronics*, vol. 64, no. 1, pp. 527-534, Jan. 2017.

[34] S. Vrkalovic, T.-A. Teban and I.-D. Borlea, "Stable Takagi-Sugeno fuzzy control designed by optimization", *International Journal of Artificial Intelligence*, vol. 15, no. 2, pp. 17-29, Oct. 2017.

[35] G. Navarro, D. K. Umberger and M. Manic, "VD-IT2, Virtual Disk cloning on disk arrays using a type-2 fuzzy controller", *IEEE Transactions on Fuzzy Systems*, vol. 25, no. 6, pp. 1752-1764, Dec. 2017.

[36] R. P. Alvarez Gil, Z. C. Johanyák and T. Kovács, "Surrogate model based optimization of traffic lights cycles and green period ratios using microscopic simulation and fuzzy rule interpolation", *International Journal of Artificial Intelligence*, vol. 16, no. 1, pp. 20-40, Mar. 2018.

[37] T. Haidegger, L. Kovács, R.-E. Precup, B. Benyó, Z. Benyó and S. Preitl, "Simulation and control for telerobots in space medicine", *Acta Astronautica*, vol. 181, no. 1, pp. 390-402, Dec. 2012.

[38] R.-E. Precup, T.-A. Teban, T. E. A. de Oliveira and E. M. Petriu, "Evolving fuzzy models for myoelectric-based control of a prosthetic hand", in *Proc. 2016 IEEE International Conference on Fuzzy Systems*, Vancouver, BC, Canada, 2016, pp. 72-77.

[39] P. Melin, I. Miramontes and G. Prado-Arechiga, "A hybrid model based on modular neural networks and fuzzy systems for classification of blood pressure and hypertension risk diagnosis", *Expert Systems with Applications*, vol. 107, pp. 146-164, Oct. 2018.

[40] Á. Takács, L. Kovács, I. Rudas, R.-E. Precup and T. Haidegger, "Models for force control in telesurgical robot systems", *Acta Polytechnica Hungarica*, vol. 12, no. 8, pp. 95-114, Dec. 2015.

[41] B. Belean, M. Streza, S. Crisan and S. Emerich, "Dorsal hand vein pattern analysis and neural networks for biometric authentication", *Studies in Informatics and Control*, vol. 26, no. 3, pp. 305-314, Sep. 2017.

[42] L. Kovács, "A robust fixed point transformation-based approach for type 1 diabetes control", *Nonlinear Dynamics*, vol. 89, no. 4, pp. 2481-2493, Sep. 2017.

[43] P. Korondi, K. D. Young and H. Hashimoto, " Sliding mode based disturbance observer for motion control", in *Proc. 37th IEEE Conference on Decision and Control*, Tampa, FL, USA, pp. 1926-1927, 1998.

[44] F. G. Filip, "Decision support and control for large-scale complex systems", *Annual Reviews in Control*, vol. 32, no. 1, pp. 61-70, Apr. 2008.

[45] D. Antić, S. Nikolić, M. Milojković, N. Danković, Z. Jovanović and S. Perić, "Sensitivity analysis of imperfect systems using almost orthogonal filters", *Acta Polytechnica Hungarica*, vol. 8, no. 6, pp. 79-94, Dec. 2011.

[46] N. Dučić, Ž. Ćojbašić, R. Radiša, R. Slavković and I. Milićević, "CAD/CAM design and genetic optimization of feeders for sand casting process", *Facta Universitatis, Series: Mechanical Engineering*, vol. 14, no. 2, pp. 147-158, May 2016.

[47] E. Osaba, X.-S. Yang, F. Diaz, E. Onieva, A. Masegosa and A. Perallos, "A discrete firefly algorithm to solve a rich vehicle routing problem modelling a newspaper distribution system with recycling policy", *Soft Computing*, vol. 21, no. 18, pp. 5295-5308, Sep. 2017.

[48] I. Dumitrache, N. Constantin and M. Drăgoicea, *Retele neurale: identificarea si conducerea proceselor*. Bucharest: Matrix Rom, 1999.

[49] A. Alique, R. E. Haber, R. H. Haber, S. Ros and C. Gonzalez, "Neural network-based model for the prediction of cutting force in milling process. A progress study on a real case", in *Proc. 15th IEEE International Symposium on Intelligent Control*, Patras, Greece, 2000, pp. 121-125.

[50] A. Azadeh, R. Babazadeh and S. M. Asadzadeh, "Optimum estimation and forecasting of renewable energy consumption by artificial neural networks", *Renewable and Sustainable Energy Reviews*, vol. 27, pp. 605-612, Nov. 2013.

[51] T. V. Tran and Y. N. Wan, "Artificial chemical reaction optimization algorithm and neural network based adaptive control for robot manipulator", *Control Engineering and Applied Informatics*, vol. 19, no. 2, pp. 61-70, Jun. 2017.

[52] R.-E. Precup and S. Preitl, "Popov-type stability analysis method for fuzzy control systems", in *Proc. Fifth European Congress on Intelligent Technologies and Soft Computing (EUFIT'97)*, Aachen, Germany, 1997, vol. 2, pp. 1306-1310.

[53] C. Pozna, R.-E. Precup, J. K. Tar, I. Škrjanc and S. Preitl, "New results in modelling derived from Bayesian filtering", *Knowledge-Based Systems*, vol. 23, no. 2, pp. 182-194, Mar. 2010.